Research Report on Co-Composting of Faecal Sludge and Municipal Organic Waste for Sustainable Crop Production in Southern Part of Bangladesh

ON-FARM RESEARCH DIVISION
BANGLADESH AGRICULTURAL RESEARCH INSTITUTE
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Executive Summary

Organic matter and nutrients contained in faecal sludge can be recycled and reused as fertilizer cum soil conditioner. It has so many positive effects on soil health which cannot be shared by chemical fertilizers use only. The objectives of the project were to determine the nutrient status of co-compost from faecal sludge and municipal organic waste along with its application for sustainable crop production. The experiment was conducted at Regional Agricultural Research Station (RARS), BARI, Jessore, to find out the effect of co-compost contained 75% municipality waste (MC) and 25% faecal sludge (FC) on yield, nutrient status and quality of cabbage, cauliflower, okra, sweet gourd, gladiolus and marigold.

Nowadays, Kushtia Paurashava, through a private company, is producing co-compost using faecal sludge and organic solid waste. The Paurashava established their co-composting plant in sub-urban areas which is about 4 km distance from the city centre. They use a special vehicle to collect faecal sludge and organic solid waste from the households, institutions, companies or markets. First, faecal sludge is discharged from the sludge collection vehicle (Vacutug) to the drying bed, where last at least 14 days to separate the liquid part. Secondly, a lot of unwanted materials like plastic and stone are separated from the bulk volume of the collected solid waste and kitchen materials. After getting the sorted organic waste materials and 14 days dried sludge, mixture of the two materials is done at the ratio 3:1, i.e. 75% from organic solid waste and 25% from faecal sludge. After that, the total mixture is transferred to the composting box for at least 40 days maintaining temperature 60-650C. To make the final product, the mixed materials are being kept into co-compost maturing box at least 10-15 days. The safe co-compost is ready for selling.

A field trial on cabbage, cauliflower and okra was conducted at RARS's farm in Jessore during the Rabi (winter) season of 2015-16 and 2016-17. Another field trial was also conducted at the same location on sweet gourd, gladiolus and marigold during the Rabi season of 2016-17 and 2017-18 for two years consecutively. The experiment was laid out in a randomized complete block (RCB) design with three replications. In the cabbage, cauliflower okra and sweet gourd experiments five treatments were used [viz., T1= 1 t ha-1co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis (STB-IPNS), T2= 2 t ha-1co-compost + STB- IPNS basis, T3= 3 t ha-1 co-compost + STB- IPNS basis, T4= Soil test based chemical fertilizer for high yield goal and T5= absolute control]. In gladiolus, five different fertilizer doses were used [viz. T1= 4 t ha-1co-compost + STB- IPNS basis, T2= 5 t ha-1co-compost + STB-IPNS, T3= 6 t ha-1co-compost + STB- IPNS, T4= STB for high yield goal and T5= absolute control]. For the marigold, another five different fertilizer doses were used in the experiment [viz. T1= 6 t ha-1co-compost + STB- IPNS, T2= 7 t ha-1co-compost + STB- IPNS, T3= 8 t ha-1co-compost + STB- IPNS, T4= STB for high yield goal and T5= absolute control].

It was found that treatment T3 (134-0-9-0-0-0 NPKSZnB kg ha-1+ co-compost @ 3 t ha-1) gave higher head yield (90.6 t ha-1) and (198.0 t ha-1) during the year of 2015-16 and 2016-17 for cabbage production. But cost and return analysis showed that treatment T2 gave higher gross margin in both cabbage and cauliflower production during the year 2015-16 and T3 gave higher gross margin in cabbage and cauliflower production in 2016-17. Similar findings were also found in the cauliflower in treatment T3 (83-0-50-0-0-0 NPKSZnB kg ha-1 + co-compost @ 3 t ha-1), which gave the higher curd yield of cauliflower (56.40 t ha-1) and (105.7 t ha-1) both the consecutive years 2015-17. Similar trend was found in okra, as treatment T3 (3 t ha-1co-compost + STB- IPNS basis) gave higher yield (14.0 t ha-) and (16.82 t ha-1) during the year 2015-16 and 2016-17, respectively. Two years results indicate that treatment T3 (3 t ha-1co-compost + STB- IPNS basis) gave higher yield in cabbage, cauliflower and okra production. The same treatment T3 (3 t ha-1co-compost + STB- IPNS basis) also performed better in case of sweet gourd yield (25.7 t ha-1).

In flower production (Gladiolus and Marigold) the results indicate that application of higher doze faecal sludge (FS) along with STB-IPNS fertilizer significantly increased the yield. Treatment T3 (25-19-0-0-0-0 kg NPKSZnB ha-1 + co-compost (75% MC+25% FS) @ 6 t ha-1) gave higher floret number, rachis length and plant height during the year of 2016-18 and similarly treatment T3 (15-7-15-0-0-0 kg NPKSZnB ha-1 + co-compost (75% MC+25% FS) @ 8 t ha-1) gave higher yield (14.93 t ha-1) and (16.00 t ha-1) during the year 2016-17 and 2017-18, respectively.

From the experimentation results it could be noted that the addition of fecal sludge as organic manure drastically reduce the use of chemical fertilizer as well as maintaining sustainable soil fertility and crop productivity.

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Abbreviation

BARI	Bangladesh Agricultural Research Institute
RARS	Regional Agricultural Research Station
OFRD	On-Farm Research Division
icddr'b	International Centre for Diarrhoeal Disease Research, Bangladesh
N	Nitrogen
P	Phosphorus
K	Potassium
S	Sulphur
Zn	Zinc
B	Boron
pH	Hydrogen ion concentration of a solution
Tk.	Taka
ha	Hectare
t	Ton
kg	Kilogram

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Abstract

The experiment was conducted at Regional Agricultural Research Station (RARS), BARI, Jashore during the *Rabi* season of 2015-17 to find out the effect of co-compost contained 75% municipality waste (MC) and 25% faecal sludge (FC) on yield, nutrient status and quality of cabbage. Five treatments viz., T_1= 1 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis (STB-IPNS), T_2= 2 t ha^{-1}co-compost + STB- IPNS basis, T_3= 3 t ha^{-1} co-compost + STB- IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. In 2015-16, it was found that treatment T_3 (134-0-9-0-0-0 NPKSZnB kg ha^{-1}+ co-compost @ 3 t ha^{-1}) gave higher head yield (90.6 t ha^{-1}) which was at par to T_2 (89.2 t ha^{-1}) and T_1 (85.40 t ha^{-1}) against T_4 (82.13 t ha^{-1}) and T_5 (23.27 t ha^{-1}). From the cost and return analysis, it was found that highest gross margin (Tk. 415894 ha^{-1}) were found from the treatment T_2 (156-0-23-0-0-0 NPKSZnB kg ha^{-1} + co-compost @ 2 t ha^{-1}) followed by T_3 (Tk. 408294 ha^{-1}) and T_1 (Tk. 407910 ha^{-1}) whereas gross margin of only chemical fertilizer treated plot T_4 was Tk. 400189 ha^{-1}. In case of quality or pathogenic status it was not found any symptom of Salmonela and E. *coli* infestation inside or outside the plant tissues. It is remarkable that the nutrient status of the soil was enhanced even after the crop harvest like Organic Carbon (1.17%), Total Nitrogen (0.10%) and Potassium (0.40 meq/100gm) as well as soil pH (7.40) but initially it was 0.64% Organic Carbon, 0.058% Total Nitrogen, 0.18 meq/100gm potassium as well as 7.45 unit of soil pH. So, considering all the factors of cabbage production it was found that treatment T_2 is a good organic and inorganic fertilizer combination to increase the yield and to get higher income as well as to improve the soil nutrient status. But in the year of 2016-17**,** the higher yield was obtained with T_3 treatment (198.00 t ha^{-1}) which was at par to T_2 (173.10 t ha^{-1}. Only chemical fertilizer treated plot (T_4) gave significantly lower yield (137.60 t ha^{-1}) than T_3 and T_2. The highest gross margin (Tk. 1052694 ha^{-1}) was obtained with T_3 treatment followed by T_2 (Tk. 919294 ha^{-1}), and in only control plot T_1 gave lowest gross margin of Tk. 60340 ha^{-1}.

Introduction

Cabbage (*Brassica oleracea* L.) is an important and nutritious winter leafy vegetable in Bangladesh. It is grown in all over the country during the cool months of the year. It comprises essential nutrients for human beings such as protein, niacin, ascorbic acid, carbohydrates, ash, calcium, potassium and phosphorus (Knot and Deanon, 1997). Fresh cabbage is an excellent source of natural antioxidant, vitamin C, vitamin B-5, vitamin B-6 and vitamin B-1. It is an established fact that use of inorganic fertilizer for the crops is not suitable because of residual effect but in the case of organic fertilizer it increases the productivity of soil as well as crop quality and yield (Tindall, 2000). A good soil should have at least 2.5% organic matter but in Bangladesh most of the soils contain less than 1.5% and, in some soils, even less than 1% (BARC, 2005). Singethal (1996) and Hedge (1998) observed that the organic sources of nutrient applied to preceding crop can benefit the succeeding crops. Nutrients can be provided to plants by applying inorganic fertilizer or organic manure or both. The application of both organic and inorganic fertilizer combinedly, can increase the yield as well as keep the environment sound (Hsieh et al., 1996). Significantly lower number of leaf hoppers and Thrips (Ramesh, 2000) *Spodopter alitura* and *Helicover paarmigera* (Rao *et al*., 2001; Rao, 2002) and their damage in field crops recorded from vermi-compost treated field. Recently municipality of Kushtia are producing organic fertilizer from faecal sludge and municipal solid waste are used in co-composting, so plant nutrient value of co-compost materials are very high. Judicious use of chemical fertilizers along with organic manure may not only help to maintain soil fertility but may also increase crop productivity. Since information on the effect of co-compost on the yield, nutrient status as well as the quality of cabbage is not available as such, the trial was conducted to study the effect of co-composting from Faecal sludge and municipal waste on the yield, nutrient status and quality of cabbage and to find out the optimum and economic dose of co-compost for cabbage production and and to study the human health issue of using co-composting from Faecal sludge and municipal waste.

Materials and Methods

Kushtia municipality in Bangladesh is now making co-compost using faecal sludge and organic solid waste. The co-composting plant is little bit away (4 km) from the city and the authority collected both the raw materials (faecal sludge and organic solid waste) from the city by their waste collected vehicle. At first, faecal sludge is discharged from the sludge collected vehicle to the drying bed at least 15 days before mixing with the organic solid waste. Secondly, a lot of unwanted materials like plastic and stone are separated from the bulk volume of collected solid / kitchen materials. After getting the sorted organic waste materials and 15 days dried sludge; mixture of two materials is done at the ratio of 25% from faecal sludge and 75% from organic solid waste. After that total mixture is transferred to the composting box for at least 40 days maintaining temperature (60-65^{0}C) before transferred to the maturing box. For final product, the mixed materials are being kept into co-compost maturing box at least 10-15 days. The final co-compost was collected from the Municipality on 22 October 2015 for trial. A field trial on cabbage was conducted at Regional Agricultural Research Station's farm, Jashore during the *Rabi* (winter) season of 2015-16 and 2016-17. The cabbage variety was K-K Cross. The plot size was 6m × 5m. Seedlings were transplanted at a spacing of 60 cm × 40 cm on 24 November 2015 and 10 November 2016. The experiment was laid out in a randomized complete block (RCB) design with three replications. The treatments comprised organic and inorganic fertilizer dozes with Integrated Plant Nutrient System (IPNS) basis viz., T_1= 1 t ha^{-1} co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 2 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 3 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control.

Co-composting analysis in different aspects were given in Appendix I. The physical and chemical properties of initial soil were presented in Tables 1 and 2.

Table 1. Physical properties of initial soil at RARS, Jashore research farm during the year of 2015-16.

Soil depth	Bulk density (g/cm3)	Particle density(g/cm3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Textural class
0-15 cm	1.60	3.11	38.02	21.54	28.31	Loam

Table 2. Chemical Properties of initial soil at RARS, Jashore during the year of 2015-16.

Soil depth	pH	OC%	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
			Meq/100 ml				µg/g						
0-15 cm	7.1	0.64	6.0	2.1	0.18	0.058	88.0	29	0.50	1.8	68	4.8	1.50
Critical Level			2.0	0.5	0.12		10	10	0.2	0.2	4.0	1.0	0.6
Interpretation	Opt.	Very low	Opt.	High	Opt.	Very Low	Very high	Very high	Opt.	Very high	Very high	Very high	Opt.

Source, BARI Soil Science Lab- Date: 14 April 2015

Table 3: Chemical Properties of initial soil treatment wise during the year of 2016-17.

Sample No	P^H	OC	OM	N	K	P	S	B	Zn
		(%)	(%)	(%)	Meq/100 gm	µg/g			
T_1 = 1 ton co-compost + STB-IPNS	7.05	1.18	2.04	0.10	0.37	24.03	7.46	0.17	1.06
T_2 = 2 tons co-compost + STB-IPNS	6.45	1.29	2.23	0.11	0.39	30.19	9.98	0.20	1.18
T_3 = 3 tons co-compost + STB-IPNS	6.70	1.32	2.28	0.11	0.46	29.60	10.89	0.23	1.35
T_4 = Soil Test Based (STB) CF	6.70	1.43	2.48	0.12	0.57	38.77	12.39	0.42	1.49
T_5 = Absolute Control	6.80	0.89	1.54	0.08	0.26	23.23	5.07	0.20	0.96
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	High	Opt.	Opt.	Opt.

The actual dozes after calculation the fertilizer requirements considering initial soil nutrients and co-compost were- T_1= 178-0-37-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC + 25% FS) @ 1 t ha^{-1} T_2 = 156-0-23-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC + 25% FS) @ 2 t ha^{-1} T_3 = 134-0-9-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC + 25% FS) @ 3 t ha^{-1} T_4= 201-10-50-5-0-0 kg NPKSZnB ha^{-1} and T_5 = absolute control. All the co-compost, phosphorus and sulphur were applied as a basal during final land preparation. Nitrogen and potassium were applied in two equal splits at 15 and 35 days after transplanting as ring method under moist soil condition and mixed thoroughly with the soil. The crop was harvested on 7 to 25 February 2016 and 2 to 15 February 2017.Yield and yield contributing characters like plant height, head diameter, head yield t ha^{-1} were measured and cost and return analysis was done on prevailing market price. Post soil analysis, nutrient uptake was done soil and pathogenic status of co-compost and cabbage from KUET and ICDDR'B, respectively.

Result and Discussion

Yield and yield attributing traits in cabbage influenced by the application of different chemical fertilizers and co-compost by IPNS basis (Table 4). Plant height and head diameter were identical in Treatment T_1 to T_4 but significant different from T_5. Higher yield (90.60 t ha^{-1}) was obtained from T_3 treatment which was at par to T_2 (89.20 t ha^{-1}) and T_1 (85.40 tha^{-1}). Only chemical fertilizer treated plot (T_4) gave significantly lower yield (82.13 t ha^{-1}) than T_3 and T_2. More and less similar trend was observed individual head weight in 2015-16. But highest individual fruit weight and head yield was recorded from treatment T_3 in 2016-17.

The treatment-wise cost and return analysis is presented in Table 6 and Table 7. The highest gross margin (Tk. 415894 ha^{-1}) was obtained with T_2 treatment followed by T_3 (Tk. 408294 ha^{-1}) and in only chemical fertilizer treated plot T_1 gave Tk. 400189 ha^{-1} gross margin in 2015-16. But highest gross margin (Tk. 1052694 ha^{-1}) was obtained with T_3 treatment followed by T_2 (Tk. 919294 ha^{-1}), T_4 (Tk. 733009 ha^{-1}), T_1 (Tk. 701310 ha^{-1}) and in only control plot T_1 gave lowest gross margin of Tk.60340 ha^{-1} during the year of 2016-17.

Table 4. Yield and yield contributing characters of cabbage during the year of 2015-16.

Treatments	Plant height (cm)	Head diam. (cm)	Individual head weight (kg)	Head yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	29.43 a	19.87 a	2.46 bc	85.40 ab
T_2 = 2 tons co-compost + STB-IPNS	29.60 a	19.97 a	2.57 ab	89.20 a
T_3 = 3 tons co-compost + STB-IPNS	29.97 a	20.08 a	2.61 a	90.60 a
T_4 = Soil Test Based (STB) CF	29.40 a	19.64 a	2.36 c	82.13 b
T_5 = Absolute Control	23.73 b	14.17 b	0.67 d	23.27 c
CV (%)	2.63	6.61	6.57	7.09

Table 5. Yield and yield contributing characters of cabbage as affected by co-compost and inorganic fertilizer during the year of 2016-17.

Treatments	Plant Height (cm)	Head Diam. (cm)	Individual fruit weight (kg)	Head Yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	30.60a	23.20bc	3.357c	134.3c
T_2 = 2 tons co-compost + STB-IPNS	30.43a	23.73ab	4.327b	173.1b
T_3 = 3 tons co-compost + STB-IPNS	30.98a	24.65a	4.950a	198.0a
T_4 = Soil Test Based (STB) CF	29.30a	22.75c	3.440c	137.6c
T_5 = Absolute Control	21.63b	14.40d	0.6633d	23.59d
CV (%)	2.62%	2.27%	7.86%	8.11%

Table 6. Cost and return analysis of cabbage during the year of 2015-16.

Treatments	Gross Return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	512400	104490	407910
T_2 = 2 tons co-compost + STB-IPNS	535200	119306	415894
T_3 = 3 tons co-compost + STB-IPNS	543600	135306	408294
T_4 = Soil Test Based (STB) CF	492780	92591	400189
T_5 = Absolute Control	139620	81200	58420

Price: (Tk. /Kg): Urea- 16, TSP-22, MOP-15, Sulpher-24, Gypsum-10, Co-compost-16 and Cabbage-6

Table 7. Cost and return analysis of cabbage during the year of 2016-17.

Treatments	Gross Return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	805800	104490	701310
T_2 = 2 tons co-compost + STB-IPNS	1038600	119306	919294
T_3 = 3 tons co-compost + STB-IPNS	1188000	135306	1052694
T_4 = Soil Test Based (STB) CF	825600	92591	733009
T_5 = Absolute Control	141540	81200	60340

Price: (Tk. /Kg): Urea- 16, TSP-22, MOP-15, Sulpher-24, Gypsum-10, Co-compost-16 and Cabbage-6

Nutrient status of soil after crop harvest (Cabbage)

It is also remarkable that the nutrient status of the soil was enhanced in T_3 treatment viz., organic carbon (1.17%), total nitrogen (0.10%) and potassium (0.40meq/100gm) as well as soil pH (7.30) but initially it was 0.64% organic carbon, 0.058% total nitrogen, 0.18meq/100 gm potassium as well as pH (7.1).

Table 8. Post analysis results of the soil in cabbage field.

Sample no	pH	% OC	K	Total N (%)	P	S	B	Zn
			Meq/100 ml		µg/g			
T_1 = 1 ton co-compost + STB-IPNS	7.28	1.17	0.28	0.10	80.35	14.15	0.22	1.13
T_2 = 2 tons co-compost + STB-IPNS	7.30	1.17	0.27	0.10	72.36	10.78	0.32	1.02
T_3 = 3 tons co-compost + STB-IPNS	7.30	1.17	0.40	0.10	83.17	10.12	0.31	0.91
T_4 = Soil Test Based (STB) CF	7.18	1.17	0.27	0.09	61.34	14.58	0.26	0.96
T_5 = Absolute Control	7.10	1.17	0.29	0.06	74.59	14.45	0.25	1.06

Source: SRDI Jhenaidah: 07-04-16

Plant analysis of cabbage for the health issues during the year of 2015-16

Table 9: Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected / Not detected	ISO 6579	Not detected

ICDDR'B, 15-03-2016

From the above table, it is apparent that the most dangerous pathogens that are mostly concerned in health issues of co-compost fertilizer were totally absent.

Plant analysis of cabbage for the health issues during the year of 2016-17

Table 10. Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected/Not detected	ISO 6579	Not detected

icddr'b, 21-03-2017

From the above table, it is apparent that the most dangerous pathogens that are mostly concerned in health issues of co-compost fertilizer were totally absent.

So, considering all the factors of cabbage production it was found that use of co-compost along with inorganic fertilizer with IPNS basis i.e., 3 t ha^{-1} co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis is a good option for the farmers to get higher income as well as increasing soil nutrient status of the soil.

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Abstract

Organic fertilizer is a major encouraging factor in crop production especially for the vegetable's crops in Bangladesh. Co-compost from faecal sludge and municipal waste may be alternative source of quality organic fertilizer for vegetables production. The experiment was carried out during the *Rabi* season of 2015-17 at RARS, BARI, Jashore to find out the effect of co-compost on yield, nutrient status and quality of cauliflower. Five treatments viz., T_1= 1 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis (STB-IPNS), T_2= 2 t ha^{-1}co-compost + STB- IPNS basis, T_3= 3 t ha^{-1}co-compost + STB- IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. The result showed that treatment T_3: 83-0-50-0-0-0 NPKSZnB kg ha^{-1} + co-compost @ 3 t ha^{-1} gave the highest yield (56.40 t ha^{-1}) closely followed by T_2 (55.60 t ha^{-1}), where in only chemical fertilizer (T_4) gave significantly lower yield (48.36 t ha^{-1}). From the cost and return analysis it was found that highest gross margin was found from the treatment T_2 (Tk. 524423 ha^{-1}) followed by T_3 (Tk. 524018 ha^{-1}), T_1 (Tk. 472366 ha^{-1}), T_4 (Tk. 465765 ha^{-1}), respectively during the year of 2015-16. In 2016-17, it was revealed that he maximum individual curd weight (2.64 kg) was recorded from T_3 followed by T_2 (2.11 kg) and T_1 (1.93 kg) but T_4 gave significantly lower curd weight (1.73 kg). Higher curd yield of cauliflower (105.7 t ha^{-1}) was obtained from T_3 treatment which was at par to T_2 treatment (84.40 t ha^{-1}) whereas; in inorganic fertilizer gave significantly lower yield (69.47 t ha^{-1}). Analysis of cost and return during 2016-17, it revealed that the highest gross margin (Tk. 1110818 ha^{-1}) was obtained from T_3 treatment followed by T_2 (Tk. 1110818 ha^{-1}), T_1 (Tk. 800206 ha^{-1}) and T_4 (Tk. 719085 ha^{-1}). Only control plot gave lower gross margin (Tk. 154000 ha^{-1}). In case of quality or pathogen status it was not found any symptom of Salmonella and E. *coli* in plant tissue parts. It is remarkable that the nutrient status of the soil was enhanced even after the crop harvest like organic carbon (1.17%), total nitrogen (0.10%) and potassium (0.30meq/100gm) as well as soil pH (7.60) but initially it was 0.64% organic carbon, 0.058% total nitrogen, 0.18meq/100gm potassium as well as soil pH (7.1). So, considering all the factors, it was found that treatment T_2 is a good fertilizer combination to increase the yield and to get higher income of cauliflower production as well as to increase the soil nutrient status.

Introduction

Cauliflower (*Brassica oleracea var. botrytis* L.) is a very popular and nutritious winter vegetable in Bangladesh. It comprises low in fat, but high in dietary fiber, foliate, water, and vitamin C, possessing a high nutritional density. Farmers are generalized in practicing imbalanced use of chemical fertilizer and pesticides. They don't use organic fertilizer. As a result, the soil fertility status degraded day by day and crop production of Bangladesh became problematic for the shortage of macro and micro nutrients. A productive mineral soil should have at 2.5 per cent organic matter (Rijpma and Jahiruddin, 2004). But the level of organic matter in Bangladesh soils is alarmingly low. It is generally around 1% in most of the soils and around 2% in few soils. In some soils, organic matter content is even lower than 0.50% (Islam, 2006). Now a day, farmers are interest in organic farming because of awareness about the residual effect of chemical substances and its environmental negative impact.

It is an established fact that use of inorganic fertilizer for the crops is not suitable for health because of residual effect but in the case of organic fertilizer such problem does not arise rather increase the productivity of soil as well as crop quality and yield (Tindall, 2000). Recently municipality of Kushtia are producing organic fertilizer from faecal sludge and municipal solid waste are used in co-composting, so plant nutrient value of co-compost come out of these materials are very high. Judicious use chemical fertilizers along with organic manure may not only help to maintain soil fertility but may also increase crop productivity. Since information on the effect of co-compost on the yield, nutrient status as well as the quality of cauliflower is not available, for these reasons study was conducted with since information on the effect of co-compost on the yield, nutrient status as well as the quality of cabbage is not available as such, the trial was conducted to study the effect of co-composting from faecal sludge and municipal waste on the yield, nutrient status and quality of cabbage and to find out the optimum and economic dose of co-compost for cabbage production and to study the human health issue of using co-composting from faecal sludge and municipal waste.

Materials and Methods

Kushtia municipality in Bangladesh is now making co-compost using faecal sludge and organic solid waste. The co-composting plant is little bit away (4 km) from the city and the authority collected both the raw materials (faecal sludge and organic solid waste) from the city by their waste collected vehicle. At first, faecal sludge is discharged from the sludge collected vehicle to the drying bed at least 15 days before mixing with the organic solid waste. Secondly, a lot of unwanted materials like plastic and stone are separated from the bulk volume of collected solid / kitchen materials. After getting the sorted organic waste materials and 15 days dried sludge; mixture of two materials is done at the ratio of 25% from faecal sludge and 75% from organic solid waste. After that total mixture is transferred to the composting box for at least 40 days maintaining temperature (60-65^{0}C) before transferred to the maturing box. For final product, the mixed materials are being kept into co-compost maturing box at least 10-15 days. The final co-compost was collected from the Municipality on 22 October 2015 for trial. A field trial on cabbage was conducted at Regional Agricultural Research Station's farm, Jashore during the *Rabi* (winter) season of 2015-16 and 2016-17. The plot size was 6m × 5m. Seedlings were transplanted at a spacing of 60 cm × 40 cm on 24 November 2015 and 10 November 2016. The experiment was laid out in a randomized complete block (RCB) design with three replications. The treatments comprised organic and inorganic fertilizer dozes with IPNS basis viz., T_1= 1 t ha^{-1} co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 2 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 3 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control. The crop was harvested on 10 to 28 February 2016. Co-composting analysis in different aspects was given in Appendix I.

Physical Properties

The soil of the field was loam in texture having bulk density and particle density of 1.60 and 3.11 g cm^3 respectively, while porosity was 38.02 %. The field capacity and initial moisture content were 28.31% and 21.54%, respectively, and it was found from 0 to 15 cm (Table 1).

Table 1. The physical properties of initial soil at RARS, Jashore during the year of 2015-16.

Soil depth	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Texture class
0-15 cm	1.60	3.11	38.02	21.54	28.31	Loam

Chemical Properties

However, the chemical properties of the soil were taken from 0 to 15 cm depth of the soil. The soil pH was 7.1 whereas OC and total N were 0.64% and 0.058% and it's seems to be very low in the initial soil. However, exchangeable K was 0.18 meq/100 g soil, exchangeable Ca was 6.0 meq/100 g soil, exchangeable Mg was 2.1 meq/100 g soil, available P was 88.0 µg/g; S was 29.0 µg/g; Zn was 1.50 µg/g; B was 0.50 µg/g; Cu was 1.8 µg/g and lastly Mn was 4.8 µg/g. Chemical proprieties of initial soil from 0-15 soil depth considered for the fertilizer dozes in the experiment (Table 2).

Table 2. Chemical Properties of initial soil during the year of 2015-16.

Soil depth	pH	OC%	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
			Meq/100 ml				µg/g						
0-15 cm	7.1	0.64	6.0	2.1	0.18	0.058	88.0	29	0.50	1.8	68	4.8	1.50
Critical Level			2.0	0.5	0.12		10	10	0.2	0.2	4.0	1.0	0.6
Interpretation	Opt.	Very low	Opt.	High	Opt.	Very Low	Very high	Very high	Opt.	Very high	Very high	Very high	Opt.

The actual dozes after calculation the fertilizer requirements considering initial soil nutrients and co-compost were- T_1= 128-0-77-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 1 t ha^{-1} T_2= 106-0-63-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 2 t ha^{-1} T_3= 83-0-50-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 3 t ha^{-1} T_4= 151-10-90-5-0-0 kg NPKS ZnB ha^{-1}, T_5= absolute control. All the co-compost, phosphorus and Sulphur were applied as a basal during final land preparation. Nitrogen and potassium were applied in two equal splits at 15 and 35 days after transplanting as ring method under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Yield and yield contributing characters like plant height, curd diameter and curd yield were measured, and cost and return analysis was done on prevailing market price.

Table 3: Chemical Properties of initial soil during the year of 2016-17.

Sample No	pH	OC	OM	N	K	P	S	B	Zn
			(%)		Meq/100 gm	µg/g			
T_1 = 1 ton co-compost + STB-IPNS	6.70	1.20	2.06	0.10	0.28	28.26	8.97	0.21	1.15
T_2 = 2 tons co-compost + STB-IPNS	6.80	1.28	2.20	0.11	0.38	30.73	10.85	0.29	1.29
T_3 = 3 tons co-compost + STB-IPNS	6.75	1.31	2.26	0.11	0.39	34.48	14.11	0.31	1.40
T_4 = Soil Test Based (STB) CF	6.90	1.42	2.44	0.12	0.46	42.98	22.96	0.53	1.67
T_5 = Absolute Control	6.80	0.90	1.56	0.08	0.20	20.96	4.65	0.12	0.90
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	High	Opt.	Opt.	Opt.

The actual dozes after calculation the fertilizer requirements considering initial soil nutrients and co-compost were- T_1= 96.4-0-10.47-12.0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 1 t ha^{-1}, T_2= 69.3-0-0-7.6-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 2 t ha^{-1}, T_3= 49.0-0-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 3 t ha^{-1}, T_4= 120-17.0-27.0-22.3-0-0 kg NPKSZn B ha^{-1}, T_5= absolute control.

Result and Discussion

From the Table 4, it was revealed that plant height, curd diameter, curd weight and yield of cauliflower were significantly influenced by the treatments during the year of 2015-16. The maximum individual curd weight (1.44 kg) was recorded from T_3 closely followed by T_2 (1.42 kg) but T_4 treatment gave significantly lower curd weight (1.24 kg). Higher curd yield of cauliflower (56.40 t ha^{-1}) was obtained from T_3 treatment which was at par to T_2 treatment (55.60 t ha^{-1}) whereas inorganic fertilizer treated plot gave significantly lower yield (48.36 t ha^{-1}). Analysis of cost and return revealed that the highest gross margin (Tk. 524423 ha^{-1}) was obtained from T_2 treatment followed by treatment T_3 (Tk. 524018 ha^{-1}). On the other hand, T_4 treatment gave lower gross margin (Tk. 465765 ha^{-1}) than organic fertilizer treated plots. From the table-5, it was revealed that plant height, curd diameter, curd weight and yield of cauliflower were significantly influenced by the treatments. The maximum individual curd weight (2.64 kg) was recorded from T_3 followed by T_2 (2.11 kg) and T_1 (1.93 kg) but T_4 treatment gave significantly lower curd weight (1.73 kg) than T_3 and T_2. Higher curd yield of cauliflower (105.7 t ha^{-1}) was obtained from T_3 treatment which was at par to T_2 treatment (84.40 t ha^{-1}) whereas lower yield (69.47 t ha^{-1}) from inorganic fertilizer.

Analysis of cost and return revealed that the highest gross margin (Tk. 11,10,818 ha^{-1}) was obtained from T_3 treatment followed by T_2 (Tk. 11,10,818 ha^{-1}), Only control plot gave lower gross margin (Tk. 154000 ha^{-1}).

Table 4. Yield and yield contributing characters of cauliflower as affected by co-compost and inorganic fertilizer during the year of 2015-16.

Treatments	Plant height (cm)	Curd diameter (cm)	Individual curd weight (kg)	Curd yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	25.17 a	18.67 a	1.28 b	50.01 bc
T_2 = 2 tons co-compost + STB-IPNS	26.36 a	19.00 a	1.42 a	55.60 ab
T_3 = 3 tons co-compost + STB-IPNS	26.10 a	19.66 a	1.44 a	56.40 a
T_4 = Soil Test Based (STB) CF	26.23 a	18.03 a	1.24 b	48.36 c
T_5 = Absolute Control	21.53 b	13.73 b	0.50 c	19.53 d
CV (%)	4.66	7.65	5.20	8.05

Table 5. Yield and yield contributing characters of cauliflower as affected by co-compost and inorganic fertilizer during the year of 2016-17.

Treatments	Plant height (cm)	Curd diameter (cm)	Individual curd weight(kg)	Curd yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	28.67 a	19.57 a	1.93 bc	77.33 bc
T_2 = 2 tons co-compost + STB-IPNS	29.67 a	20.59 a	2.11 b	84.40 b
T_3 = 3 tons co-compost + STB-IPNS	29.33 a	21.57 a	2.64 a	105.7 a
T_4 = Soil Test Based (STB) CF	27.33 a	20.49 a	1.73 c	69.47 c
T_5 = Absolute Control	24.33 b	12.81 b	0.540 d	21.60 d
CV (%)	7.21	6.31%	6.07%	6.07%

Table 6. Cost and return analysis of Cauliflower as affected by co-compost and inorganic fertilizer during the year of 2015-16.

Treatments	Gross Return (Tk. ha^{-1})	Total Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	600120	127754	472366
T_2 = 2 tons co-compost + STB-IPNS	667200	142777	524423
T_3 = 3 tons co-compost + STB-IPNS	676800	157582	524018
T_4 = Soil Test Based (STB) CF	580320	114555	465765
T_5 = Absolute Control	234360	105200	129160

Price: (Tk. /Kg): Urea- 16, TSP-22, MOP-15, Sulpher-24, Zypsum-10, Co-compost-16 and Cauliflower-12

Table 7. Cost and return analysis of Cauliflower as affected by co-compost and inorganic fertilizer during the year of 2016-17.

Treatments	Gross Return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	927960	127754	800206
T_2 = 2 tons co-compost + STB-IPNS	1012800	142777	870023
T_3 = 3 tons co-compost + STB-IPNS	1268400	157582	1110818
T_4 = Soil Test Based (STB) CF	833640	114555	719085
T_5 = Absolute Control	259200	105200	154000

Price:(Tk. /Kg): Urea- 16, TSP-22, MOP-15, Sulpher-24, Zypsum-10, Co-compost-16 and Cauliflower-12

Soil analysis after the crop harvest

It is also remarkable that the nutrient status of the soil was enhanced in the case of many components (in T_3 treatment plot) like organic Carbon (1.17%), total nitrogen (0.10%) and potassium (0.30meq/100gm) as well as soil pH (7.30) but initially it was 0.64% organic carbon, 0.058% total nitrogen, 0.18meq/100gm potassium as well as pH (7.1).

Table 8. Post analysis of the soil in cauliflower field.

Sample no	pH	OC%	K	Total N (%)	P	S	B	Zn
			meq/100 ml		µg/g			
T_1 = 1 ton co-compost + STB-IPNS	7.27	0.97	0.29	0.08	75.62	18.77	0.32	1.10
T_2 = 2 tons co-compost + STB-IPNS	7.25	1.09	0.30	0.09	70.47	20.39	0.28	1.03
T_3 = 3 tons co-compost + STB-IPNS	7.30	1.17	0.30	0.10	65.67	08.82	0.26	1.00
T_4 = Soil Test Based (STB) CF	7.20	1.17	0.29	0.08	60.15	12.67	0.30	0.98
T_5 = Absolute Control	7.10	0.97	0.26	0.06	69.80	13.00	0.24	1.08

Source: SRDI Jhenaidah: 07-04-16

Plant analysis for the health issues during the year of 2016-17.

Table 9: Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected/Not detected	ISO 6579	Not detected

Source: ICDDR'B, dated ICDDR'B, 21-03-2017

From the above table, it is apparent that E. *coli* and Salmonella pathogens that are mostly concerned in health issues were totally absent co-compost fertilizer.

Plant analysis for the health issues

Table 10: Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected/Not detected	ISO 6579	Not detected

Source: Icddr'b, dated-15-03-2016Lab-Date: 14 April 2015

From the above table, it is apparent that E. *coli* and Salmonella pathogens that are mostly concerned in health issues were totally absent co-compost fertilizer.

Considering the yield, improving soil nutrient status and pathogenic factors, co-compost along with inorganic fertilizer in IPNS basis gave profitable cauliflower production, specifically the treatment T_2 (T_2= 106-0-63-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 2 t ha^{-1}) is a good option for the farmers to get higher income.

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Abstract

The experiment was conducted at RARS, BARI, Jashore during the *Rabi* season of 2015-17 to find out the effect of co-compost contained 75% municipality waste (MC) and 25% faecal sludge (FC) on yield, nutrient status and quality of okra. There were five treatments viz., T_1= 1 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 2 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 3 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. In 2015-16, findings indicated that the T_3 treatment was the best treatment with fruit yield of 13.19 t ha^{-1} but similar to T_2 with fruit yield of 12.88 t ha^{-1}. The higher yield was obtained from treatment T_3 but higher gross margin was obtained from treatment T_2 (Tk. 83106 ha^{-1}). But in 2016-17, the higher yield (16.82 t ha^{-1}) was obtained with T_3 treatment which was statistically similar to T_1, T_2 and T_4. Only control plot (T_5) gave lower yield (12.50 t ha^{-1}) than other. Treatment T_1 with gross return of was Tk. 290424 and the total cost was Tk. 194614 ha^{-1}. So ultimately the gross margin was Tk. 95810 ha^{-1}. In treatment T_2 had the gross return of Tk. 321760 ha^{-1} with variable cost Tk. 195464 ha^{-1} due to co-compost was used 2 tons per hectare. The gross margin of T_2 treatment was Tk. 126296 ha^{-1} but in T_3 treatment was Tk. 130380 ha^{-1} where the variable cost for T_3 was Tk. 206173 ha^{-1}. The gross return was Tk. 336553 ha^{-1} in Treatment $T_{3.}$ In treatment T_4 the yield was 14.60 t ha^{-1} which price was Tk. 292047 ha^{-1} but the fertilizer and other cost was similar to treatment T_1 and T_2. However, the gross margin was Tk. 96035 ha^{-1} for treatment T_4. The treatment T_5 was absolute control where only Tk. 58258 ha^{-1} came as gross profit. Among the five treatments T_3 showed the highest return but the variable cost was also high so the profit was not the highest position.

Introduction

Ladies finger (*Abelmoschus esculentus* (L.) Moench) originated in Asia and Africa (Thomson and Kelly, 1979) is an important summer vegetable in Bangladesh (Rashid, 1999). It is a nutritious vegetable which plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market (Ahmed, 1995). These green fruits are rich sources of vitamins, calcium, potassium, and other minerals. It is cultivated throughout Bangladesh but its average national yield is poor of 3.07 t ha^{-1} (Anon., 2000). The yield is very low as compared to the yield 9-10 t ha^{-1} of other developed countries of the world (Thomson and Kelly, 1979). Donahue et al. (1990) reported that NPK fertilizer increases soil fertility and yield of okra. However, NPK fertilizer is very expensive and therefore increases cost of production. It is also not environmentally friendly (Ullysses, 1982). Combinations of inorganic and organic fertilizers in soil amendments have been used to increase okra production (Olaniyi et al., 2010; Akande et al., 2010). Okwuagwu et al. (2003) combined NPK and cattle manure at 125 kgha^{-1} and 1.5 t ha^{-1} respectively in soil amendment for the growth of okra and yield. Farmers don't use organic fertilizer. As a result, the soil fertility status degraded day by day and crop production of Bangladesh became problematic for the shortage of macro and micro nutrients. It might be due to mining of soil nutrients, excess and inefficient use of mineral fertilizer Under such situations, it is very important to add organic fertilizer in the soils to maintain soil fertility and sustain crop productivity. Now a day, farmers are interest in organic farming because of awareness about the residual effect of chemical substances and its environmental negative impact.

Recently municipality of Kushtia are producing organic fertilizer from faecal sludge and municipal solid waste are used in co-composting, so plant nutrient value of co-compost come out of these materials are very high. Judicious use chemical fertilizers along with organic manure may not only help to maintain soil fertility but may also increase crop productivity. Since information on the effect of co-compost on the yield, nutrient status as well as the quality of okra is not available, for these reasons the study was conducted to find out the effect of co-composting from faecal sludge and municipal waste on the yield, nutrient status and quality of okra, to find out the optimum and economic dose of co-compost for okra production and to study the human health issue of using co-composting from faecal sludge and municipal waste

Materials and Methods

At Present, Kusthia municipality in Bangladesh is making co-compost using faecal sludge and organic solid waste. The co-composting plant is little bit away (4 km) from the city and the authority collects both the raw materials (faecal sludge and organic solid waste) from the city by their waste collected vehicle. At first, faecal sludge is discharged from the sludge collected vehicle to the drying pit at least 15 days before mixing with the organic solid waste. Secondly, a lot of unwanted materials like plastic and stone are separated from the bulk volume of collected waste materials. After getting the sorted organic waste materials and 15 days dried sludge; mixture of two materials is done at the ratio of 25% from faecal sludge and 75% from organic solid waste. After that total mixture is transferred to the composting box at least 40 days maintaining temperature (60-65^{0}C) before going to the maturing box. For getting the final product, the mixed materials are being kept into co-compost maturing box at least 10-15 days. The co-compost was collected from the Kushtia Municipality on 22 October 2015 for the field trial at Regional Agricultural Research Station, Jashore during the *Rabi* season of 2015-16 and 2016-17. The experiment was laid out in a randomized complete block (RCB) design with three replications. There were five treatment combinations viz., T_1= 1 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 2 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 3 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control.

Physical Properties during the year of 2015-16

The soil of the field was loam in texture having bulk density and particle density of 1.58 and 3.13 g cm^3 respectively, while porosity was 38.04 %. The field capacity and initial moisture content were 27.91% and 21.11%, respectively, and it was found from 0 to 15 cm (Table 1).

Table 1. The physical properties of initial soil at RARS, Jashore farm during the year of 2015-16.

Soil depth	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Texture class
0-15 cm	1.58	3.13	38.04	21.11	27.91	Loam

Physical Properties during the year of 2016-17

The soil of the field was loam in texture having bulk density and particle density of 1.60 and 3.12 g cm^3 respectively, while porosity was 38.00 %. The field capacity and initial moisture content were 25.91% and 21.15%, respectively, and it was found from 0 to 15 cm (Table 2).

Table 2. The physical properties of post soil at RARS, Jashore farm during the year of 2016-17.

Soil depth	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Texture class
0-15 cm	1.60	3.12	38.00	21.15	25.91	Loam

Chemical Properties of initial soil during the year of 2015-16

To observe the chemical properties of the soil, sample soil was taken from 0 to 15 cm depth of the soil from different plot of treatment. The soil pH was documented from 6.45 to 7.05 which are expressed as optimal level but the OM was low in amount in the initial soil. The amount of OC and total N were 1.2% and 0.10% and it's seems to be low in soil because Chan *et al.* (2010) showed that the standard OC and Total N in soil for agriculture is about 1.5-2.5% and 1.5%. On the other hand exchangeable K range was 0.26- 0.57Meq/100gm that can be defined as standard value. It was also found that available P was 30.0µg/mg; S was around 10.0 µg/g; Zn was 1.20 µg/mg; B was 0.30µg/g. According to Iftekhar (2010), the amount of K, B, and Zn was in optimum level. The following table has shown all the chemical proprieties from 0-15 cm which was considered for the fertilizer dozes in the experiment.

Table 3: Chemical Properties of initial soil during the year of 2015-16.

Sample No	P^H	OC	OM	N	K	P	S	B	Zn
		(%)			Meq/100 gm	µg/g			
T_1 = 1 ton co-compost + STB-IPNS	7.30	1.17	2.02	0.10	0.28	80.35	14.15	0.22	1.13
T_2 = 2 tons co-compost + STB-IPNS	7.40	1.17	2.02	0.10	0.27	72.36	10.78	0.32	1.02
T_3 = 3 tons co-compost + STB-IPNS	7.75	1.09	1.89	0.09	0.40	83.17	10.12	0.31	0.91
T_4 = Soil Test Based (STB) CF	6.45	1.17	2.02	0.10	0.27	61.34	14.58	0.26	0.96
T_5 = Absolute Control	7.85	1.17	2.02	0.10	0.29	74.59	14.45	0.25	1.06
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	Very High	Opt.	Opt.	Opt.

Chemical Properties of post soil during the year of 2016-17

It is also remarkable that the nutrient status of the soil was enhanced in the case of many components (in T_3 treatment plot) like Organic Carbon (1.34%), Total Nitrogen (0.13%) and Potassium (0.42meq/100gm) except pH (6.72).

Table 4: Chemical Properties of post soil during the year of 2016-17.

Sample No	P^H	OC	OM	N	K	P	S	B	Zn
		(%)			Meq/100 gm	µg/g			
T_1 = 1 ton co-compost + STB-IPNS	6.66	1.21	2.03	0.12	0.27	28.21	8.97	0.21	1.12
T_2 = 2 tons co-compost + STB-IPNS	6.74	1.26	2.21	0.11	0.35	30.74	10.85	0.25	1.24
T_3 = 3 tons co-compost + STB-IPNS	6.71	1.29	2.23	0.13	0.37	34.57	14.11	0.33	1.41
T_4 = Soil Test Based (STB) CF	6.80	1.34	2.37	0.10	0.42	42.03	22.96	0.51	1.57
T_5 = Absolute Control	6.75	0.99	1.49	0.07	0.22	20.87	4.65	0.11	0.93
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	High	Opt.	Opt.	Opt.

Results and Discussion

Plant height and fruits number

In 2015-16, the five treatments showed different result in plant height and number of fruits per plant. It was observed that the plant height was similar in T_3 and T_4 treatment. The controlled treatment T_5 had the lowest rate of height that was 46.50cm. In plant height there was no excess variation among them because the co-efficient of variation was only 0.75%. T_3 treatment gave the most numbers of fruits among the treatment and it was 164 fruits/plant where T_1, T_2, T_4 gave about same result except T_5 treatment. In terms of number of fruits, the co-efficient of variation was 4.85% that defined the lower variation among the data. The following table shows the plant height and number of fruits per plant.

Table 5: Plant height and fruits number in different treatment of 2015-16.

Treatments	Plant Height (cm)	Number of fruits/Plant
T_1 = 1 ton co-compost + STB-IPNS	89.00 c	151.3 a
T_2 = 2 tons co-compost + STB-IPNS	94.37 b	160.7 a
T_3 = 3 tons co-compost + STB-IPNS	100.5 a	164.3 a
T_4 = Soil Test Based (STB) CF	99.47 a	150.0 a
T_5 = Absolute Control	46.50 d	119.0 b
CV (%)	0.75	4.85

In 2016-17, the five treatments showed different result in plant height and number of fruits per plant. It was observed that the plant height was similar in T_3 and T_4 treatment. The controlled treatment T_5 had the lowest rate of height of 46.52 cm. In plant height there was no excess variation among them because the co-efficient of variation was only 0.75%. T_3 treatment gave the most numbers of fruits among the treatment and it was 163.9 fruits plant^{-1} where T_1, T_2, T_4 gave about same result except T_5 treatment. In terms of number of fruits, the co-efficient of variation was 4.84% that defined the lower variation among the data. The following table shows the plant height and number of fruits per plant.

Table 6: Plant height and fruits number in different treatment during the year of 2016-17.

Treatments	Plant Height (cm)	Number of fruits / Plant
T_1 = 1 ton co-compost + STB-IPNS	89.01 c	150.9 a
T_2 = 2 tons co-compost + STB-IPNS	94.33 b	160.8 a
T_3 = 3 tons co-compost + STB-IPNS	100.51 a	163.9 a
T_4 = Soil Test Based (STB) CF	99.39 a	150.04 a
T_5 = Absolute Control	46.52 d	118.7 b
CV (%)	0.74	4.84

Fruit yield and yield attributes of ladyís finger during the year of 2015-16

In 2015-16, the length of different treatment was 9.40 cm for T_1, 11.67 cm for T_2, 14.00 cm for T_3, 11.47 cm for T_4 and 8.46 cm for T_5. Among these treatments, T_3 showed the highest length of the fruit. In terms of length of individual fruit of okra the co-efficient of variation is 10.61% that mean the variation is in middle level for field production. T_1, T_2, and T_4 treatment was similar but T_4 is the best among them. Considering the diameter of individual fruit here also T_3 treatment was the best. T_1, T_2, T_3 and T_4 treatment were in similar position but T_5 that was absolute control showed the lowest diameter of fruit. The co-efficient of variation was in control only 7.68% that showed the minimum variation among the result. But when the individual fruit weight was taken the T_1 treatment showed the best result. The individual fruit weight was similar even in T_5 treatment. The co-efficient of variation was also minimum level and that was 8.61%. The T_1 treatment had produced 12.06 tons per hectare while 12.88 ton in T_2 treatment and 13.19 tons in T_3 treatment. The chemical treatment showed the production was 12.29 ton of each hectare but the lowest production was in T_5 treatment. So, considering the production of fruits the T_3 treatment was the best but T_1, T_2, T_3 and T_4 was in similar. Here the co-efficient of variation was 7.56% that had helped to confirm the similarity of the individual treatment yield.

Table 7. Fruit yield and yield attributes of lady's finger in different treatments during the year of 2015-16.

Treatments	Length of fruit (cm)	Diameter of individual fruit (cm)	Individual fruit weight (gm)	Yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	9.40bc	7.96 a	27.37a	12.06 a
T_2 = 2 tons co-compost + STB-IPNS	11.67b	7.96 a	24.96ab	12.88 a
T_3 = 3 tons co-compost + STB-IPNS	14.00a	8.33 a	25.67ab	13.19 a
T_4 = Soil Test Based (STB) CF	11.47b	7.53 a	27.07ab	12.29 a
T_5 = Absolute Control	8.46c	5.10 b	22.73b	6.79 b
CV (%)	10.61	7.68	8.61	7.56

Fruit yield and yield attributes of ladyís finger during the year of 2016-2017

In 2016-17, among the treatments, T_3 showed the highest length of the fruit and the co-efficient of variation is 10.60% that mean the variation is in middle level for field production. Considering the diameter of individual fruit T_3 treatment was the best. T_1, T_2, T_3 and T_4 treatment were in similar position but T_5 showed the lowest diameter. The co-efficient of variation only 7.65% in treatment T_5 that showed the minimum variation. The number of fruits of T_1 treatment was little but fruit weight was high. The individual fruit weight was similar even in T_5 treatment. Here the co-efficient of variation was also minimum that was 8.60%. The T_1 treatment had produced 14.52 tons per hectare while 14.93 tons in T_2 treatment and 16.82 tons in T_3 treatment. The chemical treatment showed the production was 14.60 ton of each hectare but the lowest production was in T_5 treatment. So, considering the production of fruits the T_3 treatment was the best but T_1, T_2, T_3 and T_4 was in similar form. Here the co-efficient of variation was 7.56% that had helped to confirm the similarity of the individual treatment yield.

Table 8. Fruit yield and yield attributes of lady's finger in different treatment during the year of 2016-17.

Treatments	Length of fruit (cm)	Diameter of individual fruit (cm)	Individual fruit weight(gm)	Yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	9.42bc	7.97 a	27.33a	14.52 a
T_2 = 2 tons co-compost + STB-IPNS	11.63b	7.99 a	24.94ab	14.93 a
T_3 = 3 tons co-compost + STB-IPNS	13.09a	8.31 a	25.622ab	16.82 a
T_4 = Soil Test Based (STB) CF	11.47b	7.51 a	27.00ab	14.60 a
T_5 = Absolute Control	8.48c	5.13 b	22.71b	12.50 b
CV (%)	10.60	7.65	8.60	7.55

Economic performance of Ladies finger during 2015-16

In 2015-16, among the five treatments T_1 showed the gross return of Tk. 241220 ha^{-1} and the total variable cost was Tk. 173616 ha^{-1}. So, ultimately the gross margin was Tk. 67604 ha^{-1} but in treatment T_2 had the gross return of Tk. 257580 ha^{-1} and the variable cost of Tk.174474 ha^{-1} where the co-compost was used 2 tons per hectare. The gross profit of T_2 treatment was Tk.83106 ha^{-1} whereas in T_3 treatment was Tk. 79744 ha^{-1} and the variable cost was Tk.184176 ha^{-1}. The gross return was Tk. 263972 ha^{-1} in T_3 treatment. The chemical fertilizer treatment was T_4 which price was Tk. 245840 ha^{-1} but the fertilizer and other cost was similar to treatment T_1 and T_2. However, the gross profit was Tk. 79744 ha^{-1} for treatment T_4. but treatment T_5 incurred loss was Tk. 12576 per hectare. Among the five treatments T_3 showed the highest return but the variable cost was also high so the profit was not the highest position. As a result, treatment T_2 showed higher gross margin.

Table 9: Economic performance of ladies' finger during the year of 2015-16.

Treatment	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	12.06	241220	173616	67604
T_2 = 2 tons co-compost + STB-IPNS	12.88	257580	174474	83106
T_3 = 3 tons co-compost + STB-IPNS	13.19	263920	184176	79744
T_4 = Soil Test Based (STB) CF	12.29	245840	175002	70838
T_5 = Absolute Control	6.79	108966	121542	-12576

Economic performance of Ladyís finger of 2016-17

In 2016-17, T_1 treatment showed the gross return of Tk. 290424 ha^{-1} and the total cost was Tk.194614 ha^{-1} and the gross profit was Tk. 95810 ha^{-1}. In treatment T_2 had the gross return of Tk.321760 ha^{-1} with variable cost was Tk. 195464 ha^{-1} where co-compost was used 2 t ha^{-1} and the gross profit was Tk. 126296 ha^{-1}. The gross profit of T_3 treatment was Tk. 130380 ha^{-1} where the variable cost was Tk.206173 ha^{-1}. The gross return was Tk.336553 ha^{-1} in Treatment T_3. The chemical fertilizer treatment was T_4 with gross return Tk. 292047 ha^{-1} but the fertilizer and other cost was similar to treatment T_1 and T_2. However, the gross profit was Tk. 96035 ha^{-1} for treatment T_4. There was a small amount of benefit only Tk. 58258 ha^{-1} from T_5. Among the five treatments T_3 showed the highest return as well as gross profit but the variable cost was slightly high.

Table 10: Economic performance of lady's finger during the year of 2016-17.

Treatment	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	14.52 a	290424	194614	95810
T_2 = 2 tons co-compost + STB-IPNS	14.93 a	321760	195464	126296
T_3 = 3 tons co-compost + STB-IPNS	16.82 a	336553	206173	130380
T_4 = Soil Test Based (STB) CF	14.60 a	292047	196012	96035
T_5 = Absolute Control	12.50 b	180600	122342	58258

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Abstract

The experiment was conducted at RARS, BARI, Jashore during the winter season of 2016-17 to find out the effect of co-compost contained 75% municipality waste (MC) and 25% faecal sludge (FC) on yield, nutrient status and quality of sweet gourd. There were five treatments viz., T_1= 1 ton ha^{-1}co-compost + STB based CF (STB - IPNS), T_2= 2 t ha^{-1} co-compost + STB based CF (STB - IPNS), T_3= 3 t ha^{-1}co-compost + STB based CF (STB - IPNS), T_4= STB based CF and T_5= absolute control were used. In 2016-17, findings indicated that the T_3 (25.7 t ha^{-1}) treatment was the best treatment for sweet gourd production but the yield of T_2 (24.76 t ha^{-1}) treatment was similar to the treatment T_3. The yield of sweet gourd after T_1 was (19.48 t ha^{-1}), T_4 (15.02 t ha^{-1}) and T_5 (7.18 t ha^{-1}), respectively. Among the five treatments, the economic status in T_1 treatment had the gross return was Tk.584400 ha^{-1} and the total variable cost was Tk.191250 ha^{-1} with gross margin was Tk. 39150 ha^{-1}. In treatment T_2 had the gross return of Tk. 622800 ha^{-1} with total variable cost was Tk. 205000 ha^{-1} and the gross margin was Tk.417800 ha^{-1}. The gross margin of T_3 treatment was Tk.559000 ha^{-1} where the total variable cost was Tk.212000 ha^{-1} and the gross return was Tk. 771000 ha^{-1} in Treatment T_3. The chemical fertilizer treatment was T_4 with gross return was Tk. 450600 ha^{-1} with gross margin was Tk. 253220 ha^{-1}. There was a limited benefit Tk. 84940 ha^{-1} was obtained by the cultivation of sweet gourd in T_5. Finally, among the five treatments T_3 showed the highest return.

Introduction

Sweet gourd (Cucurbita moschata) is an annual herb belonging to the family. It is grown in all the districts of Bangladesh round the year but its production is concentrated during summer season. Sweet gourd occupied 1.17 thousand hectares of land with the total production of 11.9 thousand tons of fruits with an average yield of 8.8 t ha^{-1}in Bangladesh (BBS, 2004). The crop constitutes 8.38% and 6.44% of the total supply of vegetables in the market during the summer and winter season, respectively (BBS, 2002). Sweet gourd is appreciated by consumers as because its fruits, tender stems, leave and even flowers can be used as vegetables. It is relatively richer source of energy, carbohydrates and vitamin (Bose and Som, 1986). The high yielding sweet gourd varieties has resulted in an increase of sweet gourd production but requires huge amount of chemical fertilizer which implies health hazards and environmental pollution. Farmers are generalized in practicing imbalanced use of chemical fertilizer and pesticides. They don't use organic fertilizer. As a result, the soil fertility status degraded day by day and crop production which might be due to mining of soil nutrients, excess and inefficient use of mineral fertilizer Under such situations, it is very important to add organic fertilizer in the soils to maintain soil fertility and sustain crop productivity. Now a day, farmers are interest in organic farming because of awareness about the residual effect of chemical substances and its environmental negative impact. Recently municipality of Kushtia are producing organic fertilizer from faecal sludge and municipal solid waste are used in co-composting, so plant nutrient value of co-compost come out of these materials are very high. Judicious use chemical fertilizers along with organic manure may not only help to maintain soil fertility but may also increase crop productivity. Since information on the effect of co-compost on the yield, nutrient status as well as the quality of sweet gourd is not available, for these reasons study was conducted with the objectives, to study the effect of co-composting from faecal sludge and municipal waste on the yield, nutrient status and quality of sweet gourd, to find out the optimum and economic dose of Co-

Compost for sweet gourd production and to study the human health issue of using Co-Composting from faecal sludge and municipal waste.

Materials and Methods

The co-compost was collected from the Kushtia Municipality on 22 October 2015 for the field trial at Regional Agricultural Research Station, Jashore during the *Rabi* season of 2016-17. The experiment was laid out in a randomized complete block design (RCB) with three replications. There were five treatment combinations viz., T_1= 1 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 2 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 3 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control.

Physical Properties of soil during 2015-16

The soil of the field was loam in texture having bulk density and particle density of 1.63 and 3.15 g cm^3 respectively, while porosity was 38.01 %. The field capacity and initial moisture content were 28.01% and 21.11%, respectively, and it was found from 0 to 15 cm (Table 1).

Table 1. The physical properties of initial soil at RARS, Jashore farm during the year of 2015-16.

Soil depth	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Texture class
0-15 cm	1.63	3.15	38.01	22.11	28.01	Loam

Physical Properties of soil during 2016-17

The soil of the field was loam in texture having bulk density and particle density of 1.65 and 3.18 g cm^3 respectively, while porosity was 39.01 %. The field capacity and initial moisture content were 25.02 and 21.15%, respectively, and it was found from 0 to 15 cm (Table 2).

Table 2. The physical properties of post soil at RARS, Jashore farm during the year of 2016-17.

Soil depth	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Initial Moisture content (%)	Field Capacity (%)	Texture class
0-15 cm	1.65	3.18	39.01	21.15	26.02	Loam

Chemical Properties of initial soil during the year of 2015-16

To observe the chemical properties of the soil, sample soil was taken from 0 to 15 cm depth of the soil from different plot of treatment. The soil pH was documented from 6.48 to 7.75 which are expressed as optimal level but the OM was low in amount in the initial soil. The amount of OC and total N were 1.11 and 0.09% and it's seems to be low in soil and total N in soil for agriculture is about 1.5-2.5% and 1.5%. On the other hand, exchangeable K range was 0.26- 0.57Meq/100gm that can be defined as standard value. It was also found that available P was 30.0µg/mg; S was around 10.0 µg/g; Zn was 1.20 µg/mg; B was 0.30 µg/g.

Table 3: Chemical Properties of initial soil during the year of 2015-16.

Sample No	pH	OC	OM	N	K	P	S	B	Zn
			(%)		Meq/ 100 gm		µg/g		
T_1 = 1 ton co-compost + STB-IPNS	7.20	1.17	2.02	0.10	0.27	30.31	14.19	0.22	1.13
T_2 = 2 tons co-compost + STB-IPNS	7.30	1.18	2.02	0.11	0.27	23.34	10.78	0.32	1.04
T_3 = 3 tons co-compost + STB-IPNS	7.75	1.19	1.88	0.09	0.40	53.17	10.12	0.31	0.91
T_4 = Soil Test Based (STB) CF	6.48	1.17	2.02	0.10	0.27	32.33	14.58	0.26	0.96
T_5 = Absolute Control	7.85	1.11	2.00	0.10	0.28	24.59	14.45	0.25	1.07
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	Very High	Opt.	Opt.	Opt.

Chemical Properties of post soil during 2016-17

It is also remarkable that the nutrient status of the soil was enhanced in the case of many components (in T_3 treatment plot) like Organic Carbon (1.34%), Total Nitrogen (0.13%) and Potassium (0.42 meq/100gm) except pH (6.72).

Table 4: Chemical Properties of post soil during the year of 2016-17.

Sample No	pH	OC	OM	N	K	P	S	B	Zn
			(%)		Meq/100 gm		μg/g		
T_1 = 1 ton co-compost + STB-IPNS	6.66	1.21	2.03	0.12	0.27	28.21	8.97	0.21	1.12
T_2 = 2 tons co-compost + STB-IPNS	6.74	1.26	2.21	0.11	0.35	30.74	10.85	0.25	1.24
T_3 = 3 tons co-compost + STB-IPNS	6.71	1.29	2.23	0.13	0.37	34.57	14.11	0.33	1.41
T_4 = Soil Test Based (STB) CF	6.80	1.34	2.37	0.10	0.42	42.03	22.96	0.51	1.57
T_5 = Absolute Control	6.75	0.99	1.49	0.07	0.22	20.87	4.65	0.11	0.93
Critical Level					0.12	10	10	0.2	0.6
Interpretation	Opt.	Low	Low	Low	Opt.	High	Opt.	Opt.	Opt.

Result and Discussion

From the Table 4, it was revealed that Fruit lengths, Fruit diameter, Fruits per plant and yield of sweet gourd were significantly influenced by the treatments. Significant difference was observed in fruit length of sweet gourd. Among the treatments, longest fruit (35.61 cm) was observed in T_3 while the shortest fruit length (15.61 cm) in T_5. The highest diameter recorded in T_3 (82.61 cm) and the lowest diameter recorded in T_5 (40.16 cm). It was observed that the maximum number of fruits per plant (2.94) was produced by T_3 which was significantly different from the other treatments. The minimum fruit bearing (1.73) per plant was observed in T_5. Higher fruit yield of sweet gourd (25.7t ha^{-1}) was obtained from T_3 treatment which was at par to T_2 treatment (24.76 t ha^{-1}) whereas T_5 gave significantly lower yield (7.18t ha^{-1}).

Table 5. Yield and yield contributing characters of sweet gourd during the year of 2016-17.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruits per plant	Fruit yield (t ha^{-1})
T_1 = 1 ton co-compost + STB-IPNS	25.94 a	76.51 a	2.23b	19.48 b
T_2 = 2 tons co-compost + STB-IPNS	29.67 a	80.93 a	2.18b	24.76 a
T_3 = 3 tons co-compost + STB-IPNS	35.61 a	82.61 a	2.94a	25.7 a
T_4 = Soil Test Based (STB) CF	22.33 b	62.71 b	1.95b	15.02 c
T_5 = Absolute Control	15.61 a	40.16 a	1.73a	7.18 a
CV(%)	9.5	7.02	2.03	5.01

Economic performance of Sweet Gourd during the year of 2016-17

In 2016-17, among the five treatments T_1 showed the gross return of Tk. 584400 ha^{-1} and the total cost was Tk. 191250 ha^{-1} with the gross profit was Tk. 39150 ha^{-1}. The treatment T_2 had the gross return of Tk. 622800 ha^{-1} with total variable cost was Tk. 205000 ha^{-1} and the gross profit was Tk. 417800 ha^{-1}. The gross profit of T_3 treatment was Tk. 559000 ha^{-1} where the total variable cost was Tk. 212000 ha^{-1} and the gross return was Tk. 771000 ha^{-1}. The chemical fertilizer treatment was T_4 with gross return was Tk.450600 ha^{-1} and the gross profit was Tk.253220 ha^{-1}. In treatment T_5 was absolute control with limited benefit Tk. 84940 ha^{-1}. Finally, among the five treatments T_3 showed the highest profit.

Table 6: Economic performance of Sweet Gourd during the year of 2016-17.

Treatment	Yield ($t\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)	Total Variable cost ($Tk.\ ha^{-1}$)	Gross margin ($Tk.\ ha^{-1}$)
T_1 = 1 ton co-compost + STB-IPNS	19.48 b	584400	191250	393150
T_2 = 2 tons co-compost + STB-IPNS	24.76 a	622800	205000	417800
T_3 = 3 tons co-compost + STB-IPNS	25.7 a	771000	212000	559000
T_4 = Soil Test Based (STB) CF	15.02 c	450600	197380	253220
T_5 = Absolute Control	7.18 a	215400	130460	84940

Plant analysis for the health issues during the year of 2016-17

Table 7: Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected/Not detected	ISO 6579	Not detected

Source: ICDDR'B, dated ICDDR'B, 21-03-2017

From the above table it is apparent that E. *coli* and Salmonella pathogens that are mostly concerned in health issues were totally absent co-compost fertilizer.

Plant analysis for the health issues:

Table 1: Enumeration of β- glucuronidase positive E. *Coli* and detection of *Salmonella* spp.

Sl. No.	Test Name	Unit	Method Used	Results
1	E. *coli*	CFU/g	ISO 16649-2	<10*
2	Salmonella	Detected/Not detected	ISO 6579	Not detected

Source: Icddr'b, dated; 25-08-2017

From the above table it is apparent that E. *coli* and Salmonella pathogens that are mostly concerned in health issues were totally absent co-compost fertilizer.

Considering the yield of sweet gourd, improving soil nutrient status and pathogenic factors, co-compost along with inorganic fertilizer in IPNS basis gave profitable cauliflower production, specifically the treatment T_3 is a good option for the farmers to get higher income.

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Abstract

The experiment was conducted at On-Farm Research Station, Jashore during the Rabi season of 2016-17 to find out the optimum dose of co-compost and inorganic fertilizer for gladiolus cultivation. Five different fertilizer doses were used in the experiment viz.T_1= 4 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 5 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 6 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. The estimation of IPNS based fertilizers dose were: T_1= 25-22-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 4 t ha^{-1}, T_2= 25-21-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 5 t ha^{-1}, T_3= 25-19-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_4= 98-10-0-29-1-1.2 kg NPKSZnB ha^{-1}, T_5= control. The experiment was laid out in a randomized complete block design with three replications. During the year of 2016-17, the result showed that the treatment T_3 gave the higher plant height, length of rachis, no. of leaves and no. of floret. The highest number of florets (15.33), plant height (139.4 cm) and leaves (9.66) were also observed in T_3. In 2017-18**,** the highest number of florets (20.00), plant height (144.00 cm) and leaves (10.00) were observed in T_3.

Introduction

Gladiolus (*Gladiolus grandiflorus L.*), is a very popular flowering plant in Bangladesh. The agro ecological conditions are very favorable for the survival and culture of gladiolus. Studies have established by Momin (2006) that income from gladiolus flower production is six times higher than rice. Its elegant spikes, varieties of colour with long vase life are the reason for its ever-increasing demand. The major production belts of this flower were found in Jashore Sadar, Jhikargacha, Sharsha, Chowgacha, Kushtia, Chuadanga, Chittagong, Mymensingh, Dhaka, Savar and Gazipur regions. Recently, cultivation of this crop in other parts of the country has been started in a small scale. Nitrogen is one of the most important nutrients producing growth and yield response in gladiolus. Leaf analysis indicates that the leaves should contain on dry weight basis 2.5 to 3% nitrogen or more for optimum yield (Militiu *et al*. 2002). The quantity of phosphorus required by gladiolus is about one tenth of the nitrogen expressed in terms of foliar analysis (Militiu *et al.* 2002). Recently, co-compost is using for the production of different types of vegetables in Jashore region. Co-compost is also known as good organic manure for crop production and co-compost could be the alternative source of organic fertilizer which is also known as good source of nitrogen fertilizers. In Jhikargaca region, farmers are cultivating gladiolus in long term basis but they are little care about the fertility status of their soil. So, co-compost may be the concern now as it has a good combination of nitrogen, phosphorous, potassium, Sulphur, boron as well as organic matter. As co-compost is made from faecal sludge and municipal solid waste the research needs to be found for getting actual doze as well as health issue on flower production. So, the objectives of the study were to study the effect of co-composting from faecal sludge and municipal waste on the yield, nutrient status and quality of gladiolus, to find out the optimum and economic dose of co-compost for gladiolus production and to study the human health issue of using co-composting from faecal sludge and municipal waste

Materials and Methods

The experiment was conducted at On-Farm Research Station, Jashore during the *Rabi* season of 2016-17. In, 2016 five different fertilizer doses were used in the experiment viz. T_1= 4 t ha^{-1} co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 5 t ha^{-1} co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 6 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. The estimation of IPNS based fertilizers dose were: T_1= 25-22-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 4 t ha^{-1}, T_2= 25-21-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 5 t ha^{-1}, T_3= 25-19-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_4= 98-10-0-29-1-1.2 kg NPKSZnB ha^{-1}, T_5= control. The fertilizers were used on soil test basis. The unit plots size was 3m x 2m. The land was well prepared and seeds were sown maintaining row to row spacing 20 cm and plant to plant 15 cm on 15 November 2016. The experiment was laid out in a randomized complete block design with three replications. All of P, K, S, co-compost and two-third of N were applied as basal and the remaining N was applied as top dress after thirty days of sowing. Other intercultural operations were done as and when necessary. The crop was harvested on 07 to 19 February 2017. In 2017**,** T_1= 23-20-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 4 t ha^{-1}, T_2= 21-21-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 5 t ha^{-1}, T_3= 20-15-0-0-0-0 kg NPKSZnBha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_4= 92-12-0-22-0.5-1.0 kg NPKSZnB ha^{-1} and T_5= control. The crop was harvested on 07 to 30 February 2018. Data on yield and yield contributing characters were recorded and analyzed statistically through open source R statistical package..

Table 1. Initial analysis of the soil in Gladiolus field.

Sample no	pH	% OC	Organic matter	K	Total N (%)	P	S	B	Zn
				Meq/100 ml		µg/g			
9724	6.90	2.39	4.12	0.36	0.20	18.31	2.37	0.19	1.17

Results and Discussion

During 2016-17, it was found that the treatment T_3 (25-19-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC + 25% FS) @ 6 t ha^{-1} gave the higher plant height, length of rachis and no. of leaves. The number of florets (15.33) was similar to treatment T_3, T_2 and T_4. In 2017-18, it was found that the treatment T_3 (20-15-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1} gave the higher plant height, length of rachis, no. of leaves and no. of floret. The highest number of florets (20.00), plant height (144.0 cm) and leaves (10.0) were observed in T_3.

Table 2. Yield and yield contributing characters of gladiolus affected by fertilizers at RARS, Jashore during the year 2016-17.

Treatment	Plant length (cm)	Rachis Length (cm)	Leaf (no.)	Floret (no.)
T_1 = 4 tons co-compost + STB-IPNS	134.3	73.00	9.000	14.67
T_2 = 5 ton co-compost + STB-IPNS	126.5	72.07	9.333	15.33
T_3 = 6 tons co-compost + STB-IPNS	139.4	74.87	9.667	15.33
T_4 = Soil Test Based (STB) CF	130.5	68.43	9.000	15.00
T_5 = Absolute Control	118.8	50.13	9.333	13.00
CV (%)	4.61	7.48	8.53	4.41

Treatments: (2016-17)

T_1= 25-22-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 4 t ha^{-1}
T_2= 25-21-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 5 t ha^{-1}
T_3= 25-19-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}
T_4= 98-10-0-29-1-1.2 kg NPKSZnB ha^{-1}
T_5= control

Table 3. Yield and yield contributing characters of gladiolus affected by fertilizers at RARS, Jashore during 2017-18.

Treatment	Plant length (cm)	Rachis Length(cm)	Leaf (no.)	Floret (no.)
T_1 = 4 ton co-compost + STB-IPNS	135.2	74.03	9.00	14.00
T_2 = 5 ton co-compost + STB-IPNS	136.3	71.00	9.00	16.33
T_3 = 6 ton co-compost + STB-IPNS	144.0	77.80	10.0	20.00
T_4 = Soil Test Based (STB) CF	127.3	70.23	9.00	17.00
T_5 = Absolute Control	123.5	53.12	9.00	14.00
CV (%)	4.03	7.40	8.00	4.9

Treatments: (2017-18): T_1= 23-20-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 4 t ha^{-1}, T_2= 21-21-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 5 t ha^{-1}, T_3= 20-15-0-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_4= 92-12-0-22-0.5-1.0 kg NPKSZnB ha^{-1}, T_5= control

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Abstract

The experiment was conducted at On-Farm Research Station, Jashore during the *Rabi* season of 2016-17 to find out the optimum dose of co-compost and inorganic fertilizer for marigold cultivation. Five different fertilizer doses were used in the experiment viz. T_1= 6 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 7 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 8 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. The experiment was laid out in a randomized complete block (RCB) design with three replications. The estimation of IPNS based fertilizers dose were T_1= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_2= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha^{-1}, T_3= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 8 t ha^{-1}, T_4= 54-64-15-0-1-1 kg NPKSZnB ha^{-1}, T_5= control. It was found that the treatment T_3 (15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha^{-1} gave the higher yield plant height, no. of flowers per plant and no. of floret. The highest yield (14.93 t ha^{-1}) number of florets (181), plant height (89.13 cm) and n. of flowers per plant (166) were observed in T_3. In 2017-18, the highest yield (14.93 t ha^{-1}), number of florets (181), plant height (89.13 cm) and n. of flowers per plant (166) were observed in T_3.

Introduction

Marigold is a very popular flowering plant in Bangladesh. The agro ecological conditions are very favorable for the survival and culture of gladiolus. The major production belts of this flower were found in Jashore Sadar, Jhikargacha, Sharsha, Chowgacha, Kushtia, Chuadanga, Chittagong, Mymensingh, Dhaka, Savar and Gazipur regions. Recently, cultivation of this crop in other parts of the country has been started in a small scale. Recently, co-compost is using for the production of different types of vegetables in Jashore region. Co-compost is also known as good organic manure for crop production and co-compost could be the alternative source of organic fertilizer which is also known as good source of nitrogen fertilizers. In Jhikargaca region, farmers are cultivating gladiolus in long term basis but they are little care about the fertility status of their soil. So, co-compost may be the concern now as it has a good combination of nitrogen, phosphorous, potassium, sulphur, boron as well as organic matter. As co-compost is made from faecal sludge and municipal solid waste the research needs to be found for getting actual doze as well as health issue on flower production. So, the objectives of the study were to study the effect of co-composting from faecal sludge and municipal waste on the yield, nutrient status and quality of gladiolus, to find out the optimum and economic dose of co-compost for marigold production and to study the human health issue of using co-composting from faecal sludge and municipal waste

Materials and Methods

The experiment was conducted at On-Farm Research Station, Jashore during the *Rabi* season of 2016-17. Five different fertilizer doses were used in the experiment viz. T_1= 6 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_2= 7 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_3= 8 t ha^{-1}co-compost + soil test based chemical fertilizer for high yield goal in IPNS basis, T_4= Soil test based chemical fertilizer for high yield goal and T_5= absolute control were used. The estimation of IPNS based fertilizers dose were T_1= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_2= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha^{-1}, T_3= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 8 t ha^{-1}, T_4= 54-64-15-0-1-1 kg NPKSZnB ha^{-1}, T_5= control.

The fertilizers were used on soil test basis. The unit plots size was 4m x 5m. The land was well prepared and seeds were sown maintaining row to row spacing 40 cm and plant to plant 20 cm on 20 November 2016. All of P, K, S, co-compost and two-third of N were applied as basal and the remaining N was applied as top dress after thirty days of sowing. Other intercultural operations were done as and when necessary. The crop was harvested on 07 to 20 April 2017. In 2017-18, T_1= 12-5-13-0-0-0 kg NPKS ZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_2= 11-4-11-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha^{-1}, T_3= 14-4-13-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 8 t ha^{-1}, T_4= 51-60-12-0-0.5-0 kg NPKSZnB ha^{-1} and T_5= control. Data analyzed statistically with open source statistical package R.

Table 1. Initial analysis of the soil in Marigold field

Sample no	pH	%OC	Organic Matter	K	Total N (%)	P	S	B	Zn
				Meq/100 ml		µg/g			
9724	6.65	2.39	4.12	0.36	0.20	14.00	2.37	0.19	1.17

Results and Discussion

The result showed that plant height, no. of floret, no. of flower /plant and diameter was not significantly influenced by treatments during 2016-17. It was found that the treatment T_3 (15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1} gave the maximum yield (14.93 t ha^{-1}) but at par to treatment T_2. In, 2017-18, it was found that similar trend was observed in 2017-18. From the result it is clear that the second-year performed better in every character and it might be due to the increased co-compost and soil nutrient status at crop field.

Table 2. Yield and yield contributing characters of Marigold affected by fertilizers at On-Farm Research Division, Jashore during the year of 2016-17.

Treatment	Plant height (cm)	No. of Branch	Floret (no.)	No. of flower /Plant	Diameter (cm)	Yield (t ha^{-1})
T_1 = 6 tons co-compost + STB-IPNS	87.93 a	17.13 ab	149.6 a	140.1 a	3.467 a	12.12 b
T_2 = 7 tons co-compost + STB-IPNS	79.87 a	16.07 b	170.4 a	163.8 a	3.527 a	13.05 ab
T_3 = 8 tons co-compost + STB-IPNS	89.13 a	16.60 ab	181.2 a	166.7 a	3.573 a	14.93 a
T_4 = Soil Test Based (STB) CF	88.80 a	18.00 a	173.9 a	134.7 a	3.620 a	12.47 b
T_5 = Absolute Control	85.67 a	16.80 ab	163.1 a	155.9 a	3.647 a	10.89 c
CV (%)	6.05	5.22	13.26	13.17	7.51	10.56

Treatments: (2016-17): T_1= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1} T_2= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha$^{-1.}$ T_3= 15-7-15-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 8 t ha$^{-1,}$ T_4= 54-64-15-0-1-1 kg NPKSZnB ha^{-1} and T_5= Control

Table 3. Yield and yield contributing characters of Marigold affected by fertilizers at on farm research station, Jashore during the year of 2017-18.

Treatment	Plant height (cm)	No. of Branch	Floret (no.)	No. of flowers $plant^{-1}$	Diameter (cm)	Yield ($t\ ha^{-1}$)
T_1 = 6 tons co-compost + STB-IPNS	86.20 a	16.12 ab	155.4 a	140.1 a	3.445 a	13.10 b
T_2 = 7 tons co-compost + STB-IPNS	81.82 a	17.00 b	179.5 a	163.8 a	3.59 a	13.59 ab
T_3 = 8 tons co-compost + STB-IPNS	93.12 a	19.40 ab	192.00 a	170.30 a	3.60 a	16.00 a
T_4 = Soil Test Based (STB) CF	80.20 a	17.15 a	175.3 a	135.6 a	3.40 a	12.80 b
T_5 = Absolute Control	69.60 a	14.70 ab	140.1 a	125.97 a	3.12 a	10.00 c
CV (%)	6.00	4.45	11.21	12.00	5.50	9.56

Treatments: (207-18): T_1= 12-5-13-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 6 t ha^{-1}, T_2= 11-4-11-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 7 t ha^{-1}, T_3= 14-4-13-0-0-0 kg NPKSZnB ha^{-1} + co-compost (75% MC+25% FS) @ 8 t ha^{-1}, T_4= 51-60-12-0-0.5-0 kg NPKSZnB ha^{-1}, T_5= control.

Evaluation of physical, chemical, heavy metal and pathogen status of co-compost from faecal sludge and municipal organic waste are given below:

Co-compost

Co-composting is the composting of two or more than two organic materials together to increase its quality as a nutrient enriched organic fertilizer. Now, Kushtia municipality is making co-compost using faecal sludge and organic solid waste and it is essential to evaluate how it could be a better option for organic fertilizers in crop field and the criteria of organic fertilizer made from co-compost (25% Faecal Sludge and 75% organic solid waste.

Analysis of Co-compost

Co-compost from municipal solid waste and faecal sludge (collected from Kushtia) was analyzed to know the nutrient status, heavy metal contained and pathogen status. It was analyzed from KUET, BARI and ICDDR'B in different dimension.

Physical Characteristics:

In physical characters, it was found that total solids and total volatile solids were 809 mg/g and 719 mg/g. Other properties like co-compost temperature, electrical conductivity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) were found at the amount of 22^0 C, 1393 µS/cm, 7 mg/g, and 512 mg/g, respectively.

Table 1: Characteristics of Co-compost (Physical)

Characters	Test Result	Units
Total Solids	809	mg/g
Total Volatile solids	719	mg/g
Temperature	0C	22
Electrical Conductivity	1393	µS/cm
Biological Oxygen Demand (BOD_5)	7.0	mg/g
Chemical Oxygen Demand (COD)	512	mg/g
Color	Black	-

Source, KUET-Date: 8 October 2015

Characteristics of Co compost (Pathological)

The pathological properties of the co-compost were also analyzed from KUET and it was found that the Total Coliform (TC) was 2400 N/g but the *Escherichia Coliform* (*E.coli*) and the Eggs of Helminths were Nil.

Table 2: Characteristics of Co-compost (Pathological)

Characters	Test result	Units
Total coliform	2400	N/g
Escherichia Coliform	Nil	-
Helminths Eggs	Nil	-

Source, KUET-Date: 8 October 2015

Characteristics of Co-compost (Chemical)

The chemical properties of the co-compost were analyzed from soil science division of Bangladesh Agriculture Research Institute. The pH was 6.8, Nitrogen was 2.26% Organic Carbon was 6.7%, Phosphorus was 80%, Potassium was 1.36%, Sulphur was 0.84%, Boron was 0.20% and Copper was 0.012%. Table 3: Chemical

Characteristics of Co-compost during the year of 2015-17.

Sl. No.	Specification	Test Result	Test Result	Test Result
		Lab No. 55578	Lab No. 55578	Lab No. 55578
1.	Physical condition	Dust	Dust	Dust
2.	Colour	Black	Black	Black
3.	Moisture (%)	22.07	20.07	21.0
4.	pH	6.80	7.20	7.23
5.				
6.	OC (%)	6.70	14.10	13.15
7.	N (%)	2.26	2.30	2.25
8.	P (%)	1.80	1.90	1.88
9.	K (%)	1.36	1.20	1.19
10.	S (%)	0.84	0.89	0.82
11.	B (%)	0.20	0.25	0.23
12.	Cu (%)	0.012	0.015	0.013
13.	pb (ppm)	13.15	14.0	15.0
14.	Cd (ppm)	0.96	0.02	0.05
15.	Cr (ppm)	29.71	30.0	29.0
16.	Ni (ppm)	16.17	15.10	14.11

Characteristics of Co-compost (Pathological)

Evaluation of physical, chemical, heavy metal and pathogen status of co-compost from faecal sludge and municipal organic waste are given below:

Characters	Test result	Units
Total coliform	2400	N/g
Escherichia Coliform	Nil	-
Helminths Eggs	Nil	-

Source, KUET, Jashore, 2015 and ASIA Arsenic, Jashore, 2016-17.