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Comparative Effects of Biogas Plant Residues, Poultry Manure and Inorganic Fertilizer on Growth and Yield of Ladies Finger

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Abstract: *A field experiment was conducted in the crop field of the Department of Soil Science, University of Chittagong, Bangladesh to study the effects of biogas plant residues, poultry manure and NPK fertilizer on growth and yield of ladies finger (Abelmoschus esculentus L Moench). There were six treatments - control (no fertilizer/poultry manure/compost),* full *NPK @ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}, full biogas plant residues(BPR) @ 30 ton ha^{-1}, 50% NPK+ 50% BPR, full poultry manure (PM) @ 30 ton ha^{-1}, 50% NPK+ 50% PM. The treatments were arranged in randomized block design with three replications. The data collected were number of leaves, plant height, fruit length, fruit circumference, number of fruits and fruit yield. The results showed that full NPK fertilizer did not significantly increase the growth and yield of ladies finger over control. Compared to control addition of full poultry manure and its combination with NPK fertilizer resulted in 6.28 to 7.29 fold increases in yield. Relatively lower yields (0.34-0.17 fold) were obtained in treatments with biogas plant residues compared to treatments with poultry manure. Our result indicate that poultry manure can be used in combination with the application of inorganic fertilizers for better growth and yield of ladies finger in the valley soils of Chittagong.*

Key words: *Biogas plant residues, poultry manure, ladies finger, growth, yield.*

I. Introduction

Bangladesh is an agricultural country and its soil is of great importance as a natural resource. Continuous of mining of nutrients from the soil system of Bangladesh is going on by forcing the limited cultivable land to maximize crop yields per unit area through the use of land and soil resources. The illiterate and poor farmers of Bangladesh have tended to only exploiting the soils rather than maintaining them in a healthy fertile state. Due to intensification of agriculture to grow more food for the teeming million and indiscriminant as well as imbalanced use of chemical fertilizers with little or no addition of organic fertilizers, the soil fertility status of the country has been declining day by day. Many soils are losing their productive capacity due to continuous mining of nutrients. Under such situation to increase soil fertility and sustain crop productivity, there is no alternative besides to add organic fertilizer into the soil. Organic fertilizer can serve as a substitute to mineral fertilizers. Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity [1]. A vast range of organic fertilizers is available in different forms in our surroundings including cow dung, farm yard manure (FYM), poultry manure, composted FYM and digested biogas plant residues.

The residues generated during the production of biogas through anaerobic digestion of organic wastes are known as digestate that can represent a valuable resource to sustain and improve soil fertility and to increase soil organic matter content. It may be considered as an effective source of organic fertilizer as it contains considerable amounts of nutrients and organic matter [2, 3]. Biogas technology is becoming popular in rural Bangladesh in view of escalating costs of fuels as well as soaring prices of chemical fertilizers which our farmers find difficult to buy for their sustainable crop production. The biogas plant technology uses cow dung, poultry litter, water hyacinth and other biomass wastes to produce biogas thereby ensuring a smoke-free, odor free, clean and healthy cooking environment for rural people.

Poultry manure is a good source of major and minor mineral elements that are capable of enhancing and sustaining soil fertility [4, 5]. Poultry manure contains high percentage of nitrogen and phosphorus for the healthy growth of plants [6]. The integrated use of organic and inorganic fertilizers may be a sound soil fertility management strategy in many countries.

Ladies finger (*Abelmoschusesculentus* L Moench) is one of the most important edible and nutritious vegetable crops in Bangladesh. It belongs to the family Malvaceae, originating from tropical and subtropical Africa. The nutritional constituents of ladies finger include carbohydrate, protein, phosphorus, calcium, magnesium, iron, vitamin A and C with traces of vitamin B [1, 2, and 3]. Ladies finger is a fruit vegetable, grown mainly for the pods. The tender fruits are used as vegetables either boiled or sliced and fried. Ladies finger pod contains 8.20 % carbohydrates, 2.10% protein and a significant amount of riboflavin [7]. Information on the use of biogas plant residues and poultry manure in ladies finger production is very scarce especially in

Chittagong hilly areas. Hence, the objective of this work was to determine the effects of biogas plant residues, poultry manure on growth and yield of ladies finger relative to the recommended level of NPK fertilizer in the valley soils of Chittagong.

II. Materials and Methods

2. 1. Field experiment

A field experiment was conducted to study the comparative effects of biogas plant residues, poultry manure and NPK fertilizers on growth and yield of ladies finger in the Crop Field of the Department of Soil Science, University of Chittagong. For the study, residues of biogas plant were collected from a biogas plant established at Jubra village and poultry manure from a poultry farm at Fatehpur village nearby Chittagong University. Eighteen experimental plots (2.2 m x 2.2 m) separated by 0.5 m margins were prepared in three adjacent blocks in the crop field. There were six plots in each block for the six treatment combinations comprising of biogas plant residues (BPR), poultry manure (PM) and NPK fertilizers as follows-

T1 = Control (No fertilizer + No BPR + No PM),
T2 = Full NPK @ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}
T3 = Full biogas plant residues (BPR) @ 30 ton ha^{-1}
T4 = 50% NPK+50% BPR (60 kg N ha^{-1}, 30 kg P ha^{-1} and 40 kg K ha^{-1}+ 15 ton ha^{-1} BPR).
T5 = Full poultry manure (PM) @ 30 ton ha^{-1}, and
T6 = 50% NPK+50% PM (60 kg N ha^{-1}, 30 kg P ha^{-1} and 40 kg K ha^{-1} +15 ton ha^{-1} PM)

The treatments were arranged according to a randomized complete block design. Nitrogen in the form of urea was applied in 3 splits according to BARC [8] recommendation. One-third of nitrogen fertilizer (i.e. urea) was applied as basal dose before sowing, the 2nd dose was given after one month of sowing and the third installment was given at the flowering stage. Phosphorus and potassium fertilizers were also applied as basal at the final stage of soil preparation. All of biogas plant residues and poultry manure were applied as basal during soil preparation and soils mixed with biogas plant residues and poultry manure were allowed to equilibrate for 4 weeks prior to sowing seeds.

Ladies finger variety BARIdheros-1 released by Bangladesh Agricultural Research Institute was used in the experiment. The seeds were sown in lines 60 cm apart with seed to seed distance of 45 cm. In each point two seeds were sown. Seedlings emerged after 4 to 5 days of sowing. One healthy seedling was retained in each point. Irrigation was applied as and when necessary. The experimental plot was kept free of weeds by regular weeding. To control the pests and diseases, necessary plant protection measures were done as and when required.

2. 2. Data collection

Plant height and number of leaves were recorded at 30 and 60 days after sowing (DAS) to assess plant growth. The fruits were harvested at 3 days interval. Length of fruit, fruit circumference, numbers and fresh weights of fruit were recorded. Yield was computed based on the cumulative numbers and fresh weights of fruit at 12 harvests.

2. 3. Properties of soil, poultry manure and biogas plant residues

Soil texture was determined by hydrometer method [9], soil pH was measured in a 1:2.5 soil/water suspension with glass electrode pH meter, organic carbon by wet-oxidation method [10], total nitrogen by micro-Kjeldahl digestion and distillation and CEC by 1N NH4OAC saturation [11], and available phosphorus by Olsen method [12]. The same methods used for soil were followed for the determination of properties of poultry manure and biogas plant residues. The experimental soil was clay loam (33% sand, 19% silt and 48% clay) with pH 5.10, organic matter content 1.32%, cation exchange capacity (CEC) 8.76 cmol kg-1, total nitrogen 0.12%, and available P (Olsen P) 14 mg kg-1. Biogas plant residues used in the experiment contained pH 5.96, total nitrogen 0.28 %, available P 11.17 mg kg^{-1}. Poultry manure with pH 8.35 contained total nitrogen 0.35 %, available P 15.74 mg kg^{-1}.

2. 4. Statistical analysis

The significance of differences between the means of the treatments was evaluated by one way analysis of variance followed by Duncan's Multiple Range Test at the significance level of 5%. The statistical software Excel [13] and SPSS version 12 [14] were used for these analyses.

III. Results and Discussion

3. 1. Growth of ladies finger

The number of leaves plant^{-1} was the minimum in control (T1) and the maximum in full poultry manure (T5) treatment in both at 30 and 60days after sowing (DAS) respectively (Table 1). Application of full NPK (T2) did not increase number of leaves plant^{-1} compared to control. Similar results were found with full biogas plant residues (T3) and 50 % NPK+ 50% BPR (T4) both at 30 and 60 DAS. Application of full poultry manure (T5) and 50 % NPK+ 50% PM (T6) significantly increased number of leaves plant^{-1} over control both at 30 and 45 DAS. However, there was no significant difference between the treatments T5 and T6 in producing the number of leaves plant^{-1} at 60 DAS. At 30 DAS, the number of leaves plant^{-1} in treatments T2 (full NPK), T3 (full BPR), T4 (50% NPK+ 50% BPR), T5 (full PM)) and T6 (50 % NPK+ 50% PM) were statistically similar with each other.

Height of plants varied from 13.51 (T1) to 22.81cm (T6) at 30 DAS and 41.67 (T1) to 62.00 cm (T5) at 60 DAS (Table 1). Thus, the minimum value was obtained in the control treatment both at 30 and 60 DAS and the maximum value was obtained with 50% NPK+50% PM at 30 DAS and with full poultry manure at 60 DAS. There was no significant difference in values of plant height between control and full NPK fertilizer in any period of recording at 30 and 60 DAS. Application of full biogas plant residues (T3) and 50% NPK+50% BPR (T4) significantly increased plant height compared to that of the control at 60 DAS but not at 30 DAS. Addition of full poultry manure (T5) and 50% NPK+50% PM (T6) resulted in significantly higher plant height than control (T1) both at 30 and 60 DAS. When biogas plant residue treatments were compared with poultry manure treatments no significant difference in plant heights were found at 60 DAS.

Table 1 Effects of biogas plant residues, poultry manure and NPK fertilizers on growth of ladies finger

Treatment	Number of leaves		Plant height (cm)	
	30 DAS	60DAS	30 DAS	60DAS
T1	5.33 b	19.00 c	13.51 c	41.67 b
T2	8.00 ab	21.00 c	16.34 bc	52.33 ab
T3	7.33 ab	21.67 c	16.18 bc	56.00 a
T4	8.00 ab	25.00 bc	18.22 abc	57.33 a
T5	10.00 a	35.00 a	20.77 ab	62.00 a
T6	9.67 a	29.00 ab	22.81a	58.67a
Sig. of F value	0.05	0.05	0.05	0.05

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

3. 2. Yield components and fresh fruit yield

Fruit development started at about five weeks after sowing in all plots receiving NPK, biogas plant residues, poultry manure, and their combination and it continued till the end of the data collection. Length of fruit and fruit circumference of ladies finger were in the ranges from 11.80 to 15.57 cm and 4.30 to 5.96 cm, respectively (Table 2). The lowest length of fruit and fruit circumference was obtained with control treatment T1. The highest length of fruit and fruit circumference was obtained with 50% NPK+ 50% poultry manure. Application of biogas plant residues, poultry manure and NPK fertilizer significantly increased fruit length and fruit circumference of ladies finger from those of the control. However, fruit length of ladies finger was statistically similar among the treatments T2 (full NPK fertilizer), T3 (full biogas plant residues) and T4 (50% NPK+ 50% BPR) and between T5 (full poultry manure) and T6 (50% NPK+ 50% PM). Inorganic fertilizer combined with either biogas plant residues or poultry manures had no significant effect on fruit circumference compared to single application of biogas plant residues and poultry manures.

Number of fruits plant^{-1} is the most important yield attributing character of ladies finger. Number of fruits plant^{-1} ranged from 5.12 to 39.22 (Table 2). The lowest number of fruits plant^{-1} was found with treatment T1 (control) and the highest number of fruits plant^{-1} was observed at treatment T6 (50% NPK+50% PM). Application of full NPK fertilizer (T2) and biogas plant residues in combination with NPK fertilizers (T4) did not increase number of fruits plant^{-1} compared to control treatment T1. Number of fruits plant^{-1} in treatment T3 (13.56; full biogas plant residues) was significantly higher than T1 (5.12; control) but significantly lower than treatment T5 (34.59; full poultry manure) and T6 (39.22; 50% NPK+50% PM). Treatments T5 and T6 were statistically similar with each other in producing number of fruits plant^{-1}.

Fresh fruit yield of ladies finger grown under different treatments varied from 2.25 to 16.40 ton ha^{-1} (Table 2). The highest fresh fruit yield was obtained with treatment T6 (50% NPK+50% PM) and the lowest yield was found with control treatment (T1). Application of full NPK fertilizer (2.62 ton ha^{-1}; T2) did not significantly increase fresh fruit yield compared to control (2.25 ton ha^{-1}; T1). Fresh fruit yield in full bio gas plant residues (4.83 ton ha^{-1}; T3) was statistically similar with that in full NPK (2.62 ton ha^{-1}; T2) and 50% NPK +50% BPR (2.71 ton ha^{-1}; T4) but was significantly higher than that in control (2.25 ton ha^{-1} ; T1). TtreatmentT5 (14.13%; full poultry manure) and T6 (16.40; 50% NPK+50% PM) were statistically similar with each other but significantly higher than T1 (control), T2 (full NPK), T3 full biogas plant residues and T4 (50% NPK + 50% BPR).

Table 2 Effects of biogas plant residues, poultry manure and NPK fertilizers on yield components and fresh fruit yield of ladies finger

Treatment	Fruit length (cm)	Fruit circumference (cm)	Number of fruits plant^{-1}	Fresh fruit yield (ton ha^{-1})
T1	11.80 c	4.30 d	5.12c	2.25 c
T2	13.30 b	5.21 c	7.30 bc	2.62 bc
T3	13.23 b	5.38 bc	13.56 b	4.83 b
T4	13.27 b	5.42 bc	8.85 bc	2.71 bc
T5	14.53 a	5.77 ab	34.59 a	14.13 a
T6	15.57 a	5.96 a	39.22 a	16.40 a
Sig. F value	0.001	0.001	0.001	0.001

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

The results of the present study indicated that profitable crop growing without fertilizer application is not feasible in the experimental soil as it was very poorly fertile. Application of biogas plant residues and poultry manure enhanced plant growth and development when compared to untreated controls and that resulted in higher yields of the crop. The results were in accordance with the findings of Shabaz [15] who reported yield response of okra to bio slurry manure application. A general trend of increase in all growth parameters of carrot with successive increase in level of bio-slurry manure application was reported by Jeptoo et al. [16]. Nasir et al. [17] stated that plant height of cabbage increases by the application of cow dung biogas plant residues. Similar results were found by Rahman et al. [18]. Garg et al. [19] reported that amendments of soil with biogas slurry increased the yield of wheat over the non amended control. In the present study, the highest yield (16.40 ton ha-1) was obtained when 50% poultry manure was applied in combination with 50% NPK fertilizers. In agreement with Kibria et al. [20], application of 50% NPK+50 PM proved most effective in ensuring good performance in terms of growth and fresh fruit yield of ladies finger in the present study. Kibria et al [20] found that fresh fruit yield of ladies finger with application of full poultry manure @30 ton ha^{-1} and 50% NPK+50% PM (full NPK @120 kg N, 60 kg P and 80 Kg K ha-1) were statistically similar but significantly higher than that with the control and full kitchen compost (@ 30 ton ha^{-1} and 50% NPK+ 50% compost. Poultry manure has long been recognized as the most desirable organic fertilizer. It improves soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention [21]. Olaniyi et al. [22] reported that growth of okra (ladies finger) plant was markedly influenced by the application of organominerals, NPK fertilizer and their combination as observed from the increased plant height and number of leaves compared to control. They observed a great increase in yield of okra when NPK fertilizer was combined with organomineral fertilizer. Akande et al. [23] also reported that combined use of ground rock phosphate applied together with poultry manure significantly improved growth and yield of Okra (*Abelmoschus esculentus* L Moench) compared to application of each material separately.

The low response of ladies finger to NPK fertilizer in the present study as compared to combined application of NPK fertilizer with poultry manure or biogas plant residues corroborates the response patterns reported by other researchers on okra [24] and on maize crop [25]. Poultry manure alone and in combination with NPK fertilizer gave higher plant height, number of fruits plant^{-1} and fresh fruit yield than biogas plant residues combination and NPK alone.

IV. Conclusion

Application of poultry manure alone or in combination in the poorly fertile valley soils of Chittagong increased growth and yield of ladies finger. Biogas plant residues (30 ton ha^{-1}) and partial biogas plant residues and NPK fertilizers increased growth and yield of ladies finger over control but not to the same extent as poultry manure. Our study indicate that application of poultry manure combined with NPK fertilizer will reduce the farmer's budget for crop fertilization and will surely ensure production of crops under a less polluted environment.

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