Chinese cabbage (*Brassica chinensis*) production, using different kind and doses of organic fertilizer in Pangalengan, West Java, Indonesia

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Abstract. Pangalengan is a center of vegetables and dairy cows in the province of West Java, Indonesia. Cow dung is generally discharged into waterways and on lands irrigated by the water channels. The low utilization of cow dung in Pangalengan is due to the fact that breeder do not have time to process cow manure. Therefore, farmers prefer to use chicken manure that is ready to use. Utilization of cattle waste as manure, vermicompost, as well as biogas can be an alternative waste processing in situ at the center of a dairy farm in Pangalengan, West Java, Indonesia. The purpose of this research was to get the most suitable type and dosage of organic fertilizer that will enhance Chinese cabbage production in Pangalengan, West Java. The experiment was conducted in farmers' fields in the village of Pangalengan, West Java from November to December 2014. The study used a randomized completed block design with two treatment factors and three replications. The first factor was six kind of organic fertilizer, i.e. cow manure, chicken manure, combination of cow and chicken manure (1:1 v/v), vermicompost, and wet and dry biogas waste. The second factor was two dosages of organic fertilizer, i.e. 10 and 15 ton ha^{-1}. The results showed that there was no interaction between type and dosage of organic fertilizer. The highest production was obtained on dry biogas waste treatment which had the lowest CN ratio of organic fertilizer, but it was not significantly different from combination of cow and chicken manure treatment and wet biogas waste treatment. It means that the best organic fertilizer was the dry biogas waste, but combination of cow and chicken manure could substitute it. The best dosage of organic fertilizer was 15 ton ha^{-1}.

Key Words: *B. chinensis*, manure, cow dung, vermicompost, biogas waste.

Introduction. Pangalengan is a center of vegetables and dairy cows in the province of West Java, Indonesia. Statistic of Bandung Regency (2018) showed that the dairy cows in Pangalengan reached 24.567 individuals. Cow produces about 1.61 ft^3 (12.0 gal) of fresh manure (feces and urine) per 1,000 lb average live weight per day (Stowell & Bickert 1995). So cow manure produced in Pangalengan amounted to 39.307 fts^3 per day. Cow dung is generally discharged into waterways and on lands irrigated by the water channels, thus polluting the environment. The low utilization of cow dung in Pangalengan is due to the fact that breeder do not have time to process it. The breeder is too busy looking for forage which is recently increasingly limited. Therefore, farmers prefer to use chicken manure that is ready to use, although it must be purchased from other regions than cow manure are actually widely available raw materials. Akhtar et al (2013) reported that chicken manure had better quality as organic fertilizers instead of cow manure in terms of speed and high nutrient supply. Moreover, the need and utilization of chicken manure has overtaken the use of other animal manure (e.g. cow, pig, goat manure), because of its high content of nitrogen, phosphorus and potassium (Dikinya & Mufwanzala 2010). This was evident on many vegetables like tomato (Kalbani et al 2016), and on lettuce and cabbage (Asnawi & Mulyanti 2012).

Beside as an organic fertilizer, cow manure can be used as a growing medium and nutrient for worms, which final product can be used fertilizer, commonly called vermicompost. Vermicompost are the excreta of earthworm as biological agents to consume wastes, which are capable of improving soil health and nutrient status

(Adhikary 2012). Vermicompost is a material characterized by high porosity, aeration, drainage, water holding capacity and microbial activity (Theunissen et al 2010). Vermicompost contains nutrients such as NO_3, PO_4, Ca, K, Mg, S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil (Singh et al 2008). Vermicompost capacity to increase growth and yield of turnips was reported by Classen et al (2007) and of red amaranth by Alam et al (2007).

Dianawati & Mulijanti (2015) reported that biogas from cow dung has been developed in Pangalengan as an energy alternative at a time when renewable energy is not more limited. However sewage sludge biogas form had been discarded in the grass forage land and has not been widely used for vegetable crops. Biogas waste has been proved to be the best organic fertilizer for cabbage (Yulyatin et al 2016) and potato (Dianawati 2014). Islam et al (2016) stated that biogas waste showed a positive impact on growth and yield contributing characters of spinach and soil microenvironment which help improving the fertility status of soil.

Chinese cabbage (*Brassica chinensis*) leafs are consumed by many people as both fresh and processed vegetables. *B. chinensis* is often planted as a crop after the potato as dominant vegetable in Pangalengan. Utilization of cattle waste as manure, vermicompost, as well as waste biogas can be an alternative waste processing in situ at the center of a dairy farm Pangalengan, West Java, Indonesia. The purpose of this research was to get the best type and dosage of organic fertilizer that will enhance *B. chinensis* production in Pangalengan, Bandung regency, West Java, Indonesia.

Material and Method. The experiment was conducted in farmers' fields in the village of Pangalengan, Pangalengan sub district, Bandung district, West Java, Indonesia from November to December 2014. Research used randomized completed block design with two treatment factors and three replications. The first factor was six kind of organic fertilizer, i.e. cow manure, chicken manure, combination of cow and chicken manure (1: 1 v/v), vermicompost, wet and dry biogas waste. The second factor was two dosages of organic fertilizer, i.e. 10 and 15 tons ha^{-1}. Thus there were 36 treatment units, where each unit was 45 treatment plants.

Organic fertilizers used were obtained from the surrounding environment. Cow and chicken manure was purchased from the local farm shop. Wet biogas waste was directly applied to the soil, while dry biogas waste was dried in the sun indirectly, leaving the dregs. Vermicompost derived from the residual impurities and earthworms' media. Before the experiment, five type of organic fertilizer were analyzed concerning pH, water content, organic C, total N, P_2O_5 and K_2O in the Soil Laboratory of the Indonesian Vegetable Research Institute. Besides that, prior to the study soil was analyzed concerning its physical and chemical properties in the same laboratory.

Seeds were soaked in bactericidal solution for 15 minutes, and then were sown. Furthermore, after 5 days, seeds were moved to plate of banana leaves. Seeds that have been aged 9 days were transplanted to the land. Each plot had widths of 1.2 m and length of 2.5 m. Organic fertilizer was given in accordance with the treatment as a basic fertilizer. Land which has been applied organic fertilizer left for 3 weeks, then covered with silver black mulch. Row spacing used was 35 x 35 cm. NPK fertilizer (15-15-15) of 20 kg was applied at planting time. Plants pest control used integrated pest management system. Supplementary NPK fertilizer was given 30 days after planting (DAP) as much as 15 kg. Harvesting was done at the age of 55 DAP.

Statistical analysis. Variables observations included the number of leaves per plant and the production of fresh weight of leaves per plot and then conversion to hectare was performed. Data were analyzed by F test and if there was a significant difference, then the test was continued with Duncan test level on 95% confidence level.

Results and Discussion. Results of soil characteristics analysis showed the the soil was dust clay, rather acid, had high content of N and K, and low content of P (Table 1). The decrease in availability of phosphorus in acid soil was mainly because of its strong affinity for soil surface and reaction with Al and Fe (Eghball et al 1990), which resulted in P adsorption and precipitation (Yang et al 2013).

Table 1

Soil analysis results prior study

Soil characteristics	*Value*	*Criteria*
	Texture	
Sand (%)	40	
Dust (%)	53	Dust clay
Clay (%)	8	
pH H_2O	6	Rather acid
C (%)	5.1	Very high
N (%)	0.6	High
C/N	8	Low
P_2O_5 HCl 25% (mg %)	14.7	Low
K_2O HCl 25% (me %)	43	High
CEC (%)	27.9	High
	Cation	
Ca (me %)	13.5	High
Mg (me %)	1.7	Medium
K (me %)	0.6	High
Na (me %)	0.1	Low

Criteria based on Hardjowigeno (1987).

According Bernal et al (2009), the CN ratio of the organic material was an indication of a possible shortage of N and competition between microbes and plants in the use of available N in the soil. CN ratio of soil was low (8) indicated that the land has undergone mineralization. Soils that have undergone considerable mineralization, there are a quite high availability of nutrients like K and CEC.

The results showed that the organic fertilizers have alkaline pH (Table 2), so that when given to rather acid soil of research land (Table 1) was expected to improve soil quality. Agbede et al (2010) reported that manures could serve as good amendment materials in order to ameliorate acid soils.

Table 2

Analysis results of various organic fertilizers

Organic fertilizers	*Water pH*	*Water content (%)*	*Organic C (%)*	*Total N (%)*	*C/N (%)*	*P_2O_5 (%)*	*K_2O (%)*
Cow manure	8.5	72.9	10.9	0.7	16	0.5	0.8
Chicken manure	8.1	84.6	6.8	0.5	14	0.2	0.4
Vermicompost	6.6	32.5	26.1	1.3	21	0.3	0.7
Wet biogas waste	7.7	71.7	9.7	0.6	16	0.4	0.5
Dry biogas waste	7.8	14.9	19.7	1.7	12	3.6	2.3

From the analysis of water content contained in the organic fertilizers, dry biogas waste has the lowest water content, while cow and chicken manure, vermicompost, and wet biogas have high water content (Table 2). Sutanto (2002) stated that the water content of the organic fertilizer should not exceed 15-25%. The lower the water content of organic fertilizer, the better the quality. Akhtar et al (2013) reported that less water content in the soil will cause more cohesion. This was because water content separates the soil particles and cause softening of soil which leads to nutrient loss. So less moisture content in organic fertilizer made it suitable for soil fertility (Adeniyan et al 2011).

The CN ratio of the organic fertilizer ranged between 12 and 21 (Table 2). Goyal et al (2005) stated that the CN ratio below 20 was indicative of an acceptable compost maturity. When waste was composted, generally there was decrease in CN ratio, with time, due to losses of C as CO_2 which is stabilized in the range of 15–20. This suggested that vermicompost was an organic fertilizer with the lowest quality. Actually vermicompost has a high N, but because organic C was also high, the CN ratio was too high. Moral et al (2009) reported that the use of high C/N additives with manures in composting could lead to a significant reduction of N losses to atmosphere. High CN ratio indicated that the basic material has not been completely decomposed compost. Vermicompost organic material in the form of still solid fractions was difficult to decompose, so it cannot be absorbed by plants. This was contrary to the opinion of Adhikary (2012) which stated that the process of decomposition by earthworms was faster due to pass through the gut that produces vermicompost rich microbial activity and plant growth regulators. Edwards (1995) stated that microbial activity in vermicompost is 10-20 fold higher than in the soil or other organic material. Abbott & Parker (1981) reported that the activity of the worm gut was like a miniature composting tube that mixes conditions and inoculates the residues. They swallow large amount of soil with organics (microbes, plant, and animal debris) everyday, grind them in their gizzard and digest them in their intestine with aid of enzymes. Scheu (1987) stated that the high CN ratio of vermicompost can be explained by the fact that only 5–10% of the chemically digested and ingested material was absorbed into the body of worms. Thus, if the material is still rough, then the produced vermicompost is also high in C content. CN ratio was still high despite the decomposition time was long enough, this gives an indication that the raw materials of organic compost was difficult to decompose, so that decomposition took much longer.

CN ratio of dry biogas waste was the lowest among the other treatments. CN ratio of organic fertilizer will decline with the occurrence of mineralization (Adhikary 2012). Thus dry biogas waste has been mineralized, so it had a highest content of P and K. Insam et al (2015) stated that organic fertilizer of biogas waste has a higher total N, ammonium, and the pH than the waste that was composted, while the CN ratio declined from 10.7 to 7, so it had good quality. Nkoa (2014) stated that the biogas waste was a source of N which has a low losing risk.

Content of N, P, K of chicken manure was lower than that of cow manure. This was contrary to the Akhtar et al (2013) research which reported that chicken manure has more potential of providing nutrients mainly N, P, K than other manure samples. Chadwick et al (2015) concluded that the nutrient content of manures depended on the livestock type, their diet, and how the manure has been managed during storage, as significant losses, particularly of N and K can occur from uncovered manure heaps.

Interaction type and dosage of organic fertilizer did not affect the number of leaves from aged 1 to 3 weeks after planting (WAP). Different types of organic fertilizers did not affect the number of leaves (Table 3), but the dosages of organic fertilizer affected the number of leaves at age 3 WAP (Table 4).

Table 3

Average number of *Brassica chinensis* leaf depending on type of organic fertilizers

Organic fertilizers	*Observation time (weeks after planting)*		
	1	*2*	*3*
Cow manure	5.5	15.8	19.5
Chicken manure	5.2	16.0	18.7
Vermicompost	5.2	16.7	19.3
Cow : chicken manure (1:1)	5.3	16.3	19.0
Wet biogas waste	5.7	16.2	19.3
Dry biogas waste	5.0	16.2	19.7

Differences in various types of organic fertilizers did not affect the number of *B. chinensis* leaf from age 1 to 3 WAP (Table 3). It was suggested that the nutrient content of nitrogen of various types of organic fertilizer that play a role in the formation of leaves was not enough to increase the number of leaves. Muhammad et al (1992) stated that *B. chinensis* is a type of leaf vegetables which consumes high amount of N, so its N requirement is higher than of any other element. Hardjowigeno (1987) reported that the crop of which leaves are picked needs additional N fertilizer, so that the leaves can develop well. Thus the use of cow manure was equally well with chicken manure, concerning the number of leaves, so the use of cow dung as manure can be an alternative to chicken manure.

Table 4

Average number of *Brassica chinensis* leaves at various doses of organic fertilizers

Dosages of organic fertilizers (ton ha^{-1})	*Observation time (weeks after planting)*		
	1	*2*	*3*
10	5.3	16.2	18.6^{a}
15	5.3	16.2	19.9^{b}

Values followed by different letter on the same column showed significant differences with Duncan test on 95% confidence level.

Dosages of manure affected the amount of *B. chinensis* leaf at age 3 WAP (Table 4). Treatment of organic fertilizer 10 tons ha^{-1} produced less number of leaves than that of 15 tons ha^{-1}. Goyal et al (2005) reported that the use of organic manures as amendments to improve soil organic matter level and long term soil fertility and productivity was gaining importance. The benefits of composted organic wastes to soil structure fertility as well as plant growth have been increasingly emphasized.

Interaction of various types and dosages of organic fertilizer did not affect the fresh weight of *B. chinensis*, but both these treatments, separately, affected the *B. chinensis* production in term of fresh weight (Tables 5 and 6). Dry biogas waste ensured higher fresh weight production than cow manure, chicken manure, and vermicompost (Table 5). Lowest CN ratio of dry biogas waste with the high content of N, P, and K (Table 2) positively affected the weight of fresh *B. chinensis* (Table 5). In this terms our findings was in line with Yulyatin et al (2016) on cabbage and Dianawati (2014) on potato. Biogas waste can be used as fertilizers due to its NPK and essential elements content needed by plants. The use of biogas slurry as fertilizer can change the physical and chemical properties and soil fertility. The use of biogas slurry containing lignoselulose and lignoselulose which had decomposed significantly can improve soil physical and chemical properties (Zao et al 2013). Idnani & Varadarajan (1974) reported that during the process of sludge digestion, biogas waste was in the form of ammonia and evaporated, then the biogas slurry should be protected from direct sun in order to maintain the quality of the fertilizer. During the fermentation of manure, plant pathogens can be annihilated in an anaerobic environment, and biogas sludge has a high quality organic fertilizer (Liu 2010).

The fresh weight of *B. chinensis* in the vermicompost treatment was the lowest (Table 5), because of vermicompost high CN ratio (Table 2), so its nutrients avaibility for plants were low. Same result was reported by Marvelia et al (2006) that vermicompost reduced growth and yield of sweet corn because of its high CN ratio. Nutritional balance of soil is mainly defined by the CN ratio (Bernal et al 2009). Microorganisms require an energy source (degradable organic-C) and N for their development and activity. The adequate CN ratio for composting is in the range 10-15 (Goyal et al 2005), because it is considered that the microorganisms require 10-15 parts of C per unit of N. The best C/N ratio is less than 20 (Bernal et al 2009), but it is preferable less than 10 (Mathur et al 1993). High C/N ratios made the mineralization process very slow as there was an excess of degradable substrate for the microorganisms. Applying undecomposed compost to plants may lead to nutrients immobilization and phytotoxicity in the beginning of the decomposition process. The plant will compete with soil microorganisms for nutrients. Sutanto (2002) added that in the nutrients competition, plants are less competitive, so that the plants will experience shortage of nutrients because the nutrients were mostly used by soil microorganisms for metabolism. Therefore, this situation, in the case of vermicompost treatment, leaded to a lowest fresh weight.

Table 5
The average fresh weight of *Brassica chinensis* function of organic fertilizer type

Organic fertilizers	*Fresh weight per plant (kg)*
Cow manure	0.38^{c}
Chicken manure	0.40^{bc}
Vermicompost	0.38^{c}
Cow : chicken manure (1:1)	0.45^{abc}
Wet biogas waste	0.48^{ab}
Dry biogas waste	0.53^{a}

Values followed by different letter on the same column showed significant differences with Duncan test on 95% confidence level.

Cow and chicken provided a low *B. chinensis* fresh weight (Table 5), but they have a CN ratio below 20. This was presumably because the water content of chicken manure was high of above 50%. Sutanto (2002) stated that the high water content of organic fertilizers can degrade its own quality. Even if cow and chicken manure has a good range of CN ratio, but high water content, their quality can be lowered.

Organic fertilizer from the combination of cow and chicken manure, wet biogas waste, and dry biogas waste did not affected the weight of fresh *B. chinensis* (Table 5). This suggested that the combination of cow and chicken manure can replace organic fertilizers like wet and dry biogas waste. Ibrahim & Fadni (2013) reported that combination of chicken and cattle manure is better than each of them applied separately.

Table 6
Average fresh weight of *Brassica chinensis* function of organic fertilizer dosages

Dosages of organic fertilizer (tons ha^{-1})	*Fresh weight (kg)*	
	Per plant	*Per ha*
10	0.41^{b}	20.7^{b}
15	0.47^{a}	23.7^{a}

Values followed by different letter on the same column showed significant differences with Duncan test on 95% confidence level.

The organic fertilizer dosages factor showed that the fresh weight of *B. chinensis* in treatment of 15 tons ha^{-1} was higher than in the case of 10 tons ha^{-1} (Table 6). Wong et al (1999) observed that a general improvement in physical properties is increase of porosity and hydraulic conductivity and decrease of bulk density for *B. chinensis* and *Zea mays* L. in organic farming conditions. It means that higher dosages until 15 tons ha^{-1} manure ensures better productions than 10 tons ha^{-1}. In contrast, Dianawati et al (2017) reported that sweat corn performs optimally at 10 tons ha^{-1} of biogas waste.

Conclusions. The highest production of *B. chinensis* was obtained on dry biogas waste treatment, of which CN ratio was the lowest among other organic fertilizers, but it was not significantly different against combination of cow and chicken manure and wet biogas waste treatment. It means that the best organic fertilizer was the dry biogas waste, but combination of cow and chicken manure could substitute it. The best dosage of organic fertilizer was proved to be the 15 tonner ha^{-1} treatment.

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