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Competitive Research Grant

Sub-Project Completion Report

on

Production of compost and vermicompost from
kitchen waste and their utilization on tomato and
cabbage production

Project Duration

May 2017 to September 2018

Soil Science Division, Bangladesh Agricultural Research Institute

Submitted to

Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215



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Citation

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Acronyms

AEZ	:	Agro-ecological zone
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
cft	:	cubic feet
CD	:	Cowdung
C:N	:	Carbon to Nitrogen Ratio
dw	:	Dry weight
FRG'2012	:	Fertilizer Recommendation Guide-2012
g	:	Gram
GM	:	Gross margin
GR	:	Gross return
ha	:	Hectare
HHW	:	House Hold Waste
Kcal	:	Kilo Calorie
kg	:	Kilo Gram
MBCR	:	Marginal Benefit cost ratio
meq	:	Mili Equivalent
MSW	:	Municipal Solid Waste
n	:	number
NATP	:	National Agricultural Technology Program
RCF	:	Recommended Chemical Fertilizer
SOM	:	Soil Organic Matter
t	:	Metric ton
Tk.	:	Taka
wt.	:	Weight
µg	:	Micro Gram

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Executive Summary

Kitchen waste disposal is a serious problem in Bangladesh. About 5,000 metric tons of municipal solid wastes generate every day from Dhaka City Corporation (North and South). About 24,000 metric ton kitchen waste has been generated in urban and peri-urban area of Bangladesh. Similarly, 2.5 core rural households generate 25 lakh metric ton kitchen wastes. About 80% of the household waste of Bangladesh is organic in nature which is decomposable and can be converted to organic fertilizer. It is necessary to solve the waste disposal as well as to convert it to organic manure. Composts from kitchen wastes can be a good source of organic fertilizer which can increase the productivity and quality of tomato and cabbage. Compost, tricho-compost and vermicomposting have been reported a viable, cost effective and rapid technique for the efficient management of the kitchen wastes. The utilization of waste through recycling becomes essential for environmental safety, economic stability and ecological sustainability. Under this project, one survey work on waste characterization, three net house study on compost and vermicompost production; and two field trials on effect of compost, vermicompost and tricho-compost on tomato and cabbage production were carried out. About 60 families of A, B, C and D type were surveyed on waste characterization. Average total waste generation is higher in D type ($1.96 \text{ kg day}^{-1} \text{ family}^{-1}$) and lower in C type ($1.87 \text{ kg day}^{-1} \text{ family}^{-1}$). But per capita waste generation rate is higher in A and B type ($0.474 \text{ kg capita}^{-1} \text{ day}^{-1}$) and lower in D type ($0.317 \text{ kg capita}^{-1} \text{ day}^{-1}$). Production of compost from agricultural waste was conducted. Four levels of initial moisture content viz. household waste containing 70%, 60%, 50% and 40% initial moisture content and four levels of turning frequency of waste viz. waste were not turned and turned once, twice and thrice a week were imposed in the experiment. Highest quantity of compost (31.4 kg) with minimum quantity of moisture (19.2%) were obtained when initial moisture content of waste 50% and waste were turned twice a week. Screening on earth worm species capable to produce vermicompost from kitchen waste was conducted. *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* are found efficient in decomposing agricultural waste. Agricultural wastes were collected from BARI campus and were decomposed with the help of 4 (four) earth worm species: T₁: *Eudrilus eugeniae*, T₂: *Perionyx excavatus*, T₃: *Eisenia fetida* and T₄: Mixer of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida*. Highest quantity of vermicompost (20.54 kg/chari) were produced from *Eudrilus eugeniae* and lowest quantity of vermicompost (18.61 kg/chari) were produced from *Eisenia fetida*. Different types of agricultural wastes (T₁ : Only cowdung, T₂ : 50% CD + 50% cabbage leaf, T₃ : 75% CD + 25% cabbage leaf, T₄ : 50% CD + 50% banana pseudostem, T₅ : 75% CD + 25% banana pseudostem, T₆ : 50% CD + 50% water hyacinth, T₇ : 75% CD + 25% water hyacinth, T₈ : 25% CD + 25% cabbage leaf + 25% banana pseudostem + 25% water hyacinth) were decomposed with the earthworm species *Eudrilus eugeniae*. Among 3 agricultural wastes, best vermicompost were produced from cabbage leaf. About 23.8 kg/chari vermicompost were produced from T₂ treatment which requires 34 days for decomposition. Two field trial on effect of compost, vermicompost and trichocompost on the yield and nutrient uptake of tomato and cabbage were conducted at BARI Central Farm of Gazipur and Breeder Seed Production Centre of Debigonj during the rabi season of 2017-18. Three organic manure (compost, vermicompost and trichocompost) at three level (1.5, 3.0 and 6.0 t ha⁻¹) along with three levels of chemical fertilizer (100% RCF, 80% RCF and 60% RCF) were imposed for production of cabbage and tomato. Highest head yield of cabbage (75.2 t ha⁻¹ at Debigonj and 64.2 t/ha at Gazipur) and fruit yield of tomato (59.8 t ha⁻¹ at Gazipur) were obtained from T₇ (100% RCF + 1.5 t Vermicompost) treatment. Among three organic manures, vermicompost produces highest yield followed by tricho compost and compost. Highest gross return and gross margin was obtained from T₇ treatment for both cabbage and tomato. Application of 1.5 t t ha⁻¹ vermicompost along with 100% chemical fertilizer was found best treatment for production of cabbage and tomato at Gazipur and Debigonj. Training on solid waste collection was conducted. About 61 housewives and field staffs were trained about house hold solid waste management. Total fund released during the project period is 23,09,226 Taka and expenditure in this period has been 21,88,225 Taka.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Production of compost and vermicompost from kitchen waste and their utilization on tomato and cabbage production
2. Implementing organization: Bangladesh Agricultural Research Institute
3. Name and full address with phone, cell and E-mail of PI: Dr. Ranjit Sen
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4. Sub-project budget (Tk):
 - 4.1 Total: 24,00,000/-
 - 4.2 Revised (if any): 24,00,000/-
5. Duration of the sub-project:
 - 5.1 Start date (based on LoA signed): 9 May 2017
 - 5.2 End date: 30 September 2018
6. Justification of undertaking the sub-project:

Solid waste disposal is a serious problem in Bangladesh. About 5,000 metric tons of municipal solid wastes (MSW) generate every day from Dhaka City Corporation (North and South). About 24,000 metric ton kitchen waste has been generated in urban and peri-urban area of Bangladesh (Iftekhar Enayetullah, 2010). Similarly, 2.5 core rural households generate 25 lakh metric ton kitchen wastes (Sources: Dainik Sangbad, 10th September, 2013). About 80% of the household waste (HHW) of Bangladesh is organic in nature which is decomposable and can be converted to organic fertilizer (Iftekhar Enayetullah, 2010). Waste generates odorous and un-healthy environment which is harmful for human health. On the other hand, soil organic matter (SOM) depletion is the main constraint for crop production in Bangladesh (Bhuiyan, 1991). Soil fertility is declining day by day due to intensive crop production. Organic matter is the key matter for crop production. Most of Bangladesh soil contains less than 1.5% organic matter where as optimum organic matter for crop production is ranging from 3 to 5% (Sinha and Rahman, 2005). So it is necessary to solve the waste disposal problem and to increase the organic matter of Bangladesh soil. This project can solve these two problems simultaneously. Tomato and cabbage are two important vegetable crops in Bangladesh. Area, yield and production of these vegetables increasing day by day. Both the crops are exhaustive in nature and mines huge amount of nutrients from soil. Tomato and cabbage crop grown well in organic fertilizer applied field and their taste and quality are much better than chemical fertilizer applied field. Composts from household solid wastes can be a good source of organic fertilizer which can increase the productivity and quality of tomato and cabbage. Compost, tricho-compost and vermicomposting have been reported to be a viable, cost effective and rapid

technique for the efficient management of the solid wastes (Vasanthi and Kamaraswamy, 1999). The utilization of waste through recycling becomes essential for environmental safety, economic stability and ecological sustainability (Ushakumari *et al.*, 2006). Several indigenous and exotic species of earth worm are capable to convert waste to organic manure. It is necessary to find out suitable earthworm species for composting in Bangladesh condition. Suitable and low cost technology for compost and vermicompost production is imperative in Bangladesh. So management and utilization of household solid waste in improving soil fertility and crop productivity is necessary to be carried out in Bangladesh.

7. Sub-project goal: Minimize waste disposal problem, increase soil fertility and crop productivity by applying compost and vermicompost produced from waste
8. Sub-project objective (s):
 - i. To produce compost and vermicompost from kitchen waste;
 - ii. To find out effective microbes, process parameters and waste characteristics suitable for different types of composts; and
 - iii. To quantify the agronomic and economic effectiveness of compost, vermicompost and trichocompost in increasing yield of tomato and cabbage, and maintaining/improving soil fertility.

9. Implementing location (s): Joydebpur, Gazipur and Debigonj, Panchogarh

10. Methodology in brief:

Five experiment were designed to achieve the objectives of the project. Of them one survey work on waste characterization, three net house study on compost and vermicompost production; and one field trials on effect of compost, vermicompost and tricho-compost on tomato and cabbage production were carried out. Experiment wise methodology were describe below:

Expt. 1. Characterization of solid waste generated from BARI campus

Baseline survey on total solid waste generation, solid waste generation rate (per capita per day) was conducted during May to October, 2017. The whole BARI campus is divided into four residential category namely A, B, C and D type according to designation of the employs. Household solid waste are collected from 3 families of A type, 18 families of B type, 22 families of C type and 17 families of D type. Two waste collecting bin for organic and inorganic waste were given to each family and wastes were collected by van (Fig. 1 & 2). Information about number of members/family and total income/family were collected. Solid waste generation rate (per capita per day) was determined through total solid waste generation of a family divided by number of members in the family. Household solid waste were brought into green house of Soil Science Division and segregate to different fractions like food waste, polythene, plastic, cloth piece, paper, glass and ceramics, metals, and bones and spines (Fig. 3). Food waste were analyzed in the laboratory. Moisture content, heating value, organic matter content, carbon, nitrogen, phosphorus, potassium and sulphur content of food waste were analyzed. Possible use of the waste fractions were studied.



Fig. 1. Waste collecting van



Fig. 2. Two waste collecting bin for organic and inorganic waste



Fig. 3. Collected wastes are segregated into different fractions

Expt. 2. Production of compost from agricultural waste

The experiment was conducted at composting shed of Soil Science Division, BARI during January to April, 2018 aiming to optimize the waste characteristics (moisture content of waste) and process parameters (turning frequency of feedstock) of compost. Four levels of initial moisture content viz. M_1 = Household waste containing 70% initial moisture content, M_2 = Household waste containing 60% initial moisture content, M_3 = Household waste containing 50% initial moisture content, M_4 = Household waste containing 40% initial moisture content and four levels of turning of waste viz. T_0 = No turning, T_1 = Waste in the drum turned once a week, T_2 = Waste in the drum turned twice a week and T_3 = Waste in the drum turned thrice a week were imposed in the experiment. Therefore, there are 16 treatments. Accordingly, 16 In-vessel composting bioreactor were fabricated from PVC drum used for water storage. A few number of hole were created in each reactor to pass air flow and to exit excess leachate. Cabbage leaf was used as substrate of compost. About 100 kg substrate were used in each drum (Fig. 4a-4c). Before composting in the bioreactor, cabbage leaf were chopped into small pieces for quick decomposition. Initial moisture content of cabbage leaf were maintained through adding bulking agent sawdust. Turning was done by a bambo stick. Compost derived from different treatments were analyzed in the laboratory. Data on quantity of compost, days required for composting were recorded. The whole experiment was repeated for three times.



Fig. 4a. Waste in the drum



Fig. 4b. Turning of waste



Fig. 4c. Experimental set up

Expt. 3. Identification of effective earthworm species available in Bangladesh for vermicomposting of agricultural waste

The experiment was conducted at vermicomposting shed of Soil Science Division, BARI during November, 2017 to April, 2018. Agricultural wastes were collected from BARI campus and were decomposed with the help of 4 (four) earth worm species: T₁: *Eudrilus eugeniae*, T₂: *Perionyx excavatus*, T₃: *Eisenia fetida* and T₄: Mixer of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida*. About 15 g earth worm were added to decompose 1 kg material. About 30 kg cowdung (CD) and 10 kg water hyacinth were added in each chari. Accordingly 600 g earth worm were added to each chari. A number of 12 chari were used in this experiment. The experiment was replicated for three times. Data on quantity of vermicompost produce, time required for production of vermicompost, moisture content, granular size and bulk density were taken (Fig. 5a-5b). Manual quality of produced vermicompost were analyzed for organic matter, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content.



Fig.5a.Vermicompost produced by *Eudrilus eugeniae* & *Perionyx excavatus* Fig.5b.Granule size determination

Expt. 4. Study on quality of vermicompost produced from different agricultural wastes

This experiment was conducted at vermicomposting shed of Soil Science Division, BARI during April, 2018 to July, 2018. Different types of agricultural wastes were collected from BARI campus. These agricultural wastes were decomposed with the earthworm species *Eudrilus eugeniae*. There were eight type of agricultural waste; T₁ : Only cowdung, T₂ : 50% CD + 50% cabbage leaf, T₃ : 75% CD + 25% cabbage leaf, T₄ : 50% CD + 50% banana pseudostem, T₅ : 75% CD + 25% banana pseudostem, T₆ : 50% CD + 50% water hyacinth, T₇ : 75% CD + 25% water hyacinth, T₈ : 25% CD + 25% cabbage leaf + 25% banana pseudostem + 25% water hyacinth. After harvest unfold cabbage leaf and banana pseudostem were collected, and partially decomposed. Similarly water hyacinth were collected and partially decomposed. These three agricultural wastes were used as substrate in the above mentioned vermicomposting. Data on quantity of vermicompost produce, time required for production of vermicompost and moisture content were taken. Manual quality of produced vermicompost were analyzed for organic matter, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content.

Expt. 5. Effect of compost, vermicompost and trichocompost on the yield and nutrient uptake of tomato and cabbage

Two field trial on effect of compost, vermicompost and trichocompost on the yield and nutrient uptake of tomato and cabbage were conducted at BARI Central Farm of Gazipur (AEZ-28; Modhupur Tract) and Breeder Seed Production Centre of Debigonj, Panchogarh (AEZ-3; Tista Meander Floodplain Soil) during the rabi season of 2017-18. These soils belongs to Grey Terrace Soil and Grey Floodplain Soil. Three organic manure (compost, vermicompost and trichocompost) at three level (1.5, 3.0 and 6.0 t ha⁻¹) along with three levels of chemical fertilizer (100% RCF, 80% RCF and 60% RCF) were imposed for production of cabbage and tomato. Tomato variety was BARI Tomato-15 while

cabbage variety were Atlas-70 at Gazipur and Green King at Debigonj. About 35 days old seedlings of tomato was transplanted on 12 December and 32 days old seedling of cabbage were transplanted on 10 December at Gazipur and 1 December, 2017 at Debigonj. Tomato was harvested in the month of February and March, 2018 and cabbage was harvested in the month of February, 2018. Data on yield and yield components of tomato and cabbage were taken. Nutrient content of tomato and cabbage were analyzed in the laboratory. Nitrogen, phosphorus, potassium and sulphur content were determined. Uptake of these nutrient were measured by multiplying yield and nutrient content. Nutrient added both from chemical fertilizer and organic manure were determined and merged together as total nutrient addition. Apparent nutrient balance of these nutrients were measured through subtracting nutrient uptake from nutrient addition.

11. Results and discussion:

Expt. 1. Characterization of solid waste generated from BARI campus

Solid wastes of A, B, C and D type of BARI residential campus were collected and segregate into following categories (Table 1).

Table 1. Classification of waste components

Category	Component
Food waste	Food remains, leafs, peels of fruits and vegetables etc
Polythene	Shopping bag
Plastic	Bottle, sandals
Cloth	Textile goods, old clothes, thread etc
Paper	Righting paper, Newspaper, toilet tissues, cartons etc
Glass & Ceramics	Mirror, window glasses etc
Metals	Metal cans, spoons, blades etc
Bones and spines	Bones of different animals and spines of various fish

Average total waste generation is higher in D type ($1.96 \text{ kg day}^{-1} \text{ family}^{-1}$) and lower in C type ($1.87 \text{ kg day}^{-1} \text{ family}^{-1}$). But per capita waste generation rate is higher in A and B type ($0.474 \text{ kg capita}^{-1} \text{ day}^{-1}$) and lower in D type ($0.317 \text{ kg capita}^{-1} \text{ day}^{-1}$) (Table 2). More number of family members in D type generates more waste. As a result total waste generation is higher in D type. Monthly income/family were higher in A and B type which increases waste generation rate (kg/capita/day) in A and B type.

Table 2. Average family member, monthly income/family, total waste generation and waste generation rate of BARI residential area

Residence Type	Members/ family (no)	Monthly income/family (Tk.)	Total waste generation (kg/family/day)	Waste generation rate (kg/capita/day)
A & B type (n= 21)	4.1	67,400	1.94	0.474
C type (n = 22)	4.7	43,200	1.87	0.398
D type (n= 17)	6.2	20,560	1.96	0.317

In percentage (weight basis), food waste is higher in C (74%) and D type (80%) compared to A & B type (69%). Reversely polythene, plastic, cloth piece, paper, glass and ceramics, metals, bones and spines are higher in A & B type compared to C type and D type (Fig 6a-6c). Food waste can be converted to compost while plastic and paper can be recycle.

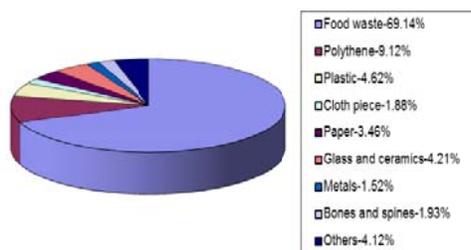


Fig 6a. Waste generation from A and B type

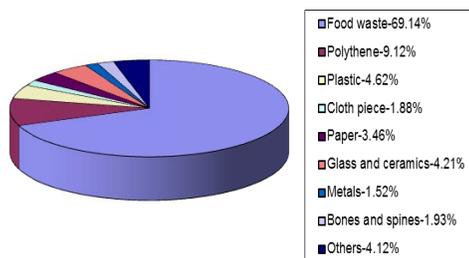


Fig 6b. Waste generation from C type

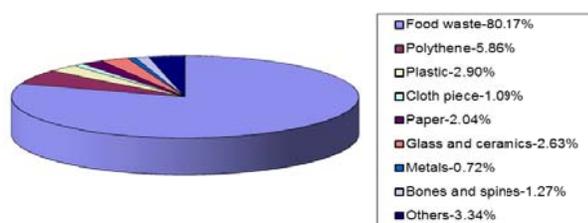


Fig 6c. Waste generation from D type

Characteristics of food waste

Food wastes are characterized by higher moisture (76.42%) content and lower heating value (890 Kcal/kg). They have higher organic matter (dry weight basis) (72.3%), higher organic carbon (41.96%) and lower nitrogen (1.08%) content (Table 3).

Table 3. Characteristics of food waste (dry weight basis)

Moisture %	Heating value (Kcal/kg)	%			C : N ratio	g kg ⁻¹		
		Organic matter	Carbon	Nitrogen		P	K	S
76.42	890	72.3	41.96	1.08	38.5	3.2	7.7	1.9

Probable use of waste fractions

Probable uses of waste fractions are discussed in Table 4.

Table 4. Probable use of waste fractions

Component	Probable usages		
	Combustible (suitable for fuel)	Biodegradable (suitable for compost, tricho compost, vermicompost)	Other process e.g. reuse & recycle
Food waste		√	
Polythene			√
Plastic	√		√
Cloth piece			√
Paper	√		√
Glass & ceramics			√
Metals			√

Plastic and paper have higher heating value and are suitable for combustion. Food waste has lower C:N ratio and are suitable for compost, tricho compost and vermicompost. Polythene, plastic, cloth piece, paper, glass & ceramics, and metals can be reused and recycled to other valuable goods.

Expt. 2. Production of compost from agricultural waste

Effect of initial moisture content of waste and turning frequency of waste on compost production has been mentioned in Table 5. Before composting weight of waste was 100 kg and initial moisture percentage were ranging from 40% to 70% (treatment wise). After composting weight of produced compost ranging from 16.2 kg to 31.4 kg and moisture% ranging from 19.2% to 27.4%. Highest quantity (31.4 kg) of compost produced when initial moisture content of waste was 50% and waste were turned twice a week (T_2M_3) and lowest quantity (16.2 kg) of compost produced when initial moisture content was 70% and waste were not turned (T_0M_1). Turning of waste exposed them to air by which aerobic bacteria decomposes them. Turning also inverts upper portion of composting material to lower portion by which composting was done homogeneously. Again too much turning, decreased the temperature of composting material which mesophilic bacteria cannot decompose. Therefore, among four turning frequency, turning twice a week found best for composting.

Initial moisture content of waste is an important criterion for composting. Excess moisture creates anaerobic condition which enables aerobic bacteria to decompose. Again, short of moisture content in waste disfavours bacteria for decomposition. Among the four initial moisture content, 50% moisture were found optimum for composting. Excess moisture enhance leaching loss of composting material which reduces the quantity of compost.

Days required for composting as influenced by different initial moisture content and turning frequency ranged from 39 to 59 days. Days required for composting was lowest (39 days) when initial moisture content was 50% and waste were turned twice a week (T_2M_3) and highest (59 days) when initial moisture content of waste was 70% and waste were not turned (T_0M_1). Excess moisture creates anaerobic condition where aerobic bacteria cannot work. On the other hand too much turning (three times a week) cools the temperature of composting pile which mesophilic bacteria cannot work. Optimum temperature for composting ranging from 50⁰C to 65⁰C and optimum oxygen required for composting ranging from 15 to 20%.

Expt. 3. Identification of effective earthworm species available in Bangladesh for vermicomposting of agricultural waste

Earth worm population, days required for vermicomposting of four earth worm species were presented in Table 6. Initial number of earth worm in *Eudrilus eugeniae*, *Eisenia fetida*, *Perionyx excavatius* and mixer of above species were 166, 312, 207 and 193 which becomes 228, 527, 324 and 278 after vermicomposting. Percent increase of earth worm during vermicomposting process are higher in *Eisenia fetida* (68.91%) and lower in *Eudrilus eugeniae* (37.34%). Days required for vermicomposting were higher in *Perionyx excavatius* (44 days) and lower in *Eudrilus eugeniae* (35 days).

Table 5. Production of compost as influenced by initial moisture content of waste and turning frequency of waste (Average of 3 replications)

Treatment	Before composting		After composting		Days required for composting
	kg	% moisture	kg	% moisture	
T ₀ M ₁	100	70	16.2	27.4	59
T ₀ M ₂	100	60	23.2	24.8	51
T ₀ M ₃	100	50	25.2	22.4	49
T ₀ M ₄	100	40	23.4	22.8	53
T ₁ M ₁	100	70	18.6	25.2	56
T ₁ M ₂	100	60	26.7	23.6	50
T ₁ M ₃	100	50	29.3	20.9	42
T ₁ M ₄	100	40	27.2	21.8	43
T ₂ M ₁	100	70	19.6	23.8	53
T ₂ M ₂	100	60	28.9	22.4	44
T ₂ M ₃	100	50	31.4	19.2	39
T ₂ M ₄	100	40	29.6	20.7	41
T ₃ M ₁	100	70	20.2	24.4	55
T ₃ M ₂	100	60	28	23.8	47
T ₃ M ₃	100	50	28.9	20.3	44
T ₃ M ₄	100	40	26.8	20.9	46

Table 6. Earth worm population of different species during vermicomposting (Average of 3 replications)

Species name	Initial wt. of earth worm	Initial no. of earth worm	No. of earthworm after vermicomposting	% increase of earth worm during vermicomposting process	Days required for vermicomposting	% increase of earth worm/day
<i>Eudrilus eugeniae</i>	600 g/chari	166	228	37.34	35	1.07
<i>Eisenia fetida</i>	600 g/chari	312	527	68.91	41	1.68
<i>Perionyx excavatius</i>	600 g/chari	207	324	56.52	44	1.28
Mixer of above species	600 g/chari	193	278	44.04	38	1.16



Fig.7a *Eudrilus eugeniae* Fig.7b *Eisenia fetida* Fig.7c *Perionyx excavatius* Fig.7d Experimental set up

Vermicompost production by different earth worm species were mentioned in Table 7 and Fig. 7. Highest quantity of vermicompost (20.54 kg/chari) were produced from *Eudrilus eugeniae* and lowest quantity of vermicompost (18.61 kg/chari) were produced from *Eisenia fetida*. Low moisture content (24.2%) and high granule size (0.50 mm) were characterized in vermicompost produced by *Eudrilus eugeniae*.

Table 7. Vermicompost production by different earth worm species (Average of 3 replications)

Earth worm species	Before vermicomposting				Weight after vermicomposting (kg)		Physical quality		
	Cow dung wt. (kg)	Water hyacinth wt. (kg)	Total weight (kg)	% moisture	With moisture	Without moisture	Moisture %	Granule size (mm)	Bulk density (g/cc)
<i>Eudrilus eugeniae</i>	30	10	40	42	27.1	20.54	24.2	0.50	0.52
<i>Eisenia fetida</i>	30	10	40	42	28.6	18.61	34.9	0.20	0.43
<i>Perionyx excavatius</i>	30	10	40	42	27.9	19.50	30.1	0.30	0.47
Mixer of 3 species	30	10	40	42	27.5	18.94	31.1	0.33	0.46

Manural quality of vermicompost produced by different earth worm species were mentioned in Table 8. Initial organic matter, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content of vermicomposting material (before decompose) were 33.5, 1.35, 0.65, 0.59, 0.92, 0.83 and 0.32%. After vermicomposting these nutrients were highest in *Eudrilus eugeniae* produced vermicompost followed by mixer species and *Eisenia fetida* produced vermicompost. Poorest nutrient quality of vermicompost were derived from *Perionyx excavatius* produced vermicompost. Larger size of *Eudrilus eugeniae* decompose the material well, adding more vermi-wash to vermicompost resulting better manural quality of vermicompost.

Table 8. Manural quality of vermicompost produced by different earth worm species (Average of 3 replications)

Decomposition state	Earth worm species	Manural quality (%)						
		OM	N	P	K	Ca	Mg	S
Before	No species	33.5	1.35	0.65	0.59	0.92	0.83	0.32
After	<i>Eudrilus eugeniae</i>	27.5	1.12	0.63	0.54	0.86	0.78	0.29
	<i>Eisenia fetida</i>	24.1	1.03	0.60	0.52	0.83	0.76	0.27
	<i>Perionyx excavatius</i>	22.6	0.96	0.58	0.50	0.80	0.74	0.26
	Mixer of 3 species	26.4	1.09	0.61	0.53	0.85	0.78	0.28

Expt. 4. Study on quality of vermicompost produced from different agricultural wastes

Properties of agricultural waste used in this experiment are mentioned in Table 9 and Fig. 8. Water hyacinth contains high moisture (58%) content compared to cabbage leaf (43%) and banana pseudostem (49%).



Fig.8a Cabbage leaf



Fig.8b Banana pseudostem



Fig.8c Water hyacinth



Fig.8d Chopping of wastes

Table 9. Composition of partially decomposed cowdung, cabbage leaf, banana pseudostem and water hyacinth used in the experiment

Properties	Cowdung	Cabbage leaf	Banana pseudostem	Water hyacinth
Moisture (%)	36	43	49	58
Nitrogen (%)	1.6	0.8	0.5	0.6
Phosphorus (%)	0.6	0.4	0.4	0.5
Potassium (%)	0.54	0.6	0.9	1.3
C : N ratio	22	43	45	35

Among three agricultural wastes, best vermicompost was produced from cabbage leaf. About 23.8 kg/chari vermicompost were produced from T₂ (75% cowdung + 25% kg cabbage leaf) treatment which requires 34 days from decomposition (Table 10).

Table 10. Vermicompost production from different agricultural wastes (average of 3 replications)

Treatment	Weight before vermicomposting						Weight after vermicomposting (kg)	Days required for vermicomposting
	Cow dung (kg)	Cabbage leaf (kg)	Banana pseudo stem (kg)	Water hyacinth (kg)	Total weight (kg)	% moisture		
T ₁	40	0	0	0	40	36.0	24.3	32
T ₂	30	10	0	0	40	37.8	23.8	34
T ₃	20	20	0	0	40	39.5	22.9	37
T ₄	30	0	10	0	40	39.3	23.4	38
T ₅	20	0	20	0	40	42.5	22.5	40
T ₆	30	0	0	10	40	41.5	22.7	42
T ₇	20	0	0	20	40	47.0	20.8	44
T ₈	10	10	10	10	40	46.5	19.2	47



Fig.9a Partially decomposed water hyacinth along with cowdung used for vermicomposting



Fig.9b 75% CD + 25% banana stem 75% CD + 25% cabbage leaf

Manural quality of vermicompost produced from different agricultural waste were mentioned in Table 11. Initial organic matter and nitrogen content were higher in those treatments where more cowdung were added (Treatment T₁, T₂, T₄, T₆). Because cowdung contains more organic matter and nitrogen compared to cabbage leaf, banana pseudostem and water hyacinth. Similarly initial phosphorus, calcium, magnesium and sulphur content were higher in T₁, T₂, T₄, T₆ treatment as cowdung contain more phosphorus, calcium, magnesium and sulphur. Initial potassium content was higher in those treatment where water hyacinth was added (Treatment T₆ and T₇) because water hyacinth contains more potassium (1.3%) than cowdung (0.54%), cabbage leaf (0.6%) and banana pseudostem (0.9%). After decomposition, nutrient contents of different treatment follows the same order as before decomposition. Organic matter, nitrogen, phosphorus, calcium, magnesium and sulphur content were higher in T₁, T₂, T₄, T₆ treatment and potassium content was higher in T₆ and T₇ treatment. Nitrogen loss during vermicomposting process where higher than all other nutrients because vermicomposting is an aerobic decomposition process where more nitrogen were lost due to ammonia volatilization.

Table 11. Manural quality of vermicompst produced from different agricultural waste (average of 3 replications)

Decomposition state	Treatment	Manural Quality (%)						
		OM	N	P	K	Ca	Mg	S
Before	T ₁	36.2	1.44	0.69	0.52	0.96	0.86	0.34
	T ₂	32.8	1.41	0.63	0.57	0.91	0.81	0.31
	T ₃	30.8	1.34	0.58	0.59	0.85	0.76	0.26
	T ₄	32.6	1.28	0.64	0.57	0.94	0.85	0.33
	T ₅	30.4	1.24	0.59	0.59	0.92	0.83	0.31
	T ₆	33.5	1.39	0.65	0.61	0.92	0.83	0.32
	T ₇	31.2	1.31	0.61	0.66	0.86	0.78	0.28
	T ₈	28.1	1.21	0.53	0.54	0.93	0.82	0.32
After	T ₁	27.8	1.16	0.67	0.50	0.92	0.82	0.31
	T ₂	25.6	1.13	0.66	0.55	0.88	0.78	0.28
	T ₃	23.8	1.10	0.61	0.56	0.85	0.74	0.24
	T ₄	25.1	1.05	0.64	0.54	0.90	0.80	0.27
	T ₅	23.2	1.01	0.62	0.55	0.89	0.79	0.27
	T ₆	26.1	1.06	0.67	0.58	0.87	0.78	0.26
	T ₇	24.9	1.03	0.65	0.61	0.86	0.79	0.25
	T ₈	20.4	0.98	0.62	0.51	0.87	0.79	0.29

Expt. 5. Effect of compost, vermicompost and trichocompost on the yield and nutrient uptake of tomato and cabbage

Initial soil status of experimental soils were presented in Table 12. Nutrient status of compost, vermicompost and trichocompost used in the experimental field were presented in Table 13.

Table 12. Chemical properties of initial soil of experimental field during 2017-18

Location	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			meq 100g ⁻¹				µg g ⁻¹						
Gazipur	5.83	1.31	4.57	1.57	0.17	0.08	15	14	0.12	2.0	68	9	1.6
Debigonj	5.56	1.26	3.98	1.48	0.15	0.07	14	14	0.11	1.8	21	6	1.8
Critical Level	-	-	2.0	0.5	0.12	-	7	10	0.20	0.2	4	1	0.6

Table 13. Nutrient status of compost, vermicompost and trichocompost used in the experimental field

Organic manure	Moisture (%)	N	P	K	Ca	Mg	S	B	Zn	C:N
		%								
Compost	19.6	1.13	0.73	0.62	1.61	1.02	0.32	0.009	0.009	14.1
Vermicompost	18.2	1.32	0.94	0.76	1.82	1.15	0.36	0.013	0.012	12.4
Trichocompost	18.7	1.18	0.82	0.69	1.75	1.08	0.39	0.011	0.011	12.9

Effect of compost, vermicompost and trichocompost on the yield of cabbage at Debigonj and Gazipur has been mentioned in Tables 14 and 15, respectively. Picture of experimental field were presented in Fig. 10 & 11. Highest head yield (75.2 t/ha at Debigonj and 64.2 t/ha at Gazipur) of cabbage were obtained from T₇ (100% RCF + 1.5 t/ha Vermicompost) treatment. Among three organic manure, vermicompost produces highest yield followed by tricho compost. Lower yield were obtained from compost treated plot. Moderate yield were obtained from chemical fertilizer treated plot. Lowest head yield (17.6 t/ha at Debigonj and 14.8 t/ha at Gazipur) were obtained from unfertilized T₁₃ treatment. About 22.87% (at Debigonj) and 23.94% (at Gazipur) yield increase of cabbage over 100% chemical fertilized plot were observed when 1.5 ton vermicompost was incorporated with 100% chemical fertilizer.

Table 14. Effect of compost, vermicompost and trichocompost on the yield of cabbage at Debigonj

Treatment	Head height (cm)	No. of unfold leaves/plant	Circumference (cm)	Marketable wt./plant (kg)	Yield (t/ha)
T ₁ (100% RCF)	12.3b	12.6d	64.8b	1.95c	61.2b
T ₂ (80% RCF)	11.3c	14.7c	58.2c	1.70d	53.6c
T ₃ (60% RCF)	10.8c	16.9b	50.4d	1.24e	38.4d
T ₄ (100% RCF+ 1.5 t/ha Com.)	13.9a	10.8e	73.1a	2.64a	72.3a
T ₅ (80% RCF+ 3.0 t/ha Com.)	12.5b	12.4d	64.2b	2.14b	64.1b
T ₆ (60% RCF+ 6.0 t/ha Com.)	11.1c	15.4c	54.9cd	1.58d	48.4c
T ₇ (100% RCF+ 1.5 t/ha Vermicom.)	14.6a	10.1e	74.6a	2.71a	75.2a
T ₈ (80% RCF+ 3.0 t/ha Vermicom.)	12.9b	12.0d	65.9b	2.21b	67.2b
T ₉ (60% RCF+ 6.0 t/ha Vermicom.)	13.8a	14.8c	56.0c	1.66d	51.2c
T ₁₀ (100% RCF+ 1.5 t/ha Trichocom.)	14.3a	10.3e	73.8a	2.68a	74.4a
T ₁₁ (80% RCF+ 3.0 t/ha Trichocom.)	12.6b	12.2d	65.4b	2.17b	66.2b
T ₁₂ (60% RCF+ 6.0 t/ha Trichocom.)	11.6c	15.4c	55.3c	1.63d	50.4c
T ₁₃ (Absolute control)	8.6d	18.6a	32.5e	0.66f	17.6e
SE (±)	0.78	0.83	2.34	0.084	2.23
CV (%)	3.42	7.10	9.56	0.89	8.10

RCF = N₁₆₀P₅₅K₁₁₀S₃₀Zn₂B₁ kg ha⁻¹ (FRG'2012)



Fig.10. Experimental field at Debigonj

Table 15. Effect of compost, vermicompost and trichocompost on the yield of cabbage at Gazipur

T ₁ (100% RCF)	Head height (cm)	No. of unfold leafs/plant	Circumference (cm)	Marketable wt./plant (kg)	Yield (t/ha)
T ₂ (80% RCF)	11.9b-e	12.1d	57.9b	1.71cd	51.8b
T ₃ (60% RCF)	10.8de	14.8b	49.9c	1.57de	43.8c
T ₄ (100% RCF+ 1.5 t/ha Com.)	10.1ef	16.3ab	42.6d	1.32e	30.2d
T ₅ (80% RCF+ 3.0 t/ha Com.)	13.2a-c	10.1fg	66.7a	2.44a	62.1a
T ₆ (60% RCF+ 6.0 t/ha Com.)	12.1a-e	12.5cd	58.8b	1.98bc	52.5b
T ₇ (100% RCF+ 1.5 t/ha Vermicom.)	10.9de	14.7b	46.8c	1.47de	40.8c
T ₈ (80% RCF+ 3.0 t/ha Vermicom.)	14.1a	9.7g	69.9a	2.53a	64.2a
T ₉ (60% RCF+ 6.0 t/ha Vermicom.)	12.8a-d	11.6e-g	60.1b	2.10b	53.8b
T ₁₀ (100% RCF+ 1.5 t/ha Trichocom.)	11.4c-e	14.4bc	48.3c	1.52de	41.8c
T ₁₁ (80% RCF+ 3.0 t/ha Trichocom.)	13.7ab	9.9fg	68.8a	2.51a	63.6a
T ₁₂ (60% RCF+ 6.0 t/ha Vermicom.)	12.7a-d	11.9ef	59.4b	2.04b	53.4b
T ₁₃ (Absolute control)	11.2c-e	14.6bc	47.6c	1.48de	41.4c
SE (±)	8.1f	17.2a	26.7e	0.57f	14.8e
CV (%)	0.69	0.73	2.19	0.09	2.18
T ₁ (100% RCF)	8.92	7.33	9.55	8.33	9.88

RCF = N₁₅₅P₅₀K₈₀S₂₀Zn₂B₁ kg ha⁻¹ (FRG'2012)



Fig. 11. Experimental field at Gazipur and harvested cabbage

Effect of compost, vermicompost and trichocompost on the yield of tomato at Gazipur has been mentioned in Table 16. Picture of experimental field was presented in Fig. 12. Highest fruit yield (59.8 t/ha) was obtained from T₇ (100% RCF + 1.5 t /ha Vermicompost) treatment. Among three organic

manure, vermicompost produces highest yield followed by tricho compost and compost. Moderate yield were obtained from chemical fertilizer treated plot. Lowest fruit yield (12.4 t/ha) was obtained from unfertilized T₁₃ treatment. About 28.05% yield increase of tomato over 100% chemical fertilized plot was observed when 1.5 ton/ha vermicompost were incorporated with 100% chemical fertilizer.

Table 16. Effect of compost, vermicompost and trichocompost on the yield of tomato

Treatment	No. of fruits/plant	Single fruit wt. (gm)	Fruit wt./plant (kg)	Yield (t/ha)
T ₁ (100% RCF)	52.1c	26.7a	1.39b	46.7b
T ₂ (80% RCF)	46.3d	25.6a	1.18c	39.1c
T ₃ (60% RCF)	33.5e	24.1a	0.79d	26.2d
T ₄ (100% RCF+ 1.5 t/ha Com.)	61.4b	28.1a	1.71a	57.2a
T ₅ (80% RCF+ 3.0 t/ha Com.)	54.3c	26.8a	1.43b	47.8b
T ₆ (60% RCF+ 6.0 t/ha Com.)	45.2d	25.0a	1.13c	37.2c
T ₇ (100% RCF+ 1.5 t/ha Vermicom.)	71.2a	28.8a	1.80a	59.8a
T ₈ (80% RCF+ 3.0 t/ha Vermicom.)	54.9c	27.4a	1.49b	49.2b
T ₉ (60% RCF+ 6.0 t/ha Vermicom.)	45.7d	25.4a	1.14c	37.5c
T ₁₀ (100% RCF+ 1.5 t/ha Trichocom.)	62.6b	28.4a	1.76a	58.9a
T ₁₁ (80% RCF+ 3.0 t/ha Trichocom.)	53.9c	27.1a	1.45b	48.6b
T ₁₂ (60% RCF+ 6.0 t/ha Trichocom.)	43.1d	25.2a	1.08c	36.4c
T ₁₃ (Absolute control)	20.2f	18.1b	0.34e	12.4e
SE (±)	2.03	1.65	0.067	1.96
CV (%)	8.34	9.10	9.63	9.07

RCF = N₁₆₀P₆₀K₁₀₅S₂₅Zn₃B₂ kg ha⁻¹ (FRG'2012)



Fig. 12 Experimental field at Gazipur

Nutrient added, uptake and balance of cabbage at Debigonj were presented in Figures 13a and 13b. Nitrogen, potassium and sulphur balance were negative while phosphorus balance was positive. Phosphorus fixation by Fe, Mn in acidic soil are responsible for low uptake of phosphorus thereby resulting higher P balance. All four nutrient balances were negative in T₁₃ (Absolute control) treatment as no nutrients are added in this treatment.

Nutrient added, uptake and balance of cabbage at Gazipur were presented in Figures 14a and 14b. Nitrogen and potassium balance were negative while phosphorus and sulphur (except T₆, T₉ and T₁₂ treatment) balance were positive. Phosphorus fixation by Fe, Mn in acidic soil are responsible for low uptake of phosphorus thereby resulting higher P balance. Addition of more amount of sulphur and uptaking lower amount of sulphur resulting positive S balance.

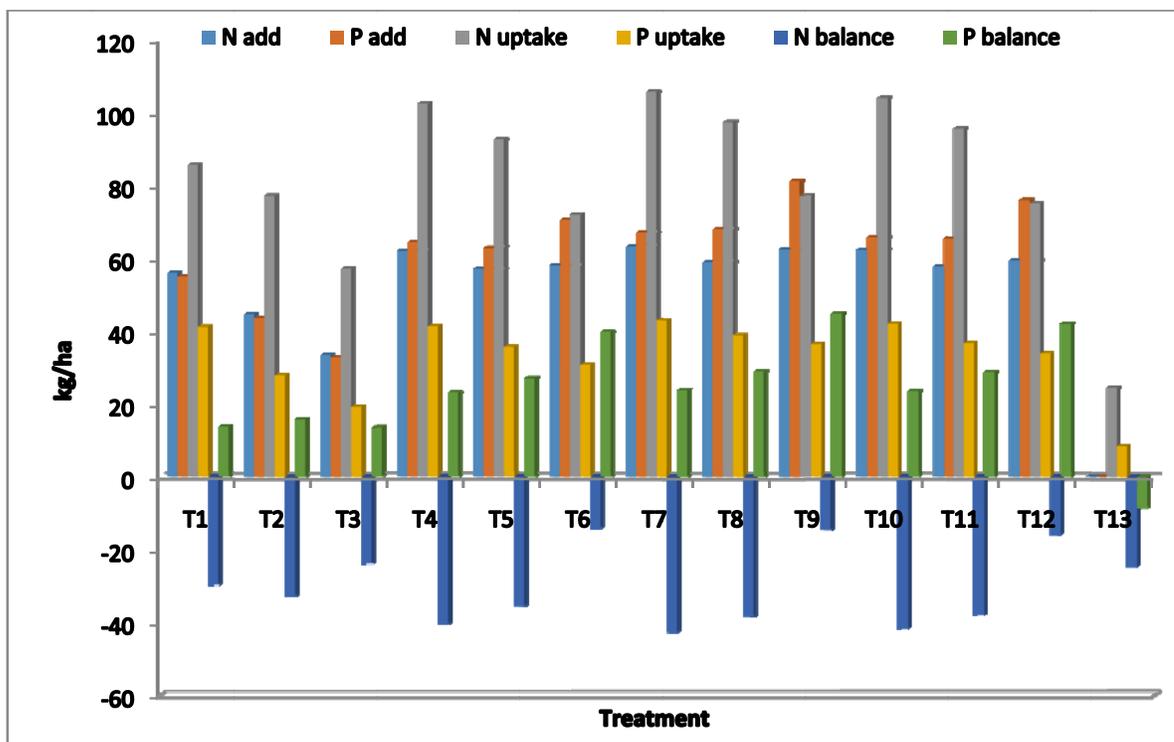


Fig. 13a. Nitrogen and Phosphorus added, uptake and balance of cabbage at Debigonj

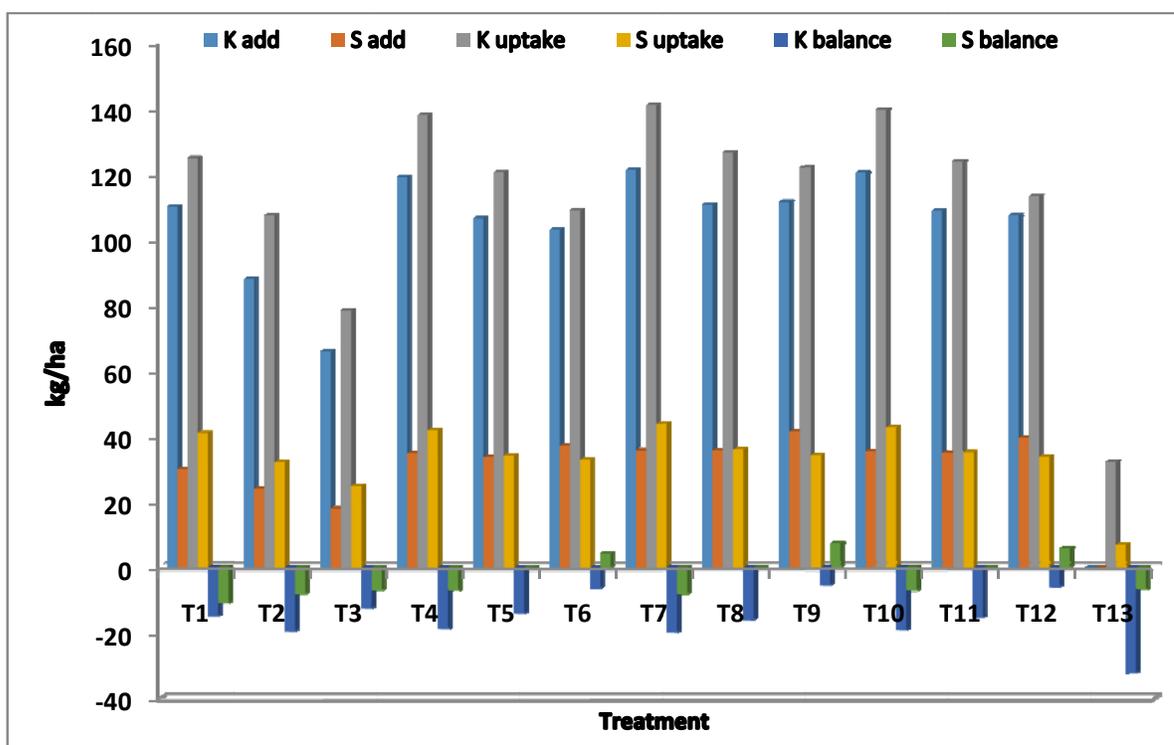


Fig. 13b. Potassium and Sulphur added, uptake and balance of cabbage at Debigonj

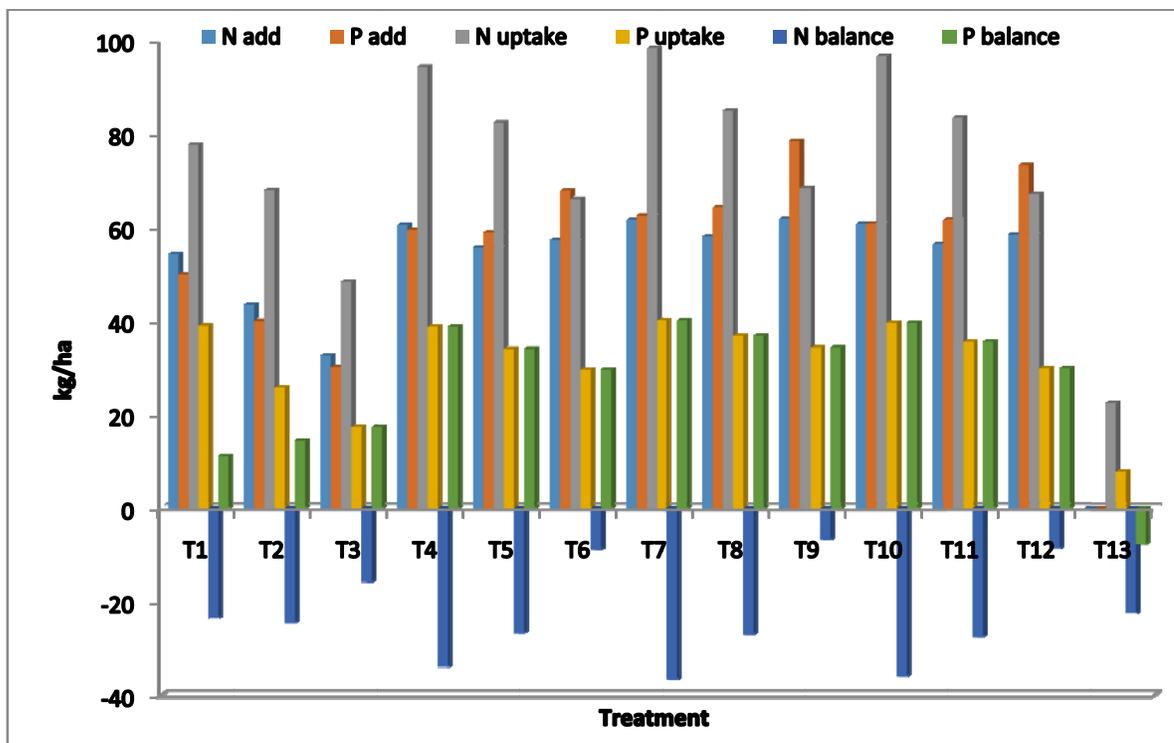


Fig. 14a. Nitrogen and Phosphorus added, uptake and balance of cabbage at Gazipur

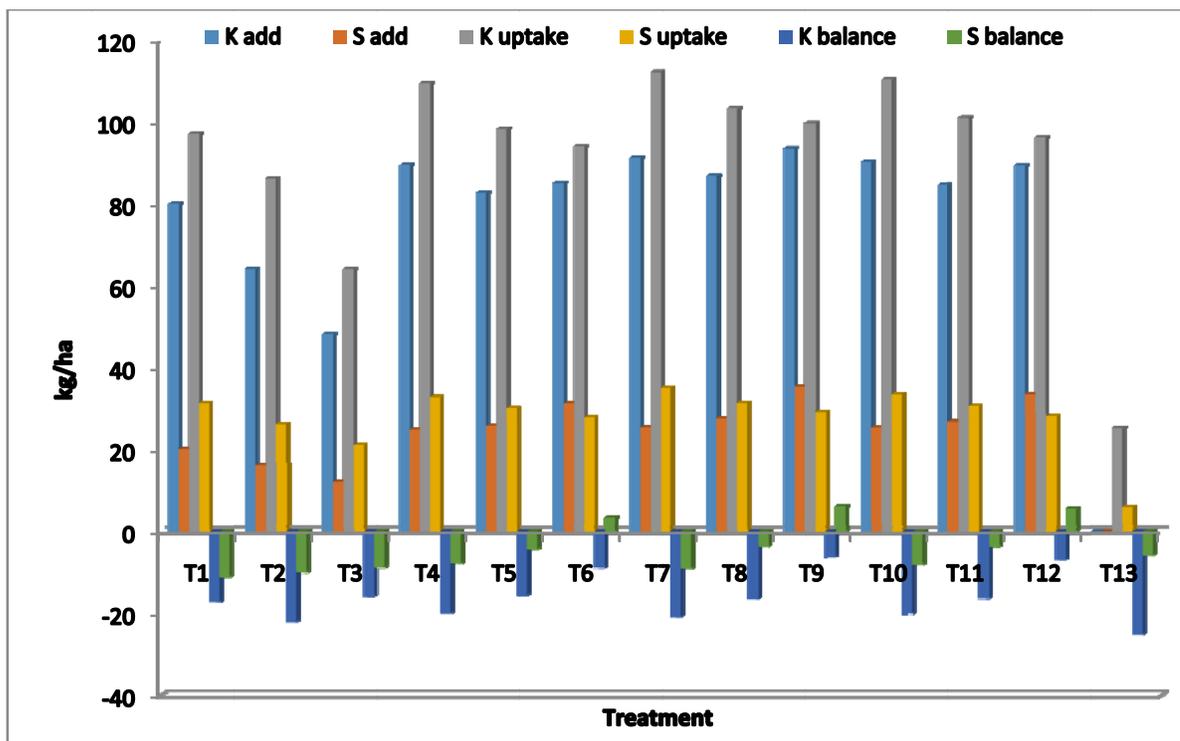


Fig. 14b. Potassium and Sulphur added, uptake and balance of cabbage at Gazipur

Nutrient added, uptake and balance of tomato were presented in Figures 15a and 15b. Nitrogen, potassium and sulphur balance were negative while phosphorus balance was positive. Phosphorus fixation by Fe, Mn in acidic soil are responsible for low uptake of phosphorus thereby resulting higher P balance.

All four nutrient balances were negative in T₁₃ (Absolute control) treatment as no nutrients are added in this treatment.

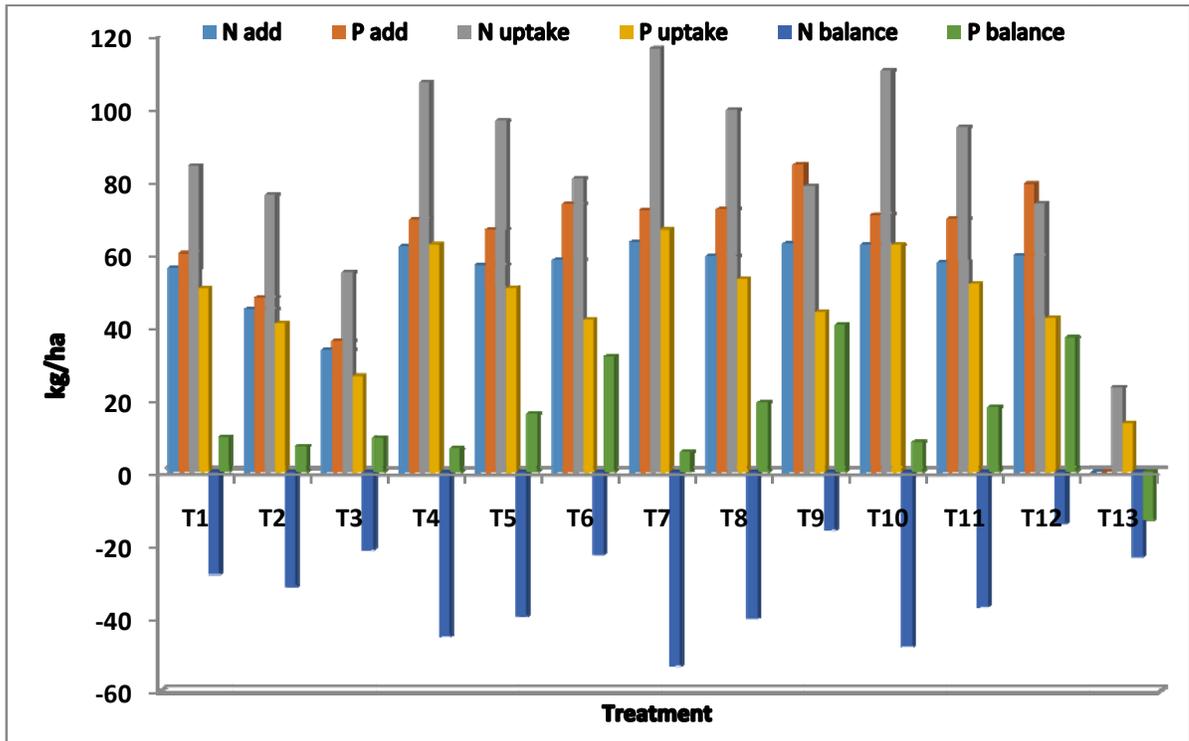


Fig. 15a. Nitrogen and Phosphorus added, uptake and balance of Tomato at Gazipur

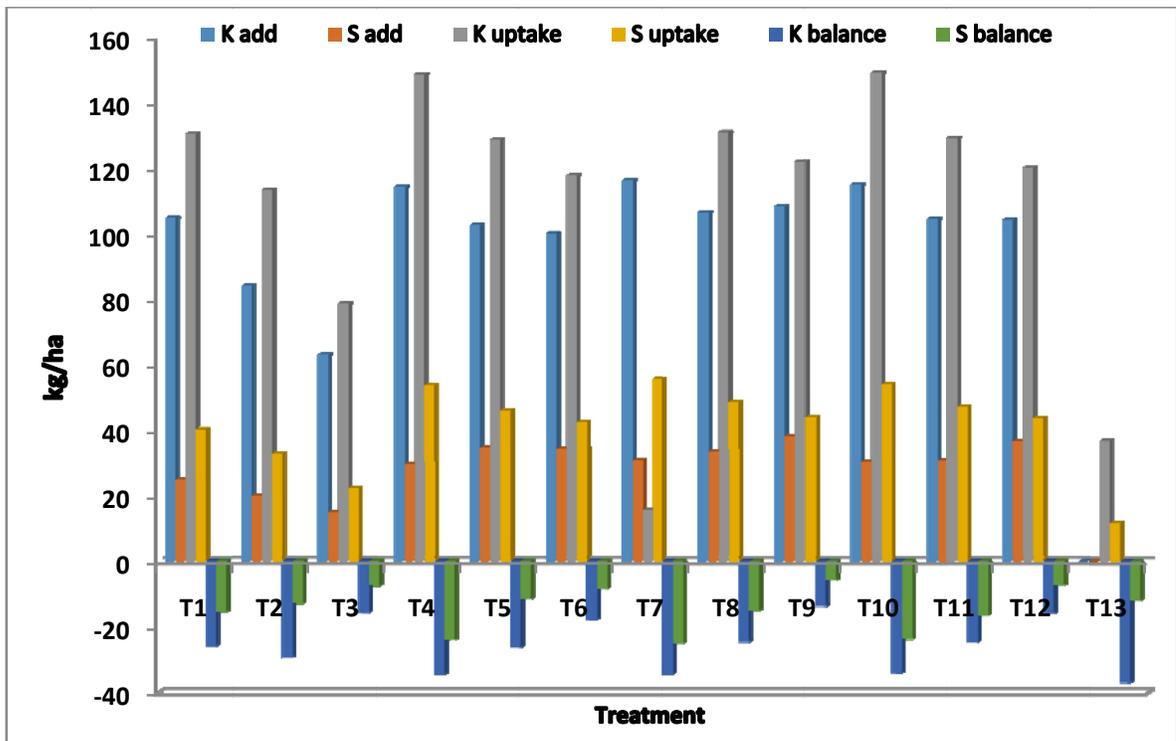


Fig. 15b. Potassium and Sulphur added, uptake and balance of Tomato at Gazipur

Economic analysis of cabbage production as influence by different treatments has been mentioned in Table 17. Highest gross return (5,57,600 Tk./ha) and gross margin (3,94,731 Tk./ha) was obtained from T₇ (100% RCF + 1.5 t/ha Vermicompost) treatment although its manural cost is high. Highest marginal cost benefit ratio (MBCR = 15.35) was obtained from T₂ treatment (80% RCF). MBCR of organically treated plot were 7.10 (T₇) , 6.99 (T₁₀) and 6.71 (T₄).

Table 17. Economic analysis of cabbage production as influence by different treatments (average of 2 locations)

Treatment	Average yield (t/ha)	Gross return (Tk./ha)	Gross margin (Tk./ha)	Marginal gross margin (Tk./ha)	Total cost (Tk./ha)	Marginal increase in cost (Tk./ha)	MBCR
T ₁ (100% RCF)	46.7	452000	322131	302531	129869	19869	15.22
T ₂ (80% RCF)	39.1	389600	263705	244105	125895	15895	15.35
T ₃ (60% RCF)	26.2	274400	152479	132879	121921	11921	11.14
T ₄ (100%RCF+ 1.5 t/ha Com.)	57.2	537600	374731	355131	162869	52869	6.71
T ₅ (80%RCF+ 3.0 t/ha Com.)	47.8	466400	274505	254905	191895	81895	3.11
T ₆ (60%RCF+ 6.0 t/ha Com.)	37.2	356800	102879	83279	253921	143921	0.58
T ₇ (100%RCF+ 1.5 t/ha Vermicom.)	59.8	557600	394731	375131	162869	52869	7.10
T ₈ (80%RCF+ 3.0 t/ha Vermicom.)	49.2	484000	292105	272505	191895	81895	3.33
T ₉ (60%RCF+ 6.0 t/ha Vermicom.)	37.5	372000	118079	98479	253921	143921	0.68
T ₁₀ (100%RCF+ 1.5 t/ha trichocom.)	58.9	552000	389131	369531	162869	52869	6.99
T ₁₁ (80%RCF+ 3.0 t/ha Trichocom.)	48.6	478400	286505	266905	191895	81895	3.25
T ₁₂ (60%RCF+ 6.0 t/ha Trichocom.)	36.4	367200	113279	93679	253921	143921	0.65
T ₁₃ (Absolute control)	12.4	129600	19600	0	110000	0	-

Economic analysis of tomato production as influence by different treatments has been mentioned in Table 18. Highest gross return (6,97,000 Tk./ha) and gross margin (5,14,131 Tk./ha) was obtained from T₇ (100% RCF + 1.5 t Vermicompost) treatment although its manural cost is high. Highest marginal cost benefit ratio (MBCR = 21.33) was obtained from T₂ treatment (80% RCF). MBCR of organically treated plot were 9.88 (T₇) , 9.74 (T₁₀) and 9.40 (T₄).

Table 18. Economic analysis of tomato production as influence by different treatments

Treatment	Yield (t/ha)	Gross return (Tk./ha)	Gross margin (Tk./ha)	Marginal gross margin (Tk./ha)	Total cost (Tk./ha)	Marginal increase in cost (Tk./ha)	MBCR
T ₁ (100% RCF)	56.5	565000	415131	413131	149869	19869	20.79
T ₂ (80% RCF)	48.7	487000	341105	339105	145895	15895	21.33
T ₃ (60% RCF)	34.3	343000	201079	209079	141921	11921	17.54
T ₄ (100%RCF+ 1.5 t/ha Com.)	67.2	672000	489131	497131	182869	52869	9.40
T ₅ (80%RCF+ 3.0 t/ha Com.)	58.3	583000	371105	379105	211895	81895	4.63
T ₆ (60%RCF+ 6.0 t/ha Com.)	44.6	446000	172079	180079	273921	143921	1.25
T ₇ (100%RCF+ 1.5 t/ha Vermicom.)	69.7	697000	514131	522131	182869	52869	9.88
T ₈ (80%RCF+ 3.0 t/ha Vermicom.)	60.5	605000	393105	401105	211895	81895	4.90
T ₉ (60%RCF+ 6.0 t/ha Vermicom.)	46.5	465000	191079	199079	273921	143921	1.38
T ₁₀ (100%RCF+ 1.5 t/ha trichocom.)	69.0	690000	507131	515131	182869	52869	9.74
T ₁₁ (80%RCF+ 3.0 t/ha Trichocom.)	59.8	598000	386105	394105	211895	81895	4.81
T ₁₂ (60%RCF+ 6.0 t/ha Trichocom.)	45.9	459000	185079	193079	273921	143921	1.34
T ₁₃ (Absolute control)	16.2	162000	32000	0	130000	0	-

Application of 1.5 t/ha vermicompost along with 100% chemical fertilizer was found best treatment for production of tomato and cabbage at Gazipur and Debigonj.

12. Research highlight/findings:

- About 80% (weight basis) of household solid waste is organic in nature which can be converted to compost, vermicompost and trichocompost.
- *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* are found efficient earthworm species in decomposing organic waste.
- Best vermicompost are produced from 75% cow dung along with 25% cabbage leaf.
- 1.5 t vermicompost ha⁻¹ with 100% recommended chemical fertilizer produces highest yield of cabbage and tomato.

13. References

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B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laptop Computer (1) Desktop Computer (1) Laser printer (1) Scanner (1) UPS (offline) (1) Digital camera (1)	185000	Laptop Computer (1) Desktop Computer (1) Laser printer (1) Scanner (1) UPS (offline) (1) Digital camera (1)	180000	100%
(b) Lab & field equipment	-	-	-	-	-
(c) Other capital items	-	-	-	-	-

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Composting Shed (no.)			1	1	100%
Land development i.e. vitimati incorporation (cft)	4000	4000			100%



Fig. 16. Compost production house

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training (2 batch)	19	42	61	1 day	100%
(b) Workshop					
(c) Field day					



Fig. 17. Training on waste management

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	551565	542000	526076	*15924	97.06	*58781 TK. Return to PIU-BARC
B. Field research/lab expenses and supplies	1283760	1250631	1208749	*41882	96.65	Lack of GoB fund *58781 TK. Return to PIU-BARC
C. Operating expenses	125575	88075	84620	*3455	96.08	*58781 TK. Return to PIU-BARC
D. Vehicle hire and fuel, oil & maintenance	25000	23500	23500	0	100	Lack of GoB fund
E. Training/workshop/seminar etc.	111100	111100	111100	0	100	
F. Publications and printing	100000	89000	29500	**59500	100	**PCR cost 59500 Tk. return to PIU-BARC
G. Miscellaneous	22000	23920	23710	*210	99.12	
H. Capital expenses	181000	181000	181000	0	100	-

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
a) To produce compost and vermicompost from kitchen waste	<ul style="list-style-type: none"> -Earthworm species collection -Earthen chari collection for use in experiment -Different agricultural wastes collection -Experiment conduction -House wives training on kitchen waste management -Field level workers training on vermicompost production 	<ul style="list-style-type: none"> -Effective earthworm species capable to produce vermicompost were find out. -Agricultural wastes suitable for compost/vermicompost production were find out. -About 31 house wives were trained about kitchen waste management. -About 30 field level workers were trained about vermicompost production. 	<ul style="list-style-type: none"> -Well quality compost/vermicompost were produced. -Soil fertility and crop productivity has been improved. -Waste disposal problem has been minimized.
b) To find out effective microbes, process parameters and waste characteristics suitable for different types of composts	<ul style="list-style-type: none"> -Plastic drum collection for use in experiment. -Different agricultural wastes collection for use in experiment. -Experiment conduction. 	<ul style="list-style-type: none"> -Waste characteristics suitable for composting were find out. -Optimizing process parameter (turning frequency and initial moisture content of waste) suitable for composting were find out. 	<ul style="list-style-type: none"> -Well quality compost/vermicompost were produced. -Soil fertility and crop productivity has been improved. -Waste disposal problem has been minimized.
c) To quantify the agronomic and economic effectiveness of compost, vermicompost and trichocompost in increasing yield of tomato and cabbage, and maintaining/improving soil fertility.	<ul style="list-style-type: none"> -Production of compost, vermicompost for use in experiment. -Field trials on compost, vermicompost and trichocompost on tomato and cabbage production were carried out. 	<ul style="list-style-type: none"> -Appropriate dose of chemical fertilizer and organic manure (compost, vermicompost, trichocompost) for tomato and cabbage production at Grey Terrace Soil of Gazipur (AEZ-28) and Grey Flood Plain Soil of Debigonj (AEZ-3) were find out. -About 28.87% (at Debigonj) and 23.94% (at Gazipur) yield increase of cabbage were observed when 1.5 ton vermicompost was incorporated with 100% chemical fertilizer. In case of tomato, yield increase was 28.05%. -Highest gross margin of 394731 Tk./ha in cabbage and 514131 Tk./ha in tomato were obtained when 1.5 ton vermicompost was incorporated with 100% chemical fertilizer. -MBCR were found 7.10 in cabbage and 9.88 in tomato which ensure the increasing of farmers income. 	<ul style="list-style-type: none"> -Soil health has been improved. -Nutritional quality of tomato and cabbage were improved -Yield of tomato and cabbage has been increased. -Farmers' income were increased.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	1	1	গৃহস্থলী বর্জ্য ব্যবস্থাপনা: সমস্যা ও সমাধান Vermicompost : A ecofriendly organic fertilizer (in Bengoli)
Journal publication	-	-	-
Information development	-	-	-
Other publications, if any (Housewives training Manual)	-	1	প্রশিক্ষণ ম্যানুয়াল "বসতবাড়ির বর্জ্য ব্যবস্থাপনা"



Fig. 18a. A booklet on kitchen waste management safe



Fig. 18b. Poster presentation in organic farming and food fair, 16-17 February, 2018 at BARC

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

a) Identification of effective earth worm species capable for vermicomposting

Eudrilus eugeniae, *Eisenia fetida* and *Perionyx excavatus* were found efficient earth worm species capable to produce vermicomposting. Of them *Perionyx excavatus* is an indigenous earth worm species found in rotten banana plants which are available all over Bangladesh.

b) Identification of suitable agricultural wastes for vermicomposting

75% cowdung + 25% cabbage leaf was found best substrate for producing vermicompost. High quality vermicompost was produced from this substrate.

c) Developed chemical fertilizer and organic manure package:

Tomato: var. BARI Tomato -15

Location	Soil type & AEZ	Chemical fertilizer	Organic manure
Gazipur	Grey Terrace Soil (AEZ-28; Modhupur Tract)	160-60-105-25-3-2 kg ha ⁻¹ of N-P-K-S-Zn-B	1.5 t ha ⁻¹ of vermicompost

Cabbage: var. Atlas-70 at Gazipur

Location	Soil type & AEZ	Chemical fertilizer	Organic manure
Gazipur	Grey Terrace Soil (AEZ-28; Modhupur Tract)	155-50-80-20-2-1 kg ha ⁻¹ of N-P-K-S-Zn-B	1.5 t ha ⁻¹ of vermicompost

Cabbage: var. Green King at Debigonj

Location	Soil type & AEZ	Chemical fertilizer	Organic manure
Debigonj	Grey Floodplain Soil (AEZ-3; Tista Meander Floodplain Soil)	160-55-110-30-2-1 kg ha ⁻¹ of N-P-K-S-Zn-B	1.5 t ha ⁻¹ of vermicompost

- ii. **Generation of new knowledge that help in developing more technology in future**
Three earthworm species were found efficient to produce vermicompost. Screening of earthworm species need to be carried out so that more earthworm species capable to produce vermicompost will be find out. Cabbage leaf, water hyacinth and banana psedostem were found suitable for vermicomposting. Suitability of kitchen waste and other agricultural waste for vermicomposting need to be tested. Application of 1.5 t/ha vermicompost along with 100% chemical fertilizer was found best treatment for production of tomato and cabbage at Gazipur (AEZ-28) and Debigonj (AEZ-3). It needs to develop for other crops suitable to grow in the same AEZ. Continuation of those studies is needed for those areas and also for other AEZs.
- iii. **Technology transferred that help increased agricultural productivity and farmers' income**
Telecast different type of earthworm species, vericomposting process and produce vermicompost was broadcasted on BTV (Programme name : Prithivi) which is now available in You tube . Dissemination of the developed technologies is needed for those areas and also for all other AEZs.
- iv. **Policy Support**
 - All organic manure need to promote for crop production along with chemical fertilizers.
 - Organic manure need to be subsidized like Urea, Triple Super Phosphate and Muriate of Potash.
 - Organically produced vegetables need higher price for sale
 - Farmers need soft loan for compost/vermicompost production.

G. Information regarding Desk Monitoring

- Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):**
- Duration of monitoring workshop: 24 September 2018
 - Output: Results of field trial are based on one year experimentation. Continuation of these studies are needed for another one year for confirmation of the result.
 - Nutrient content, uptake and balance should be done.

H. Information regarding Field Monitoring

- Field Monitoring (time& No. of visit, Team visit and output):**
- Duration of Field Visit: 20 March 2018
 - Location(s) of the Program: Vermicomposting shed, Soil Science Division, BARI.
 - Field Monitoring Members: Teachers and students of Soil Science Dept., Khulna University
 - Output: More trainings are need to disseminate vermicomposting technology.

I. Lesson Learned/Challenges (if any)

- i) Kitchen waste collection is a difficult task as both organic and inorganic waste are mixed together in a same bucket. Two bucket system: Green one for collecting organic waste and yellow one for collecting inorganic waste-can be introduced in every household. Thus waste segregation problem can be solved.
- ii) Waste management is a multi-disciplinary problem. Several stakeholders are involved in this matter. To solve waste disposal problem multi-disciplinary approach are needed.
- iii) Conversion of organic waste to organic fertilizer is a technical matter. Householder owners need training about compost production.
- iv) More media coverage need to disseminate the technology of compost/vermicompost production from agricultural waste.
- vii) Field trials are affected by late transplanting. Natural calamities especially depression delayed transplanting of tomato and cabbage at Gazipur location where the soils are clayey. Delayed transplanting

lowering the yield of tomato and cabbage at Gazipur. Land development of experimental soil by incorporating vitimati can be a remedial measure. Or such experiment can be conducted at northern region of the country where effect of depression is very low.

J. Challenges (if any)

Natural calamities especially depression, untimely rainfall and insect pest infestation are major challenges for field trial conduction. Waste collection from door to door is a difficult task. Only professional sweepers agree to collect these wastes. Production of compost and vermicompost from kitchen waste/agricultural waste is an expensive and labour intensive work. As a result cost of produced compost and vermicompost are high compared to chemical fertilizer as they are subsidized. Subsidy also needed for organic manures produced from organic waste. More training and media coverage were needed to popularize the technology.

Signature of the Principal Investigator
Date
Seal

Counter signature of the Head of the
organization/authorized representative
Date
Seal