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Yield performance of okra (*Abelmoschus esculentus*) through integrated nutrient management

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Abstract

Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in Bangladesh. Anthropogenic factors such as inappropriate land use systems, monocropping, nutrient mining and inadequate supply of nutrients aggravated the situation. Integrated nutrient management (INM) is an option to alleviate soil fertility problem as it utilizes available organic and inorganic nutrients for sustainable agricultural production and productivity. Thus, to investigate the effect of integrated nutrient management, an experiment was conducted at On Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Rangpur, during kharif season of 2012 to maximize the yield of okra. There were seven treatments viz. T_1: 100% Recommended Chemical Fertilizer (RCF), T_2: 85% RCF, T_3: 70% RCF, T_4: 85% RCF + 3 t/ha Organic Fertilizer (OF), T_5: 85% RCF + 1 t/ha OF, T_6: 70% RCF + 3 t/ha OF and T_7: 70% RCF + 1 t/ha OF. The results revealed that the highest yield was obtained from the treatment T_4 (14.60 t/ha) which was statistically similar with T_6 (13.99 t/ha) and T_5 (12.71 t/ha) at both locations. Maximum gross return & gross margin was also obtained from T_4 treatment at both the locations.

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Introduction

Soil fertility is a dynamic property which varies with crop, cropping intensity input use and erosion. The fertility of the soil has a declined trend throughout the country. This is because of low organic matter content of the soil, intensive cropping system, improper cropping sequence, imbalance use and faulty management of fertilizer. Crop production in Bangladesh will then be sustainable if we apply balance nutrient elements and organic matter against crop removal and nutrient loss phenomena. Farmers of Bangladesh usually use fertilizer on mono crop basis without considering the resident effect of the applied nutrients in preceding crop to the succeeding one. The development of appropriate nutrient management system for different crop felt an urgent need for soil fertility research.

A crop production system with high yield targets is not sustainable unless balanced nutrient inputs are supplied to soil to counteract the negative effect caused by the removal of nutrients by crops (Dobermann *et al*., 2002; Dobermann *et al*., 2003a, 2003b; Khurana *et al*., 2008; Pasuquin *et al*., 2014). Intensive cropping with modern varieties, leaching of nutrients by monsoon rains, and acid and light textured soil also favor micronutrient deficiency in Bangladesh soil. Sustainable crop production is also possible through the integrated use of nutrient management (Dobermann *et al.,* 2002; Ferdous *et al.* 2014). Integrated nutrient management determines sustainable soil fertility and productivity (Baruah and Baruah, 2015; Ferdous *et al.* 2011a, b). Continuous crop cultivation without balanced fertilization is one of the major causes of soil degradation (Leite *et al*., 2011; Chauhan *et al*., 2012; Hossain *et al*., 2016).

Okra is an important vegetable crop grown in Bangladesh. Okra cultivation is gaining popularity day by day. Vegetable becomes important in Bangladesh due to its higher price and favorable agro-climatic conditions for its cultivation. Since last few years, rice cultivation is non profitable due to low market price of rice. Imbalance chemical fertilizer management and no addition of organic matter is becoming a threat for soil health and sustainable yield.

For this reason, maximizing okra production through nutrient management is national demand. Soil organic matter is one of the most important components of a soil that consists of plant and animal residues in various stages of decay. It improves many physical, chemical, and biological characteristics of the soil, including water holding capacity, cation exchange capacity, pH buffering capacity, and chelating of micronutrients. Organic matter content in the soil is the indicator of soil fertility (Rahman *et al.* 2011; Sarker *et al.* 2010). A productive mineral soil should have at least 2.5 percent organic matter (Rijpma and Jahiruddin, 2004). But the level of organic matter in Bangladesh soils is alarmingly low (Anowar *et al.* 2015). It is generally around 1% in most and around 2% in few soils. In some soils organic matter content is even lower than 0.50% (Islam, 2006). This is due to intensification of agriculture to grow more food for the teeming millions and indiscriminate as well imbalanced use of chemical fertilizers with little or no addition of organic fertilizers. As a result, the fertility of the country's soils has been declining day by day and many soils are losing their productive capacity. Under such situations, it is very important to add organic fertilizer in the soils to maintain soil fertility and sustainable crop production. The present study was undertaken to evaluate the effect of annupurna (commercial organic manure) organic fertilizer on the yield and yield components of Okra.

Materials and method

Site description and experimental design

The study was initiated at Farming System Research and Development (FSRD) site Lahirirhat, Rangpur, and Multilocation Testing (MLT) site, Domar, Nilphamari, Bangladesh during 2012 cropping seasons in the farmer's field condition of 6 selected farmers to maximize the okra production through nutrient management. The study area is located at 21°24' N latitude and 88°23' E longitude with 31 m above mean sea level. The area mostly falls under high and medium high land areas of the Tista Meander Floodplain with an extent of 946,803 ha (Ferdous *et al.* 2016).

The soils of this region are moderately acidic (pH of 4.6–6.5), low in organic matter content on the higher land (< 1 %), but moderate in the lower parts (~ 2 %). Overall, the fertility level is low to medium, but the status of K and CEC is medium in most of the places. Soils in general have good water holding capacity (Anowar *et al.* 2015; Ferdous *et al.* 2016). The area receives an annual rainfall of around 2,160 mm with relatively early onset and late cessation.

The land was well prepared by tractor driven disc plough followed by laddering. The initial soil samples of the experimental fields were collected and analyzed following standard methods.

The analytical report has been presented in the Table 1. Weather data during crop growing season were presented in table 2. There were seven treatments viz. T_1: 100% Recommended Chemical Fertilizer (RCF), T_2: 85% RCF, T_3: 70% RCF, T_4: 85% RCF + 3 t/ha Organic Fertilizer (OF), T_5: 85% RCF + 1 t/ha OF, T_6: 70% RCF + 3 t/ha OF and T_7: 70% RCF + 1 t/ha OF. Zinc sulphate monohydrate ($ZnSO_4.H_2O$) was used as a source of Zn. Urea, TSP, MOP, Gypsum and Boric acid were used as the sources of N,P,K,S and B, respectively. The experiment was laid out in a RCB design in six dispersed farmer's field (Ferdous *et al.* 2016).

Table 1. Initial status of soils of the experimental plots at Lahirirhat FSRD site, OFRD, Rangpur and MLT site Domar during 2012.

Soil characteristics	FSRD site Lahirirhat, Rangpur	MLT site Domar, Nilphamari
Land type and soil texture	Medium High Land and Loamy	Medium High Land and Loamy
pH	6.03	6.07
Organic Matter (%)	1.25	1.29
K (mleq/100 soil)	2.55 (High)	3.13 (Very High)
N (%)	0.06 (Very low)	0.07 (Very low)
P (Micro gram/g soil)	30.66 (Very high)	30.23 (Very high)
S (Micro gram/g soil)	33.3 (High)	31.5 (High)
Zn (Micro gam/g soil)	0.52 (Low)	0.88 (Low)
B (Micro gram/g soil)	0.49 (Optimum)	0.55 (Optimum)

Table 2. Weather conditions during the growing period of okra in Tista Meander Floodplain Agro Ecological Zone in Bangladesh at 2012.

Year	Month	Total rainfall (mm)	Temperature	
			Maximum	Minimum
2012	January	7.0	21.9	9.8
	February	1.5	26.3	12.9
	March	1.4	29.7	17.2
	April	190.3	31.3	21.5
	May	332.1	32.8	23.4
	June	305.7	32.7	25.2
	July	388.3	32.2	26
	August	412.4	32.1	26
	September	404	31.8	25.7
	October	57.7	31.2	22.6
	November	--	28.2	16.1
	December	--	23.2	13.4

Source: Regional meteorological office, Rangpur, Bangladesh.

Crop management

The entire amount of organic manure was applied 4 days before final land preparation. Full amount of PKS and 1\3 of N were applied at the time of final land preparation. One weeding was done at 30 days after emergence (DAE).

Irrigation was done at 15-20, 30-35, 60-70 and 85-95 days after sowing (DAS). The rest of N was applied into two equal splits at 25-30 DAS and at 40-50 DAS. Twenty day's old seedlings of Okra were transplanted on May to June 2012 at both the locations. Other intercultural operation was done as and when necessary.

Preventive measures were taken to control insect and diseases applying appropriate insecticides and fungicides. The crop was harvested from July to September, 2012 at both the locations.

Data collection and statistical analysis

After maturing randomly 5 plants were harvested to record the yield and yield contributing characters of okra. Fresh fruit yield was harvested from randomly pre-selected central areas (about 9 m^{-2}) of each plot and converted into tons per hectare (t ha^{-1}). Mean data was analyzed statistically and was carried out to analysis of variance (ANOVA) using the MSTAT-C (Gomez and Gomez, 1984). Further statistical validity of the differences among treatment means was estimated using the least significant difference (LSD) comparison method. Gross return (GR), total variable cost (TVC) and gross margin (GM) have been calculated using the following formula:

GR= Return of main product.

=Yield Price (Tk.)

TVC=All input cost except land cost and interest on operating capital.

GM=GR-TVC

Results

Weight of fruits per plant

Weight of fruits per plant of okra is presented in Table 3 at MLT site, Domar and table 4 at FSRD site, Lahirirhat, Rangpur. The highest Weight of fruits per plant was obtained from the treatment T_4 (443.3 $plant^{-1}$) which was statistically similar with T_6 (413.5 $plant^{-1}$) and T_7 (409.9 $plant^{-1}$) at MLT site Domar**.** Similar result was found in FSRD site Rangpur.

Number of fruits per plant

The maximum number of fruits per plant was recorded from the treatment T_4 (42.01 $plant^{-1}$) which was statistically similar with all treatments except T_2 (33.67 $plant^{-1}$) and T_3 (33.96 $plant^{-1}$) at MLT site Domar (Table 3). The maximum number of fruits per plant was recorded from the treatment T_4 (34.3 $plant^{-1}$) which was statistically similar with all treatments except T_2 and T_3 at FSRD site Rangpur (Table 4).

Yield performance of okra under different nutrient management

Yield performance of okra is presented in Table 3 and 4 at MLT site, Domar as well as FSRD site Rangpur. The highest yield was obtained from T_4 (14.60 t ha^{-1}) which was statistically similar with T_6 (13.99 t ha^{-1}) and T_5 (12.71 t ha^{-1}) (Table 3). The lowest yield was obtained from the treatment T_3 (11.70 t ha^{-1}) which was statistically similar with all treatments except T_4 (85% recommended fertilizer with 3 t/ha organic manure) at MLT site Domar. The highest yield was also obtained from T_4 (12.85 t ha^{-1}) which was statistically similar with T_6 (11.54 t ha^{-1}) and T_5 (10.96 t ha^{-1}) (Table 4). The lowest yield was obtained from the treatment T_2 (9.50 t ha^{-1}) which was statistically similar with all treatments except T_4. Treatment 85% recommended fertilizer with 3 t/ha organic manure gave highest economic benefit under nutrient management practice.

Table 3. Yield and yield attributes of okra as influenced by annopurna organic fertilizer at MLT site, Domar, Rangpur during 2012.

Treatment	Weight of fruits $plant^{-1}$ (g)	Number of fruits $plant^{-1}$	Yield (t ha^{-1})
T_1: 100% Recommended Chemical Fertilizer (RCF)	392.7	36.78	12.28
T_2: 85% RCF	386.3	33.67	11.90
T_3: 70% RCF	375.7	33.96	11.70
T_4: 85% RCF + 3 t/ha Organic Fertilizer (OF)	443.3	42.01	14.60
T_5: 85% RCF + 1 t/ha OF	398.2	36.52	12.71
T_6: 70% RCF + 3 t/ha OF	413.5	37.92	13.99
T_7: 70% RCF + 1 t/ha OF	409.9	35.57	12.10
Level of significance	**	**	**
LSD	41.83	7.21	2.21

**Significant for $P < 0.01$. T_1: 100% Recommended Chemical Fertilizer, T_2: 85% Recommended Chemical Fertilizer, T_3: 70% Recommended Chemical Fertilizer, T_4: 85% Chemical Fertilizer + 3 t/ha Organic Fertilizer, T_5: 85% Chemical Fertilizer + 1 t/ha Organic Fertilizer, T_6: 70% Chemical Fertilizer + 3 t/ha Organic Fertilizer and T_7: 70% Chemical Fertilizer + 1 t/ha Organic Fertilizer.

Table 4. Yield and yield attributes of okra as influenced by annopurna organic fertilizer at FSRD site, Lahirirhat, Rangpur during 2012.

Treatment	Weight of fruits plant^{-1} (g)	Number of fruits plant^{-1}	Yield (t ha^{-1})
T_1: 100% Recommended Chemical Fertilizer (RCF)	383.5	31.7	10.66
T_2: 85% RCF	366.3	29.6	9.50
T_3: 70% RCF	355.7	30.4	9.60
T_4: 85% RCF + 3 t/ha OF	420.9	34.3	12.85
T_5: 85% RCF + 1 t/ha OF	383.2	32.2	10.96
T_6: 70% RCF + 3 t/ha OF	403.5	33 .8	11.54
T_7: 70% RCF + 1 t/ha OF	399.9	31.6	10.07
Level of significance	**	**	**
LSD	25.83	2.01	2.06

**Significant for $P < 0.01$.

Economic performance of okra under different nutrient management

The cost and return analysis of different treatments are presented in Table 5 & 6. The highest gross return (Tk. 292000) was found in T_4 treatment followed by T_6 (Tk.279000) and the lowest gross return (Tk. 234000) was recorded from T_3 at MLT site, Domar (Table 5). The highest gross margin (Tk. 113702/ha) followed by T_6.

The lowest gross margin (Tk. 74819/ha) was obtained from T_3 treatment (Table 5). The highest gross return (Tk. 257000) was found in T_4 treatment followed by T_6 (Tk.230000) and the lowest gross return (Tk. 190000) was recorded from T_2 at FSRD site, Rangpur (Table 6). The highest gross margin (Tk. 99620/ha) followed by T_6. The lowest gross margin (Tk. 50620/ha) was obtained from T_2 treatment (Table 6).

Table 5. Economic performance of okra as influenced by annopurna organic fertilizer at MLT site, Domar, Rangpur during 2012.

Treatment	Gross return (Tk/ha)	Cost of Cultivation (Tk/ha)	Gross Margin (Tk/ha)
T_1: 100% Recommended Chemical Fertilizer (RCF)	245600	161418	84182
T_2: 85% RCF	238000	160298	77702
T_3: 70% RCF	234000	159181	74819
T_4: 85% RCF + 3 t/ha OF	292000	178298	113702
T_5: 85% RCF + 1 t/ha OF	254200	166298	87902
T_6: 70% RCF + 3 t/ha OF	279800	177181	102619
T_7: 70% RCF + 1 t/ha OF	242000	165181	76819

Exchange rate in 2012: 1 USD = approx. 82 BDT (Bangladeshi Taka) Market price of okra @ 10 BDT kg^{-1}, urea @ 16, triple super phosphate @ 25, muriate of potash @15, gypsum @10, zinc sulphate @ 150 and boric acid@ 150 BDT kg^{-1}, Organic manure @ 6 BDT kg^{-1}

Table 6. Economic performance of okra as influenced by annopurna organic fertilizer at FSRD site, Lahirirhat, Rangpur during 2012.

Treatment	Gross return (Tk/ha)	Cost of Cultivation (Tk/ha)	Gross Margin (Tk/ha)
T_1: 100% Recommended Chemical Fertilizer (RCF)	213200	140500	72700
T_2: 85% RCF	190000	139380	50620
T_3: 70% RCF	192000	138260	53740
T_4: 85% RCF + 3 t/ha OF	257000	157380	99620
T_5: 85% RCF + 1 t/ha OF	219200	145380	73820
T_6: 70% RCF + 3 t/ha OF	230800	156260	74540
T_7: 70% RCF + 1 t/ha OF	201400	144260	57140

Exchange rate in 2012: 1 USD = approx. 82 BDT (Bangladeshi Taka) Market price of okra @ 10 BDT kg^{-1}, urea @ 16, triple super phosphate @ 25, muriate of potash @15, gypsum @10, zinc sulphate @ 150 and boric acid@ 150 BDT kg^{-1}, Organic manure @ 6 BDT kg^{-1}.

Discussion

Balanced nutrient management application significantly increased okra yield compared to the unbalanced treatment (Table 3 & 4). Agronomic management practices had significant effects on okra yield over the 2012 study periods. The authors attributed the yield decline to imbalanced and inadequate nutrient application by farmers. Besides, the current nutrient use in the high input crop systems indicates imbalance plant nutrition with very high use of N and less use of P and negligible use of K fertilisers and micro nutrients. This has led to nutrient imbalances in soils and lower nutrient use efficiency and economic profitability (Datta *et al*., 2015; Detchinli and Sogbedji, 2015). This warrants adequate and balanced use of plant nutrients not only for specific farm and ecology but also in production systems using fertilizer best management practices adapted to local situations and farm typologies to achieve better efficiency and nutrient stewardship. Achieng *et al.* (2010) found that the used of balanced fertilization increased crop yields 108 to 103% higher as compared with control treatments. Abebe *et al.* (2013) and Detchinli and Sogbedji, 2015 documented similar performance of the mineral fertilizer, and Ferdous *et al.* (2011a,b, 2014) concluded that application of combined nutrient management is the best combination for sustainable crop yield. Ferdous *et al.* (2011a, b) who reported highest gross margin was found with combination of organic and inorganic fertilizer application at Rnagpur region in Bangladesh. Application of 85% recommended chemical fertilizer and combination with 3 t/ha organic manure gave higher economic benefit for okra cultivation at both the locations (Table 5 & 6). Similar result was reported by Sarker *et al.* (2010) and Rahman *et al.* (2011) who report highest gross margin with combination of poultry bio slurry and inorganic fertilizer application.

The results of our study indicate that there is the potential to increase the productivity of okra in the Tista Meander Floodplain Agro-Ecological Zone of Bangladesh. The simultaneous use of chemical fertilizer and organic manure approach resulted in higher okra productivity well as higher rates of economic return under farmers field condition. Among these treatments with 85% recommended chemical fertilizer and combination with 3 t/ha organic manure gave the highest yield and economic return. Organic manure played a significant role in increasing the productivity of okra as well as increases the farmers' income. This study also indicates that the use of chemical fertilizers alone in okra cultivation in the Tista Meander flood plains of Bangladesh could not maintain soil fertility and crop productivity, but can be improved and sustained through the combined use of fertilizers and manure (i.e., the integrated nutrient management system approach).

Conclusion

From the study it is evident that Shudha (organic fertilizer) has significant positive effect on growth and yield of Okra at both the locations. The highest yield, maximum gross return & gross margin were obtained from organic fertilizer (3 t/ha) coupled with 15-30% reduction of chemical fertilizers.

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