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Effect of organic source of nutrients in growth and yield parameters of Okra (*Abelmoschus esculentus* L.) in Karbi Anglong district of Assam

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Abstract
A field experiment was conducted in the farmers' field of Karbi Anglong district of Assam in the year 2016-17 and 2017-18 to study the effect of organic sources of inputs on growth, yield and economics of Okra (*Abelmoschus esculentus* L.). Results revealed that FYM @ 5t/ha + Vermicompost @ 1t/ha + Seed treatment with *azotobacter* and PSB @ 7.5 g each/100g+ soil application of rock phosphate @ 13 Kg/ha (T_3) showed significantly higher values of plant height (108.50 cm), first fruiting node (5^{th} node), number of fruits per plant (9.25), average fruit weight (21.05 g), average fruit length (16 cm), average fruit girth (4.75 cm) and yield (80.58 q/ha) than T4 (control). The economical parameters in terms of Net return (Rs.105640.00), Gross return (Rs. 161310) and B:C ratio (3.04) were also found to be considerably higher in T_3 as compared to T_1 (Recommended NPK) and T_2 (Recommended NPK + FYM). Farmers' practice (T_4) recorded the least B:C ratio of 2.17. Therefore, T_3 was found to be the feasible option for obtaining higher yield and profitable income.

Keywords: Okra, organic farming, *azotobacter*, vermicompost

Introduction

In the present context of healthy food habit, organic product is one of the most talked about topic in today's agriculture. Moreover, climate change and climate variability are becoming a great concern to the farming with issues like extreme weather conditions, desertification, water stress and adverse health effects. Excessive use of chemical fertilizers to obtain high yield resulted in several hazards to the soil, deficiency of micronutrients (Kanwar and Randhawa, 1978) [1], non-development of good plant characters such as good root system, shoot system, nutritional characters (Chandini *et al.*, 2019) [2] and nutrient imbalance (Singh *et al.*, 1989) [3], ultimately resulting in the poor crop yield. Under such circumstances, adaptation of organic agriculture can sustain a well established practice as organic farming restricts its boundary to nutrient exploitation and increases soil organic matter content (Babu *et al.*, 2017) [4]. The International Federation of Organic Agriculture Movements (IFOAM) defines Organic agriculture asa production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Karbi Anglong is blessed with favourable climatic conditions to a wide range of horticultural crops. Okra (*Abelmoschus esculentus* L.) is one of such potential crop. It is grown over a wide range of soil and climatic condition with a warm season and favours a preferable temperature between 22 °C and 35 °C. The crop is susceptible to frost at temperatures below 12°C. Subtropical humid climate of Assam with hot summer during May to August is suitable for okra cultivation (Kumar *et al.* 2017) [5].

Okra is a rich source of Iodine and other vital minerals and vitamins. Mucilage present in Okra fruit is polysaccharides *i.e* galacturonic and glucuronic acids (Singh and Ram, 2018) [6]. Additionally, it has medicinal applications when used as a plasma replacement or blood volume expander. The mucilage of okra binds cholesterol and bile acid carrying toxins dumped into it by the liver (Gemede *et al.*, 2015) [7].

Okra seed is rich in protein and unsaturated fatty acids such as linoleic acid. In some countries, okra is used in folk medicine as antiulcerogenic, gastro protective and diuretic agents (Gurbuz, 2003) [8]. It is also a very good source of calcium and potassium.

Many attempts have been made already to enhance the productivity without degrading the nutrient status of the soil using biofertilizers such as *Azospirillum*, PSB, VAM which have potential practical applications by increasing biological nitrogen fixation, increase availability or uptake of nutrients through phosphate solubilization or increase absorption capacity, stimulation of plant growth or by rapid decomposition of organic residues *etc. Azotobacter* is free living bacteria. It has been reported to fix 20 kg N ha^{-1} in field of non legume crop and also secretes some growth promoting substances (Singh and Ram, 2018) [6]. Okra is cultivated in majority portions of the district and the farmers of Karbi Anglong district are not much interested in use of inorganic fertilizers. Thus, a study has been carried out under farmers' field conditions to study the effect of organic inputs like *Azotobacter*, PSB and Rock Phosphate along with FYM in enhancing the productivity of the crop.

Materials and Methods

The study was carried out in the farmers' field during *rabi* season of 2016-17 and 2017-18 at Eight (08) villages in Karbi Anglong district under hill zone of Assam. The experimental soils were sandy loam to clay loam with an average pH range from 5.5 to 6.5. The villages were taken as replications and in all the villages four (04) treatment combinations were followed. The treatment combinations were: T_1-Only recommended NPK, T_2-Recommended NPK + FYM, T_3 - FYM @ 5t/ha + Vermicompost @1t/ha+ Seed treatment with *Azotobacter*(AZB) and PSB @7.5 g each/100g + soil application of Rock phosphate @13 Kg/ha and T_4 (Control)– Farmers 'practice which is only use of FYM @ 1-2t/ha without any chemical fertilizer. The variety used in this study was "Arka Anamika", released by the Indian Institute of Horticultural Research (IIHR), ICAR.

The recommended dose of NPK fertilizers were applied in treatment T_1 and T_2. The seeds were treated with inoculums of *Azotobacter* (AZB) and Phosphate Solubilising Bacteria (PSB) @ 7.5g per 100gms of seed and then sown immediately. Along with FYM @ 5 t/ha, Vermicompost @ 2t/ha and Rock phosphate @ 313 kg/ha were also applied into the soil during the time of land preparation. The T_4 treatment was used as Farmers' practice which is only FYM application @ 1-2 t/ha. The parameters *viz.* plant height, plant height at first fruiting, first fruiting node, number of fruits per plant, average fruit weight, average fruit length and average fruit girth were recorded. Days to first and final harvest, final crop yield were also recorded. Finally economics were calculated and accordingly data on gross return, net return and B:C ratio were recorded for all the treatments.

The experimental findings were pooled over two growing seasons and statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F 'test at 0.05 probability level (Gomez and Gomez, 2010; Cochran and Cox, 1977) [9, 10].

Result and Discussion

Growth Parameters

The data regarding the growth parameters are presented in the Table 1. Significantly tallest plant was recorded in T_3(108.50 cm) followed by T_2 (95.03 cm) and T_1 (92.51 cm) as against the least in T_4 (89.55 cm). This might be due to capability of the applied three organic inputs that have been used in T3 in providing nutrients to the plants in their respective form. This in turn resulted in better plant growth and development. Wu *et al.* (2019) [11] reported that single and mixed strains of PSB can influence the growth of the plant positively. Similarly, Ditta *et al.* (2018) [12] stated that application of rock phosphate enriched composts increases nodulation, growth and yield of chickpea. Moreover, improved plant growth by *Azotobacter sp.* and PSB may be attributed to several mechanisms especially growth hormone production, improving root efficiency and combined nitrogen and phosphorus availability (Vessey, 2003) [13].

Table 1: Effect of organic and inorganic inputs in Okra cultivation

Treatment	Plant height (cm)	Plant height at first fruiting (cm)	First fruiting node	Fruits/plant (no.)	Avg. Fruit weight (g)	Avg. Fruit length (cm)	Avg. Fruit girth (cm)
T1-Recommended NPK	92.51	64.15	8.25	7.00	14.45	14.40	3.50
T2-Recommended NPK + FYM	95.03	63.01	8.00	7.00	16.95	13.90	3.85
T3-FYM @ 5t/ha + Vermicompost @ 1t/ha. Seed treatment with AZB and PSB @ 7.5 g each/100g soil application with Rock phosphate @ 13 Kg/ha	108.50	81.50	5.00	9.25	21.05	16.00	4.75
T4-Farmers' practice	89.55	69.80	7.50	5.87	15.55	14.55	3.45
S. Ed	1.933	1.428	-	0.609	0.995	1.00	0.12
C.D. (P=0.5)	4.04	2.990	-	1.275	2.082	2.09	0.26

The increased height may also be due to more balanced C: N ratio, sufficient supply of available nutrients and synthesis of other compounds. Similar findings has also been reported by Naidu *et al.* (1999) [14]; Abusaleha and Shanmughavelu (1988) [15]. In case of T_3, the first fruiting node was found to be in the 5^{th} node whereas, in case of both the treatments $T_1$and T_2 were the same (8^{th} node) and in T_4, the first fruiting took place at the 7^{th} node. The earlier flowering in T_3 might be attributed to higher microbial activity and beneficial effect of PSB and *Azotobacter* which enhances nutrient availability and production of growth promoting substances. The delayed flowering in 7^{th} node in case of farmers' practice might be due to nutrient stress. Early flowering in okra was also observed with the integrated nutrient application (Prabhu *et al.*, 2002) [16]. Moreover, Joshi and Vig (2010) [17] reported significant changes on growth parameters due to application of vermicompost.

The numbers of fruits per plant, the most important yield attribute in okra were also significantly influenced by the combined application of FYM, Biofertilizers and rock phosphate as compared to chemical fertilizers alone and farmers' practice. The highest number of fruits was recorded in T_3 (9.25) as compared to lowest in T_4 (5.87). The higher number of fruits per plant might be due to better availability and uptake of nutrients by plants and longer productive period. *Azotobacter* can effectively hasten plant development through nitrogen nutrition and production of plant growth promoting substances. On the other hand PSB helps in increasing root development. Thus the increase in fruits per plant in this study might be due to combined effect of *Azotobacter* and PSB (Mishra and Tripathi, 2011) [18]. Similar findings have also been reported by Gajbhiye *et al.* (2003) [19]. Moreover, Mishra *et al.*, 2018 [20] also confirmed that number of fruit per plant was highest when *azotobacter* was applied in Brinjal.

Significant increase in fruit weight, fruit length and fruit girth was observed in T_3 over all other treatments (Table 1) indicating beneficial effect of biofertilizers applied with FYM and rock phosphate. *Azotobacter* produces antibacterial and antifungal compounds, hormones and siderophore (Sharma, 2002) [21]. When applied, the cells stick to the seed or roots and multiply in the soil to form a thick sheath of bacterial population in the roots and in due course they fix atmospheric nitrogen (Prasad *et al.*, 2017) [22]. And this released nitrogen in the root zone is quickly absorbed by the roots which ultimately help in increase in fruit weight, fruit length and fruit girth of the crop. Ranna and chandel (2003) [23] applied biofertilizer and nitrogen in the strawberry and found that *Azotobacter* inoculated treatments showed higher fruit weight, fruit length and girth. Similar findings were also reported by Sharma *et al.*, 2018 [24]. Das *et al.*, 2017 [25] observed increase in fruit weight due to combined treatment of bio-fertilizers.

Table 2: Effect of inputs on days to harvest, yield and economics of Okra cultivation

Treatment	Days to first harvest (days)	Days to last harvest (days)	Yield (q/ha)	Gross cost	Gross return (Rs.)	Net return (Rs.)	B:C ratio
T_1-Recommended NPK	66.875	104.875	63.9	42539	95850	53311	2.28
T_2-Recommended NPK + FYM	65.5	109	65	47039	115000	67961	2.42
T_3-FYM @ 5t/ha + Vermicompost @ 1t/ha. Seed treatment with AZB and PSB @ 7.5 g each/100g soil application with Rock phosphate @ 13 Kg/ha	52.5	120.375	80.5875	55170	161310	105640	3.04
T_4-Farmers' practice	63.675	106.875	57.55	40775	86325	45550	2.17
S. Ed	1.38	0.941	1.02	-	-	-	-
C.D. (P=0.5)	2.89	1.970	2.13	-	-	-	-

Statistically significant differences were found among the treatments for days to first and days to last harvest. T_3 showed significant increase in the yield parameters over T_2, T_1 and control treatment signifying the importance of organic manures in improving growth and yield of okra. The increase in yield might have been due to the higher values of various yield attributing parameters namely average fruit weight, average fruit length, average fruit girth, and fruits produced per plant. These in turn might be due to biofertilizer treatment where apart from increasing the availability of nitrogen and phosphorous in soil, the nitrogen fixers and phosphorous solubulizers also increased their translocation from root to flower (Singh and Singh, 2009) [26]. Similar findings have also been reported by Mishra and Tripathi (2011) [18]; Wange *et al.* (1998) [27] and Tripathi *et al.* (2010) [28] in strawberry where combination of a*zotobacter* and PSB have resulted in maximum yield of the fruits. Higher yield in T_3 might also be due to the additive effect of biofertilizers which might have facilitated better soil conditions like improved soil fertility, nitrogen fixation, phosphate solubilization, which ultimately enhanced the activities of other microbes and release of other growth stimulants as well (Choudhary *et al.*, 2015) [29;] Das *et al.*, 2017 [25]; Ram *et al.*, 2007 [30]; Dutta *et al.*, 2009 [31] and Barne *et al.*, 2011[32] reported that better fruit retention and yield could be obtained through application of biofertilizers in guava. Rathava *et al.*, 2018 [33] also reported highest yield per hectare in okra due to application of *Azotobacter*. Mishra *et al.*, 2018 [20] also reported highest yield in Brinjal when *azotobacter* is added. Pattanayak *et al.* (2001) [34] reported increase in yield of okra when FYM is added at the rate of 5t ha^{-1} along with *Azotobacter*. Moreover, Azarmi *et al.* (2008) [35] reported that soil application of vermicompost works effectively on Tomato cultivation in increasing its yield parameters

The duration of harvest was significantly more in T3 (120.375 days) and T2 (109 days) which may be attributed to better plant nutrition whereas the plants in treatment T4 showed early senescence (106 days) which might be due to nutrient stress. The present findings are in conformity with Rathava *et al.*, 2018 [33] who reported maximum days of harvest in okra when combination of PSB and *Azotobacter* was applied. Similar findings have also been reported by Mishra and Tripathi (2011) [18] and Tripathi *et al.* (2010) [28].

Economics

The economics regarding gross cost, gross return, net return and benefit cost ratio is presented in Table 2. It is clearly evident from the table that T3 has the highest gross return (Rs. 161310.00) due to highest yield with a net return of Rs. 105640.00 whereas, the control treatment possesses the lowest gross return of Rs. 86325.00 and a net return of Rs. 45550.00 The B:C ratio was found highest in case of T3 (3.04) followed by T2 (2.42) and T1(2.28). The B:C ratio of the control was found to be the lowest with 2.17.

Conclusion

The present study revealed that among all the treatments,T_3 (FYM @ 5t/ha + Vermicompost @ 1t/ha. Seed treatment with AZB and PSB @ 7.5 g each/100g soil application with Rock phosphate @ 13 Kg/ha and) is the best treatment followed by T_2 (Recommended NPK + FYM) and then T_1 (Recommended NPK) as comapared toT_4 (farmers' practice).Superiority of T_3 not only in terms of growth and yield parameters but also in terms of profitable cost benefit ratio (3.04) and higher net income (Rs. 105640.00) demonstrated the financial feasibility of the intervention. The study once again proved that organic source of nutrients could be a better option in terms of optimum growth, yield and profitability of the crop.

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