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Effects of fresh and digested cowdung and poultry litter on the growth and yield of cabbage (*Brassica oleracea*)

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Abstract

A field experiment was conducted during Rabi season in the experimental field of BCSIR to see the effects of fresh and digested cowdung (CD) and poultry litter (PL) bio-slurry on the growth and yield of cabbage (*Brassica oleracea*). The experiment was laid in a Randomized Complete Block Design (CRBD) with six different treatments including control. Cabbage variety Atlas-70 was transplanted at the age of 35 days and was harvested at 120 days. Plant height, circumference, marketable weights and whole plant weight were examined to perceive the effects on the growth and yield of cabbages. The experiment revealed that both digested PL and CD bio-slurry had a significant effect ($P < 0.01$) on the growth and yield components of cabbage. Increased plant growth and yield were in the order of digested PL bio-slurry > digested CD bio-slurry > fresh PL > fresh CD in combination with recommended dose of fertilizers (RDF). Among the treatments, the highest head yield of cabbage (97.6 t ha^{-1}) was obtained from RDF + 5 t ha^{-1} digested PL bio-slurry which was 366 % higher than the control.

Keywords: Bio-slurry; Digested; Cowdung; Poultry litter; Yield; Cabbage

Introduction

Cowdung, poultry litter, water hyacinth and other biomass wastes are widely used to produce biogas which is potential renewable energy alternative in rural areas of Bangladesh. More than 30,000 biogas plants of varying gas-producing capacities run with cowdung and poultry litter for domestic purposes. These biogas plants generate more than 200,000 tones of bio-slurry on dry weight basis (Islam, 2006). Bio-slurry, released from hydraulic chamber of bio-gas plant is anaerobically decomposed organic material of cowdung, poultry litter, water hyacinth, human excreta and other organic wastes. No effective program has been undertaken to use bio-slurry in agriculture. Although digested cowdung bio-slurry has a low content of N, P and K as compared to chemical fertilizers, it is a valuable source of humus substance (Gaur *et. al.,* 1984). Preliminary investigations show that both cowdung and poultry litter bio-slurry contain considerable quantities of plant nutrients, which may be used to improve soil fertility and thus the use of chemical fertilizers can be reduced to a great extent. Poultry litter bio-slurry is especially suitable for acid soils as it has strong liming effect. It reduces the acidity of the soils and thereby protects crops from aluminium toxicity. These organic fertilizers can effectively be utilized for organic farming for high value crops that is the demand of the day in Bangladesh and elsewhere.

The organic matter content as well as the fertility status of Bangladesh soil is low. Now it is well agreed that depleted soil fertility is a major constraint for higher crop production in Bangladesh and indeed, yield of several crops are declining in some soils (Bhuiyan, 1991). Maintenance of soil fertility is a prerequisite for long term sustainable agriculture and it is certain that organic manure (cowdung, poultry manure and their slurry) can play a vital role in the sustainability of soil fertility and crop production. Bio-slurry organic fertilizer contains 20-30 % more nutrients than commonly used organic fertilizers such as cowdung, duck and poultry manure, farmyard manure and compost as it is especially produced from biogas plants. This fertilizer also contains heavy metals much below acceptable limit. Bio-slurry may be used raw or after air drying to fertilize agricultural land.

Anaerobically digested bio-slurry contains more plant nutrient than aerobically decomposed cowdung and poultry manure. So, it is imperative to evaluate cowdung and poultry manure and their bio-slurry and slurry compost as a source of organic manure. Use of cowdung and poultry manure along with inorganic fertilizer should be the common practice for sustainable crop production and maintaining soil fertility. This may take care of maintaining good physical condition of soil and balancing other macro and micro-elements needed by plant. The beneficial effects of organic manure in vegetable production have been demonstrated by many workers (Robin, 1994; Singh *et. al.,* 1970 and Subhan 1991). Balanced fertilization is prerequisite for exploiting optimum yield potentials of high yielding vegeta-

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bles varieties. The present investigation with cabbage (*Brassica oleracea*) was undertaken to evaluate the effect of anaerobically digested cowdung and poultry litter bio-slurry in combination with recommended dose of inorganic fertilizers and compare it with the efficiency of undigested cowdung and poultry litter.

Materials and methods

The field experiment was conducted during Rabi season of 2009 at BCSIR experimental field to see the effects of cowdung and poultry litter (both before and after digestion) on the growth and yield of cabbage. The experiment was set up in a Randomized Complete Block Design (CRBD) with six different treatments and three replications of each treatment (Fig. 1). Six different treatments were: T_1 - Soil test based inorganic fertilizer (RDF); T_2 - RDF + 5 t ha^{-1} CD (fresh); T_3 - RDF + 5 t ha^{-1} CD bio-slurry (after digestion); T_4 - RDF + 5 t ha^{-1} PL (fresh); T_5 - RDF + 5 t ha^{-1} PL bio-slurry (after digestion); T_6 - Native fertility (absolute control). There were a total (6 treatments × 3 replications) of 18 plots each having an area of 2 m × 2 m. Digested cowdung and poultry litter bio-slurry (end products that are released from a biogas chamber after anaerobic decomposition) were collected from the biogas plant situated at the Institute of Fuel Research and Development, BCSIR Dhaka. Fresh cowdung and poultry litter were also collected from the same source. Both fresh and digested cowdung and poultry litter were taken to the field of BCSIR and they were air dried for several days and were ground before field application. Both digested and fresh cowdung and poultry litter were incorporated with the soil during land preparation. Fertilizers were applied as per treatment based on soil analysis and Recommended Dose of Fertilizers (RDF) according to Fertilizer Recommended Guide 2005 (BARC, 2005). Amount of nutrients applied as per RDF during cultivation of cabbage (*Brassica oleracea*) are shown in Table I. Urea, TSP, MP, Gypsum and Boric acid were used as a source of N, P, K, S and B respectively. Whole amount of P, K, S, B, cowdung, poultry litter and 1/3 of N were applied at the time of final land preparation and remaining 2/3 of N was applied in two equal installments at 20 and 45 days after planting. Equal sized healthy cabbage seedlings (Atlas-70 variety) of 35 days were transplanted on October 24 and 25, 2009 with a spacing of 60 cm from line to line and 45 cm from plant to plant within a line. Cabbages were harvested at 120 days after sowing by uprooting from the soil. For harvesting, 5 plants were selected randomly from each plot considering the boarder effect. Plant height, circumference, marketable weights and whole plant weight were taken at the field after harvesting.

Table I. Amount of nutrients applied as per Recommended Dose of Fertilizers (RDF) during cultivation of cabbage (*Brassica oleracea*)

Yield goal (t ha^{-1})	Nutrients applied as per RDF (kg ha^{-1})				
	N	P	K	S	B
High yield goal (80 ± 8)	126	50	14	16	0.5

Source: Fertilizer Recommendation Guide, BARC 2005

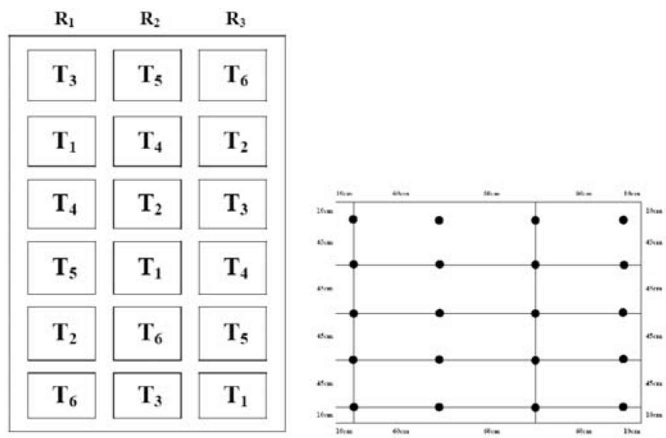

Fig. 1. Layout of the experimental field

*T- represents Treatmens *R-represents Replications/Blocks

Collection and preparation of soil and bio-slurry for laboratory analysis

Before initiation of the experiment, the soil samples representing 0-15 cm depth from surface of the experimental field were collected by composite soil sampling method as suggested by the soil survey staff of the USDA (1951). The soil samples were scraped from top to bottom with the help of an augur and mixed thoroughly. Collected soil samples were put in polythene bags, tagged with rubber band and labeled. Bio-slurry of cowdung and poultry litter were collected from the bulk amount that were applied in the experimental field in dried state and were put in polythene bags, tagged with rubber band and labeled. The collected soil samples were dried in air for 3 days by spreading on a thin layer of plastic paper. Visible roots and debris were removed from the soil sample and discarded. Ground samples of soil were screened to pass through a 2 mm stainless still sieve. The sieved samples were then mixed thoroughly for making the composite sample. Soil samples were preserved in plastic containers and labeled properly. The soil sample was used for various physical analyses. Another portion of the soil samples was screened to pass through a 0.5 mm sieve. The sieved sample were mixed thoroughly for making composite samples and preserved in the same way as above. These soils were used for chemical and physicochemical analyses. For the chemical analysis of bio-slurry, the sample preparation followed the same procedure as for soil samples.

Laboratory analysis

For the determination of moisture content 10 gm of each of the fresh soils and bio-slurry were weighed and dried at 100 °C ± 5 °C for 48 hours. The moisture content of soil was determined from the difference in weights of the wet soil, and the dry soil and the results were calculated on the basis of dry weight. pH of the soil and organic sample was determined using a digital pH meter at a soil/organic sample : water ratio of 1 : 2.5 according to method described in Thomas (1996). Carbon content in soil and bio-slurry were determined by the chromic acid digestion method of Walkley and Black as reported by Sparks (1996). The total Nitrogen (N) was determined by Macro Kjeldahl digestion method according to Bremner (1996). The distillation of digested samples was done with 40 % NaOH and the distillate was collected on a 4 % Boric acid with mixed indicator. The distillate was titrated against N/100 H_2SO_4. Available Phosphorous (P) in the soil sample was extracted by Bray and Kurtz method as described by Kuo (1996). Phosphorus (P) content of the soil and bio-slurry was determined colorimetrically in a UV-VIS spectrophotometer at 420 nm by vanadomolybdophosphoric yellow color method in nitric acid system (Jackson, 1962). Both available and total Sulfur (S) contents were determined by turbidimetric method with $BaCl_2$ and Tween-80 reagent (Huq and Alam, 2005). Water soluble Boron (B) of the experimental soil was determined by spectrophotometer at 540 nm by using curcumin reagent (MoA, 2003). Calcium (Ca), Magnesium (Mg), Potassium (K) of the soil from experimental field was extracted with neutral normal ammonium acetate buffer according to Helmke and Sparks (1996). Exchangeable K was determined using Flame Photometer and exchangeable Ca and Mg by Atomic Absorption Spectrophotometer (AAS). Fe and Mn content was determined by Atomic Absorption Spectrophotometer (AAS) by digesting 1 gm of the soil sample and bio-slurry sample (< 2 mm fraction) in 1:1 mixture of concentrated nitric and perchloric acids by heating the mixture in a fume cupboard and heated to dryness (Ure, 1990). The mixture was finally filtered by Whatman No. 40 filter paper and made to a certain volume by distilled water. The resultant extracts were analyzed for Fe and Mn using AAS (APHA-AWWA-WPCF, 1980). The nitric and perchloric acid digested aliquot of bio-slurry was used to determine total Phosphorous, Potassium, Sulfur, Calcium, Magnesium, Iron and Manganese content.

Statistical Analysis

All measured data were subjected to analysis of variance (ANOVA) using statistical software Sigma Plot (version 11.0) following the experimental design. As test criterion for looking differences between means the $LSD_{0.01}$ was used (Gomez and Gomez, 1976).

Results and discussion

Representative soil sample from the experimental field was analyzed in the laboratory before setup of the experiment to see the nutrient status of the experimental soil. Nutrient status of the experimental soil is presented in the Table II.

Table II. Nutrient status of soils from the experimental field

Parameters	Value
pH	6.2
Organic Matter (OM)	1.14 %
Total Nitrogen (N)	0.062 %
Calcium (Ca)	680 mg kg^{-1}
Magnesium (Mg)	192 mg kg^{-1}
Potassium (K)	39.9 mg kg^{-1}
Phosphorous (P)	12 mg kg^{-1}
Sulfur (S)	11 mg kg^{-1}
Boron (B)	0.19 mg kg^{-1}
Copper (Cu)	5 mg kg^{-1}
Iron (Fe)	127 mg kg^{-1}
Manganese (Mn)	41 mg kg^{-1}
Zinc (Zn)	2.09 mg kg^{-1}

Collected cowdung, poultry litter and effluents (bio-slurry) of cowdung and poultry litter from anaerobic digestion systems of biogas plants used for the experiment were also analyzed for their nutrient status (Table III).

Plant height, circumference, marketable weights and whole plant weight of cabbage (*Brassica oleracea*) were taken into consideration to see the effect of different fertilizer treatments on the growth and yield of cabbage. The mean head yield and yield attributes like plant height, circumference, whole plant weight and marketable weight of cabbages were significantly influenced by different fertilizer treatments.

Plant height

Mean plant height of cabbage was found to be affected significantly by the type of fertilizer treatments applied (Fig. 2). The mean plant height of cabbage grown on soil treated with digested CD and PL bio-slurry were found to be significantly different from the control plants ($P < 0.01$). Highest mean plant height (46.2 cm) of cabbage was obtained from treatment T_5 i.e. RDF + 5 t ha^{-1} digested PL bio-slurry and the mean lowest plant height (19.7 cm) was obtained from native fertility (Fig. 2). In case of soil test based inorganic fertilizer application (T_1) the mean plant height was 39.9

Table III. Nutrient status of fresh and digested cowdung and poultry litter used in the field experiments

Parameter	Cowdung (CD)		Poultry litter (PL)	
	Fresh	Digested	Fresh	Digested
pH	7.39	7.48	7.61	7.69
Moisture	17.90 %	18.52 %	16.69 %	18.44 %
Nitrogen	1.16 %	1.55 %	1.22 %	1.95 %
Phosphorus	0.86 %	1.89 %	2.01 %	3.14 %
Potassium	0.89 %	1.04 %	0.88 %	1.12 %
Sulfur	0.51 %	0.81 %	0.75 %	1.01 %
Calcium	0.74 %	0.98 %	2.25 %	3.45 %
Magnesium	0.28 %	0.33 %	0.75 %	0.88 %
Iron	0.089 %	0.105 %	0.125 %	0.195 %
Manganese	445 mg kg^{-1}	835 mg kg^{-1}	345 mg kg^{-1}	697 mg kg^{-1}

cm which was lower than the treatment along with cowdung, poultry litter and their bio-slurry. Between the digested and fresh sources, digested sources gave better results. Again, among the two sources, poultry litter performed better than the cowdung.

The number of unfold leaves of each cabbage plant were also recorded during harvest time. The highest number of unfold leaves per plant was recorded at native fertility i.e. treatment T_6. Applied treatments appeared to have significant ($P < 0.01$) influence in reducing unfolded leaves of cabbages. The lowest number of unfolded leaves per plant (average 10 leaves per plant) of cabbages were recorded for treatment T_5 (RDF + 5 t ha^{-1} digested PL bio-slurry) which was close to treatment T_3 (RDF + 5 t ha^{-1} digested CD bio-slurry).

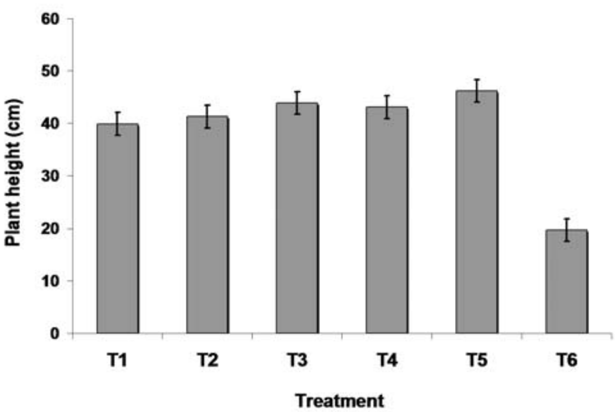

Fig. 2. Effect of different fertilizer treatments on the mean height (cm) of cabbage (*Brassica oleracea*)

Circumferences

Like plant height the circumferences of cabbage plants grown on soil treated with digested CD and PL bio-slurry was significantly affected ($P < 0.01$). The highest mean plant circumference was obtained from RDF + 5 t ha^{-1} digested PL bio-slurry (T_5) treated plot which was 82.7 cm and the lowest was obtained from native fertility (Fig. 3). PL along with RDF either fresh or digested gave better results than that of CDs. On an average, the mean circumferences of cabbage were found higher for digested cowdung and poultry litter bio-slurry treated plot (i.e. treatment T_3 and T_5) than the undigested cowdung and poultry litter treatment (i.e. treatment T_2 and T_4) which were statistically significant ($P < 0.01$).

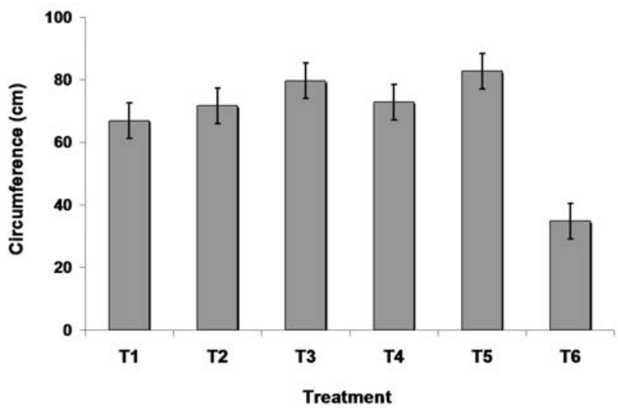

Fig. 3. Effect of different fertilizer treatments on the mean circumference (cm) of cabbage (*Brassica oleracea*)

Whole plant weight and Marketable weight

Both mean marketable and whole plant weight of cabbage were relatively higher for RDF with digested CD and PL bio-slurry than the RDF with undigested CD and PL treated plot. Significant statistical differences ($P < 0.01$) in the mean marketable and whole plant weight were found for all the sources of CD and PL application. Both the mean whole plant weight (3.45 kg) as well as the mean marketable weight (2.89 kg) of cabbage was the highest for RDF + 5 t ha^{-1} digested PL bio-slurry treatment which was closer to

RDF + 5 t ha^{-1} digested CD bio-slurry treatment where the mean whole plant weight was 3.35 kg and mean marketable weight was 2.78 kg respectively, these values were statistically different ($P < 0.01$). Relatively higher mean whole

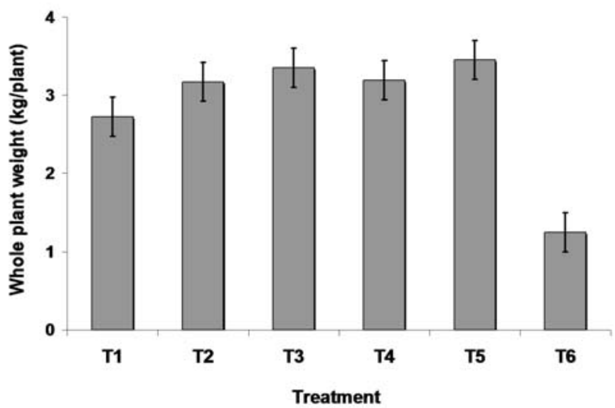

Fig. 4. Effect of different fertilizer treatments on mean whole plant weight (kg) of cabbage (*Brassica oleracea*)

plant weight (3.19 kg at T_4 and 3.17 kg at T_2) and marketable weight (2.69 kg at T_4 and 2.75 kg at T_2) of cabbage were obtained with fresh CD and PL treatment ($P < 0.01$) than the only soil test based inorganic fertilizer application (whole plant weight was 2.72 kg and marketable weight was 2.61 kg). The lowest mean whole plant weight (1.25 kg) and marketable weight (0.75 kg) of cabbage was obtained for T_6 (native fertility) treatment.

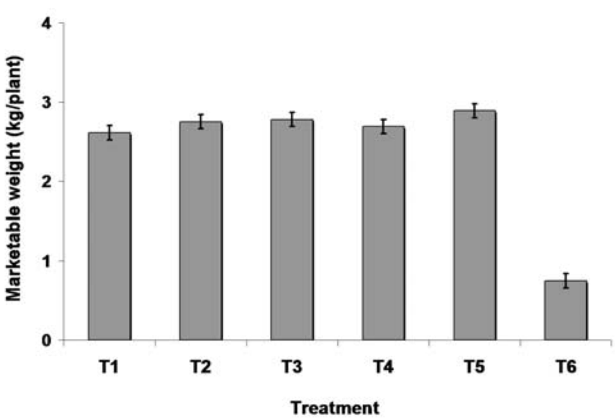

Fig. 5. Effect of different fertilizer treatments on mean marketable weight (kg) of cabbage (*Brassica oleracea*)

Head yield

Obtained head yield of cabbage are expressed in t ha^{-1} and shown in Fig. 6. Head yield of cabbage grown on soil treated with different sources of fresh and digested CD and PL were significantly affected by the materials ($P < 0.01$). Significant statistical differences ($P < 0.01$) in head yield production of cabbage were observed for all the treatments (Fig. 6). Highest mean head yield of cabbage (97.6 t ha^{-1}) was obtained from RDF + 5 t ha^{-1} digested PL bio-slurry (T_5) which was significantly different ($P < 0.01$) from all the treatments. This was followed by T_3 (95.7 t ha^{-1}), T_4 (87.9 t ha^{-1}), T_2 (86.9 t ha^{-1}) and T_1 (83.3 t ha^{-1}) (Fig. 6). Lowest mean head yield of cabbage 20.9 t ha^{-1} was obtained from native fertility (T_6).

About 366 % yield increase of cabbage over native fertility (T_6) was recorded in T_5 (RDF + 5 t ha^{-1} digested PL bio-slurry) treatment ($P < 0.01$). Yield increase of cabbage due to application of RDF + 5 t ha^{-1} digested CD bio-slurry (T_2) was 357 % which was similar to yield increase for treatment T_5 but significantly different ($P < 0.01$) from the native fertility (T_6). Due to application of fresh PL and CD yield increases of cabbage were 320 % and 315 % respectively in comparison with native fertility which were also statistically significant ($P < 0.01$). 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. Batsai *et. al.* (1979) reported in an experiment that chemical fertilizer along with organic fertilizer produced the highest yield of cabbage (*Brassica oleracea*). The yield increases due to the incorporation of PL or CD could be related to the extra nutrients added for these sources in addition to the RDF.

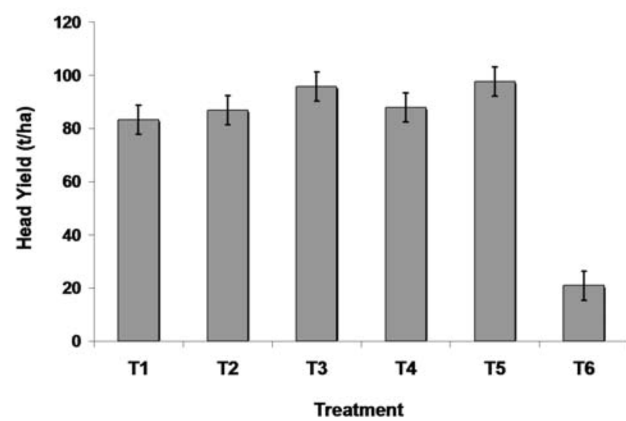

Fig. 6. Effect of different fertilizer treatments on the mean head yield (t ha^{-1}) of cabbage (*Brassica oleracea*)

Conclusion

The results obtained in this field experiment revealed that amongst the four fertilizer treatments digested poultry litter (PL) bio-slurry was found to be the best for cabbage production followed by digested cowdung (CD) bio-slurry, fresh poultry litter (PL) and cowdung (CD) in combination with recommended dose of fertilizers (RDF). For economically profitable higher production of cabbage both poultry litter bio-slurry (5 t ha^{-1}) and cowdung bio-slurry (5 t ha^{-1}) after anaerobic digestion along with soil test based recommended dose of fertilizers were found better than traditionally decomposed poultry litter and cowdung.

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