Comparative Study on the Effect of Applying Biogas Slurry and Inorganic Fertilizer on Soil Properties, Growth and Yield of White Cabbage (Brassica oleracea var. capitata f. alba)

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Abstract
The use of locally available, nutrient rich organic sources is an effective means for improving soil fertility and increasing crop yield in view of the escalating cost of inorganic fertilizers and low fertilizer use efficiency of crops in Ethiopia. This study was conducted in Sebeta Hawas Woreda with the objective of comparing the effectiveness of bio-slurry and inorganic fertilizer on soil properties, growth and yield of white cabbage. Laboratory analysis and field experiment were done on bio-slurry in liquid and composted form to determine the nutrient content and effect of bio-slurry and inorganic fertilizer on plant height, number of leaves, head yield and nutrient content of cabbage as well as physical and chemical properties of the soil. The maximum plant height (cm) was obtained from T6 (recommended dose of inorganic fertilizer (RDIF) + biogas slurry compost (BGSC) at (8ton/ha), while the lowest plant height (cm) was recorded in T1 (control). Cabbage plants treated with T7 ((1/2 RDIF) + (½ BGSC)), T6 ((RDIF) + BGSC at 8ton/ha),T5 (BGSC at (8ton/ha)) and T6 showed the highest number of leaves at 2,4,6 and 8 weeks after planting respectively. With regard to fresh weight of individual head, T6 showed the highest value for fresh weight of individual head. Considering major nutrient content of white cabbage, it can be inferred that bio-slurry and inorganic fertilizer showed no significant effects on leaf phosphorous and potassium value but bio-slurry applied in combination with inorganic fertilizers has positive influence on nitrogen content. The study also revealed that there was significant contribution of bio-slurry to increase organic carbon, phosphorus and cation exchange capacity of soil.
Keywords: Growth, head yield, soil properties, bio-slurry, fertilizer

1. INTRODUCTION

Vegetables are very significant sources of vitamins, minerals and plant proteins in human diet all over the world. Vegetable cultivation is one of the most efficient and major branches of agriculture and of economic value as well. At the same time, vegetable cultivation is becoming more costly due to the increasing use of purchased inputs such as pesticides and fertilizers to sustain production levels (Muhammad, 2011).

Cabbage (*Brassica oleracea* var. *capitata* f. *alba*) is an important vegetable cultivated and consumed by both urban and rural dwellers in Ethiopia. Cabbage is regarded as a good source of vitamins, fibre, glutamine, minerals and anti-oxidant which are useful for normal functioning of body systems and prevention of cancer (Knavel and Herron, 2000).

In spite of its economic and health importance, the optimum production of cabbage in Ethiopia has not been attained because of difficulty in the increasing cost of purchased fertilizers to sustain production levels. Despite, its importance, the fertilizer use per hectare of crop land in Ethiopia is very low (14.7 kg) when compared with the world average which is 82.4 Kg (Haile Wassie, 2012). Therefore, biogas technology that can produce methane gas for cooking and lighting as well as organic, nutrient-rich bio-slurry for use as a fertilizer is among the best options of making maximum use of these scarce resources. The slurry that is obtained after extraction of the energy content of animal manure is still an excellent fertilizer, rich in major nutrients (nitrogen, phosphorous and potassium) and organic matter (humus) that determine the soil fertility and yield of different crops and vegetables. Due to the decomposition and breakdown of parts of its organic content, digested slurry provides fast-acting nutrients that easily enter into the soil solution, thus becoming immediately available to plants (Gaur *et al*., 1984).

It seems that there is a general consensus on the ability of biogas slurry to improve the physical and biological quality of soil besides providing both macro and micro-nutrients to crops and vegetables. At the same time it prevents adverse environmental impacts of waste disposal. Application of bio-slurry also helps in reduction of dependence on mineral fertilizers (Karki, 1997).

The present investigation with cabbage (*Brassica oleracea* var.*capitata* f.*alba*) was undertaken to evaluate the effect of bio-slurry singly or in combination with chemical fertilizers and compare it with the efficiency of chemical fertilizer under Ethiopian condition.

2. MATERIALS AND METHODS

The experiment was conducted in Sebeta-Hawas woreda, which is found in South-West Shoa Zone. It is found

25 km South-West of Addis Ababa.

The treatments used on cabbage field were inorganic fertilizers, slurry compost and liquid digested slurry. To test fertilizer effect two levels of inorganic fertilizers (Urea, Diamonium phosphate and Murate of Potash) (recommended dose and half less than the recommended dose) and for the bio-slurry a dose of 8ton/ha was tested and also the interactions of inorganic fertilizers and bio-slurry was tested. The slurry compost was added at the planting time. Concerning liquid slurry split application was used, half dose of liquid slurry was added during planting (just after planting) and the remaining half dose was added after a month of the planting date.

The experiment was conducted in a randomized complete block design (RCBD) with three replications (Lentner and Bishop, 1993).

Soil samples were taken at 15 cm depth by using soil auger. The soil samples were mixed well in a plastic bag and 100gm of representative sample was taken. For bulk density determination core sampler with cylindrical core was used.

A total of 4 households were chosen for collecting the liquid slurry and slurry compost samples for physicochemical analyses. The analysis of liquid digested slurry and slurry compost involved determining the pH, organic matter, major nutrients (N, P, and K).

Five plants were randomly selected from each unit plot for the collection of data. Height of five cabbage plants was measured in centimeter (cm) with the help of measuring tape from soil surface to the top of plants. Average plant height of all three replications was calculated. On the same plants where cabbage height data was collected, the numbers of fully expanded leaves were also counted and readings were recorded as number of leaves per plant (Mbatha, 2008). After the completion of harvesting, three cabbages were selected randomly from each unit plot. Then cabbage head weight was recorded with the help of electrical balance, and mean was calculated (Mbatha, 2008).

Before conducting the trial, representative samples of the soil in the study site were analyzed to obtain first hand information on the soil properties like pH, N, P, K, OM, CEC, and BD.

After the experiment soil samples were taken in order to determine the soil properties improvement because of bio-slurry and inorganic fertilizer application.

3. RESULTS AND DISCUSSION

3.1. Nutrient content of liquid digested slurry and slurry compost

Physicochemical analysis of liquid digested slurry and slurry compost was conducted to determine the pH, organic matter and major nutrients (N, P and K).

pH

The pH of digested liquid slurry ranged between 7 and 9.09. On the other hand, the pH of slurry compost ranged from 6.95 to 8.60. This result has no similarity with the pH result reported by Dhobighat and Painyapani (2006), which report that the pH of liquid digested slurry ranges from 6.8 to 6.9 and pH of the slurry compost ranges between 6.6 and 7.0.

Organic Matter

The organic matter in digested liquid slurry ranged between 57.1 percent and 87.9 percent. On the other hand, in slurry compost ranged between 14.37 percent and 53.8 percent. This result agrees with the result reported by Dhobighat and Painyapani (2006) and Mohabbat *et al*. (2008). The result of Dhobighat and Painyapani (2006) indicates that the OM content of liquid digested slurry ranges between 61.2 percent and 73.3 percent while the OM content of slurry compost ranges between 43.4 percent and 55.27 percent. Mohabbat *et al*. (2008) also reported that the OM content of liquid digested slurry ranges between 16.44 percent and 44 percent while the OM content of slurry compost ranges between 21 percent and 23 percent. But the result of this study is different from the result reported by Tennakoon and Hemamala (2003) and Zebider Alemneh (2011). The result of Tennakoon and Hemamala (2003) reported that the slurry compost have the higher organic matter content than that of liquid digested slurry. The report indicates that the OM content of the liquid digested slurry ranges between 46.5 percent and 49.9 percent while that of the slurry compost ranges between 25.9 percent and 68.9 percent. Zebider Alemneh (2011) also reported that the OM content of liquid digested slurry ranges between 1.86 percent and 35.34 percent while the OM content of slurry compost ranges between 39.82 percent and 70.60 percent.

Total Nitrogen

From this study, the total nitrogen (TN) in liquid digested slurry was found to be the highest, which ranges between 2.20 percent and 3.60 percent. The total nitrogen content of slurry compost was found to be in the range between 0.78 percent and 2.55 percent. This result coincides with the result of Dhobighat and Painyapani (2006) which reported that the liquid digested slurry contain higher total nitrogen than slurry compost, for liquid digested slurry the TN content ranges between 1.76 percent and 2.02 percent and for slurry compost it ranges between 1.54 percent and 1.76 percent but the TN content result of the liquid digested slurry and slurry compost in this study exceed the result reported by Dhobighat and Painyapani (2006). TN content of the two organic manures as reported by Tennakoon and Hemamala (2003) is also in agreement with the result of this study in which the liquid digested slurry contains the higher TN value than that of slurry compost, which report that TN content of liquid digested slurry and slurry compost ranges from 1.7 percent to 2.0 percent and 1.3 percent to 1.7 percent respectively. But TN value result of the liquid digested slurry and slurry compost in this study exceeded that of Tennakoon and Hemamala (2003).

Available Phosphorous

Phosphorus (P) is vital to plant growth and is found in every living plant cell. The value of available Phosphorous in digested liquid slurry ranged between 0.7 percent and 0.95 percent, the available P content of slurry compost was between 0.13 percent and 0.8 percent. This indicates that the liquid digested slurry has the higher available P content. This result is also in agreement with the result reported by Dhobighat and Painyapani (2006) and Zebider Alemneh (2011). The result of Dhobighat and Painyapani (2006) indicates that the available P content of liquid digested slurry ranges between 1.74 percent and 1.95 percent, while that of the slurry compost ranges between 0.87 percent and 1.50 percent. Zebider Alemneh (2011) also reported that the available Phosphorous in digested liquid slurry ranges between 0.76 percent and 0.98 percent, the available P content of slurry compost ranges between 0.60 percent and 0.85 percent.

Available Potassium

Potassium (K) is a key nutrient for plant growth. The value of available potassium in digested liquid slurry ranges between 0.13 % and 0.5%, the available K content of slurry compost ranges between 0.46 % and 2 %. This indicates that the available K contained in slurry compost is higher than that of liquid digested slurry. This result is also in agreement with the result reported by Zebider Alemneh (2011) who reported that the available Potassium in digested liquid slurry ranges between 0.3 percent and 0.39 percent, while the available Potassium content of slurry compost ranged between 0.4 percent and 1.04 percent.

Carbon to nitrogen ratio (C: N)

The value of C: N ratio in digested liquid slurry ranges between 9.20 and 19.54, the C: N ratio content of slurry compost ranges between 8.36 and 16.17. This indicates that the C: N ratio in liquid digested slurry is higher than that of slurry compost. The lower the C: N ratio of liquid digested slurry accelerates the N mineralization process. This, in turn, helps the uptake of N by vegetables.

3.2. The effect of inorganic fertilizer and bio-slurry on growth parameters

3.2.1. Plant height

Bio-slurry and inorganic fertilizer showed significant effects on cabbage mean plant height overall sampling times at $p\leq 0.05$ level of probability.

The statistically analyzed data clearly indicated that application of bio-slurry and inorganic fertilizer affected the plant height.

At 2 weeks after planting (WAP), the highest plant height (15cm) was observed in T6 while minimum plant height (10.37 cm) was observed in control though this was not significantly different from T2 and T3.

At 4 WAP, the highest plant height (19.07cm) was observed in T6 while minimum plant height (10.37 cm) was observed in control though this was not significantly different from T3.

At 6 WAP, the highest plant height (20.5cm) was observed in T6 which was not significantly different from T4 (20cm) while minimum plant height (12.4 cm) was observed in control which was not significantly different from T2 and T3.

At 8 WAP, the highest plant height (21.73cm) was observed in T6 while minimum plant height (12.4 cm) was observed in control.

The mean plant height results are compared among themselves. Biogas slurry in liquid form increased mean plant height ranging from 27.7 to 30.5 %, 43.7 to 51.5 %, 50.7 to 57.5% and 47.7 to 58.2% over inorganic fertilizer treatment at 2, 4, 6 and 8 weeks respectively. Similarly the liquid slurry increased mean plant height 8.6 %, 17.4 % ,3.3 % and 5.2 % over slurry compost at 2, 4, 6 and 8 weeks respectively. The combination of slurry compost and full dose of fertilizer (T6) increased mean plant height 41.1%, 64.4 %, 54.5 % and 53.4% over full dose of inorganic fertilizer at 2, 4, 6 and 8 weeks respectively. Likewise, the half dose of inorganic fertilizer with half of the slurry compost (T7) decreased mean plant height 23.5 %, 35%, 7% and 10 % over full dose of inorganic fertilizer with 8ton/ha of slurry compost at 2, 4, 6 and 8 weeks respectively.

3.2.2. Leaf number

The application of bio-slurry and inorganic fertilizer on cabbage leaves at weeks 2, 4 ,6 and 8 weeks after planting shows significant effects at $p\leq 0.05$ level of probability .

At 2 weeks after planting (WAP), plants with inorganic fertilizer (1/2 Recommended dose) + ½ Biogas slurry compost (T7) recorded the highest number of leaves though this was not significantly different from T4, T5, T6, T1 and T2 The lowest values of leaf number was obtained by no bio-slurry and inorganic fertilizer (T1).

At 4 WAP, plants with T6 recorded the highest number of leaves though this was not significantly different from T2, T4, T5 and T7. The lowest values of leaf number was obtained by no bio-slurry and inorganic fertilizer (T1). This was not significantly different from T3.

At 6 WAP, plants with T5 recorded the highest number of leaves though this was not significantly different from T4. The lowest values of leaf number was obtained by no bio-slurry and inorganic fertilizer (T1).

At 8 WAP, plants with T6 recorded the highest number of leaves though this was not significantly different from T2, T3, T4, T5 and T7 .The lowest values of leaf number was obtained by no bio-slurry and inorganic fertilizer (T1).

3.3. The effects of inorganic fertilizer and bio-slurry on head yield

Cabbage yield was significantly influenced by bio slurry and inorganic fertilizer at $p \leq 0.05$. The maximum yield was recorded by plants supplied with inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha (T6). All treatments can be arranged in decreasing order as follows: T6> T5 > T4 > T2>T7 > T3. The lowest values of Cabbage yield was obtained by no bio-slurry and inorganic fertilizer treatment. Application of inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha (T6) has resulted into the highest yield increment of 66.7 % compared to the control (Tl). Similarly, the second highest yield increment (57.5%) was brought about with biogas slurry compost at 8ton/ha (T4). On the other hand, addition of recommended dose of inorganic fertilizer (T2) and inorganic fertilizer (1/2 Recommended dose) + ½ biogas slurry compost (T7) gave almost the same yield increment 20.44 % and 20.2%, respectively. While there was only 14.6 % increase in the yield of cabbage over the control due to application of 1/2 recommended dose of chemical fertilizer (T3).

The yield results are compared among themselves. Biogas slurry in liquid form yielded 18.2 percent higher than the half dose of in organic fertilizer treatment. Similarly slurry compost produced 16.3 percent higher than the liquid slurry whereas full dose of inorganic fertilizer produced 30.8 percent lower than the slurry compost. The combination of slurry compost and full dose of fertilizer (T6) produced 38.4 percent higher yield than full dose of inorganic. Likewise, the half dose of fertilizer with half of the slurry compost (T7) was 38.7 percent inferior to full dose of inorganic fertilizer with 8ton/ha of slurry compost. This result is in line with the result of Singh *et al*. (1995) who reported that the combination of fertilizer and bio slurry significantly increased the yield of rice, corn, soybeans and okra.

3.4. The effect of inorganic fertilizer and bio-slurry on nutrient content (NPK) of cabbage

Bio-slurry and inorganic fertilizer showed significant effects on leaf nitrogen content .The highest leaf N content (1.18%) was produced when the greatest dose of both bio-slurry and inorganic fertilizer was applied; while the lowest (0.7%) produced by control treatment.

Leaf P and K contents were not significantly affected by bio-slurry and inorganic fertilizers, except leaf K content was significantly higher at T7. However, the differences among fertilizers were found non significant.

3.5. Effect of bio-slurry and inorganic fertilizer application on soil properties

pH

The pH of the soil after the application of the bio-slurry in liquid and composted formdecreased but the change is not significant. This result agrees with the result of Muhammad (2011) which report that the application of liquid digested slurry and slurry compost slightly improve the pH of soil but the improvement is not significant. The change in soil pH is very effective to plants as most of the essential elements, for instance, phosphorus is dependent upon soil pH. In the same way calcium, magnesium and molybdenum also are affected by pH and affect the plant growth (Sankaran and Swaminatiian, 1988).

Organic Matter (OM)

The organic matter content of the soil before the experiment was 2.65, after the experiment the soil treated with slurry compost contained higher OM than the soil before experiment and soil treated with inorganic fertilizer. This is because the compost was mixed with different organic wastes like crop residues, old compost and soil during composting process (Fentaw Ejigu, 2010). The soil treated with liquid digested slurry contained lower OM content than the soil treated with slurry compost but it is better than the organic matter content of the soil before the experiment and soil treated with inorganic fertilizer. Therefore the application of bio-slurry in the two different forms increases the soil organic matter content than inorganic fertilizer. This result is not in line with the result of Muhammad (2011) which reported that application of bio-slurry in liquid and composted form brought no change in the organic matter content of the soil.

Nitrogen

The nitrogen content of the soil before the experiment was 0.27, after the experiment the soil treated with half recommended dose of inorganic fertilizer contained higher N than the soil before experiment and soil treated with two forms of bio slurry. Although the content of total N in the soil is high, the contribution made by the application of such a high dose of bio slurry did not leave any notable amount of residue. This is mainly because cabbage (*Brassica oleracea* var. *capitata*) is a heavy feeder of nitrogen and potassium (Hemy, 1984). The result of this study agrees with the result of Krishna (2001) which reported that the application of liquid digested slurry and slurry compost does not show any change to soil. The result of this study is also not in agreement with the result of Zebider Alemneh (2011) who reported that the application of liquid digested slurry and slurry compost change TN content of the soil.

Cation Exchange Capacity (CEC)

Application of bio-slurry in the two different forms increased the cation exchange capacity of the soil before experiment. However higher amount of cation exchange capacity has been observed where inorganic fertilizer was applied. This result partially in line with the result of Zebider Alemneh (2011) who reported that application of digested liquid slurry and slurry compost increased the CEC of the soil.

Phosphorus

Application of bio-slurry in the two different forms showed difference in the available P content of the soil before experiment. However higher amount of available P has been observed where inorganic fertilizer was applied. Available phosphorus content in the soil with nothing added and ½ less the recommended dose of inorganic fertilizer +1/2 compost at dry form (T7) shows lower P value than the soil P value before experiment .The available P content in the soil after cabbage harvest show change. This result disagree with the result of Muhammad (2011) which report that application of mineral fertilizer and bio slurry had shown positive contribution on the availability of N and K content in soil, whereas the P content in the soil has shown no significant change. This result also in line with the result of Zebider Alemneh (2011) who reported that application of bio-slurry in the two different forms showed significant difference in the available P content of the soil.

Potassium

Application of bio-slurry and inorganic fertilizer did not show improvement of the potassium content of the soil before experiment . This is mainly because cabbage (*Brassica oleracea* var. *capitata* f.*alba*) is a heavy feeder of nitrogen and potassium (Hemy, 1984). This result disagree with the result of Muhammad (2011) which report that application of mineral fertilizer and bio slurry has showed positive contribution on the availability of potassium content of soil.

Bulk Density

The bulk density of the soil before the experiment was 1.33, after the experiment the soil treated with two forms of bio slurry decreased BD of the soil than inorganic fertilizer treated soil but the change is not significant. This is in line with the result of Zebider Alemneh (2011) which reported that application of the bio-slurry in liquid and composted form decreased BD of soil but the change is not significant.

4. CONCLUSION

Biogas slurry is an effective fertilizer as compared to chemical fertilizer because of the following reasons.

1. Biogas slurry gave better growth and yield parameters as compared to inorganic fertilizers. However the best results were observed in case of bio slurry combination with recommended chemical fertilizer.
2. Biogas slurry is a good efficient amendment for improving the physical, chemical and nutritional properties of the soil and it is environmentally friendly, whereas continuous use of chemical fertilizer alone, without the addition of organic fertilizer, has been found to have detrimental effect on soil quality in the long run mainly because of constant loss of humus and micronutrients.

Therefore, this research breakthrough had opened the opportunities for both small scale and commercial farmers to produce cabbage by bio slurry than inorganic fertilizer for home consumption and export trade in Ethiopia.

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Table 1. Comparison of pH, Organic Matter, C: N and NPK value of bio-slurry

Parameters	Unit	Liquid digested slurry				Slurry compost				Sig.
		Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D	($P \leq 0.05$)
pH	-	**7**	9.09	7.59	1.01	6.95	8.6	7.77	0.87	0.839
OM	% dry weight	57.1	87.9	72	12.78	14.37	53.8	36.55	17.3	0.025
TN	% dry weight	2.2	3.6	2.84	0.58	0.78	2.55	1.8	0.77	0.077
P	% dry weight	0.7	0.95	0.85	0.1	0.13	0.8	0.6	0.31	0.105
K	% dry weight	0.13	0.5	0.38	0.08	0.46	2	0.97	0.72	0.213
C:N	-	9.20	19.54	15.36	4.55	8.36	16.17	11.87	3.28	0.391

Table 2. Effect of bio-slurry and inorganic fertilizer on mean height (cm) of cabbage (*Brassica oleracea* var.*capitata* f.*alba*)

Treatments	Treatment detail	Mean plant height in cm at different weeks			
		Weeks 2	Weeks 4	Weeks 6	Weeks 8
T1	Control (No inorganic fertilizer and bio-slurry)	10.37^{a}	10.37^{a}	12.40^{a}	12.40^{a}
T2	Recommended dose of inorganic fertilizer (100kg of DAP , 50kg urea and 50Kg Murate of potash) per hectare	10.63^{a}	11.60^{bc}	13.27^{a}	14.17^{c}
T3	1/2 of recommended dose of inorganic fertilizer	10.40^{a}	11^{ab}	12.70^{a}	13.23^{b}
T4	Biogas slurry in liquid form (8ton/ha).	13.57^{d}	16.67^{e}	20^{cd}	20.93^{e}
T5	Biogas slurry compost (8ton/ha)	12.50^{c}	14.20^{d}	19.37^{bc}	19.90^{d}
T6	Inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha	15.00^{e}	19.07^{f}	20.50^{d}	21.73^{f}
T7	Inorganic fertilizer (1/2 Recommended dose) + ½ Biogas slurry compost at 8ton/ha	11.47^{b}	12.40^{c}	19.07^{b}	19.60^{d}

Means with in a column followed by the same letter are not significantly different according to Duncan's multiple range test (DMRT) at ($P \leq 0.05$).

Table 3. Effect of bio-slurry and inorganic fertilizer on cabbage leaves

Treatments	Treatment detail	Mean cabbage leaves number in different weeks			
		Weeks 2	Weeks 4	Weeks 6	Weeks 8
T1	Control (No inorganic fertilizer and bio-slurry)	6.00[a]	8.33[a]	10.00[a]	14[a]
T2	Recommended dose of inorganic fertilizer (100kg of DAP , 50kg urea and 50Kg Murate of potash) per hectare	6.67[ab]	12.00[bc]	12.00[b]	17.00[b]
T3	1/2 of recommended dose of inorganic fertilizer	6.33[ab]	9.33[ab]	12.00[b]	16.67[b]
T4	Biogas slurry in liquid form (8ton/ha)	7.00[ab]	10.00[abc]	15[c]	16.67[b]
T5	Biogas slurry compost (8ton/ha	7.33[ab]	11.33[abc]	16[c]	18.77[b]
T6	Inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha	7.00[ab]	12.67[c]	13.00[b]	19.00[b]
T7	Inorganic fertilizer (1/2 Recommended dose) + ½ Biogas slurry compost at 8ton/ha	8.00[b]	11.00[abc]	13.33[b]	17.63[b]

Means with in a column followed by the same letter are not significantly different according to Duncan's multiple range test (DMRT) at ($P\leq 0.05$).

Table 4. Yield of cabbage due to application of bio-slurry and inorganic fertilizer

Treatments	Treatment detail	Yield Kg/9m^2	Yield (Ton/ha)	Increment in yield **over control (percent)**
T1	Control (No inorganic fertilizer and bio-slurry)	14.4	160	0
T2	Recommended dose of inorganic fertilizer (100kg of DAP , 50kg urea and 50Kg Murate of potash) per hectare	17.34	192.7	20.44
T3	1/2 of recommended dose of inorganic fertilizer.	16.5	183.3	14.6
T4	Biogas slurry in liquid form (8ton/ha)	19.5	216.7	35.4
T5	Biogas slurry compost (8ton/ha)	22.68	252	57.5
T6	Inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha	24	266.7	66.7
T7	Inorganic fertilizer (1/2 Recommended dose) + ½ Biogas slurry compost at 8ton/ha	17.31	192.3	20.2

Table 5.Bio-slurry and inorganic fertilizer effect on cabbage (NPK)

Treatments	Treatment Detail	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T1	Control (No inorganic fertilizer and bio-slurry)	0.7[a]	0.55[a]	1.73[a]
T2	Recommended dose of inorganic fertilizer (100kg DAP , 50kg urea and 50 kg Murate of potash) per hectare	0.83[ab]	0.48[a]	2.05[a]
T3	1/2 of recommended dose of inorganic fertilizer	0.72[a]	0.65[a]	2.06[a]
T4	Biogas slurry in liquid form at 8ton/ha	0.85[ab]	0.51[a]	2.7[a]
T5	Biogas slurry compost at 8ton/ha	0.85[ab]	0.33[a]	2.7[a]
T6	Inorganic fertilizer (Recommended dose) + Biogas slurry compost at 8ton/ha	1.18[b]	0.37[a]	2.1[a]
T7	1/2 inorganic fertilizer (Recommended dose) +1/2 biogas slurry compost (8ton/ha)	1.03[ab]	0.4[a]	4.35[ab]

Means with in a column followed by the same letter are not significantly different according to Duncan's multiple range test (DMRT) ($P \leq 0.05$).

Table 6. Residual effect of bio-slurry and inorganic fertilizer on soil after Cabbage harvest

Treatment	**Treatment detail**	**pH**	**OM %**	**N %**	**P mg/ Kg Soil**	**K mg/ Kg Soil**	**CEC cmol(+)/ Kg soil**	**Bulk Density g/cm^3**
A	Before experiment	7.65	2.65	0.27	63.7	70	20.6	1.33
B	After experiment							
T1	Control	7.03	2.35	0.18	36	38.8	27.9	1.4
T2	Recommended dose of inorganic fertilizer (100Kg DAP,50Kg Urea and 50 Kg Murate of potash) per hectare	7.8	2.65	0.25	81.3	51.9	33.1	1.35
T3	½ less than the recommended dose of fertilizer	7.2	2.9	0.29	77.33	53.7	31.4	1.35
T4	Biogas slurry in liquid form at 8ton/ha	7.5	3.1	0.2	65.3	49.5	26.6	1.26
T5	Biogas slurry compost at 8ton/ha	7.32	3.2	0.24	66	63.5	24	1.31
T6	Recommended dose of inorganic fertilizer +bio-slurry compost at 8ton/ha	7.3	2.8	0.19	65.3	44.4	29	1.3
T7	½ less the recommended dose of inorganic fertilizer +1/2 bio-slurry compost (8ton/ha)	7.1	2.53	0.2	48	41.82	29.63	1.35