J. Soils and Crops 34 (1) 69-74, June 2024

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

IMPACT OF BIOGAS SLURRY ON SOIL HEALTH AND YIELD OF RICE AND BEETROOT

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ABSTRACT

In concern with food security and sustainability, the organic manures are the most important supplement for the plant nutrients. The field trial was conducted during the year 2021 at RVS farms (Unit IV) to analyze macro nutrient content present in different organic manures. The results showed that Biogas Slurry (BS) anaerobically digested organic material had a higher NPK content than aerobically and undigested organic materials. The experiments were carried out in rice and beetroot to examine the yield and available nitrogen in soil by the biogas slurry (10 t ha^{-1}) application with blanket recommended nitrogenous fertilizers (75%, 100% and 125% of recommended dose) and with biofertilizer *Azospirillum* and *Azotobacter.* The results indicated that the application of biogas slurry (10 t ha^{-1}) in combination with N chemical fertilizer (125% of recommended dose) *i.e.* 187.5 N kg ha^{-1} and biofertilizer (*Azospirillum*) increased grain yield and available soil nitrogen in rice. In beetroot, biogas slurry (10 t ha^{-1}) with 100% blanket recommendation of N (120 kg ha^{-1}) and biofertilizer (*Azotobacter*) resulted in higher yield. The biogas slurry increased the nutrient availability and maintains the soil nitrogen pool throughout the crop stages and thus resulted in higher yield.

(Key words: Biogas slurry, soil nitrogen, rice, beetroot, yield)

INTRODUCTION

Owing to the growing population, the synthetic fertilizers are tremendously used in crop production to increase the yield and to ensure the food security. Chemical fertilizers can no longer be substituted in global agriculture in order to sustainably increase crop yield and fulfill the rising demand for food. According to Ministry of Agriculture and Farmers welfare, Govt. of India (2021) the consumption of fertilizer has increased from 95 to 133 kg ha^{-1} during the year 2000-2020 (Anonymous, 2021). High inputs of chemical fertilizers cause an adverse effect on soil structure, micro-organisms, water, fodder and it disturb the ecological balance. Despite of high content in inorganic fertilizers, the efficiency of fertilizers are lower in comparison with organic manures. The slow-releasing nature and growth-promoting compounds in organic manures help to maintain the soil fertility. In recent years, awareness has been created to perform crop management in a sustainable manner. The sustainable agriculture rely in recycling and reuse of farm wastes, as well as the production of food grains without harming the environment or the soil. The only choice available in this case is organic manures, which include farmyard manure, biofertilizers, biogas slurry, and vermicompost (Nasir *et al.,* 2012).

One of the methods of recycling the wastes is the anaerobic decomposition. Bio-slurry is an anaerobic fermented organic material generated from the biogas plant as a byproduct after production of combustible methane gas residues. Biogas slurry is a typical organic fertilizer that ensures the proper use of livestock waste for organic crop management and maintenance of an eco-friendly, pollution-free environment (Islam *et al.,* 2010).

Moller *et al.* (2008) stated that digestion process in biogas plant produces materials containing high contents of N. The produced bio slurry contains essential nutrients for the crop growth. Raw undigested cattle slurry materials have lower pH value, higher NH_4^+-N as well as C:N ratio compared with digested cattle slurry. Cow dung and poultry manure that has been digested anaerobically contains more plant nutrients than aerobic digestion (Shahariar *et al.*, 2013). The decomposed farm residues can be made substitute for chemical fertilizers.

Despite the nitrogen, phosphorus and potassium content of organic manures are low in nature, the anaerobically decomposed organic manures pretended to be slightly high than aerobically decomposed manures but lesser than the synthetic fertilizers. The organic manures in addition to chemical fertilizers increased the yield.

Bio-slurry found in different forms and varies

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according to the digester and feeding substances. The fully-digested bio slurry can be easily identified with good smells, black or dark brown in colour. In Biogas slurry digestion, organic matter will give a large amount of organic acids, which can timely neutralize the release of ammonia and fix it in the fermentative substrate so as to stop it from escaping. The bio slurry increased the crop yield (Rahaman *et al.,*2021). The higher N uptake (10-20%) was observed in crops applied with biodigested slurry than undigested slurry. The significant increase in crop yield also observed in crop applied with biogas slurry (Kumar *et al.*, 2015). The integrated form of nutrient management through chemical fertilizer, organic manure and bio fertilizer reduces quantity and cost of chemical fertilizer without any negative effect in the ecology and maintain the sustainability. Hence, the present study was conducted to evaluate the influence of biogas slurry with different combination of synthetic nitrogen fertilizer and biofertilizers on soil fertility and yield of rice and beetroot.

MATERIALS AND METHODS

The macro nutrients (NPK) content in various organic manures *viz.,* fresh cattle dung, farm yard manure, compost, biogas slurry, poultry manure, cattle urine, paddy straw and wheat straw were estimated. The available nitrogen (N) content was estimated by following Alkaline permanganate method (Subbiah and Asija, 1956). The available phosphorus (P_2O_5) and potassium (K_2O) content was estimated through Olsen P method (Olsen, 1954) and flame photometer method (Jackson, 1967) respectively.

Field trials were conducted in Randomized Block Design at RVS Farms (Unit IV) during the year 2021 on beetroot (Burpee's Red ball) using the biogas slurry in addition with nitrogenous fertilizer. The chemical nitrogenous fertilizer was applied as 75%, 100% and 125% of recommended dose of N in combination with biogas slurry at 10 t ha^{-1} and biofertilizer *Azospirillum* 600 g for rice as seed treatmentand *Azotobacter* 600 g for beetroot as seed treatment.

The treatments in rice were T1-Control, T2-*Azospirillum*+ biogas slurry, T3-75% RDF + *Azospirillum*, T4-100% RDF + *Azospirillum,* T5-125% RDF + *Azospirillum*, T6-75% RDF + *Azospirillum* + biogas slurry, T7-100% RDF + *Azospirillum* + biogas slurry, T8-125% RDF + *Azospirillum* + biogas slurry and replicated three times. The blanket recommendation for rice was 150:50:50 kg ha^{-1}. The plants were planted at 20 x 10 cm.The treatments in beetroot were T1-Control, T2-*Azotobacter*+ biogas slurry, T3-75% RDF + *Azotobacter,* T4-100% RDF + *Azotobacter,* T5-125% RDF + *Azotobacter,* T6-75% RDF + *Azotobacter* + biogas slurry, T7-100% RDF + *Azotobacter* + biogas slurry, T8-125% RDF + *Azotobacter* + biogas slurry and replicated three times. The blanket recommendation for beetroot was 120:160:100 kg ha^{-1}. The plants were planted at 45x 30 cm.

The straight fertilizer urea was applied as the nitrogenous chemical fertilizer. Except nitrogenous fertilizer, cultural practices were followed based on guidelines from crop production guide of Tamil Nadu Agricultural University. The biogas slurry was applied before the last ploughing.

The total nitrogen, total phosphorus and total potassium in different organic manures were estimated by using Micro kjeldhal's method (Humphries, 1956), Triple acid digestion with colorimetric estimation (Jackson, 1973) and Triple acid digestion with flame photometric method (Stanford *et al*., 1949) respectively.

In rice the growth and yield parameters *viz.,* plant height, number of panicles per m^2, grain and straw yield were recorded. The available soil nitrogen at different stages namely, active tillering, panicle initiation and at harvest were analyzed. In beetroot, the observations were recorded on selected plants in each plot *viz.,*plant height (cm) and number of leaves $plant^{-1}$. Similarly, after harvest, the measured parameters were economic yield (t ha^{-1}), biological yield (t ha^{-1}) and soil available nitrogen at 30 DAS, 60 DAS and at harvest (75 DAS). It was statistically analyzed by Fisher's method of ANOVA, (Gomez and Gomez, 1984) and results were discussed.

For initial available soil nitrogen, soil samples were collected randomly from the experimental field before ploughing and composite sample was obtained by quartering method for pre sowing soil analysis. The samples were then sieved through 2 mm mesh and analysis was carried out using standard procedures and estimated by alkaline permanganate method (Subbiah and Asija, 1956).

RESULTS AND DISCUSSION

Assessment of macro nutrients in different organic manures

The study resulted that, among 8 different organic manures the higher percentage of nitrogen, phosphorus and potassium content was observed in biogas slurry (1.5 - 2.5% N; 1.0-1.5% P_2O_5 and 0.8-1.2% K_2O) followed by poultry manure. The fresh cattle dung had a lower percentage of NPK in comparison with other organic manures studied (Table 1).The digested manure had slightly higher level of nutrient content than the undigested manure. The enrichment of nutrients in the organic manure can be possessed by the anaerobic decomposition. The anaerobic fermentation increased the NH_4^+ content in the substrate and also increased the stability of organic manure, but decreased the C:N ratio remarkably, resulting in a product with a high content of directly available N. There are many intermediates formed during the anaerobic digestion *viz.,* methane, volatile fatty acids and some organic compounds which act as the source for microorganism that result in maintaining the soil fertility (Sanger *et al.,*2010). The biogas slurry had a higher macro nutrient content among the different manures. This may be due to the anaerobic digestion and the microorganism involved in digestion. The microorganism that holds the essential nutrients and made available in the soil for the plant growth thus increases the crop yield. Shahariar *et al.* (2013) reported that bio gas digested slurry applied at 5 t ha^{-1} in addition to chemical fertilizer produced higher yield and yield attributes about 366 per cent than the fresh poultry and cattle dung in cabbage.

Ferdous *et al.* (2018) reported in maize that the higher number of cobs, test weight and yield has been produced by the supplementation of bio digested cow dung than undigested cow dung. Ferdous *et al.* (2020) also reported that cow dung or poultry biogas slurry (5 t ha^{-1}) along with chemical fertilizer produced the higher yield (20-24 per cent) and greater profit margin (52-53 per cent). Yadav and Garg (2016) also recorded the higher tomato fruit yield for plants grown with synthetic fertilizer + cow dung bioslurry compared with other fertilizer treatments. The higher potato tuber yield and economic returns were recorded by the application of poultry bio slurry in combination with inorganic fertilizers (Sarker *et al.,* 2010).

Influence of Biogas Slurry (BS) on yield and soil nitrogen in rice

The yield of rice was influenced by the chemical N fertilizer with biofertilizer and BS (Table 2). The higher plant height and higher number of panicles m^{-2}, higher grain (6575 kg ha^{-1}) yield and straw yield (13147 kg ha^{-1}) was observed in the treatment with combination of biogas slurry (10 t ha^{-1}) and 125% recommended dose of nitrogen with biofertilizer (*Azospirillum*). The grain yield was increased about 72 per cent and straw yield by 71 per cent over the control plot which was followed by 100% recommended dose of N and biofertilizer *Azospirillum* application with BS 10 t ha^{-1}. And also the results revealed that the available N after the harvest was higher in the treatment where 125% of recommended dose of N combined with *Azospirillum* and 10 t ha^{-1} of biogas slurry. Whereas, in the treatment without biogas slurry the available nitrogen in soil was drastically reduced (Figure 1).

The higher plant height may be due to the nitrogen that increases the meristematic cellular activity. Application of nitrogen fertilizer (125% of recommended dose) along with biogas slurry(10 t ha^{-1}) and biofertilizer *Azospirillum* increased the number of panicles m^{-2} and yield in rice. This might be due to the increased application of nitrogen fertilizer and availability of essential nutrients and trace element for the proper growth and yield of rice. Biogas slurry might acts as the source for organic carbon and maintains the soil microflora thus leads to the balance in the soil nutrition. Chemical fertilizer and BS raised the soil NH_4^+ and NO_3^- - N levels, resulting in appropriate nutrient uptake at various crop growth stages. The results are in line with Hossain *et al.* (2018), who reported that bio-slurry application on four different varieties of boro rice namely BRRI dhan28, BRRI dhan29, Binadhan-8 and Binadhan-10 resulted in maximum plant height, number of tillers $hill^{-1}$, panicle length and number of grains $panicle^{-1}$.

The result might be due to the sound photosynthetic activity and dry matter accumulation in the vegetative stage. More over the crop undergoes a fertilization demand throughout the crop period and this can be identified and supplemented by the organic manure and biofertilizer to make the sustainable yield. Parvathy and Vaishnavy (2009) stated that the biogas slurry increased the plant height, dry weight, chlorophyll content and leaf area thus led to the higher yield in rice.

Organic manure induced nutrient-shift along with shift in the microbial communities of rice field which further affects the growth and productivity of rice (Su *et al.,* 2015). The soil available nitrogen after the harvest in rice showed the positive correlation with combination of both inorganic and organic N supplied to the crop (Sharma *et. al*., 2021). The greater availability of N in soil by the application 125% recommended dose of N and BS 10 t ha^{-1} and biofertilizer *Azospirillum* was observed. The losses of nitrogen through leaching and denitrification were found in inorganic N fertilizer where as the steady increase in mineralization of organic manure adds the nitrogen to the soil pool. The higher yield and available soil N, P and K by the application of bioslurry in bean crop was observed by Abd-Eladl *et al.*(2016). The application of vermicompost and chemical fertilizer increased the yield in soybean (Fayera and Wagari, 2021).

Influence of biogas slurry on yield and soil nitrogen in beet root

The data revealed that 100% blanket recommendation of NPK combined with *Azotobacter* and the application of BS at 10 t ha^{-1} recorded the higher tuber (14506 kg ha^{-1}) and biological (19343 kg ha^{-1}) yield over the control. Tuber beet yield was increased by 78 % and leaf yield by 79 %. The result was on par with the application of 125% blanket recommendation of N combined with *Azotobacter* and BS at 10 t ha^{-1} (Table 2). The availability of soil nitrogen at different growth stages was higher in the treatment with 100% recommended N in combination with *Azotobacter* and biogas slurry at 10 t ha^{-1}.The soil available nitrogen was drastically reduced in the treatments with chemical fertilizer alone (Figure 1).

The application of 100% recommended dose of nitrogen with biofertilizer *Azotobacter* and BS at 10 t ha^{-1} significantly increased the yield of the beetroot. The results might be due to the balanced application of organic manure and inorganic fertilizers. The higher yield could be attributed with nutrient availability and the better physical property of soil. The organic manure generally increases the quality of the crop and reduces the bulk density of the soil. It might help the beet root in root elongation and enlargement and results in higher yield. The bio slurry readily supplies the essential macro and micronutrients required for the growth and development. Maqbool *et al.* (2014) reported that the 50% recommended dose of chemical fertilizer with 50% N from the fresh biogas slurry in okra significantly obtained the higher plant height (15 per cent), root length (23 per cent), number of fruits $plant^{-1}$ (25 per cent) and fruit fresh weight (36 per cent). In carrot, the application of 7.8 t ha^{-1} biogas slurry with the N chemical fertilizer at 75 kg ha^{-1} increased the dry weight of leaves and root, plant height and yield by 8.8 per cent in season I and 23.5 per cent in season II (Jeptoo *et al.*, 2013). Yamika *et al.* (2019) reported that the application of biogas slurry and inorganic fertilizer increase number of fruits produced, the weight of the fruit, the total weight of fruit produced plant^{-1} and hectare^{-1}. Biogas slurry improved organic matter from 0.29% to 2.06%, N total from 0.06% to 0.15%, P_2O_5 from 93.48 ppm to 224.31 ppm, K_2O from 2.01me 100 g^{-1} to 100 me 100 g^{-1}, and C/N ratio from 3 to 9 in cucumber.

The higher soil available nitrogen at all the growth stages of beet root was found in 100 % recommended dose of nitrogen in combination with biogas slurry (10 t ha^{-1}) and reduced level of available nitrogen was found in the treatment where only the chemical fertilizers applied. This shows that the organic manure (biogas slurry) increases the nutrient availability and maintains the soil nitrogen pool throughout the crop stages and thus resulted in higher yield.

Table 1. Assessment of macro nutrient in different organic manures

S.No.	Manure	N_2 content (%)	P_2O_5 content (%)	K_2O content (%)
1.	Fresh cattle dung	0.3 - 0.4	0.1 - 0.2	0.1 - 0.3
2.	Farmyard manure	0.4 - 1.5	0.3 - 0.9	0.3 - 1.9
3.	Compost	0.5 - 1.5	0.3 - 0.9	0.8 - 1.2
4.	Biogas slurry	1.5 - 2.5	1.0 - 1.5	0.8 - 1.2
5.	Poultry manure	1.0 - 1.8	1.4 - 1.8	0.8 - 0.9
6.	Cattle urine	0.9 - 1.2	Trace	0.5 - 1.0
7.	Paddy straw	0.3 - 0.4	0.8 - 1.0	0.7 - 0.9
8.	Wheat straw	0.5 - 0.6	0.1 - 0.2	1.1 - 1.3

Table 2. Effect of biogas slurry and chemical fertilizer on plant height (cm), number of panicles m^{-2}, grain and straw yield (kg ha^{-1}) of rice

Treatments	Plant height (cm)	Number of panicles m^{-2}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1	77.93	199	1838	3783
T2	83.90	224	2433	5573
T3	85.40	291	4083	8234
T4	84.33	313	5428	10835
T5	92.80	379	5950	11147
T6	88.20	344	5342	9751
T7	102.33	430	6338	12168
T8	100.80	417	6575	13147
S Ed ±	1.13	9.71	234	427
CD at 5 %	2.38	20.38	585	1023

Table 3. Effect of biogas slurry and chemical fertilizer on root and biological yield (kg ha^{-1}) of Beetroot

Treatments	Beet root yield [kg ha^{-1}]	Biological yield [kg ha^{-1}]
T1	8148	10455
T2	9267	11766
T3	10951	13910
T4	11205	15442
T5	12624	16414
T6	12191	15021
T7	14506	19343
T8	13926	18754
S Ed ±	497	437
CD at 5 %	1067	918

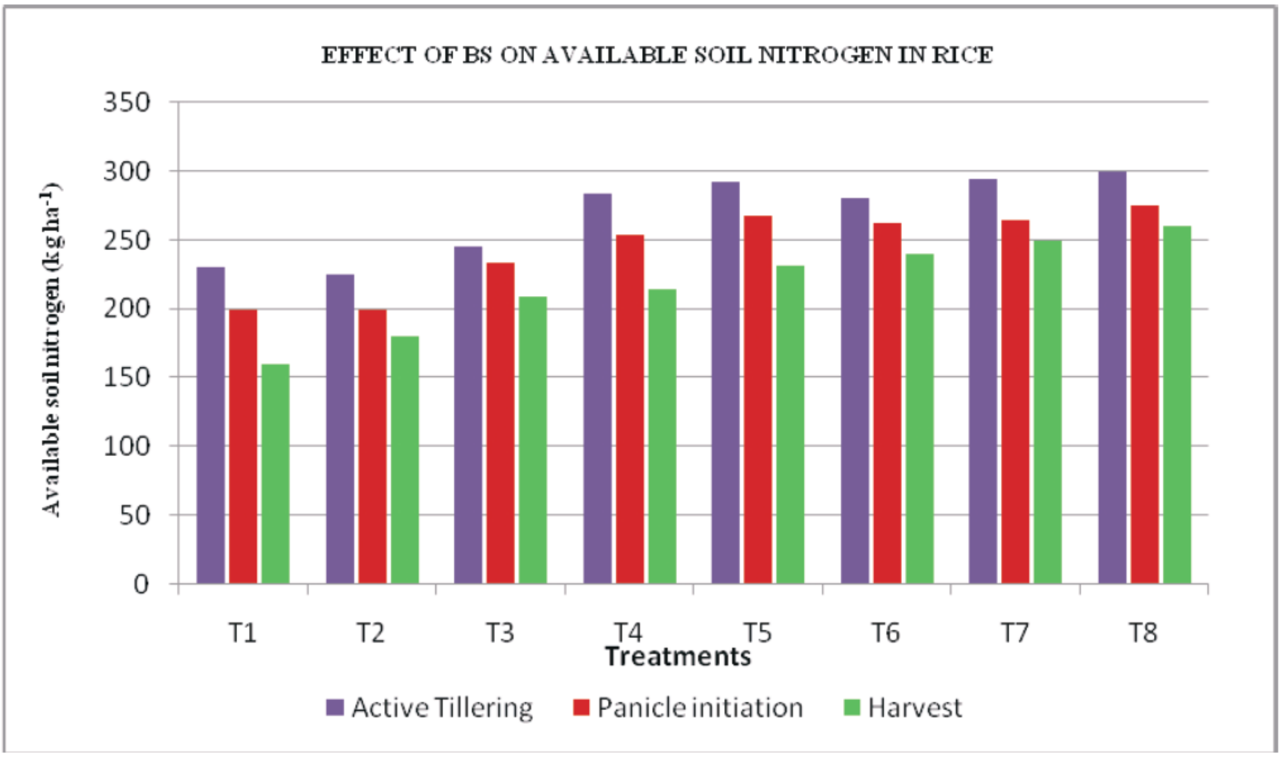

Figure 1. Effect of biogas slurry on soil available nitrogen in rice

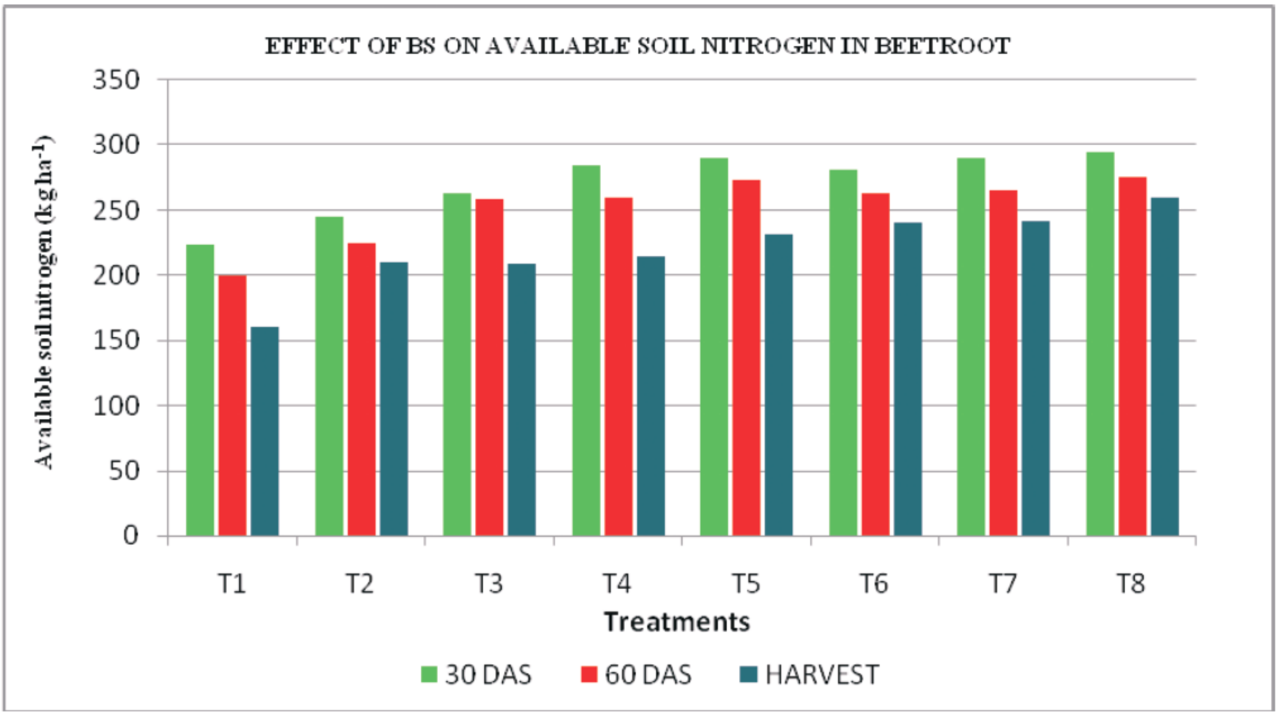

Figure 2. Effect of biogas slurry on soil available nitrogen in beetroot crop

REFERENCES

Abd-Eladl, M., S.Fouda and N. Abou-Baker, 2016. Bean yield and soil parameters as response to application of biogas residues and ammonium nitrate under different water requirements. Egypt. J. Soil Sci. **56**(2):313-326.

Anonymous, 2021. Annual Report 2020-2021 of Department of Fertilizers, Ministry of Chemicals and Fertilizers Government of India.

Fayera, A. and A. Wagari,2021. Effect of organic and chemical fertilizers on growth, yield and yield components of Soyabean (*Glycine max* L.) in western Ethiopia. J. Soils and Crops, **31**(1):1-6.

Ferdous, Z., H. Ullah, A. Datta, M. Anwar and A. Ali, 2018. Yield and profitability of tomato as influenced by integrated application of synthetic fertilizer and biogas slurry. Int. J. Veg. Sci.**24**(5):445-455.

Ferdous, Z., H. Ullah, A. Datta, A. Attia, A. Rakshit and S.H. Molla, 2020. Application of biogas slurry in combination with chemical fertilizer enhances grain yield and profitability of maize (*Zea mays* L.). Commun. Soil Sci. Plant Anal. **51**(19):2501-2510.

Gomez, K.A., and A.A. Gomez,1984. Statistical procedures for agricultural research: John Wiley & Sons.

Hossain, M.N., U.K. Sarker, M.R. Uddin, S. Rehana, M.M.I. Hoque and M.A. Islam, 2018. Effects of bio-slurry with chemical fertilizer on the performance of some high yielding varieties of boro rice (*Oryza sativa* L.). Arch. Agri. Sci. J. **3**(2): 109-115.

Humphries, E.C. 1956. "Mineral components and ash analysis." In Modern Methods of Plant Analysis, Springer. Verlag. **1**: 468-502.

Islam, M.R., S.M.E. Rahman, M.M. Rahman, D.H. Oh and C.S. Ra, 2010. The effects of biogas slurry on the production and quality of maize fodder. Turk J Agric For. **34**(1):91-99.

Jackson, M.L. 1967. Soil Chemical Analysis. Prentice Hall Inc., Englewood Cliffs.

Jeptoo, A., J. N. Aguyoh and M. Saidi, 2013. Improving carrot yield and quality through the use of bio-slurry manure. Sustain. Agric. Res. **2**(526-2016-37907).

Kumar, S., L.C. Malav, M.K. Malav and S.A. Khan, 2015. Biogas slurry: source of nutrients for eco-friendly agriculture. *Int.* J. Extensive Res. **2**(2):42-46.

Maqbool, S., A. Ul. Hassan, M. Javed Akhtar and M. Tahir, 2014. Integrated use of biogas slurry and chemical fertilizer to improve growth and yield of okra. Sci. Lett. **2**(1):56-59.

Moller, K., W. Stinner, A.Deuker and G. Leithold, 2008. Effects of different manuring systems with and without biogas digestion on nitrogen cycle and crop yield in mixed organic dairy farming systems. Nutr. Cycl. Agroecosystems, **82**(3):209-232.

Nasir, A., M.U. Khalid, S. Anwar, C. Arslan, M.J. Akhtar and M. Sultan, 2012. Evaluation of bio-fertilizer application to ameliorate the environment and crop production. Pak. J. Agri. Sci. **49**(4):527-531.

Olsen, S.R.1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (No. 939). US Department of Agriculture.

Parvathy, S. and S.S. Vaishnavy, 2009. "Effect of biogas slurry on growth and biomass production of Sorghum vulgare and *Oryza sativa*", J. Ecobiol. **24**: 335-338.

Rahaman, M.A., Q. Zhang, Y. Shi, X. Zhan and G. Li, 2021. Biogas slurry application could potentially reduce N_2O emissions and increase crop yield. Sci. Total Environ. **778**:146-269.

Sanger, A., D.Geisseler and B. Ludwig, 2010. Effects of rainfall pattern on carbon and nitrogen dynamics in soil amended with biogas slurry and composted cattle manure. J. Plant. Nutr. Soil Sci. **173**(5):692-698.

Sarker, M.A.I., Z. Ferdous, M. Anwar, N.U. Mahamud and M. Ali, 2010. Performance of poultry bio-slurry as a source of organic manure on wheat production. Bangladesh J. Environ. Sci. **19**:36–38.

Shahariar, M.S., M.Moniruzzaman, B. Saha, G. Chakraborty, M. Islam, and S. Tahsin, 2013. Effects of fresh and digested cowdung and poultry litter on the growth and yield of cabbage (*Brassica oleracea*). Bangladesh J. Environ. Sci. **48**(1):1-6.

Sharma, S., P. Singh, O.P. Choudhary, and Neemisha, 2021. Nitrogen and rice straw incorporation impact nitrogen use efficiency, soil nitrogen pools and enzyme activity in rice-wheat system in north-western India**.** Field Crops Res. **266**: 108131.

Stanford, G., L. English, R. E. Comstock, H. F. Robinson, and P. H. Harvey, 1949. "Use of the flame photometer in rapid soil tests for K and Ca." Agron. J. **41** (9):446-447.

Subbiah, B.V., and G.L. Asija, 1956. A rapid procedure for the determination of available nitrogen in soils**.** Curr. Sci. **25**:259–260.

Su, J.Q., L.G. Ding, K. Xue, H. Y. Yao, J. Quensen, S.J. Bai and Y.G. Zhu, 2015. Long-term balanced fertilization increases the soil microbial functioned diversity in a phosphorus - limited paddy soil. Mol. Ecol. **24**(1) : 136-150.

Yadav, A., and V.K. Garg, 2016. Vermiconversion of biogas plant slurry and parthenium weed mixture to manure. Int. J. Recycl. Org. Waste Agric. **5**:301–309.

Yamika, W.S.D., N.Herlina and S.Amriyanti, 2019.The effect of biogas slurry and inorganic fertilizer on soil fertility and yield of cucumber (*Cucumis sativus* L.). J. Degrade. Min. Land Manage. **6**(4):18-29.

Rec. on 11.08.2023 & Acc. on 17.10.2023