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RESEARCH PAPER

The potentiality of using bio-slurry as organic manure for cabbage production

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ABSTRACT

Vegetable cultivation is becoming more costly due to the increasing use of purchased inputs. Bio-slurry is a by-product of anaerobic digestion of biogas plant that will be the alternative to chemical inputs. A field experiment was conducted at Bangladesh Agricultural University (BAU) farm Mymensingh with an objective to evaluate the performances of poultry manure bio-slurry and cowdung bio-slurry in cabbage production. There were seven treatments which includes T_1 (Control), T_2 (100% NPKS), T_3 (70% NK), T_4 (70 % NK+ PM bio-slurry), T_5 (70 % NK+CD bio-slurry), T_6 (70 % NK+PM) and T_7 (70% NK+CD). Treatment effects were examined on plant height; unfold leaves, length of breath, root length, head diameter, % marketable head, marketable head weight, head yield, and N, P, K & S uptake by the crops. There was a significant positive effect of the treatments on yield, yield components, and nutrient uptake of cabbage. Treatments T_4 (70%NK+poultry manure bio-slurry) and T_6 (70%NK+poultry manure) produced significantly higher crop yield and nutrient uptake over sole chemical fertilizers (T_2:100%NPKS). Between the digested and fresh sources, digested sources gave better results. Again, among the two sources, poultry bio-slurry and poultry litter performed better than the cowdung and their bio-slurry. The overall results indicate that it is possible to reduce 30% of the recommended N & K fertilizers and 100% of the P & S fertilizers through the use of poultry or cowdung bio-slurry in cabbage production. Integrated use of inorganic fertilizers with organic manures not only sustains the crop production but also the effective in improving soil health.

Key words: Bio-slurry, Yield, Nutrient uptake, Cabbage

Introduction

Cabbage (*Brassica oleracea var. capitata f. alba*) is an important vegetable cultivated and consumed by both urban and rural dwellers in Bangladesh. Cabbage is a good source of vitamins, glutamine, minerals and anti-oxidant which are useful for normal functioning of body systems (Knavel and Herron, 2000). 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). Bio-slurry is one of the organic sources which have been obtained as byproduct of fermented biogas which is generated through the anaerobic decomposition of various organic materials that can be used for crop production (Mosquera *et al.*, 2000; Abubaker 2012; Haque *et al*., 2015, Haque *et al*., 2018). Maintenance of soil fertility is a prerequisite for long term sustainable crop production and it is certain that organic manure (e.g. bio-slurry) can play a vital role in the sustainability of soil fertility and crop production (Shankarappa *et al.*, 2012; Khan *et al.*, 2015). 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 (Yalemtsehay and Itana, 2016). 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). Neither organic manure nor chemical fertilizer alone is enough to meet the demand of soil-plant systems (Rahman, 2013). Integrated use of inorganic fertilizers with organic manures not only sustains the crop production but also the effective in improving soil health and enhancing nutrient use efficiency (Verma *et al.,* 2005; Ali *et al.,* 2009). Cowdung and poultry manure, their slurry could be a potential source of organic fertilizer to support soil health and crop productivity. The present investigation was undertaken to evaluate the performance of biogas slurry as organic fertilizer on growth and yield of cabbage (*Brassica oleracea var.capitata f.alba).*

Materials and methods

Description of the study area and soil sampling

The experiment was carried out during 2015–2016 at the Soil Science field laboratory of Bangladesh Agricultural University (BAU) Mymensingh. The experimental field was located 24.75° N latitude and 90.5° E longitude with an elevation of 18 m from the sea level. The experimental location is characterized by sub-tropical humid weather conditions. The mean annual rainfall of the experimental area during 2015-2016 was around 2200 mm; temperature range was 20.1°C to 29.5°C and 73.2% relative humidity were recorded during the study period. The studied soil belongs to 'Sonatala' soil series an Inceptisol (FAO, 1988) under the AEZ 9 (Old Brahmaputra Floodplain) and characterized by Non-Calcareous Dark Grey Floodplain Soil. Before starting the experiment soil samples were collected from 10 spots of the experimental site. Samples were air-dried at room temperature for two weeks, then ground and homogenized. The dried soil samples were crumbled with a porcelain mortar and pestle and sieved through 2 mm nylon sieve and stored in an airtight clean Ziploc bag and kept frozen until chemical analysis (Islam *et al.* 2015a, b). The experimental field had 6.6 pH, 1.38% organic matter, 0.078% N, 11.8 mg kg^{-1} available P, 0.075 cmol kg^{-1} exchangeable K and 6.62 mg kg^{-1} available S contents.

Experimental treatments

There were seven treatment combinations including T_1 (Control), T_2 (100% NPKS), T_3 (70% NK), T_4 (70 % NK+ PM - slurry), T_5 (70 % NK+CD- slurry), T_6 (70% NK+PM) and T_7 (70% NK+CD. The T_2 and T_3 treatment received sole chemical fertilizers. Next four treatments received poultry bio-slurry (T_4), Cow dung bio-slurry (T_5), poultry manure (T_6) and cow dung (T_7). Under integrated plant nutrition system (IPNS), poultry bio-slurry, poultry manure, cow dung bio-slurry and cow dung manure were applied at a rate of 30% of NK fertilizer. The amount of nutrients in the treatments (T_4–T_7) supplied from the manures were first calculated based on organic manure chemical analysis and NK content in cowdung, cowdung bio-slurry, poultry manure and poultry bio–slurry was 0.64 % & 0.52%, 0.85% & 0.59, 0.94% & 0.60% and 1.20% & 0.64%. Recommended rate of fertilizers was calculated based on initial soil chemical analysis data according to Fertilizer Recommendation Guide (FRG 2012).

Chemical analysis

Before application in the field all the manures were chemically analyzed for N, K and S content using acid digestion. Nitrogen was determined according to the method described by Page *et al.,* (1982). Phosphorus was determined colorimetrically using molybdovanadate solution yellow colour method (Yoshida *et al.,* 1976) and S concentration by turbidity method (Chapman and Pratt 1964). The K concentration in the acid digest was determined directly by flame photometer. All the manures were applied at 15% moisture content basis.

Manure and fertilizer application

The treatments were tested on cabbage during the season 2015-2016. Urea (46% N), Triple Superphosphate (20% P), Muriate of potash (50% K) and Gypsum (18% S) were used as chemical fertilizers. The amount of chemical fertilizers was adjusted with nutrient supplied from organic manures in different treatments. Besides these, a blanket dose of Zn 2.5 kg ha^{-1} as Zinc Sulphate (heptahydrate) ($ZnSO_4 7H_2O$) (23%), was applied in all plots of cabbage crop. During fertilizer calculation for IPNS system, it was assumed that 50% of the total nutrients would be available from the manures. Nitrogen and MoP were top dressed at 3 equal splits on final land preparation, 20 and 45 days after transplanting of cabbage. The amount of chemical fertilizers were applied for cabbage in different treatments is given in Table 1.

Experimental design and layout:

The experiments were laid out in a randomized complete block design, with three replications, each plot size being 4 m ×3 m and were separated by 30 cm wide bunds. One meter distance was maintained between the replications. The cabbage was transplanted on 27 October of 2015. The crop variety was Atlas70. Four weeding were done followed by irrigation during urea fertilizer top dressing.

Crop harvest and data recording

Treatment and replication wise head yield and yield contributing data of crop were recorded after harvest at physiological maturity.

Data analysis

Data was subjected to analysis of variance (ANOVA) using computer based statistical program STAR (Statistical Tool for Agricultural Research), developed at IRRI, following the basic principles, as outlined by Gomez and Gomez (1984). Significant effects of the treatments were determined by analysis of variance (ANOVA) and the treatment means were compared at 5% level of significance by Duncan's Multiple Range Test (DMRT).

Results and discussion

Growth and yield attributes

Plant height

Plant height was increased consistently with advanced

Table 1. Amount of nutrient supplied from manure and fertilizer under different treatment in cabbage (Atlas70) in 2015 - 2016

Treatments	Nitrogen (N)		Manure Share (%)	Phosphorus (P)	Potassium (K)		Manure Share (%)	Sulphur (S)	Zinc (Zn)
	CF (kg ha^{-1})	Manure (kg ha^{-1})			CF (kg ha^{-1})	Manure (kg ha^{-1})			
T_1: Control	0	-	-	0	-	-	-	0	2.5
T_2: 100% NPKS	188	-	-	50	78	-	-	25	2.5
T_3: 70% NK	132	-	-	-	55	-	-	-	2.5
T_4: 70% NK+PM slurry	132	56	30	-	55	23	30	-	2.5
T_5: 70% NK+CD slurry	132	56	30	-	55	23	30	-	2.5
T_6: 70% NK+PM	132	56	30	-	55	23	30	-	2.5
T_7: 70% NK+CD	132	56	30	-	55	23	30	-	2.5

age of the crop irrespective of various treatments. Application of 70%NK+poultry manure slurry (T_4) showed most effective in improving the plant height of cabbage at the growth stage followed by 70%NK+ poultry manure (T_6) and other treatments, being at par. The increase in plant height may be attributed to balance supply of nutrient through organic and inorganic fertilizers resulting in higher plant canopy which in turn increased photosynthetic processes during development (Kumar *et al.* 2013).

Number of unfold leaves

The number of unfold leaves of each cabbage plant was also recorded at harvest. The highest number of unfold leaves per plant was recorded at control i.e. treatment T_1. Applied treatments appeared to have significant ($P < 0.01$) influence in reducing unfolded leaves of cabbage. The lowest number of unfolded leaves per plant (average 10.77 leaves per plant) of cabbages were recorded at treatment 70% NK + Poultry manure bio-slurry (T_4) which was statistically close to treatment T_2 (100%NPKS) and T_6 (70% NK+ Poultry manure).

Leaf length (cm)

The leaf length of cabbage was significantly increased due to application of manure and fertilizers by the different treatments (Table 2). The leaf length varied from 8.67 cm to 34.33 cm over the treatments. The highest leaf length was recorded in the treatment T_4 (70%NK+Poultry manure bio- slurry) which was statistically similar with T_6 (70%NK + Poultry manure) treatments and the lowest leaf length was found in control treatment (T_1).

Leaf breadth (cm)

Leaf breath was significantly varied with different types of manure and fertilizer application for growth and development of cabbage. It was measured that the highest leaf breath was obtained with 70% NK+ Poultry manure bio-slurry (T_4) treatment which was statistically similar to 70% NK+ Poultry manure (T_6) treatment and superior to other treatments. The lowest leaf breadth was recorded from control (T_1) treatment. The results obtained under the present study were supported by Souza *et al*., (2008).

Root length (cm)

Root length is an important plant character for contributing higher yield performance. Root length was significantly influenced by different manure and fertilizers treatments (Table 2). It was evident that different types of organic and inorganic fertilizer showed different root length. The highest root length was found in 70%NK+Poultry manure bio- slurry (T_4) which was statistically similar with 70%NK+Poultry manure (T_6) and inorganic fertilizer treatment (T_2). On the other hand, the lowest root length was measured with control (T_1) treatment. The results obtained under the present experiment was in agreement with Souza *et al.,* (2008).

Head diameter (cm)

Diameter of head significantly influenced due to different manure and fertilizer treatment (Table 3). The maximum head diameter was obtained from 70%NK+Poultry manure bio-slurry (T_4) which was statistical similar to 70 % NK+ Poultry manure (T_6) and the minimum head diameter was obtained from control treatment (T_1). The second highest head diameter was obtained from T_2 (100%NKPS) treatment. Statistically similar results were also found from treatment T_5 (70%NK+Cowdung bio- slurry) and T_7 (70% NK+ Cowdung manure). Shaharia *et al.,* (2013) found that circumference of cabbage was obtained from treatment T_5 i.e. RDF+5tha^{-1} digested PL bio-slurry.

Marketable head (%)

Marketable head (%) of cabbage was significantly influenced by the different treatments (Table 3). The highest marketable head was produced with the treatment T_4 (70%NK+Poultry manure bio- slurry) which was statistically similar with T_2 (100% NKPS) and T_6 (70%NK+Poultry manure) treatments and the lowest marketable head (20.95%) was found in control treatment (T_1).

Whole plant weight

The statistically significant differences were found in whole plant weight with different treatments (Table 3). Whole plant weight (3054.0 g) of cabbage was the highest for T_4 (70%NK+Poultry manure bio-slurry) treatment which was closer to T_6 (70%NK+Poultry manure) treatment. The lowest whole plant weight (402.7g) of cabbage was obtained for T_1 (control)

Table 2. Effects of different manure and fertilizer treatments on the growth and yield contributing characters of cabbage (Atlas70) in 2015 -2016

Treatments	Plant height (cm)	Unfold leaves (no.)	Leaf length (cm)	Leaf breadth (cm)	Root length (cm)
T_1: Control	10.77 d	14.97 a	8.67 e	6.47 e	10.77 d
T_2: 100%NPKS	29.60 b	12.00bcd	29.20 bc	27.33 b	31.60 a
T_3: 70% NK	20.47 c	13.10 b	18.20 d	14.13 d	20.47 c
T_4:70%NK+PM slurry	33.00 a	10.77 d	34.33 a	34.20 a	33.00 a
T_5: 70%NK+CD slurry	27.13 b	12.10 bc	25.00 c	22.60 c	27.13 b
T_6: 70%NK+PM	32.13 a	11.27 cd	32.07 ab	31.93 a	32.13 a
T_7: 70%NK+CD	25.73 b	12.90 b	24.87 c	20.43 c	25.73 b
CV (%)	5.38	5.40	10.61	11.50	8.37
Level of significance	**	**	**	**	**
SE (±)	0.75	1.40	1.38	0.79	0.3589

T_4-T_7 IPNS basis treatments. Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, CD= Cowdung, CD bio-slurry = Cowdung bio-slurry, PM= Poultry manure, PM bio-slurry = Poultry manure bio-slurry.

Table 3. Effects of different manure and fertilizer treatments on the growth and yield contributing characters of cabbage (Atlas70) in 2015 -2016

Treatments	Head diameter (cm)	Marketable head (%)	Whole plant weight (g)	Marketable weight (g)	Head yield (t ha^{-1})
T_1: Control	5.3 e	20.9 e	402.7 d	372.5 e	5.8 e
T_2: 100%NPKS	20.0 b	72.4 ab	2409.10 b	1909.0 b	45.1 b
T_3: 70% NK	13.5 d	41.9 d	910.5 c	859.0 d	21.5 d
T_4:70%NK+PM slurry	22.7 a	85.7 a	3054.0 a	2744.3 a	57.9 a
T_5: 70%NK+CD slurry	16.4 c	60.0 bc	2158.3 b	1747.1 c	42.6 c
T_6: 70%NK+PM	22.0ab	81.9 ab	2981.0 a	2687.3 a	56.6 a
T_7: 70%NK+CD	16.1 c	50.6 cd	1987.3 b	1665.2 c	41.5 c
CV (%)	8.82	12.05	5.52	3.83	5.26
Level of significance	**	**	**	**	**
SE (±)	0.79	5.38	51.21	31.83	0.77

T_4-T_7 IPNS basis treatments. Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, CD= Cowdung, CD bio-slurry = Cowdung bio-slurry, PM= Poultry manure, PM bio-slurry = Poultry manure bio-slurry.

Table 4. Effects of different manure and fertilizer treatments on the N, P, K & S content (%) and uptake (kg ha^{-1}) by cabbage (Atlas70) in 2015-2016

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (kgha^{-1})
T_1: Control	8.70 f	1.61 f	7.87 f	2.31 f
T_2: 100%NPKS	108.78 c	26.08 c	85.70 c	29.47 c
T_3: 70% NK	46.72 e	7.59 e	34.82 e	12.22 e
T_4:70%NK+PM slurry	151.08 a	34.52 a	110.78 a	39.10 a
T_5: 70%NK+CD slurry	100.39 d	22.95 d	76.24 d	27.43 cd
T_6: 70%NK+PM	135.43 b	31.14 b	100.47 b	36.26 b
T_7: 70%NK+CD	95.72 d	20.34 d	72.42 d	24.78 d
CV (%)	4.25	7.79	6.89	6.26
Level of significance	**	**	**	**
SE (±)	2.09	0.86	2.57	0.82

T_4-T_7 IPNS basis treatments. Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, CD= Cowdung, CD bio-slurry = Cowdung bio-slurry, PM= Poultry manure, PM bio-slurry = Poultry manure bio-slurry

treatment. Alam *et al*., (2017) reported that the maximum whole plant weight of cabbage was found in 100% RCF+ Vermicompost (VC) @ 1.5 t ha^{-1}.

Marketable plant weight

Statistically significant of marketable plant weight of cabbage was found with different treatments (Table 3). The highest marketable plant weight (2444.3 g $plant^{-1}$) was produced with 70%NK + poultry manure bio-slurry (T_4) treatment which was statistically similar to 70%NK + poultry manure (T_6) treatments. TreatmentT_5 (70%NK + cowdung bio-slurry) and T_7 (70% NK + cowdung manure) were closely identical to each other. The lowest marketable head (372g $plant^{-1}$) was found in control treatment (T_1). Shaharia *et al.,* (2013) also found that marketable weights of cabbage was obtained from RDF + 5 t ha^{-1} digested PL bio-slurry.

Yield

The yield of cabbage heads improved significantly by most of the treatments over the control. The head yield of cabbage ranged from 5.79 t ha^{-1} to 57.94 t ha^{-1}. Highest head yield of cabbage (57.94 t ha^{-1}) was obtained from 70% NK + poultry manure bio-bio-slurry (T_4) which was statistically at par with 70% NK + poultry manure (T_6) treatment and significantly different from all other treatments. The lowest head yield of cabbage 5.79 t ha^{-1} was obtained from control (T_1). In case of soil test based inorganic fertilizer application (T_2) the head yield was 45.08 t ha^{-1} which was lower than the treatment along with poultry litter and their bio-slurry. Between the digested and fresh sources, digested sources gave better results. Again, between the two sources, poultry bio-slurry and poultry litter performed better than the cowdung and their bio-slurry. Noor *et al.* (2005) reported that the highest head yield of cabbage was produced due to integrated use of poultry manure (5 t ha-1) along with reduced dose (70%) of chemical fertilizers, which are in agreement with the findings of the present study. In an experiment. Jayakumar *et al.,* (1993) found that biogas slurry at the rate of 300 gm per pot produced the largest head of sunflower. Manna and Hazra (1996) reported that application of biogas slurry increased cob yield of Maize. Observation and documentation made by different researcher and scientists like Aktar *et al.,* (1996); Azad (2000); Haque (2000); Souza *et al.,* (2008), are also supported of the present findings, They reported that when organic manure is used in the soil, some metallic trace elements stimulated root growth that ultimately increases the yield of crop.

Nutrient uptake by cabbage

The samples of cabbage were analyzed for N, P, K and S concentrations. The nutrient uptake was calculated from the yield and nutrient concentration data. The concentration of N, P, K and S in cabbage were expressed as fresh weight basis. The nitrogen, phosphorus, potassium and sulphur uptake by the heads of cabbage was significantly affected by different treatments (Table 4) The use of poultry manure bio-slurry was better than poultry manure in terms of uptake of all nutrients by cabbage. Cowdung bio-slurry showed higher N, P, K and S uptake over cowdung but such effect was not statistically significant. The highest N, P, K and S uptake by the cabbage was found when poultry manure bio-slurry was added with 70%NK (T_4) which was statistically superior to all other treatments. Among the manures cabbage grown with poultry manure bio-slurry showed significantly higher NPKS uptake compared to that grown with cow manure. The lowest nutrient uptake was found in control treatment. The results are in agreement with the findings of Reddy (2008), Chaitanya *et al,* (2013) and Sepat *et al.,* (2012) reported that nutrient uptake was increased in tomato due to application of organic manures. Muhmood *et al.,* (2015) reported that the uptake of nutrients by vegetables was also improved with the integration of organic and inorganic fertilizers. Kurbah and Thomas (2017) reported that the treatment combination of @$N_{30}P_{60}K_{40}$ kg ha^{-1} + @ FYM 15 t ha^{-1} + *Rhizobium* @ 200g/10kg of seed showed the better results in respect of nutrient uptake by plant.

Conclusion

Bio-slurry with the integrated plant nutrient systems (IPNS) can support quality cabbage production. Poultry manure bio-slurry and cowdung bio-slurry supply greater amounts of nutrients compared to their respective original state of poultry manure and cowdung. The combined application of poultry manure bio-slurry and inorganic fertilizers had shown a marked effect on the growth and yield of cabbage in the study area. The result revealed that, the combined use of 70%NK fertilizer with 30% poultry manure bio-slurry noticed as optimum level for production of cabbage. Combined application of poultry manure bio-slurry with chemical fertilizers not only increased crop production but also maintained soil fertility status in intensive cropping system.

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