Effect of Biogas Slurry Foliar Application on Growth and Yield Performance of Red Onion (Allium cepa L.)

[1]S.Rakshana, Dr (Mrs.)., [1]S.Santhirakanthan*

[1]Eastern University, Sri Lanka, Faculty of Technology

rakshana2486@gmail.com, suthamathyn@esn.ac.lk

Abstract

The study was conducted to evaluate the effect of biogas slurry combined with the inorganic fertilizer on the growth and yield performance of red onion (Allium cepa L.). This study was designed with four treatments having five replicates. Treatments are T1 with recommended fertilizer (control treatment), T2 -1:1, T3-1:2 and T4 -1:3 (slurry: water on the volume basis). Except the control treatment 1/3 of recommended fertilizers by Department of Agriculture (RDOA) were applied to the other treatments. All agronomic practices were done according to the DOA recommendation. Canopy height, number of leaves were measured at weekly interval. Fresh and dry weight of plant, Bulb diameter, number of bulbs and yield were measured at the time of harvesting (6th week after planting). Analysis of variance was performed to determine significant differences among the treatments ($p<0.05$) by using Minitab 17.0 software. The results showed that these treatments, combining with inorganic fertilizers with biogas slurry significantly enhanced the growth and yield performance (T3 and T4) compared to the control treatment (T1). Especially in the T4 concentration than the other treatments, this treatment significantly enhanced plant height up to 52.14±2.79 cm, leaf number up to 8.60±0.24, and bulb's diameter up to 2.70±0.05 cm. The findings suggest that biogas slurry can serve as an effective organic foliar fertilizer combined with inorganic fertilizer, contributing to improved growth and potentially higher yield in red onion cultivation.

Key words: - Biogas, Canopy, Comparison, Concentration, Slurry, Yield.

Introduction

Food security means that all the times, all the people have to have access to sufficient, safe and nutritious food. Food security is a growing concern globally, especially in developing nations, where agriculture is a key livelihood. Ensuring the crop production and environmental problems is important for the sustainable agriculture production. According to the Food and Agriculture Organization of the United Nations (FAO), food production needs to increase by 60% between 2005 and 2050 to meet the demand of growing population density, assuming biofuel policies remain unchanged. This improvement must be achieved while declining environmental impacts of agriculture and nutrient managements of crops. These food demands can be achieved by proper agricultural practices by reducing the impacts of chemical fertilizers (Heffer et al., 2016).

Slurry from the biogas digestion process is an important bio fertilizer because it is a cost-effective organic matter source that improves the crop yield and particularly enhances the livelihood of smallholder farmers in developing countries. According to the recent estimation in Sri Lanka, over

5000 biogas units have been installed under many renewable energy and waste management programs (National Engineering Research & Development Centre, 2023).

Red onion cultivation makes a considerable contribution to Sri Lanka's agricultural GDP, based on the production levels, annual rainfall and market dynamics, onion cultivation holds high value segment in vegetable cultivation sector. According to the record of Department of Census and Statistics exposed that the vegetables including onions, contributed more than 9% to the total value of crop production, highlighting the role of consumer preference, profits of the farmers, local consumption and reduction in import dependency (Central Bank of Sri Lanka,2023). Red onion (Allium cepa L) is an important bulb crop used in culinary dishes for their distinctive flavor and taste. Onions are used in worldwide throughout the cultivation process. As example leaves of the onion crops can be used as garnish to the dishes, immature onions can be used to make salads and pickles and mature onions can be used in curries for flavoring the food. Onion cultivation has significant agricultural importance in Sri Lanka, especially in the dry and intermediate zones such as Northern and Eastern provinces. It is a cash crop for small scale producers, providing income and job vacancies throughout the marketing chain. Onion farming in Sri Lanka faces several challenges that hinder the productivity and profits.

This study explores the use of biogas slurry as an organic fertilizer combine with inorganic fertilizer in red onion crop cultivation, which ensure optimum production by supporting the low cost, locally available nutrient source. Improving the health of the soil and reducing the dependency on the chemical fertilizers, this biogas slurry will contribute to stand the sustainable agricultural products that is the pillar of the national economy. This experiment will contribute to the food security in a sustainable way to improve crop yield performance of red onion cultivation. Enhancing the crop productivity by using eco-friendly inputs, the study promotes the consistent food security all over the world especially in rural areas.

Materials and Methods Area of Study

This experiment was carried out from July 2025 to October 2025 at the Faculty of Technology, Eastern University, Sri Lanka located in the Batticaloa district of Eastern province. The attitude of this area is around 100m above mean sea level and it is classified under the agro-ecological zone of Low Country Dry Zone (DL2). The latitude and longitude of the site are 7047'N and 81034'E respectively and average elevation of the experimental site is 100m above the sea level.

Experimental Design

All the experiments were arranged in a completely randomized design (CRD).

Treatments

The experiment was carried out with four treatments, each with five replicates.

Table 1

Treatment descriptions for pot experiment

Treatments	Ratios (Biogas slurry: Water) (Volume basis v/v)
T_1 (Control)	Recommended basal fertilizer
T_2	1:1 and 1/3 of recommended basal fertilizer
T_3	1:2 and 1/3 of recommended basal fertilizer
T_4	1:3 and 1/3 of recommended basal fertilizer

Cultural practices

As recommended by Department of Agriculture, Sri Lanka all the cultural practices were done.

Media preparation

Potting mixture was prepared two weeks before the planting to allow the decomposition process. Sandy soil, cow dung and paddy husk ash were used as potting materials as the same amount of ratio 6:2:1. Potting mixture was filled into each polybag up to a height of leaving 10 cm from the top. 14 inches polybags were used as the pots in this experiment, which are very cheap and normally available in the shops. All the treatments were arranged randomly in the field.

Seed bulb treatment

Red onion variety, Vethalam was used in this study. Undeteriorated, vital, and uniform size of bulbs were used for this planting. The bulbs were treated with captan (50% WP) to control seed-borne fungal diseases such as damping-off, foot rot, and root rot. The treatment was applied at a rate of 300g per 100kg of seed bulbs. Captan 20g was dissolved in 10 liters of water, and the bulbs were soaked in the solution for 30 minutes then air dried for another 30 minutes.

Planting and spacing

Eight bulbs were planted at the spacing of 10 cm × 10 cm in each bag in a depth of 2.5 cm, because the tip slightly visible above the soil surface.

Fertilizer application

Basal application of fertilizer was done before two days of planting at the rate of 1/3 part of 65kg/ha urea, 100kg/ha for Triple Super Phosphate (TSP) and 50kg/ha for Muriate of Potash (MOP) as per the area of pot ($0.03m^2$). The top dressing was done after three weeks from planting with only urea. Biogas slurry was applied three times at two weeks interval through the foliar spray ($2.5l/m^2$). The details of fertilizers used in this experiment are annexed in the appendices portion.

Irrigation

Onion needs sufficient moisture in the soil for the growth. Two times watering was done daily. Watering was stopped before seven days of harvesting. Until the harvesting the moisture of the soil has to be considered carefully except the rainy days.

Neck twisting

Neck twisting is a traditional practice, which was practiced to enhance the bulb development of onions after the 5th week of planting.

Weed management

Weeding was done manually.

Pest and disease control

There was no any pest and disease attacks were observed during the experiment period.

Harvesting

Onion bulb harvesting is an important factor to decide the storage life of onions. Up to six months onions can be stored under the atmospheric conditions. Harvesting can be depended on several factors such as cultivar, planting, seasons, market fluctuation, and the best time for harvesting is major part of the leaves are broken and dried. Harvesting was done after 50 days in the late evening to reduce the water losses. The onion bulbs were pulled out carefully from the soil. Onions were collected separately from the leaves after cleaning.

Statistical analysis

The Minitab software application (version 17) was used to analyze all the data at a significance level of 5%.All the mean differences were analyzed using the Tukey range test.

Results and discussion

Growth parameters Height of the canopy

Height of the canopy is an indicator of crop growth and development. Canopy height of red

onion plants were measured at weekly interval from the 2nd week after planting and there were no any significant differences ($P>0.05$) among treatments up to the harvesting. At the 2nd WAP, canopy height of control treatment T1 and the T4 ranged from 21.84±1.74,

28.22±1.62 respectively. T1 had the least amount of canopy height in the experiment. At the

6th WAP canopy height of control treatment T1 and the T4 ranged from, 46.84±2.42,

52.14±2.79 respectively. T4 had the highest amount of canopy height in the experiment. This may due to the positive effects of biogas slurry on the plant nutrient uptake and growth. However, the p-values indicate that these differences were not statistically significant.

These results highlighted the potential organic components of biogas slurry to improve vegetative growth, even if such effects may not always reach statistical significance under certain conditions. The canopy height estimation is essential for evaluating aboveground biomass and carbon dynamics, supporting ecosystem monitoring services (Castro et al., 2024).

Table 2

Canopy height (cm)					
Treatments	2nd week	3rd week	4th week	5th week	6th week
T1	21.84±1.74[a]	34.30±2.90[a]	41.2±1.55[a]	45.1±2.28[a]	46.84±2.42[a]
T2	24.78±1.35[a]	38.80±0.71[a]	43.40±2.41[a]	47.90±3.44[a]	49.32±3.31[a]
T3	26.50±2.73[a]	40.80±1.16[a]	44.60±2.09[a]	49.70±2.50[a]	51.46±2.51[a]
T4	28.22±1.62[a]	41.20±1.85[a]	49.00±1.72[a]	50.60±2.71[a]	52.14±2.79[a]

Means followed by similar letters in each column are not statistically indicated significant difference among the treatments at 5% significance level by Tukey's studentized range test.

Number of leaves per plant

The number of leaves per plant is a crucial indicator of plant development, it will be reflected on the overall growth and health of the plants. Number of green leaves per plant at 2nd WAP indicated that high values obtained in this table suggests that T3 showed intermediate performance. Specifically, p-values were suggesting strong treatment effects on leaf number over the time. Number of leaves in T1 and T4 ranges from 3.40±0.24, 5.20±0.20 respectively at the 2nd WAP. It was raised up to 7.00±0.00, 8.60±0.24 respectively in T1 and T4.

At the 2nd WAP, the plants treated with biogas slurry exhibited low number of leaves in T1 and T2.T4 had 8.60±0.24 leaves per plant, significantly higher than the control treatment, which had 7.00±0.06 leaves per plant. This result supports the hypothesis that biogas slurry application may enhance leaf production, possibly by increasing nutrient availability and plant health. These results indicate that biogas slurry has a significant positive effect on leaf production in red onion plants, with T4 showing the greatest benefit.

Table 3

Number of leaves per plant					
Treatments	2nd week	3rd week	4th week	5th week	6th week
T1	3.40 ± 0.24^{c}	4.40 ± 0.24^{c}	5.20 ± 0.20^{b}	6.20 ± 0.20^{b}	7.00 ± 0.00^{b}
T2	4.00 ± 0.31^{bc}	5.00 ± 0.31^{bc}	5.80 ± 0.20^{ab}	6.40 ± 0.24^{b}	7.40 ± 0.24^{b}
T3	4.60 ± 0.24^{ab}	5.60 ± 0.24^{ab}	6.20 ± 0.20^{a}	7.00 ± 0.31^{ab}	7.80 ± 0.20^{ab}
T4	5.20 ± 0.20^{a}	6.20 ± 0.20^{a}	6.60 ± 0.24^{a}	7.60 ± 0.24^{a}	8.60 ± 0.24^{a}

Means followed by dissimilar letters in each column are statistically indicated significant difference among the treatments at 5% significance level by Tukey's studentized range test.

Yield parameters

4.2.2.1 Fresh and dry weight of the plant

This result indicates a statistically significant difference among the treatments in fresh weight of the plants indicated statistically significant difference among the treatments ($p<0.05$) and dry weight of onion plants showed statistically not difference among the treatments ($p>0.05$). T4 recorded the highest fresh weight and dry weight followed by T3, T2, T1. The grouping letters of Tukey's test suggest that T4 is significantly superior. It shows that the increase treatment levels enhanced plant biomass, possibly due to better nutrient uptake2 and T3 are indicating no significant difference between them, though they were higher than T1. Dry weight refers to all constituents of crops except water and more reliable option to analyze the weight (Huang et al., 2019).

Table 4

Fresh weight and air-dry weight of the plants at the time of harvesting(g)		
Treatments	**Fresh weight(g)**	**Dry weight(g)**
T1	26.36 ± 0.63^{b}	21.37 ± 0.99^{a}
T2	28.21 ± 0.34^{ab}	22.31 ± 0.42^{a}
T3	30.10 ± 1.23^{ab}	24.59 ± 1.19^{a}
T4	31.87 ± 1.38^{a}	25.22 ± 1.67^{a}
***p*-value**	**0.007**	**0.099**

Means followed by dissimilar letters in column 1 are statistically indicated significant difference among the treatments and similar letters in column 2 are statistically indicated not difference at 5% significance level by Tukey's studentized range test.

Diameter of bulbs per plant

Diameter of the plant bulb is one of the important yield indicators to assess the yield performance of onion plants. These results revealed a significant difference in bulb diameter among the treatments, indicating that the applied treatments had a strong influence on bulb development. Treatment T4 recorded the highest bulb diameter 2.70±0.05, followed by T3, T2 and the lowest in T1. The grouping letters make sure that each treatment was significantly different from the others at the 5% significance level.

Average bulb diameter ranges from 1.63cm to 1. 98cm.Increasing K uptake leads to increase in accumulation of carbohydrates and pungency of onion (Singh and Verma, 2001). According to this results bulb development and size of the bulbs are superior in T4 due to the application of biogas slurry at the suitable concentration.

Table 5:

Diameter of the bulbs at the time of harvesting

Bulb diameter (cm)	
Treatments	**Diameter of the bulbs(cm)**
T1	1.16 ± 0.06^{c}
T2	1.34 ± 0.09^{c}
T3	2.16 ± 0.05^{b}
T4	2.70 ± 0.05^{a}
p-value	**0.000**

Means followed by different letters in each column are statistically indicated significant difference among the treatments at 5% significance level by Tukey's studentized range test.

Number of bulbs per plant

The number of bulbs per plant at the time of harvesting was showed significant difference ($P<0.01$) among the treatments4 gave more number of bulbs per plant while T1 showed low value in number of bulbs per plant and average number of bulbs per plant ranges from 5.2 to 9.2.About 80% of nutrients taken up by the crops are removed by bulbs (Fieiert et al., 1997).The reason for this higher number of bulbs per plant in T4 might be the high uptake of nutrient P and K by plants through the foliar application of biogas slurry than the others. Data analysis clearly indicated that uptake of nutrient was high in T4.

This results clearly demonstrate that the application of biogas slurry through the foliar significantly enhanced the number of bulbs per plant. This indicates that the improved nutrient uptake, especially of phosphorus and potassium, positively improved bulb development.

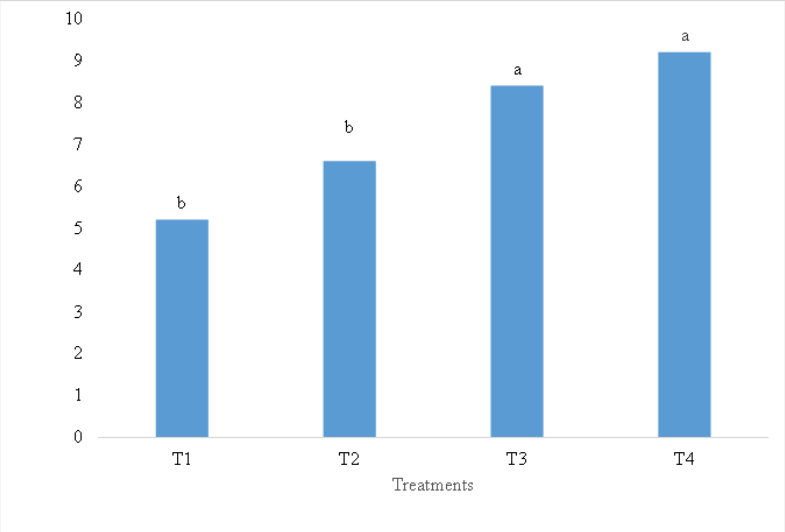

Figure 1: Number of bulbs per plant at the time of harvesting

Yield per treatment

The obtained result showed a significant difference ($P<0.01$) among the treatments. Average yield per treatment ranges from 1.44kg/m2 and 3.04kg/m2 in T1 and T4 respectively. The yield was high in T4 and lower in T1 (control). The yield per treatment varied significantly among the different biogas slurry concentrations. Thus, the application of biogas slurry at 1:3 and 1/3 of recommended fertilizer in T4 (slurry: water and 1/3 of recommended fertilizer) concentration can be recommended to improve yield performance in red onion cultivation.

Table 6:

Yield per treatment at the time of harvesting

Yield	
Treatments	**(kg/m^2)**
T1	1.44 ± 4.33^{d}
T2	2.22 ± 10.7^{c}
T3	2.61 ± 3.67^{b}
T4	3.04 ± 10.1^{a}
p-value	**0.000**

Means followed by different letters in each column are statistically indicated significant difference among the treatments at 5% significance level by Tukey's studentized range test.

Conclusion

Red onion gave good response to organic manures combined with inorganic fertilizers such as urea, MOP and TSP. Onion fertilized by biogas slurry foliar application showed best performance and gave highest yield. The concentration 1:3 (slurry: water) gave the best results than the others. 1:2 (slurry: water) gave second highest yield and growth performance. The combined use of biogas slurry and recommended inorganic fertilizers also showed notable growth and yield improvements. The

experiment clearly demonstrated that the application of biogas slurry had a significant impact on the growth and yield performance of red onion cultivation. Among the treatments, T4 consistently showed superior performance in terms of canopy height, number of leaves, number of bulbs, diameter of the bulbs, fresh and dry weight of the plants and overall yield. This suggests that the optimal concentration of biogas slurry enhances the nutrient availability, supports better bulb development, and promotes healthy plant growth. The use of biogas slurry, particularly T4 level, when used in combination with inorganic fertilizers can be recommended as a sustainable and eco-friendly practice for improving red onion cultivation.

Acknowledgment

We highly acknowledge the facilities provided by the Department of Biosystems Technology, Faculty of Technology, Eastern University of Sri Lanka, to make this work a success.

Author Contribution

All the authors equally contributed to this study.

Disclosure of Conflicts of Interest

No conflicts of interest are disclosed by the authors.

REFERENCES

Abdulkareem, A. S., & Abdulkareem, M. A. (2019). Effects of biogas slurry fertilizer on soil properties and maize yield in Nigeria. International Journal of Agricultural Science and Research, 9(2), 35–42.

Azam, M. G., Islam, M., Gulandaz, M. A. and Mahmud, J. A. 2013. Effect of Different Source of Nutrients on the Performance, Growth and Quality of Summer Onion. J. Environ. Sci. Nat. Res., 6(1): 159 – 162

Bhattacharjee, S., Sultana, A., Sazzad, M. H., Islam, M. A., Ahtashom, M. M. and Asaduzzaman, 2013. Analysis of the proximate composition and energy value of two varieties of onion (Allium cepa L.) bulbs of different origin: A comparative study. Int. J. Nutri. Food Sci., 2(5):246-253.

Bommesha, B., Naik, M. I., Mutthuraju, G. P., Pannure, A., Imran, S. and Prashantha, P. (2012). Effect of organic manures on biochemical components of pigeon pea (Cajanus cajan (L.) Current Biotica, 6: 171-180.

Central Bank of Sri Lanka. (2017). Annual report 2017. https://www.cbsl.gov.lk/en/reports/annual-reports

Central Bank of Sri Lanka. (2017). Annual report 2017. https://www.cbsl.gov.lk/en/reports/annual-reports

Central Bank of Sri Lanka. (2022). Annual report 2022. Central Bank of Sri Lanka. (2022). Annual report 2022.

Chaudhary, S.K., Yadav, S.K., Mahton, D.K., Azmi, Y., Ranjan, A.N.S. and Sharma, R.P. (2019). Impact of Organic and Inorganic Sources of Nutrients on Growth, Yield Attributes and Yield of Bottle gourd (Lagenaria siceraria (Mol.) Standl.) in Bihar.Journal of AgriSearch, 6: 54-58.

Chhonkar, P. K. (2003). Organic farming: Science and belief. Dr R. V. Tamhane Memorial lecture delivered at the 68th Annual Convention the Indian Society of Soil Science, CSAU and T, Kanpur.

Dang, Q. T., & Tran, Q. D. (2017). The effects of organic fertilizer and inorganic fertilizer on yield and quality of lettuce. International Journal of Agricultural Science and Research, 7(4), 33–42.

Dhaker, B., Sharma, R. K., Chhipa, B.G. and Rathore, R. S. 2017. Effect of different organic manures on yield and quality of onion (Allium cepa L.). Int. J. Current Micro. Applied Sci., 6(11): 3412-3417.

Dibsdall, L. A., Lambert, N., Bobbin, R. F. and Frewer, L. J. (2003). Low-income consumers' attitudes and behaviour towards access, availability and motivation to eat fruit and vegetables. Public health nutrition, 6(2): 159-168.

Dimri, D. C. and Singh, V. P. 2005. Response of FYM, N and row spacing on bulb weight and yield of onion (Allium cepa L.) cv. VL-3. Prog. Hort., 37: 185-187.

Food and Agriculture Organization of the United Nations. (2008). Soil fertility management in sustainable agriculture.

Gaur, A. C. (1991) Bulky Organic Manures and Crop Residues. In: Fertilizers, organic matter recyclable wastes and biofertilizer H. L. S Tandon,Fertilizer development and consultation Organization, New Delhi

Gomez, K.W. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. Willy-Inter Science Publication, New York, USA, pp. 60-65.

Gupta r.k., bhatt r., sidhu m.s., dhingra n., alataway a., dewidar a.z., mattar m.a. evaluating biogas slurry for phosphorus to wheat in a rice–wheat cropping sequence. Journal of soil science and plant nutrition, 23, 3726, 2023. 28.

Habibzadeh, M., & Baghaie, A. (2022). Role of nitrogen (N) in plant growth, photosynthesis pigments, and N use efficiency: A review.

Hartz, T.K., Mitchell, J.P. and Giannini, C. 2000. Nitrogen and carbon mineralization dynamics of manures and compost. Horticulture Science, 35: 209-212.

Jawadagi, R. S., Basavaraj, N., Patil, B. N., Naik, B. H. and Channappagoudar, B. B. 2012. Effect of different sources of nutrients on growth, yield and quality of onion (Allium cepa L.) cv. bellary red Karnataka. J. Agric. Sci., 25(2):232-235. Islam. M. S. 2006.

Kameswari, P., L. and Narayanamma, M. (2011). Influence of integrated nutrient management in ridge gourd (Luffa acutangula). Journal Research Acharya N.G. Ranga Agriculture University, 39(3): 16-20.

Khachi, B., Sharma, S. D., Vikas, G., Kumar, P. and Mir, M. (2015). Study on comparative efficacy of bio-organic nutrients on plant growth, leaf nutrient contents and fruit quality attributes of kiwi fruit. Journal of Applied and Natural Science, 7(1): 175-181.

Khan, A. A., & Ditta, A. (1991). Influence of nitrogen and phosphorus on growth and bulb yield of onion (Allium cepa L.). Scientia Horticulturae, 46(3-4), 251–258.

Kumar, A., Verma, L. M., Sharma, S., & Singh, N. (2022). Overview on agricultural potentials of biogas slurry (BGS): applications, challenges, and solutions. Biomass conversion and biorefinery, 1–41. Advance online publication.

Loria, E. R., Sawyer, J. E., Barker, D. W., Lundvall, J. P., & Lorimor, J. C. (2007). Use of anaerobically digested swine manure as a nitrogen source in corn production. Agronomy Journal, 99(4), 1119–1129.

Mansour, E., Kandil, A. A., Abou-Elenein, R. A., El-Oksh, I. I., & El-Bassiony, A. M. (2022). Nitrogen fertilizer modulates plant growth, chlorophyll pigments, and enzymatic activities under different irrigation regimes.

Mgxaji, Y., Mutengwa, C. S., Mukumba, P., & Dzvene, A. R. (2025). Biogas Slurry as a Sustainable Organic Fertilizer for Sorghum Production in Sandy Soils: A Review of Feedstock Sources, Application Methods, and Agronomic Impacts. Agronomy, 15(7), 1683. https://doi.org/10.3390/agronomy15071683

Mgxaji, Y., Mutengwa, C. S., Mukumba, P., & Dzvene, A. R. (2025). Biogas Slurry as a Sustainable Organic Fertilizer for Sorghum Production in Sandy Soils: A Review of Feedstock Sources, Application Methods, and Agronomic Impacts. Agronomy, 15(7), 1683. https://doi.org/10.3390/agronomy15071683

Nagdev, R., Khan, S. A., & Dhupper, R. (2024). Assessment of Physico-Chemical Properties of Biogas Slurry as an Organic Fertilizer for Sustainable Agriculture. Journal of Experimental Biology and Agricultural Sciences, 12(4), 634–644.

Peu, P., Birgand, F., & MartineZ, J. (2007). Long term fate of slurry derived nitrogen in soil: a case study with a macrolysimeter experiment having received high loads of pig slurry (Solepur). Bioresource Technology, 98(17), 3228–3234.

Raharjo, S. H., & Punja, Z. K. (2009). Bulbing in long-day onion (Allium cepa L.) cultured in vitro: Comparison between sugar feeding and light induction. Scientia Horticulturae, 122(3), 407–413.

Rodriguez-Vila, A., Asensio, V., Forjan, R., & Covelo, E. F. (2016). Assessing the influence of technosol and biochar amendments combined with Brassica juncea L. on the fractionation of Cu, Ni, Pb and Zn in a polluted mine soil. Journal of Soils and Sediments, 16(2), 339–348

Saepudin, A., Wijaya, A. A., Dani, U., & Aaz Azamudin Tifani. (2024). The effect of liquid beef bio-slurry on the growth and yield of red onion plant (Allium ascalonicum L.). Journal of Agronomy Science, 1(1), 53–60.

Shaheb, M.R., Nazrul, M.I. and Khan, A.S.M.M.R. (2017). Agro economic performance of bio-slurry on boro rice cultivation in some sites of Moulvibazar district. Bangladesh.

J. Agril. Res. 42 (2), 357-371

Shi, Z., Yang, Y., Fan, Y., He, Y. and Li, T. (2023). Dynamic responses of rhizosphere microorganisms to biogas slurry combined with chemical fertilizer application during the whole life cycle of rice growth. Microorganisms 11, 1755.

Shil, N.C., Saleque, M.A., Islam, M.R. and Jahiruddin, M. (2016). Soil fertility status of some of the intensive crop growing areas under major agro-ecological zones of Bangladesh. Bangladesh J. Agril. Res. 41, 720–757.

Sun, H., Shi, K., Ding, H., Ding, C., Yang, Z., An, C., Jin, C., Liu, B., Zhong, Z., Xiao, X., & Hou, F. (2023). The effect of biogas slurry application on biomass production and the silage quality of corn. Animal bioscience, 36(12), 1918–1925.