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Effect of Solid Waste Slurry from Biogas Plant on Soil Parameters and Yield of Spinach (*Spinacia oleracea L.*)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MNH, MF and MNH designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors MRI, MNH and KR performed the experiments and analyzed the data. Authors MF and MAB managed the literature searches and discuss the conclusion. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the effect of Solid Waste (MSW) slurry from biogas plant on soil micro-parameters and yield of spinach.
Study Design: A completely randomized design was used in this study.
Place and Duration of Study: The study was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh during Rabi-1 season (October-December, 2012).
Methodology: Different combination of MSW and regular fertilizer was applied to experimental fields and effect of MSW on soil micro-parameters and yield of spinach was determined.

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Results: Application of MSW slurry showed significant effect on soil moisture, organic matter, total nitrogen, available phosphorus, exchangeable potassium and available sulphur in post plant soil except soil pH over control. For ensuring of organic farming, improving soil parameters and soil health, 20 ton/ha slurry + 50% of the recommended fertilizer dose was found the best. Application of MSW slurry had significant positive effect on plant height, leaves per plant and individual plant weight over control. Rate of photosynthesis did not vary significantly due to the application of MSW slurry.

Conclusion: MSW slurry showed a positive impact on growth and yield contributing characters of spinach and soil microenvironment which help improving the fertility status of soil.

Keywords: B solid waste; biogas; soil; spinach; yield.

1. INTRODUCTION

Bangladesh is a highly populated developing country with 0.15 acres lands per capita [1]. Her agriculture plays a vital role in national economy as about 85% of the total population depends directly or indirectly on agriculture for their livelihood. Rapid growth of urbanization and uncontrolled urban expansion, severely degrade environment and consequently undetermined equitable and sustainable development [2]. With the rapid urbanization and industrialization in our country, the average production of waste is increasing day by day. Being a densely populated country, huge amount of wastes are produced in Bangladesh every day especially solid wastes in urban areas. About 1.5 ton per day and about 2 kg per household solid waste were generated in Dhaka [3]. Islam et al. [4] found that the average waste from household waste, kitchen waste and ashes were 0.517, 0.055 and 1.290 ton/year respectively in Mymensingh. The situation in other cities or towns prevails more or less same.

Solid waste management (SWM), is a important environmental health service, and is an integral part of basic urban services. From the earliest primitive human society there have been attempts to safely dispose of solid waste [5]. In the early days, disposal did not pose difficulty as habitations were sparse and land was plentiful. Disposal became problematic with the rise of towns and cities where large numbers of people started to congregate in relatively small areas in pursuit of livelihoods. On one hand, the density of population increased in these centers of congregation and therefore wastes generated per unit area also increased [6]. On the other hand, available land for disposal of waste decreased in proportion. SWM thus emerged as an essential, specialized sector for keeping cities healthy and livable [7].

Karim [8] more than 50% of cultivated soils of Bangladesh have organic matter content below the critical level (1.5%). Deficiencies of sulphur in almost 9.92 million acres (45%) and zinc in 4.96 million acres (23%) of arable lands that limits to attain the expected yield [9]. In addition to that about 100-200 kg/acres of nutrients are removed each year through nutrient mining by the intensive rice cultivation. Most of the soils of Bangladesh have low organic matter content, usually less than 2% [10]. Under such concerns, new agronomic and soil amendment practices are necessary for sustainable agricultural development [11]. Municipal waste based organic farming is expected to be such an effort of the environment friendly agricultural production system as it conserves natural resources and does not cause the pollution of the atmosphere and water bodies [12].

MSW slurry is an anaerobically digested organic material released as byproduct from this biogas plant. The percentage composition of MSW combined from all locations is about 74.4% organic matter, 9.1% paper, 3.5% plastic, 1.9% textile and wood, 0.8% leather and rubber, 1.5% metal, 0.8% glass and 8% other waste. The biodegradable fraction (organic matter) is normally very high as compared to other fractions, due to the use of fresh vegetables and foods, which is common in each city [13]. The biodegradable part of MSW can use as feedstock in biogas plant. It reduces the amount of waste as well as produce biogas and slurry. About 25 to 30% of organic matter is converted into biogas during the anaerobic fermentation process, while the rest becomes available as manure (bio-slurry). This residual manure is normally rich in macro and micro nutrients and is considered as a quality organic fertilizer [14]. The slurry can be used as organic fertilizer most suitable for organic farming of some high value field and horticultural crops including vegetables, fruits, flowers as well as ornamental plants. Beside this yield responses of vegetable crops to bio-slurry manure application have been reported in different crops including okra, maize and cabbage and organic manure can serve as a substitute to mineral fertilizers [15]. Manures supply the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce [16-18].

Spinach *(Spinacia oleracea* L.) a member of the family Chenopodiaceae is an important vegetable crop in the world. Spinach is a rich vegetable from the nutritional point of view, containing appreciable amount of vitamins and minerals. The edible part contains high amount of P-carotene, calcium and iron [19]. The chief nutritive value of spinach lies in their content of P-carotene (Precursor of vitamin A) and vitamin C. It contains carotene (9300 I.U) vitamin C (43 mg), calcium (274 mg), carbohydrate (5.0 g), protein (3.4 g), fat (0.7 g) and calories (30 Kcal.) per 100 g of edible portion [12]. According to the nutritionists, 3% of the total food calories come from vegetables. The availability of vegetables per capita in Bangladesh is only 53 g/day whereas the Japanese consume 425 g/day on an average [4]. Vegetable crops response more to organic fertilizer than any other crops. Spinach is a leafy vegetable and organic matter has profound effect on its quality. Beside this, organically produced crops and fruits are healthy and nutritious, and have better shelf life as well as higher market values. Demand for organically produced crops are increasing day by day in Bangladesh and elsewhere in the world [20].

However, there is very little information available on effect of MSW slurry on soil microenvironment and quality of spinach in the world. In fact, organic farming is not well known in Bangladesh. This study was designed to determine the effect of MSW slurry from biogas plant on the growth and yield of spinach plant and soil micro environment.

2. MATERIALS AND METHODS

The experiment was carried out during *Rabi-1* season from November-December of 2012 at the Field Laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The materials used and methods followed in the whole experiment are divided into the following:

2.1 Experimental Site

The experiment was set up at the Field Laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh is situated at 20°28’ N latitude and 88°44’ longitudes.

2.2 Soil

The soil of the experimental field was medium high, non-calcarious; dark gray flood plain with loamy texture belongs to the Agro Ecological Zone (AEZ) - Old Brahmaputra flood plain. The morphological, physical and chemical characteristics of the soil are shown in the Tables1 and 2.

Table 1. Morphological characteristics of pre plant soil

Location	BINA farm, Mymensingh
General soil type	Old Brahmaputra flood plain
Parent material	Brahmaputra river borne deposits
Soil series	Sonatala series
Vegetation	Cropped with paddy, wheat, pulse etc.
Flood level	Above flood level

2.3 Climate

The climate of the experimental area is characterized by high temperature, humidity and heavy rainfall with occasional gusty winds during *kharif* season (March-September) and scanty rainfall associated with moderately low temperature during the *Rabi* season (October-February).

2.4 Land Preparation

The land was first opened on November 2012 by repeated plowing with a power tiller followed by spading. Laddering which helped breaking clods and leveling the land followed by every plowing. Weeds, stabbles, and crop residues were removed from the land.

2.5 Spinach Crop

"Copi palong" a high yielding variety of spinach was used as test crop in the experiment. The average yield of the variety generally lies between 8-10 t ha^{-1} [12].

2.6 Layout of the Experiment

The experiment was laid out in Randomized Complete Block Design (RCBD), with three replications. Thus total number of unit plots was 15. The unit plot size was 2m × 2m and plots were separated from each other by drains (50 cm). Treatments were randomly distributed within the blocks.

2.7 Treatments

The treatments used for the experiment were as follows-

- T_{0} = No slurry (Control)
- T_{1} = 10 ton/ha slurry
- T_{2} = 20 ton/ha slurry
- T_{3} = 10 ton/ha + 50% of the recommended fertilizers
- T_{4} = 20 ton/ha + 50% of the recommended fertilizers

2.8 Manures and Fertilizer Application

Nitrogen (N) (100 kg ha^{-1} from urea), phosphorus (P) (14 kg ha^{-1} from triple super phosphate (TSP)), potassium (K) (30.00 kg ha^{-1} from muriate of potash (MP)), sulphur (S) (15 kg ha^{-1} from gypsum) [28] were applied in the treatment (T_0) plot and 50% of all fertilizers were applied in the treatments (T_3 & T_4). Half (50%) of urea and MP, and rest of all were applied as basal dose one day before sowing and rest 50% urea and 50% MP were applied in the plots 21 days after seed sowing (DAS). The MSW slurry (wet basis) was incorporated in the plots as per treatments at 3 days before sowing and after two days they were mixed thoroughly with the soil.

2.9 Seed Sowing

Before sowing seeds were soaked in water for 18 hours. For sowing small (2.5 cm deep) holes were made at requisite distance and 3 seeds were placed in each hole which was then filled with soil. Three seeds per hole were planted in order to ensure uniform stand of the crops in 15th November, 2012. Row to row distance was 20 cm and plant to plant distance was 15 cm. Immediately after sowing watering was done twice a day for ensuring uniform germination.

2.10 Intercultural Operations

Thinning and first weeding was done 21 days after sowing. After thinning one seedling per hill was retained. The growing points of the seedlings to be removed were pinched off. Uprooting was not done since there were possibilities of injuring the adjacent seedlings that were left behind. There were many kinds of weeds but Durba grass (*Cynodon dactylon*) was most troublesome. The plants were irrigated by watering-can initially and as the plants grew older, sprinkler irrigation were given whenever required. During early stage, the rate of growth was rather slow, probably due to infestation of weeds and slow release of nutrient. There was no attack of insects and diseases. Top dressing of urea and muriate of potash was done in the plots after three weeks of seed sowing which was followed by irrigation.

2.11 Harvesting Green Crop (Foliage)

Harvesting was done one time. Harvesting was done at 38 DAS, by uprooting the whole plants. The soil adhering to the roots could be easily thrown away by jerking. Weight of the sample plants and total plants with attached roots were taken from each unit plot immediately after harvesting.

Table 2. Physical and chemical characteristics of pre plant soil

Characteristics	Value	Reference
pH	6.42	Source: Agriversity Humbolt soil laboratory, Department of Soil science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
Sand (%)	60.00	
Silt (%)	32.00	
Clay (%)	8.00	
Textural class	Sandy loam	
Soil moisture	23.32	
Total nitrogen (%)	0.11	
Organic carbon (%)	0.68	
Available phosphorus (ppm)	12	
Exchangeable potassium (m.e. %)	0.10	
Non- Exchangeable potassium (m.e. %)	0.61	
Available sulphur (ppm)	19.00	
Available zinc (ppm)	2.40	

2.12 Data Collection

Data on following parameters were collected and recorded.

2.12.1 Collection and preparation of soil sample

After crop harvest, soil samples were collected from each plot at 0-15 cm depth. After getting weeds and other unwanted things removed, the samples were air dried ground, sieved through a 2 mm sieve and kept for analysis.

2.12.2 Soil moisture

The moisture of soil was determined by gravimetric method and was calculated using following formula [21].

$$\text{Sample moisture Sample moisture (Soil moisture \%)} = \frac{(\text{W} - \text{W1})}{\text{W1}} \times 100 \text{ (weight basis)}$$

Where,

W = Weight of moist sample in grams
W_1= Weight of air dry sample in grams

2.12.3 Soil Ph

Soil pH was measured with the help of a glass electrode pH meter using soil water suspension of 1:2.5 as described by Black [22].

2.12.4 Organic carbon

Organic carbon was determined by wet oxidation method as described by Black [22] and the organic matter content was calculated by multiplying the percent organic carbon with the Van Bemmelen factor of 1.73 [23].

2.12.5 Total nitrogen

Total nitrogen in soil and treatments were determined by micro-kjeldahl method. Digestion was made with H_2O_2, concentrated H_2SO_4 and catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$: Se in the ratio of 100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in $H_3BO_3$with 0.01N H_2SO_4 [24].

2.12.6 Available phosphorus

Available phosphorus was extracted from the soil and treatments by shaking with 0.5 M NaHCO3 solutions at pH 8.5 following the method of [25]. The extracted phosphorus was determined by developing blue color by $SnCl_2$ reduction of phosphomolybdate complex and measuring the intensity of color colorimetrically at 660 nm wave length and calibrating the reading to the standard P curve.

2.12.7 Exchangeable potassium

Exchangeable K was extracted with 1.0 N NH40Ac (pH-7) and determined from the extract by flame photometer [22] and calibrated with a standard K curve.

2.12.8 Available sulphur

Available sulphur was determined by extracting the soil and treated samples with CaCl2 solution (0.15%). The extraction method was described [23]. The S content in the extract was estimated turbidimetrically with spectrophotometer at 420 nm [23].

2.13 Physical Quality Analysis and Yield of Spinach

2.13.1 Rate of photosynthesis

To determine the rate of photosynthesis 5 plants were randomly selected from each plot. The rate of photosynthesis was measured by using Portable Photosynthesis System (Model: Li 6400 XT) in µ mol co_2 m^{-2} s^{-1}.

2.13.2 Yield and yield component

To evaluate the effect of MSW slurry on quality of spinach 10 plants were selected at random from each unit plot at harvesting. The following physical quality related characters were studied using 10 plants in each unit of plot and yield per plot (kg $plot^{-1}$) and total yield (t ha^{-1}) was recorded.

2.13.3 Statistical analysis

The collected data were compiled and tabulated in proper form and were subjected to statistical analysis by F-test to examine the treatment effects. The analysis of variance was done following the computer package programme MSTAT. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) [26] and ranking was indicated by letters.

3. RESULTS AND DISCUSSION

3.1 Soil Parameters

Application of slurry manures caused decreasing effect on the pH of the post-harvest soils (Table 3). All the treatments except T_1 (10 ton/ha slurry) slightly decreased the soil pH as compared to pre-plant soil. The decreasing effect was higher where (T_4) 20 ton/ha slurry + 50% of the recommended fertilizer treatment was applied. This might be due to organic acids released from organic matter through decomposition leading to a decreasing effect on soil pH. The pH value of post-harvest soils ranged from 6.37-6.16 and varied significantly. Yadav et al. [27] observed that the pH of the soil decreased significantly with the addition of organic manure and Gypsum. Similar results have been reported by More [28] and Mian and Eaqub [9].

Application of organic manures and chemical fertilizers caused an increasing effect on soil moisture percentage (Table 3). All the treatments increased the soil moisture as compared to pre-plant soil except T_1 and T_3 (10 ton/ha + 50% of the recommended fertilizers). The increasing effect was higher where 20 ton/ha slurry + 50% of the recommended fertilizers was applied. The ranking of soil moisture was T_4>T_2 (20 ton/ha slurry)>T_3>T_0 (no slurry)>T_1. This might be due to bulky organic matter conserving more water. The soil moisture of post-harvest soils ranged from 22.37 to 25.25% and varied significantly. Sharma et al. [29] observed that integrated application of farmyard manure (FYM) and chemical fertilizer significantly improve water holding capacity of soil. Malewar et al. [30] reported that FYM improved soil physical properties.

The organic matter content of the post-harvest soil was increased in all treated samples compared to the initial soil (Table 3). Soil organic matter content due to treatments ranged from 1.16 - 1.27% after harvest of crops and the treatment T_2 (20 ton/ha slurry) recorded the highest value. Many investigators found that application of organic manures increased the organic matter content in the soil with the chemical caused a decreasing effect [31]. Organic carbon also increased due to application of organic manure as reported by Mathew and Nair [32], Ahmad et al. [33] and Salakinkop and Hunshal [34].

The total N content of post-harvest soils varied significantly among treatments (Table 3). The highest N content was 0.169% obtained in treatment T_4 where 20 ton/ha slurry + 50% of the recommended fertilizers were applied. The lowest value (0.090%) was found in control (T_0) treatment where fertilizers were not used. The data indicated that slurry showed better performance in maintaining total N in soil compared to inorganic source of fertilizer. Application of organic manure increased the total N concentration in soil as reported by Wong et al. [16], Mathew and Nair [32] and Abdel and Hussein [31].

Available P content of post-harvest soil was influenced by different treatments (Table 3). Available P content varied from 10.11 to 19.63 ppm. The P content in pre-plant soil was 12.00 ppm. The highest and lowest available P content were recorded in the treatments T_2 (20 ton/ha slurry) and T_3 (10 ton/ha slurry + 50% of the recommended fertilizers). Soils treated with 20 ton/ha slurry gave higher value of available P compared to other treatments. The release of more available P from the decomposition of slurry might cause higher value in soils treated with slurry manure. Application of organic manures increased the available P in soil as reported by Mathew and Nair [32], Abdel and Hussein [31], Iftikhar and Qusim [20] and Rosen et al. [35].

The highest exchangeable K content in post-harvest soil was obtained in T_4 treatment (0.25 me/100 g soil) and the lowest value (0.14b me/100 g soil) was found in control (T_0) treatment (Table 3). All the treatments significantly increased K content in soil than the initial value (0.10 me/100 g soil). Results indicate that exchangeable K content was higher in soils treated with MSW slurry manures than treated with chemical fertilizer and control. Abdel and Hussain [31] showed that a significant effect of organic manures in improving the exchangeable K in soil. Similar results were also reported by Wong et al. [16], Mathew and Nair [32] and Rosen et al. [35].

Sulphur content in soil was significantly influenced by treatments after harvest of spinach (Table 3). The pre-plant sulphur was 19 ppm but after application of organic manures the highest sulphur content was recorded in treatment T_4 (30.38 ppm). The lowest value of sulphur (16.00 ppm) was in the control. The sulphur content in the post-harvest soils was higher in soils treated with MSW slurry compared to the soils treated with the chemical fertilizer. Smith and Hughes

[36] found that application of organic fertilizers increased available sulphur content in soil compared to that of inorganic fertilizer.

The MSW slurry did not affect soil temperature significantly (Table 3). The maximum soil temperature was measured in T_1 treatment where slurry was applied as 10 ton/ha and minimum in T_0 treatment. The decreasing order of soil temperature at 30 DAS was $T_1>T_2>T_3>T_4>T_0$. On the contrary, Smith and Hughes [36] measured highest temperature (69℃) in compost made from market and garden refuse whereas compost made purely from garden refuse the highest temperature was 53℃. Giri and Singh [37] observed soil temperature under straw mulch was lower at 2-4 pm.

3.2 Physical Quality of Spinach (Yield Component and Yield)

3.2.1 Plant height

Result from Table 4 indicated that the plant height significantly differed among treatments. The highest plant height (27.31 cm) was observed in treatment T_4 and the lowest (23.30 cm) was found in T_0 (control) treatment. This result was possibly due to higher rate of N levels in organic manures. Budhan et al. [38] also reported that application of cattle manure resulted in increase of plant height.

3.2.2 Leaf number

Result from Table 4 showed that leaf number varied among different treatments. The number of leaves ranged from 8.00 to 9.89. The highest number of leaves was obtained in treatment T_4 (20 ton/ha slurry + 50% of the recommended fertilizers) and lowest in the control. Possible reason behind this result is MSW slurry added higher phosphorus, potassium content in soil than conventional farming. Kant and Kumar [39] reported that organic manures resulted in increase of number of tiller of rice.

3.2.3 Rate of photosynthesis

The MSW slurry did not affect rate of photosynthesis significantly (Table 4). The maximum rate of photosynthesis was measured in T_0 treatment (36.12 µmol CO_2 m^{-2} s^{-1}) and minimum in T_4 treatment (31.09 µmol CO_2 $m^{-2}s^{-1}$). The decreasing order of rate of photosynthesis at 30 DAS was $T_0>T_1>T_3>T_2>T_4$.

3.2.4 Individual plant weight (g)

Result from Table 4 showed that individual plant weight varied among different treatments. The highest individual plant weight was obtained in treatment T_2 (54.44 g) and the lowest in the treatment T_3 (41.11 g). Similarly total dry matter of many field crops improved due to application of MSW [40]. Possible reasons behind this result is MSW slurry added higher phosphorus, potassium content in soil than conventional farming.

3.2.5 Total yield

There was significant effect on total yield (t/ha) of spinach (Table 4). Maximum yield (9.85 t/ha) was recorded in 10 ton/ha slurry + 50% of the recommended fertilizers treated treatment (T_3) and minimum (7.00 t/ha) was in T_1 treatment.

Many previous studies have showed potential of biogas slurry to improve soil quality and crop yield. Yu et al. [41] reported that biogas slurry is cheap source of plant nutrients and offer extra benefits to soil fertility and fruit quality of tomato as well as tomato cultivation. Islam et al. [42] reported that biogas slurry improved production and quality of maize fodder. Wu et al. [43] reported that application of biogas slurry to oil-seed rape increased protein, iron, manganese, copper and zinc content of the rapeseed and yield of the rape plant. LiNa et al. [44] reported that application of biogas slurry to rice field resulted similar or slightly higher yield compared to chemical fertilizers. TongGuo et al. [45] reported that application of biogas slurry can effectively promote the yield of green pepper, tomato and cucumber and change the qualities of vegetables. Treatment of seed with biogas slurry can significantly increase germination, root length and seedling vigour index of sesamum, sunflower and safflower crops [46]. Improvement of yield and crop quality of many other crop types with the application of biogas slurry has also been reported [2,47,48].

Table 3. Soil pH, moisture, organic matter, N, P, K and S content of post-harvest soil as influenced by different treatments

Treatments	Soil pH	Soil moisture (%)	Organic matter (%)	Total N (%) in soil	Available P (ppm) in soil	Exchangeable K (me /100 g) in soil	Available S (ppm) in soil	Soil temperature (℃)
T_0	6.37a	22.62bc	1.20	0.090b	15.42c	0.14b	16.00d	12.25
T_1	6.45a	22.37c	1.25	0.130ab	14.62c	0.16b	18.57c	12.59
T_2	6.20b	23.76b	1.27	0.156a	19.63a	0.21a	27.17b	12.46
T_3	6.25b	23.15bc	1.16	0.143ab	10.11d	0.21a	27.42b	12.45
T_4	6.16b	25.25a	1.19	0.169a	18.12b	0.25a	30.38a	12.36
LSD	0.165	0.762	0.119	0.0028	0.540	0.011	0.675	0.236
CV (%)	3.16	2.99	8.82	3.50	3.19	11.54	3.6	3.74
Pre plant data	6.42	23.32	0.68	0.11	12.00	0.10	19.00	-

Figure(s) in the column having common letter(s) do not differ significantly at 5% level or at 1% level; T_0 = No slurry, T_1 = 10 ton/ha slurry, T_2 = 20 ton/ha slurry, T_3 = 10 ton/ha slurry + 50% of the recommended fertilizers, T_4: = 20 ton/ha slurry + 50% of the recommended fertilizers

Table 4. Growth and yield component of spinach at 38 DAS as influenced by different treatments

Treatments	Plant height (cm)	No. of leaves/ plant	Rate of photosynthesis (μmol $co_2\ m^{-2}\ s^{-1}$)	Individual plant weight(gm)	Yield / plot (kg)	Total yield (t / ha)
T_0	23.30b	8.00c	36.12	45.56c	2.90c	7.25c
T_1	23.91b	8.45bc	35.89	47.78b	2.73c	7.00c
T_2	24.37b	9.50ab	35.24	54.44a	3.50b	8.75ab
T_3	26.86a	9.72a	35.44	41.11d	3.94a	9.85a
T_4	27.31a	9.89a	31.09	42.22d	3.70ab	8.31bc
LSD	0.623	0.687	2.803	0.901	0.197	0.862
CV(%)	3.28	6.93	7.42	3.79	5.38	9.63

Figure(s) in the column having common letter(s) do not differ significantly at 5% level or at 1% level; T_0 = No slurry, T_1 = 10 ton/ha slurry, T_2 = 20 ton/ha slurry, T_3 = 10 ton/ha slurry + 50% of the recommended fertilizers, T_4: = 20 ton/ha slurry + 50% of the recommended fertilizers

4. CONCLUSION

MSW slurry from biogas plant showed positive impact on growth and yield contributing characters of spinach and soil parameters and organic matter status as well as improving the fertility status of soil. Use of MSW as bio-fertilizer in agriculture will offer an alternative to manage these MSW which may pose health hazard and to convert them into value added products. Though further research is needed to make bio-fertilizer from MSW, it has the advantages of being less expensive, non-hazardous and eco-friendly and it can contribute to better agriculture production in Bangladesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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