
Utilization of manure and green organic composts as alternative fertilizers for cauliflower production

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Cauliflower (*Brassica oleracea* var. *botrytis*) is a vegetable crop which is grown over the world. Cultural practices of vegetables production are always dealing with fertilization technologies either using mineral fertilizers, organic fertilizers, or a combination of mineral and organic fertilizers. This study was aimed to determine the effect of reduced the dose of mineral fertilizers and substituted by organic fertilizers from compost of cow manure and compost of trailing-daisy weeds (*Wedelia trilobata*). A single factor evaluated was arranged in a completely randomized design (CRD) as follows: treatment of a mineral fertilizer with nitrogen, phosphate, and potassium applied at 10, 20 and 30 days after planting at recommended dose (T_1), compost of trailing-daisy weeds at 20 ton ha⁻¹ (T_2), compost of cow manure at 20 ton ha⁻¹ (T_3), 50% of T_1 + compost of trailing-daisy weeds at 20 ton ha⁻¹ (T_4), 50% of T_1 + compost of trailing-daisy weeds at 10 ton ha⁻¹ (T_5), 50% of T_1 + compost of cow manure at 20 ton ha⁻¹ (T_6), 50% of T_1 + compost of cow manure of 10 ton ha⁻¹ (T_7), and without fertilizer as a control (T_0). Each treatment was repeated five times so that overall there were 40 plants in 40 polybags. The results showed that the fertilizer combinations were significantly affected plant height, shoot fresh weight, dry weight of total plant biomass, and curd yield of cauliflower. The highest plant height and shoot fresh weight were observed in the treatment of 50% of mineral fertilizers combined with compost of trailing-daisy weeds at 10 ton ha⁻¹ (T_5), the highest of total dry weight of plants were observed in the treatment of cow manure compost (T_3), and the highest curd yield of cauliflower was observed in the treatment of 50% of mineral fertilizers combined with cow manure compost at 20 ton ha⁻¹ (T_6). In conclusion, organic fertilizers from compost of trailing-daisy weeds (*Wedelia trilobata*) and from cow manure can be used as an alternative fertilizer to substitute mineral fertilizers on the cauliflower production.

Keywords: cauliflower, compost, manure, mineral fertilizer, *Wedelia trilobata*.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is among the most consumed vegetables in the world. This crop is a fresh vegetable which becomes Indonesian export commodities (CBSI, 2014). It is a good source of protein, thiamin, riboflavin, phosphorus and potassium, and a very good source of dietary fiber, vitamin C, vitamin K, vitamin B6, folate,

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pantothenic acid and manganese (Bhandari and Kwak, 2015). This vegetable is also low in saturated fat and cholesterol.

Cauliflower production in Indonesia increased from 2009 to 2013 which are 96.038, 101.205, 113.491, 135.837, and 151.188 ton year⁻¹, respectively (CBSI, 2014). This indicated the interest of farmers to grow cauliflower to meet the demand of market. One factor that may influence cauliflower production is soil fertility and fertilizers. Continuing of using and increasing doses of mineral fertilizer will be declining quality of soil fertility. Soil structure will be hardened and the nutrient balance will be disturbed for long period of time (Troeh and Thompson, 2005). Biological properties of soil will be declined and the activity of microorganisms will be disrupted (Brady and Weil, 2010). In a broad sense the productivity of land will be seriously decreased. Therefore it is necessary to add organic amendments in cultivation practices such as compost of green biomass and cow manure that may function as an alternative to substitute mineral fertilizers and to improve the physical and biological properties of soil (Hue and Silva, 2000; Golabi *et al.*, 2004; Fronning *et al.*, 2008).

In the last decade efforts to reduce dependency on using mineral fertilizers by developing organic fertilizers produced from natural materials are arisen in agricultural practices (Golabi *et al.*, 2004; Brown and Cotton, 2011). Organic fertilizers are derived from organic materials either from green plants or animals that have undergone further decomposition or undergoing in a process of decomposition (Hue and Silva, 2000; Troeh and Thompson, 2005). Materials that have been or are undergoing decomposition would be a source of energy for soil microorganisms and source of nutrients for plants through the mineralization process such as NH₄, NO₃, SO₄, and PO₄ (Hue and Silva, 2000; Brown and Cotton, 2011). Humus is a material that has decomposed completely and fertilizes the soil. Humus also improve soil structure and increase water holding capacity of soil. Humus may affect plant growth by improving the drainage and permeability as well as the penetration of plant roots (Golabi *et al.*, 2004; Troeh and Thompson, 2005).

The use of organic fertilizers will help to overcome the negative effects of excessive use of mineral fertilizers. Various types of organic material that can be used as organic fertilizer can be derived from waste of animal and residue of plants that can be used after composting process (Hue and Silva, 2000; Hartatik and Widowati, 2013; Louisa and Taguiling, 2013). Applying organic compost on agricultural land is aimed to improve the properties of soil biology and physics, including maintaining the function of soil nutrients in the soil so easily used by plants, stimulate microbial activity in the soil to help plants to absorb nutrients provided by organic and inorganic fertilizers, thus contributing to growth and yield (Brown and Cotton, 2005; Mucheru-Muna and Mugendi, 2007; Farahzety and Aisah, 2013).

Trailing-daisy or Singapore-daisy or Creeping-daisy plants (*Wedelia trilobata*) is a herb weeds that can grow on land either low or high plain (Invasive Species Special Group, 2007). *Wedelia trilobata* is an invasive vegetation used to restore soil fertility and commonly used for ground cover that can improve soil quality ecologically. It is a noxious weeds in agricultural land, but some studies reported that trailing-daisy weeds can be used as a green compost or organic fertilizer for crop production. Trailing-daisy weeds has a high potency as organic fertilizer due to the high content of nitrogen as well as availability of abundant populations around the agricultural areas or in uncultivated lands. Previous study showed that compost of trailing-daisy weeds can significantly increase the growth and yield of mustard and chilli peppers because improvement of chemical and physical properties of soil (Setyowati *et al.*, 2014).

Compost of cow manure is mixed of solid and liquid waste from the cow's shed which is used as an organic fertilizer on crops (Hartatik and Widowati, 2013). Cow manure contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati, 2004). The use of cow manure can improve the growth and yield some crops such as maize, soybean, cucumber, and some vegetable crops (Mucheru-Muna and Mugendi, 2007; Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009; Jahan *et al.*, 2014).

From these backgrounds, the experiment conducted aimed to study the effects of a combination of mineral fertilizers and organic fertilizers from compost of cow manure and compost of trailing-daisy weeds (*Wedelia trilobata*) on the growth and yield of cauliflower.

Materials and Methods

Field experiment was conducted around the campus of Agricultural Faculty the University of Bengkulu, Indonesia from October 2013 to February 2014. The experiment was arranged in completely randomized design (CRD) with one factor of experiment which consisted of eight variation of the combination of mineral fertilizers and organic compost fertilizers as follow: mineral fertilizer at a recommended doses (T_1), compost of trailing-daisy weeds at 20 ton ha^{-1} (T_2), compost of cow manure at 20 ton ha^{-1} (T_3), 50 % of T_1 + compost of trailing-daisy weeds at 20 ton ha^{-1} (T_4), 50% of T_1 + compost of trailing-daisy weeds at 10 ton ha^{-1} (T_5), 50% of T_1 + compost of cow manure at 20 ton ha^{-1} (T_6), 50% of T_1 + compost of cow manure at 10 ton ha^{-1} (T_7), and without fertilization as a control (T_0). Treatment of mineral fertilizer consisted of nitrogen (N), phosphate (P_2O_5), and potassium (K_2O) fertilizers applied at (75, 150, and 75 kg ha^{-1}) at 10 days after planting; (75, 75, and 150 kg ha^{-1}) at 20 days after planting, and (100 and 150 kg ha^{-1} of nitrogen and potassium) at 30 days after planting, respectively.

Cow manure fertilizer consist of solid and liquid wastes, and residual forages on the cowsheds that have been decomposed for 3 months. Trailing-daisy weeds (*Wedelia trilobata*) were collected as fresh forage materials in the field. Green organic compost is a mixture of forages that have been finely chopped on a size of 2-3 cm, lime and rice husk charcoal with a ratio of 80:10:10 percent. These ingredients mixture were stirred homogeneous and evenly moistened by spraying a sugar solution at a concentration of 25 % (w/v) added with inoculant EM-4 at a concentration of 0.05% (v/v). After mixing homogenously, the mixtures were piled on dry container and covered with transparent plastic. The mixture was stirred evenly every 3 days until composting process was at least 30 days old or until the mixture was completely composted which was characterized by dark colors .

Media of planting was prepared in a mixture of finely ground soil from topsoil combined with compost of cow manure or compost of trailing-daisy weeds in accordance with the treatment doses. Calculation of the fertilizer doses was based on the number plant population of 40 thousand plants per hectare. A total of 10 kg of planting medium which was mixed homogeneously with organic compost in accordance to the treatment was filled into a polybag sized of 35 cm x 40 cm.

Then seedlings of cauliflower that has been sowing 3 weeks prior to transplanting (the number of leaves 3-4 strands) was transplanted into a polybag. One seedling of cauliflower was planted in each polybag. The polybags were organized in CRD as described previously and placed on the open area with 50 cm distance between polybags. Maintenance of plants is done in accordance with the standard procedures as follows, stitching at one week after planting, manual weed control performed routinely by pulling emerged weeds in and around polybags, watering the plants every day if there was no rain, and preventive control of insect and disease. Fertilization with mineral fertilizers consisted of nitrogen (N), phosphate (P_2O_5), and potassium (K_2O) was done in accordance with the treatment doses as previously described. Cauliflower curds were harvested at 90 days after planting. Two or three of leaf blades were harvested together with curds in order to protect the curds damaged.

Data of experiment were observed on plant height (cm), number of leaves (pieces), greenness level of leaves, shoot fresh weight ($g\ plant^{-1}$), fresh weight of cauliflower curd ($g\ plant^{-1}$), and the dry weight of the total biomass ($g\ plant^{-1}$). Data were subjected to analysis of variance (ANOVA) at 5% using statistical software CoStat version 6.4. Separation of means were done with LSD 0.05. Laboratory analysis of chemical contents of composted trailing-daisy weeds and data of daily rainfall were used to support the experiments.

Results and Discussion

Growth ability of cauliflower seedlings after transplanting reached 100 percent. During the study insect and diseases did not appear in plants but prevention control were done regularly. Chemical analysis of the forage compost of trailing-daisy weeds was carried out in Laboratory of Soil Science, Faculty of Agriculture, the University of Bengkulu and result were presented in Table 1. It appears that total N was higher in the compost of trailing daisy weeds than in the compost cow manure, while C, P and K were lower in the compost of trailing daisy weeds (Table 1). From this analysis it appears that the compost of trailing-daisy weeds has a potential to be used as an alternative source of organic fertilizer and to supplant mineral fertilizers.

Table 1. Chemical composition of trailing-daisy weeds (*Wedelia trilobata*) and cows' manure composts.

No	Chemical composition	Compost of <i>Wedelia trilobata</i> (%)	Compost of cows' manure (%) ¹⁾
1	C-organik	4.80	18.81
2	Total N	3.20	1.12
3	Total P	0.38	1.13
4	Total K	4.33	7.49

¹⁾ Suparman and Supiati (2004)

The circumstances of rainfall during conducting the experiment were presented in Table 2. The lowest monthly rainfall was 287.8 mm in October 2013, while the highest was 636.8 mm in January 2014. Overall average monthly rainfall was 379.5 mm. The distribution of rainfall was certainly insufficient for the growing needs of cauliflower, especially at the beginning of transplanting which was only 287.8 mm so that watering the plants remained to be done if there was no rain during a day.

Table 2. Data of the rainfall in Bengkulu City from October 2013 to February 2014¹⁾.

Month	Number of days	Total rainfall (mm month ⁻¹)
October 2013	13	287.8
November 2013	22	632.8
December 2013	15	329.3
January 2014	22	636.8
February 2014	18	340.5

¹⁾ Climatology Station, Agricultural Faculty, The University of Bengkulu

Statistical analysis on variables observed were presented in Table 3. It appears that the combination of fertilization significantly affected plant height, shoot fresh weight, curd fresh weight, and dry weight of total biomass of cauliflowers, while the number of leaves and leaf greenness level were not influenced by treatment combination fertilization.

Further statistical testing with LSD 0.05 showed that the tallest plants was 39.4 cm observed in the treatment T₅ and was significantly different with control. Treatment of organic compost or mineral fertilizers combined with organic compost showed an increased plant height. This suggests that organic fertilizers such as compost of cowmanure and compost of trailing-daisy weeds can be used as an alternative fertilizer or complementary of mineral fertilizers in order to improve better growth of cauliflowers.

Table 3. Effects of mineral fertilizers, organic compost, or combination of mineral fertilizers and organic composts to growth and yield of potted cauliflowers¹⁾.

Treatment	Plant Height (cm)	Number of leaves (plant ⁻¹)	Greenness of leaves	Shoot fresh weight (g plant ⁻¹)	Curd fresh weight (g plant ⁻¹)	Dry Weight of total biomass (g plant ⁻¹)
T ₀	30.4 c	16.0	52.70	91.04 c	168.46 c	17.40 c
T ₁	30.8 c	15.8	52.46	115.10 bc	281.34 c	22.52 c
T ₂	32.6 bc	14.2	52.66	133.32 bc	334.30 bc	39.40 b
T ₃	33.0 bc	14.6	54.60	165.34 ab	334.16 bc	48.08 a
T ₄	33.0 bc	15.8	55.94	151.76 ab	331.46 bc	36.68 b
T ₅	39.4 a	14.8	55.90	185.44 a	335.60 bc	41.38 ab
T ₆	36.0 ab	17.8	55.26	149.10 ab	490.78a	38.50 b
T ₇	33.2 bc	16.0	60.12	149.14 ab	372.94 b	40.50 ab
F-values	6.02 *	(ns)	(ns)	2.72 *	5.62 *	14.75*
CV (%)	7.04	6.66	31.43	1580	4120	35.31
LSD(0.05)	3.42	3.32	7.22	51.22	82.69	7.71

¹⁾ Numbers followed by similar letters in the same column were not significantly different at LSD0.05. T₁: mineral fertilizers of nitrogen, phosphate, and potassium applied at 10, 20 and 30 days after planting at recommended doses, T₂: compost of *Wedelia tribolata* at 20 ton ha⁻¹, T₃: cow manure compost at 20 ton ha⁻¹, T₄: 50 % T₁ combined with T₂, T₅: 50 % T₁ combined with 50 % of T₂, T₆: 50 % T₁ combined with T₃, T₇: 50 % T₁ combined with 50 % of T₃, T₀: without fertilization as a control.

Similarly, fresh weight of shoot, fresh weight of curd, and dry weight of total biomass of cauliflower also were affected by fertilization combination treatments. In Table 3 it appears that the highest fresh weight of shoot reached 185.44 g plant⁻¹ observed at T₅ treatment which was 50% of doses of mineral fertilizer plus compost of trailing-daisy weeds. The

highest yield of cauliflower curd reaches 490.78 g plant⁻¹ observed in T₆ treatment which was 50% of doses of mineral fertilizers combined with cowmanure compost. The highest dry weight of total biomass reached 48.08 g plant⁻¹ observed in T₃ treatment which was compost of cowmanure. Overall the combination of mineral fertilizers and organic fertilizers improved fresh weight of shoot, curd of cauliflower, and dry weight of total biomass. Similar results on cauliflower were also investigated by Farahzety and Aishah (2013) and Jahan *et al.* (2014). In this experiment, fertilization with only mineral fertilizers did not showed improvement in growth and yield of cauliflowers.

Treatment of organic fertilizer alone or in combination with mineral fertilizers showed better growth and yield of cauliflower. This is due to the improvement of the planting media quality, availability of nutrients for plants, and the improvement of the physical and biological properties of the soil media (Mahmoud *et al.*, 2009). The availability of nutrients in the soil which was influenced by improvement biological properties were influencing the growth and development of roots (Golabi *et al.*, 2004). Improvement of soil structures such as larger soil pores due to application of organic fertilizers will enhance root development and the ability of the roots to absorb water and nutrients (Brady and Weil, 2010).

To be able to grow and develop during the genetical stage of cauliflower, cell division must be stimulated in the meristematic region of plants (Troeh and Thompson, 2005). Inorganic fertilizers which supply the needs of the phosphorus influence to the process of cell division and tissue growth in the meristematic part of the plant. Availability of phosphorus not only crucial for vegetative growth but also for the formation of cauliflower curd. Organic compost fertilizers from manure or from trailing-daisy weeds enhanced availability of phosphorus and potassium in addition to elements of mineral fertilizers (Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009). Fertilization at the age of 20 and 30 days after planting will supply the adequacy and availability of nutrients for growth and development of cauliflower and curd formation.

Dry weight of plant biomass was the entire vegetative material of shoots and roots after drying which was accumulation of photosynthesis that build up the vegetative organs of the plant. The highest value of the dry weight of cauliflower biomass reached 48.08 g plant⁻¹ observed on the treatment of composted cow manure at 20 ton ha⁻¹. This weight showed that a high dose of manure fertilizers stimulated the processes of photosynthesis efficiently. The weight gain of plant or plant organs indicated that the plant growth and development occurred by increasing the size and volume of the cell. This is may due to availability of nutrients from manure compost at 20 ton ha⁻¹ than other treatments (Farahzety and Aishah, 2013; Jahan *et al.*, 2014).

Conclusions

Combination of mineral fertilizers and compost of organic fertilizers showed a significant response on the growth and yield of cauliflowers. Mineral fertilizers combined with compost of trailing-daisy weeds (*Wedelia trilobata*) (T₅) indicated the best response on height and fresh weight of shoot of cauliflower which were 39.4 cm plant⁻¹ and 185.44 g plant⁻¹, respectively. While compost of cow manure (T₃) gave the best of total dry weight of biomass which was 48.08 g plant⁻¹. A combination of mineral fertilizers and compost of cow manure (T₆) gave the best response to the curd yield of cauliflowers which was 490.78 g plant⁻¹.

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