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Impact of Biogas Slurry as a Nutrient Source on Wheat (Triticum Aestivum L.) Production and Soil Health

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Abstract: *Biogas slurry (BGS) obtained from biogas digester, being rich in available nutrients has the potential to alleviate the use of costly inorganic fertilizers and improves the soil health consequently enhancing the crop yields. It has necessitated to generate the nutro-information of biogas slurry in context with its levels as well as its conjunctive application with chemical fertilizer on yield, quality of wheat and soil properties. Therefore a pot study was carried out at PMAS-Arid Agriculture University, Rawalpindi during Rabi 2015-16 to evaluate the effects of different doses of biogas slurry and its co-application with inorganic fertilizers for the improvement of yield and quality of wheat. Six treatments in the study were: T_1= without fertilizer (control), T_2 = chemical fertilizer equivalent to 125Kg N ha^{-1}, T_3 = biogas slurry equivalent to 125Kg N ha^{-1}, T_4 = 50% T_2 + 50% T_3, T_5 = 75% T_2 + 25% T_3, T_6 = 25% T_2 + 75% T_3. Experiment was laid out in complete randomized design with three replications. Results indicated that the treatment where biogas slurry and chemical fertilizer were applied @ 50% each significantly improved the leaf area index (5.82), chlorophyll contents(40.50), root length (12.57), plant height (77.93), number of tillers $plant^{-1}$ (3.33), spike length(10.133 cm) biological yield (13.052 t ha^{-1}), thousand grain weight(2.867 g), grain yield (4.988 t ha^{-1}) and harvest index (38.216) when compared with control. Our results also suggested that the application of combined use of biogas slurry and chemical fertilizer @ 50% each not only has a good strategy for sustainable crop yield but also improved the soil health*

Keywords: *Biogas slurry (BGS), soil pH, ECe, N, growth and grain yield*

INTRODUCTION

Agriculture is crucial for economic growth of the most developing countries, whereby, mostly farmers' use chemical fertilizers to fulfill the crop nutritional requirements. But recently these essential fertilizers are much expensive and, occasionally not accessible in time. Under this situation it is necessary to explore some other sources of nutrients. One of such approaches is the integrated use of organic and inorganic fertilizers, which can decrease the sole reliance on the use of expensive chemical inputs. Among different types of organic and inorganic fertilizers, biogas slurry (BGS) is not only the environment friendly organic fertilizer, but it is also the efficient utilization of waste material in many Asian countries (Kumar *et al.,* 2015).

The BGS is one of the end products of the anaerobic digestion in the biogas plants. It results during anaerobic fermentation of organic matter as a by-product after the process of methane production has been completed (Nasir *et al.*, 2012). Amide assimilation strategy around 25 to 30 % of the aggregate dry matter of creature/human wastes are changed over into a burnable gas and remaining buildup turns out as muck which is known as biogas slurry. The other nomenclature for processed slurry is slurry, bio-slurry, sludge, effluent slurry, bio-fertilizer, organic fertilizers and natural manures. It is an effective source of organic fertilizer containing high amount of nutrients and organic matter (Islam, 2009).

The utilization of biogas slurry as excrement gives two folds favorable position of biogas plant. The stringy and inorganic material which can't process or change over into methane settle down in the biogas plant or turn out through outlet in fluid structure. It is extremely rich in nutritive components including i.e. N, P, K and trace elements such as Ca, Zn, Ni, Fe, Na, B, Co, Cr and Cd (Gupta, 2007). In addition to above biogas slurry also contains organic nitrogen, mineral elements, and bio-active substances like hormones, humic acids and vitamins (Liu *et al.*, 2008).

Pakistan is the largest producer country ranks 9th number in the world in wheat (*Triticum aestivum*) production; representing 3.04% of the world's wheat production from an area of 3.57% of the world Food and Agriculture Organization. Wheat is the main wheat grain of Pakistan and being staple eating routine of the general population and its stubbles encourage to animals. It contributes 14.4% to the worth included farming and 3.1% to GDP. 85% of wheat generation develops in watering system framework (tube well, trenches) and 15% of wheat production in rainfed/ Barani area of Pakistan DAWN, (2014).

In Pakistan wheat is the leading growing crop than cotton, rice and maize. Punjab is the leading province in the wheat production contributes 76% of the total production of country, whereas the shares of Sindh, Khyber PukhtunKhwa (KP) and Baluchistan are 16 %, 5% and 3 % in the total production of the country respectively.

Keeping in view the above stated importance of biogas slurry as a nutrient source the present study was planned with objectives:-

To generate reliable data about the effect of biogas slurry on crops and soil and

To compare the effects of different levels of the biogas slurry as a sole or in conjunction with the chemical fertilizer on wheat crop yield and soil properties.

Materials and Methods

A pot experiment was conducted at research area of PMAS- Arid Agriculture University, Rawalpindi. The soil physico-chemical characteristics of the soil used in pots was analyzed. The selected soil was loamy in texture having organic matter 0.69%, phosphorus 0.56%, potassium 1.2%, soil pH 7.55, saturation rate 36%, and electrical conductivity 0.79. Biogas slurry was obtained from biogas-plant installed at PMAS- Arid Agriculture University, Rawalpindi. Slurry was analyzed for NPK before application to determine its dose for nitrogen. Biogas slurry analyzed by the processes of kjeldahl method (slurry was dried in oven at 60 C^0, after that dried matter grinded by grinding bowl) contained 2.91% Nitrogen, 1.57% phosphorous and 1.15% potassium, pH 7.50 at 24 C^0 and electric conductivity 1.31 dS m^{-1}. The soil was collected, grinded and sieved and mixed with biogas slurry as per treatments. The pots were filled with 8 kg of soil. Half of the chemical fertilizer applied after two days of sowing and remaining half during the tillering stage. Eighteen wheat seeds were sown in each pot which was thinned to ten plants after one month of germination. The experimental

treatments were ordered in a Complete Randomized Design (CRD) and all treatments were replicated three times. Treatments included in the study were:
T_1= control (No addition of N)
T_2= chemical fertilizer (Urea) equivalent to 125Kg N ha^{-1}
T_3= biogas slurry equivalent to 125Kg N ha^{-1}
T_4= 50% T_2 + 50% T_3
T_5= 75% T_2 + 25% T_3
T_6= 25% T_2 + 75% T_3
All the phosphorus and potassium were applied @ 90 and 60 kg ha^{-1} respectively at the time of sowing. The source of N, P and K were di-ammonium phosphate (DAP), urea, and sulphate of potash (SOP) correspondingly. All the cultural practices except treatments were carried out as per requirement. Following soil and growth parameters were recorded at the harvest of crop. Soil pH, electrical conductivity, mineral nitrogen, germination percentage (m^{-2}), days to 50% seedling emergence, leaf area index (LAI), chlorophyll contents (%), root length (cm), plant height (cm), number of tillers $plant^{-1}$, spike length (cm), biological yield (t ha^{-1}), 1000 grain weight (g), grain yield (t ha^{-1}) and harvest index (%).
Data collected on soil parameters and growth parameters were dissected using a computer software statistix 8.1 by utilizing the Fisher's examination of change procedure and noteworthy of treatment levels were tried utilizing least significant difference (LSD) test at 5% probability level.

Results and Discussions

Results showed (Table-1) that the combined use of biogas slurry and chemical fertilizer applied @ 50 % each decreased the soil pH to a minimum level of as compared to the other treatments. Maximum pH value (7.50) was found in control (without amendments) which is statistically at par with T_2 (7.42) where biogas slurry 25% and Chemical fertilizer 75% treatment. Yu, (2005) also accomplished that the application of BGS significantly decreased the soil pH from 8.75 to 8.21 accordingly.
Data presented in the (Table-1) showed that the integrated use of biogas slurry and chemical fertilizer had a significant effect on soil ECe. Soil analysis after harvest of crop showed that the maximum decrease in soil ECe (1.24 dS m^{-2}) was observed in the treatment (T_4) where biogas slurry and chemical fertilizer were applied @ 50% each that was found statistically at par with T_2 (1.32 d S m^{-2}), T_3 (1.29 d S m^{-2}) and T_6 (1.29 d S m^{-2}). Results also indicated that the minimum decrease in soil ECe (1.416 d S m^{-2}) was observed in control (T_1). These results are inconfirmatory to the findings as reported by Rehman *et al.* 2008 that biogas slurry reduced soil ECe because of its higher ability to exchange action's (CEC). Results also revealed that the combined use of biogas slurry and chemical fertilizer maximum N contents were found in treatment T_4 (0.3653) statistically at par with T_2 (0.36) where biogas slurry and chemical fertilizer applied @ 100 , while minimum N contents (0.303%) were observed in T_1(control). Similar results were reported by Balsari *et al.,* (2005) stated that the inclusion of slurry and organic matter is essential for maintaining and improving organic and nitrogen compounds in soil, which decomposed slowly but regularly and upgraded organic matter, and substance of amino acids, solvent sugar, growths and accessibility of N, P and K in the soil (Yu *et al.,* 2010).

Table 1: Post harvest soil analysis

Treatment	pH	ECe	N%
T_1= Control	7.50 a	1.42 a	0.300 d
T_2= Chem fertilizer (100%)	7.42 a	1.32 bc	0.360 a
T_3= BGS (100%)	7.35 b	1.29 bc	0.349 b
T_4= BGS 50% +Che-ferti 50%	7.24 c	1.24 c	0.365 a
T_5= BGS 25% +Che-ferti 75%	7.31 b	1.34 ab	0.336 c
T_6= BGS 75% +Che-ferti 25%	7.33 b	1.29 bc	0.311 d
L.S.D ≤ 5%	0.05	0.09	0.01

Results indicated that the maximum number of days taken to 50% seedling emergence was found in treatment T_2 (7.00) and T_4 (7.00) which were statistically at par with treatment T_3 (6.67), However the minimum number of days taken to 50% seedling emergence were observed in T_1 (6.00) statistically at par with T_6 (6.33) and T_5 (6.33) as shown in Table-2. Similar results were reported by Moselhy & Zahran, (2002) and Shafi *et al.,* (2014) who found that nitrogen application (i.e. organic and inorganic) had little or no consequence on days to emergence. Data regarding leaf area index (Table-2 also showed in Fig 1) indicated that the maximum value of LAI was recorded in T_4 (5.82 cm^2) followed by T_2 (4.84), whereas minimum LAI were recorded in T_1 (24.98 cm^2). These results were in confirmatory with Garg *et al.,* (2005) who concluded that the chemical fertilizers with bio slurry amendment magnified leaf area index, density and plant height of wheat and rice crops.

Data given in (Table-2) revealed that the maximum chlorophyll contents (40.50) were observed in treatment T_4 where biogas slurry and chemical fertilizer applied @ 50% each, followed by T_2 (38.00) where chemical fertilizer applied @ 100%, T_3 (37.00) where biogas slurry applied @ 100% and T_6 (36.20), However the minimum chlorophyll contents were observed in control T_1 (29.067 cm^2) (Showed in Fig 1). Similar consequences were described by Liu *et al.,* (2009) that the BGS significantly improved chlorophyll contents of red Fuji Apple leaves were 3.319% higher than control. Results in line with Xianjun *et al.,* (2008) that the BGS and chemical fertilizer application of 300 mL BGS treatment in the developed period contrasted and fertilizer treatment, the chlorophyll contents % were increased by 6.52% separately and by utilization of BGS with 900 ml at one time. Results (Table-2) indicated that the maximum root length were found in treatment T4 (12.57) followed by treatment T2 (11.50) and T3 (9.90) and minimum root length were found in treatment T1 (without fertilizer). Similar results were reported by Maqbool, (2014) accomplished that the conjunct application of biogas slurry and chemical fertilizer significantly increase root length (23%) over control. Results of this study showed in Table-2 that the maximum plant height were attained in T4 (77.93) followed by T2 (75.40) and statistically at par with T3 (74.23) and T6 (74.07) where biogas slurry applied @ 75% and chemical fertilizer applied @ 25%, while minimum plant height were attained in T1 (without fertilizer. Likely investigated by Maqbool, (2014) that the combined application of biogas slurry and chemical fertilizer significantly increase plant height (15%), root length (23%), fruits per plant (25%) and fruit fresh weight (36%). Budhan et al., (1991) reported that application of cattle manure (slurry) resulted to enhance of spinach plant height.

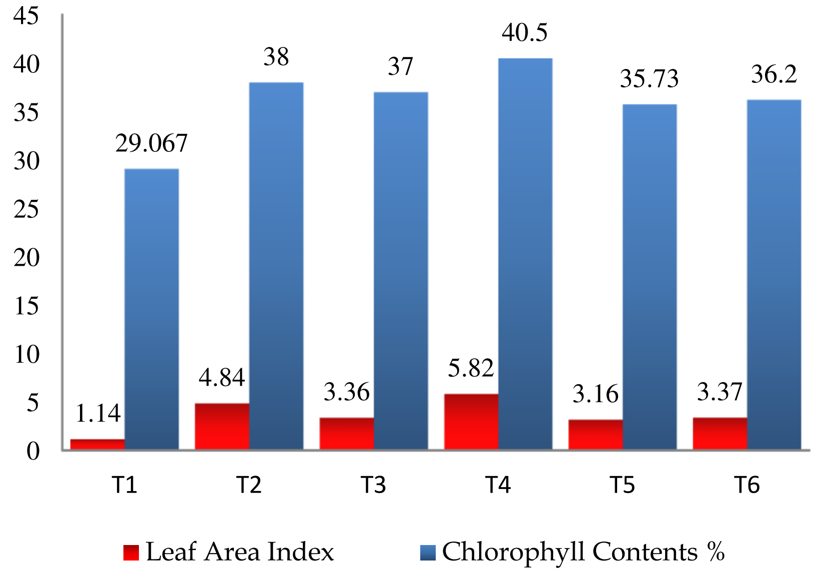

Figure 1: Interactive effect of BGS and chemical fertilizer on LAI and Chlorophyll Contents% in different treatments showed highly significant difference (LSD P<5%)

Table 2: Effect of BGS and chemical fertilizer on wheat growth i.e. Germination% (m^2), D to 50% seedling emergence, LAI, Chlorophyll Contents%, Root length (cm) and Plant height (cm)

Treatments	Germination % (m^{-2})	D to 50 % Emergence	LAI	Chlorophyll Contents %	Root Length (cm)	Plant Height (cm)
T_1= Control	74.077	6.00 c	1.14 e	29.067 e	5.33 e	63.33 d
T_2= Chemical fertilizer (100%)	85.187	7.00 a	4.84 b	38.00 b	11.50 b	75.40 b
T_3= BGS (100%)	75.927	6.67 ab	3.36 c	37.00 bc	9.90 c	74.23 b
T_4= BGS 50% + Che-ferti 50%	92.593	7.00 a	5.82 a	40.50 a	12.57 a	77.93 a
T_5= BGS 25% + Che-ferti 75%	92.590	6.00 c	3.16 d	35.73 d	8.70 d	70.63 c
T_6= BGS 75% + Che-ferti 25%	90.740	6.33 bc	3.37 c	36.20 cd	8.70 d	74.07 b
L.S.D ≤ 5%	NS	0.59	0.03	1.16	0.94	2.24

Data regarding the spike length (Table-3) showed that the biogas slurry and chemical fertilizer were significantly improved the spike. The maximum spike lengths were recorded in T_4 (10.133) where biogas slurry and chemical fertilizer applied @ 50 each, followed by T_3 (9.733), T_2 (9.233) and treatment T_2 at par with T_6 (9.100) while minimum spike length were recorded in treatment T_1 (6.767). Our results are in line with Maqshoof *et al.,* (2014) the combined use of BGS and PGPR in the presence of 100% recommended improving length and weight of maize cob, grown under salt-affected conditions as compared to the sole application. The application of PGPR and biogas slurry was also effective for improving the cob length and cob weight at 0, 50 and 100% of the recommended nitrogen levels. Similar results were stated by Jianhua, (2008) that the BGS used in liquid form improved enhanced notably the yield and quality of the crops (e.g. nutritive elements). BGS maximized spikelet length, grain number and 1000- grain weight. Zamil *et al.,* (2004) reported that the biogas slurry and chemical fertilizers enhanced the yield contributing characters of rice like panicle length; number of grains panicle^{-1} and 1000- grain weight.

In our results (Table-3) maximum number of tillers plant^{-1} were observed in T_4 (3.33) where biogas slurry and chemical fertilizer applied @ 50% each, and at par with T_2 (3.00) followed by T_3 (2.33) and T_6 (2.00) and T_6 at par with T_5 (1.67) respectively, though minimum tillers plant^{-1} were observed in

T_1 (0.33). Results are in line with previous study of Kapil *et al.,* (2016) He concluded that the combined use of 75% RFD (NPKSZnB) + Compost (T_7) and 75% RFD (NPKSZnB) + PM slurry boost up significantly the number of tillers of rice crop. That means that the application of bio slurry along with chemical fertilizers produced similar number of tillers compared to T_7. Our results indicated that the biological yield were significantly affected by treatment T_4 (13.052 t ha^{-1}) where biogas slurry and chemical fertilizer applied @ 50% each, followed by T_2 (12.890 t ha^{-1}) and T_3 (12.691 t ha^{-1}) while the minimum biological yield were observed in treatment T_1 (9.134).

Data presented in the Table-3 showed that the combined application of biogas slurry and chemical fertilizer applied @ 50% each, had the maximum 1000 grain weight were attained in T_4 (52.867 g) followed by T_2 (50.483 g) and at par with T_3 (50.387 g) where chemical fertilizer and biogas slurry applied @ 100% respectively, However the minimum 1000 grain weight were attained in T_1 (40.807). It was in line with Somasundaram *et al.,* (2007) they stated that the maize and sunflower treated by biogas slurry with Panchagavya achieved higher yields. They also reported that the grain green gram yield was higher among the proposed dose treatment, but similar to biogas slurry and Panchagavya (mixture of five products of cow in proper ratio). Similar remarks were reported by Nasir *et al.,* (2010) that The Biogas Slurry applied @ 20 t ha^{-1} improved significantly the different parameters than rest of treatments improved data found in plant height, cob yield, grain yield, thousand grain weight and N, P and K level in the soil.

Data regarding the effects of assimilated use of biogas slurry and chemical fertilizer on grain yield revealed in (Table-3 and Fig 2) maximum results were found significant in treatment T_4 (4.988) where biogas slurry and chemical fertilizer applied @ 50% followed by T_2 (4.421), T_3 (4.332) and T_6 (4.169) respectively, while minimum were found in T_1 (2.033). Our results in line with Islam *et al.,* (2010) concluded that the biogas slurry enhanced production and quality of maize fodder. Wu *et al.,* (2013) also reported that application of biogas slurry to oilseed rape increased protein, iron, manganese, copper and zinc content of the rapeseed and yield of the rape plant. Lina *et al.,* (2011) reported that application of biogas slurry to rice field resulted similar or slightly higher yield as compared to chemical fertilizers. Zhao *et al.,* (2007)

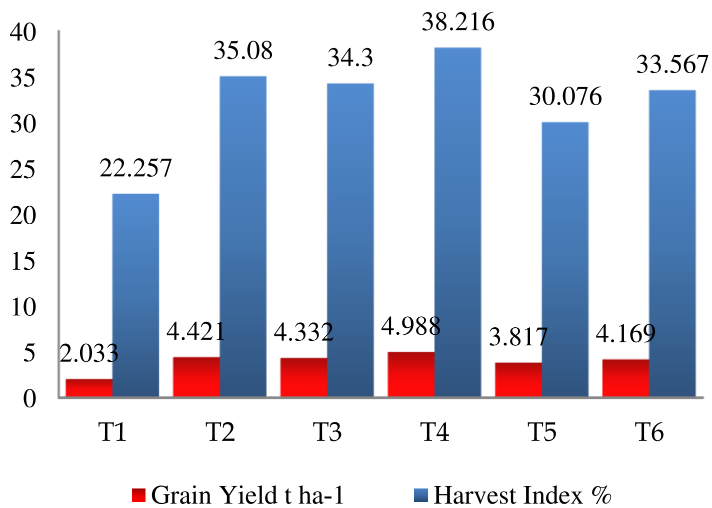

Figure 1: Interactive effect of BGS and chemical fertilizer on Grain Yield ton ha^{-1} and Harvest Index% in different treatments showed highly significant difference (LSD P<5%)

Table 3: Effect of BGS and chemical fertilizer on wheat growth and yield i.e. Spike length (cm), No of tillers/plant, Biological yield/t ha, 1000-grain yield (g), Grain yield/t ha and Harvest index%

Treatments	Spike Length (cm)	No of Tillers Plant^{-1}	Bio-yield t ha^{-1}	1000-grain Weight (g)	Grain Yield t ha^{-1}	Harvest Index %
T_1= Control	6.767 d	0.33 d	9.134 f	40.807 e	2.033 f	22.257 f
T_2= Chemical fertilizer (100%)	9.733 ab	3.00 ab	12.890 b	50.483 b	4.421 b	35.080 b
T_3= BGS (100%)	9.233 bc	2.33 bc	12.691 c	50.387 b	4.332 c	34.300 c
T_4= BGS 50% +Che-ferti 50%	10.133 a	3.33 a	13.052 a	52.867 a	4.988 a	38.216 a
T_5= BGS 25% +Che-ferti 75%	8.800 c	1.67 c	12.349 e	47.757 d	3.817 e	30.076 e
T_6= BGS 75% +Che-ferti 25%	9.100 bc	2.00 c	12.421 d	48.407 c	4.169 d	33.567 d
L.S.D ≤ 5%	0.8511	0.8386	0.0325	0.5923	7.2630	2.2099

Investigated different concentrations BGS spraying on Chili peppers of the leaves surface significantly maximized by using 50% concentration spraying slurry has yielded 25.42% maximum over control. The results concerning the effect of BGS and chemical fertilizer on harvest index (HI) were shown in (Fig 2 and Table-3). The maximum harvest index (HI) were obtained in treatment T_4 (38.216) where biogas slurry and chemical fertilizer applied @ 50% each, followed by T_2 (35.080) where chemical fertilizer applied @ 100%, While the minimum HI were obtained in the treatment T_1 (22.257). Our results concur with the findings of the Akanbi *et al.,* (2010) Used bio-slurry with N fertilizer significantly improved harvest index compared to control (without fertilizers).

Conclusion

It was concluded that the integrated use of BGS and chemical fertilizer @ 50% each not only enhanced the growth, yield and yield components but also improved the soil health.

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