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RESIDUAL EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON FRUIT YIELD AND QUALITY OF OKRA IN RICE-OKRA CROPPING SEQUENCE

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Abstract

The experiment was conducted to evaluate the residual effects of organic and inorganic fertilizers on nutrient value and yield of okra fruit in rice-okra cropping sequence. Except control and recommended doses of urea-N, eight other treatments were composed of urea and organic sources where 50 and 75% of the recommended doses of N were applied through urea and the remaining 50 and 25% of this nutrient were supplied using either poultry manure (PM), vermicompost (VC), trichocompost (TC) or biogas slurry (BS) for Boro rice. Okra was grown in the same plots in Kharif season. Morphological character (fruit length, fruit diameter and fruit weight), yield increase and nutrient content in okra were the best in treatment receiving 50% nitrogen from urea and the remaining 50% nitrogen from VC in preceding rice crop. The highest fruit yield increase (95.60%) with N, P, K, S, Ca, Mg, Zn, Cu, Fe and Mn contents in fruit of okra was obtained from the residual effect of 9.32 mt/ha VC with 94 kg/ha urea-N applied in Boro. The residual effect of VC was the most pronounced than that of PM, TC and BS.

Introduction

Vegetables are a great significant source of vitamins, minerals, plant proteins and carbohydrate in human diet all over the world. The nutrient in vegetable overcomes the common disorders like anemic deficiency disorder and other ailments in human beings.

In Bangladesh, vegetable production and supply are not uniform round the year. It is abundant in winter but scanty in summer, and the shortage is acute during September to mid November (Husain 1992). Okra (*Abelmoschus esculentus* (L.) Moench) is a popular and important vegetable grown mainly for its tender green fruits in Bangladesh. The green fruits are rich in vitamin A and C and minerals like Ca, Mg and Fe. So production of okra in summer season may meet up the market demand by using higher yield potential cultivar during the lean period of vegetable supply and improve the nutritional status of the people. About 51,885 metric tons of okra is produced from 11,355 hectares of land with an average yield of 4.57 t/ha in Bangladesh, which is very poor (BBS 2015). Lack of adequate nutrient supply and poor soil structure are the main constraints to agricultural production systems in low-input agriculture. Chemical fertilizers are not the most appropriate solution to overcome these constraints, especially for vegetables that have short growing period and are consumed as fresh. Use of chemical fertilizers are also expensive and a threat to human health (Waltzing 1990). Integration of organic with inorganic fertilizers improves the physiological system of the crop, provides adequate growth regulating substances and modifies

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soil physico-chemical behavior and results in augmented crop yield (Hukkeri *et al.* 1977). Hence, it is suggested that there should be an emphasis on finding alternatives to chemical fertilizers such as biogas slurry, compost which are cheaper than other sources of nutrients and relatively safe. The use of available and cheap cow-dung by vegetable farmers ensure sustainability of production and balanced nutrition. Amanullah *et al.* (2007) found that tuber yield was the highest with composted poultry manure (CPM) followed by FYM plus CPM which was due to higher availability of nutrients and uptake by the crop as influenced by CPM. But no work on integrated use of urea with newly introduced organic manure *viz.* trichocompost, biogas slurry and vermicompost on rice vegetable cropping sequence has been done in our agro-climatic condition. So, the present study was undertaken to assess the residual effect of organic and inorganic fertilizer on yield and nutrient content of okra fruit as succeeding crop of Boro rice.

Materials and Methods

The study was conducted at the Research Farm of the Bangabandhu Sheikh Mojibur Rahman Agricultural University, Gazipur, Bangladesh (24.09^0 N latitude and 90.26^0 E longitude).

Okra variety BARI Dherosh-1 was used as test crop. The treatment combinations in Boro rice were: no nitrogen i.e. control (T_1), recommended dose of N (T_2), 75% N through urea and 25% N through PM (T_3), 50% N through urea and 50% N through PM (T_4), 75% N through urea and 25% N through VC (T_5), 50% N through urea and 50% N through VC (T_6), 75% N through urea and 25% N through TC (T_7), and 50% N through urea and 50% N through TC (T_8). 75% N through urea and 25% N through BS (T_9), and 50% N through urea and 50% N through BS (T_{10}). All the treatments received recommended dose of phosphorus, potassium and sulphur. No manure and fertilizer were applied after Boro rice harvest. Preparing the experimental plot of first experiment 15 days old seedlings were planted in the field maintaining row to row and plant to plant spacing of 60 cm and 50 cm, respectively. Intercultural operations were done throughout the cropping period for proper growth and development of the seedlings. For controlling Jassid, Nogos @ 0.02% was sprayed four times in an interval of seven days after fruit setting. The okra field was properly irrigated an interval of 10-15 days as required. Stagnant water was drained out after heavy rain. Fruits were harvested at every alternate day at edible stage. The harvested fruits of each plot were weighed. Ten plants from each plot were selected randomly and tagged and then the following yield (mt/ha) and fruit morphology (fruit length, fruit breadth, and individual fruit weight) were recorded. The fruit samples were collected from the field at final harvesting. Fruits were collected from each plot of selected plants. The fruits were first air-dried and then oven-dried at 65^0C for 72 hrs. The fresh weight and oven dry weights of plants and fruits were recorded. After drying and weighing, these samples were ground in a grinding machine (Cap/small 1029-8, Yoshida Seisakusho Co. Ltd.) and stored in polyethylene bags in the dessicator for chemical analysis.

The samples of okra fruit were digested with nitric-perchloric acid (HNO_3: $HClO_4$ in the ratio 2 : 1) mixture for available P, S, B, Zn, Cu, Fe, and Mn contents, but with sulphuric acid for the estimation of N. Nitrogen content in the digest was determined following the Kjeldahl procedure is the official method of the American Association of Official Cereal Chemists (Anon. 1987) and the Association of Official Analytical Chemists (Helrich 1995). Phosphorus was determined colorimetrically using a UV-visible spectrophotometer (model UV mini 1240, Shimadzu Corporation, Kyoto, Japan) at 420 nm wavelength after developing the yellow color with vanadomolybdate as described by Barton (1948) and Jackson (1962). Potassium, Ca, Mg, S, Zn, Cu, Fe, and Mn contents in the digest were determined with atomic absorption spectroscopy (AAS) (Hitachi 170-30, Japan) from the digested solution.

The analysis of variance for the collected data was done following the ANOVA technique and the mean values were adjusted by DMRT (Gomez and Gomez 1984).

Results and Discussion

Fruit length, fruit diameter and single fruit weight of okra fruit were significantly influenced by the residual effect of organic manures (Table 1). The highest length (13.28 cm), diameter (1.43 cm), and single fruit weight (14.59 g) were noted in the residual effect of treatment T_6 (9.32 mt/ha VC with chemical fertilizer) which was statistically similar to treatments T_4 (4.58 mt/ha PM with chemical fertilizer), T_8 (9.80 mt/ha TC with chemical fertilizer) and T_{10} (9.58 mt/ha BS with chemical fertilizer). This was due to the residual effect of organic manure that supplied balanced nutrient elements which was favorable for increasing the fruit morphological characters. The residual effects of treatments T_3 (2.29 mt/ha PM with chemical fertilizer) were, however, statistically similar to treatments T_5 (4.66 mt/ha VC with chemical fertilizer), T_7 (4.90 mt/ha TC with chemical fertilizer), and T_9 (4.79 mt/ha BS with chemical fertilizer). The lowest length (9.46 cm), diameter (1.18cm) and single fruit weight (11.10 g) of fruit was noted in control (T_1), for inadequate supply of nutrients from untreated plots that has led to less growth of plant which eventually caused reduction in length, diameter, and weight of fruit. These results are in good agreement with that of Chattoo *et al.* (2010), Tiamiyu *et al.* (2012) and Vennila and Jayanthi (2008) who reported that the residual effect of organic manures and inorganic fertilizers increased pod number/plant of okra, poultry manure positively increased fresh pod weight of okra by 34.6% compared to control treatments and application of cent per cent of recommended dose of fertilizers along with vermiwash spray (2 per cent) significantly increased the yield attributing characters of okra, respectively.

Table 1. Residual effect of organic and inorganic fertilizers on morphological characters of okra fruit in rice-okra cropping sequence.

Treatment	Fruit length (cm)	Fruit diameter (cm)	Single fruit wt. (g)
T_1	9.46d	1.18c	11.10d
T_2	10.60c	1.26bc	13.06c
T_3	11.64b	1.34b	13.29bc
T_4	12.51ab	1.42a	13.90abc
T_5	12.07b	1.32b	13.35bc
T_6	13.28a	1.43a	14.59a
T_7	12.08b	1.28b	13.31bc
T_8	12.61a	1.40a	14.40ab
T_9	12.07b	1.27b	13.14c
T_{10}	12.28ab	1.39a	14.07abc
CV (%)	4.67	3.46	4.41

Means in a column followed by the same letter(s) are not significantly different at $p < 0.05$ by Fisher's protected least significant difference test.

The residual effect of organic manures significantly affected the fruit yield of okra. All the treatments containing organic manures caused an increase in fruit yield per plot over control (Fig. 1). The reason is that applied organic manures slowly release nutrients to the soil and number of fruits improves. That is why residual effect of organic manures showed better results than control in fruit yield increase. The highest fruit yield increase (95.60%) over control was recorded for the residual effect of treatment T_6 which was statistically similar to treatment T_8 (93.41%). The residual effects of treatments T_4 were statistically similar to treatments T_{10}, where the yield increase was second highest. Similar results were reported by Chattoo *et al.* (2010) who assessed the residual effect of organic manures and inorganic fertilizers on succeeding crop pea in okra-pea rotation and revealed that integration among organic with inorganic sources in equal proportion (50:50) registered higher values of 118.84 q pod yield/ha of okra. Uwah *et al.* (2012) reported that fresh pod yield of okra increased to 160% by 10 mt/ha PM compared with the unamended control plots. Zhou (2009) observed that the application of biogas slurry @ 120 kg per unit area as basal fertilizer and 0.6 kg chemical fertilizer and 75 kg biogas slurry as top dressing could increase the yield by 16.06%.

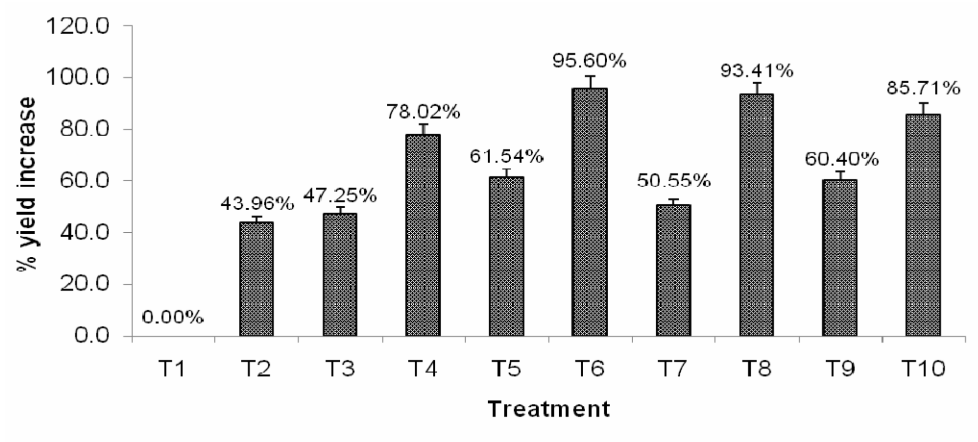

Fig. 1. Residual effect of organic and inorganic fertilizers on fruit yield increase of okra fruit in rice-okra cropping sequence.

Nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) content in fruit varied significantly with the residual effects of organic manures (PM, VC, TC and BS) (Table 2). The maximum N (2.19), P (0.73%), K (2.40%), and S (0.25%) content in fruit was noted in residual effect of treatment T_6 which were statistically similar to treatments T_8 for N, P, K, and S and T_4 for P and K. The lowest value of N (1.21%), P (0.47%), K (1.35%) and S (0.15%) content in fruit was noted in control (T_1). These results are well corroborated with Moyin-Jesu (2007) who revealed that the application of 6 mt/ha of plant residues increased N, P and K of pod. Desuki *et al.* (2010) proved that N, P and K content of pods significantly increased by increasing the applied compost @ of 100, 120 up to 140 kg N. Kostov *et al.* (2007) also reported that application of compost significantly increased fruit quality in comparison with soil treated with mineral fertilizers and manure.

The maximum Ca (0.777%), Mg (0.360%), Cu (9.13 ppm), and Mn (25.57 ppm) content in fruit was observed in treatment T_6, but Zn (52.13 ppm) and Fe (27.17 ppm) content was the highest in T_4 treatment which was statistically identical to treatments T_8. The effects of treatments T_6 were, however, statistically identical to the treatments T_4, T_8 and T_{10} in recording Ca, Mg, Zn, and Fe content in fruit. Copper and Mn content in fruit were statistically identical in the T_6 and T_4 treatments. The lowest Ca (0.473%), Mg (0.290%), Zn (43.10ppm), Cu (6.20 ppm), Fe (2261.67 ppm), and Mn (18.47 ppm) was found in control (T_1). These results support the findings of Moyin-Jesu (2007) who observed that the application of plant residues increased Ca and Mg content of pod. Organic amendments improved leaf Mg concentration compared with the control (Agbede and Adekiya 2012). Hernandez *et al.* (2010) observed that Ca, Zn, Cu and Mn treatment of vermicompost showed a higher contribution of Ca, Zn, Cu and Mn in the leaf of lettuce compared to the use of compost. Desuki *et al.* (2010) also reported that Fe and Mn content of pods significantly increased by increasing the applied compost @ of 100, 120 up to 140.

Table 2. Residual effect of organic and inorganic fertilizers on nutrient content (%) of okra fruit in rice-okra cropping sequence.

Treatment	N (%)	P (%)	K (%)	S (%)
T_1	1.21f	0.47e	1.35e	0.15d
T_2	1.50e	0.60d	1.80d	0.19c
T_3	1.74d	0.68bc	2.10c	0.21b
T_4	2.00bc	0.71ab	2.27ab	0.22b
T_5	1.88cd	0.68bc	2.20bc	0.20bc
T_6	2.19a	0.73a	2.40a	0.25a
T_7	1.80d	0.67c	2.07c	0.22b
T_8	2.10ab	0.73a	2.40a	0.25a
T_9	1.82d	0.68bc	2.17bc	0.20bc
T_{10}	1.99bc	0.71ab	2.30ab	0.24a
CV (%)	4.18	3.27	4.13	4.44

Means in a column followed by the same letter(s) are not significantly different at $P < 0.05$ by Fisher's protected LSD test.

Table 3. Residual effect of organic and inorganic fertilizers on mineral content (%) of okra fruit in rice-okra cropping sequence.

Treatment	Ca (%)	Mg (%)	Zn (%)	Cu (%)	Fe (%)	Mn (%)
T_1	0.473e	0.290d	43.10c	6.20e	2261.67d	18.47g
T_2	0.567d	0.317c	44.23c	6.70d	2374.17cd	19.30fg
T_3	0.687c	0.327c	46.23bc	7.60c	2513.33bc	21.60de
T_4	0.743ab	0.357a	52.13a	8.53b	2704.17a	24.97ab
T_5	0.717bc	0.333b	45.87bc	7.57c	2510.00bc	22.13cd
T_6	0.777a	0.360a	51.27a	9.13a	2610.83ab	25.57a
T_7	0.723bc	0.323bc	45.67bc	7.90c	2513.33bc	20.53ef
T_8	0.740ab	0.353a	49.27ab	8.93ab	2637.50ab	24.80ab
T_9	0.710bc	0.330bc	45.53b	7.47c	2515.83bc	20.40ef
T_{10}	0.760ab	0.354a	49.23ab	8.60b	2628.33ab	23.47bc
CV (%)	4.02	2.29	4.46	3.19	3.26	3.79

Means in a column followed by the same letter(s) are not significantly different at $p < 0.05$ by Fisher's protected least significant difference test.

Results showed that the residual effect of organic manures significantly affected the uptake of nutrient (Fig. 2). The N, P, K and S uptake by plant varied from 12.92 - 38.23, 4.35 - 11.69, 12.2 - 33.81 and 2.82 - 9.12 kg/ha, respectively. The maximum uptake of N (38.23 kg/ha), P (11.69 kg/ha), K (33.81 kg/ha) and S (9.12 kg/ha) by plant was recorded in the residual effect of treatment T_6 which was statistically similar to those recorded in the treatment T_8 but superior to the rest of the treatments.

The second highest value was observed for the residual effect treatment T_4 which was statistically similar to the treatment T_{10}. The lowest N (12.92 kg/ha), P (4.35 kg/ha), K uptake (12.27 kg/ha), and S (2.82 kg/ha) were recorded in the control (T_1). These results are well corroborated with Yu *et al.* (2010) who found that bio slurry and compost itself provide N, P and K to the soil and also affect the chemical properties of soil that increased N, P and K uptake to plant. Similar results were reported by Liu *et al.* (2008) who reported that digested slurry and compost contains organic nitrogen (mainly amino acids), abundant mineral elements, and low-molecular-mass bioactive substances (e.g. hormones, humic acids, vitamins etc.) and could be used as organic manure that may increase nutrient concentration and uptake in plant. Kader *et al.* (2010) also reported that water levels and both plant residues and chicken manure significantly affected N, P and K uptake.

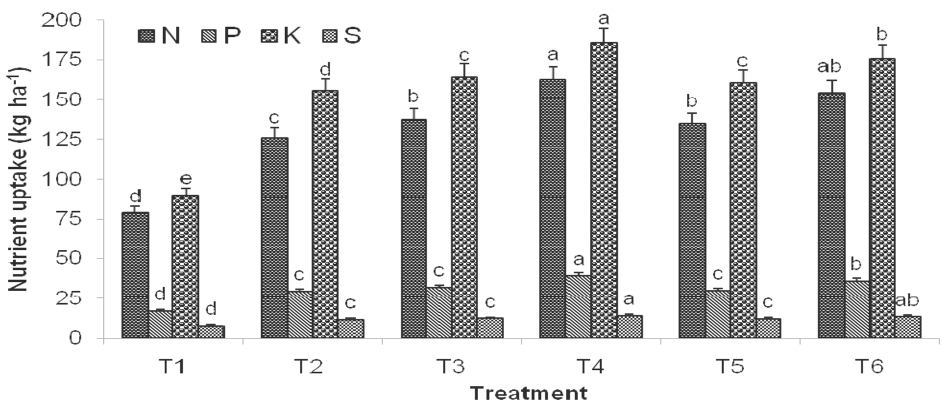

Fig. 2. Residual effect of organic and inorganic fertilizers on nutrient uptake by okra plant in rice-okra cropping sequence

Organic manures with chemical fertilizer had a significant positive residual effect on okra as a succeeding crop of rice. Application of 50% N from urea and 50% N from VC in Boro rice recorded higher fruit yield of okra compared to other management practices in rice - okra cropping sequence. Among the organic manures, VC showed best performance in recording yield and quality *viz.* N, P, K, S, Ca, Mg, Zn, Cu, Fe and Mn and nutrient contents in fruit with N,P,K,S by plant. Vermicompost 9.32 mt/ha with N 94 kg/ha from urea in Boro rice may be recommended for getting better yield with quality fruit of okra in rice-okra cropping sequence for the Shallow Red Brown Terrace soil of Bangladesh.

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