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Growth and Yield of Pak Choi (*Brassica rapa* Subsp. *Chinensis*) in Responses to *Leucaena* Leaf-based Liquid Organic Fertilizer

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ABSTRACT

The uses of liquid organic fertilizer (LOF) have been increasingly practiced in organic vegetable to increase the effectiveness of solid organic fertilizer application. Farmers can produce LOF by using locally available green biomass in the surrounding production areas, including leaves of Leucaena leucocephala (Lam) de Wit. This experiment aimed to determine the best concentration of Leucaena leaf-based LOF on growth and yield of Pak Choi (*Brassica rapa* Subsp. *Chinensis*). An experiment was arranged in Randomized Complete Design with seven replicates. Treatments are several concentrations of *Leucaena* leaf-based LOF, 0%, 25%, 50%, 75% and 100%. Although, the concentration of 50% was likely able to increase shoot length, leaf area and leaf greenness of Pak Choi, but the effects of *Leucaena* leaf-based LOF on leaf numbers, shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of Pak Choi were insignificant. Consistency effects of *Leucaena* leaf-based LOF in the production of Pak Choi should be re-evaluated.

INTRODUCTION

Pak choi plant (*Brassica rapa* Subsp. Chinensis) belongs to family Cruciferae and very popular in many Asian countries, including Indonesia. According to Ram (2009), this vegetable which contains glucose, protein, fat, dietary fiber, and vitamin C can be harvested at four to five weeks after transplanting. There is no specific data on Indonesian national production of pak choi since national production of this vegetable is included in annual Chinese cabbage category (BPS, 2022), which accounted for 652.723 tons (2019), 667.473 tons (2020), 727.467 (2021), 760.608 tons (2022). Meanwhile, annual per capita consumption of vegetables for Indonesian people continues to increase from year to year, from 23.65 kg/capita/year in 2019, 24.19 kg/capita/year in 2020 and 25.21 kg/capita/year in 2021 (Indonesian Ministry of Agriculture, 2022). In addition, consumer demands to organic vegetables, including pak choi, steadily increases along with the increased awareness of the community about the importance of healthier products and sustainable agricultural resources (Slamet *et al*., 2016). Such increases must be balanced

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with sufficient supplied of organic vegetables to meet the consumer demands.

In organic production systems, the use of solid organic fertilizer remains as the major sources of nutrients to support plant growth and development. Despite of its favorable impacts on the soil environment, solid organic fertilizer often takes more time to mineralize than a crop's life cycle which eventually limits nutrient requirement during the early crop growth and development. According to Hartz *et al*. (2000), less than 10% of the original nitrogen content of the majority of solid organic fertilizer composts applied to the soil was well decomposed within the first four to six months. The uses of liquid organic fertilizer (LOF) have been increasingly practiced in organic vegetable production as a complementary nutrient source for solid organic fertilizer application. Even though the nutrient content of LOF is rather low and its composition strongly depends on the composing materials, its nutrients are quickly absorbed by plants and can be applied at various phases of plant growth. Increased yields of organic vegetable crops due to LOF application have been reported in caisim (Al-Akhyar *et al*., 2019), carrots and green onions (Fahrurrozi *et al*., 2022), cauliflower (Gomies *et al*., 2012), pak choi (Hardiansyah *et al*., 2019), potatoes (Fahrurrozi *et al*., 2019), carrot (Fahrurrozi *et al*., 2015), and tomatoes (Zhai *et al*., 2009). Although commercial LOFs are widely available in the markets, farmers can produce LOF by using locally available materials in the surrounding production areas, especially green biomass.

The proper use of green biomass in the production of LOF determines the quantity and quality of green plant-based LOF nutrients. The plants or plant parts used as one of material in producing LOF could be plants that specifically grown for this purpose, or weed that grow well around vegetable production areas. Leaves of *Leucaena leucocephala* (Lam) de Wit, known as lamtoro in Indonesia, is one of the leguminosae plants that can be used as source of nutrient in manufacturing LOF. According to Hartadi *et al*. (2005), leaves *Leucaena* plant contained crude protein 23.7%, crude fiber 18% and crude fat 5.8%. Fahrurrozi *et al*. (2017) identified that *Leucaena* leaves contained 0.84% N, 0.81% P, 3.53% K, 0.97% Ca, 0.01% Mg, and 67.92% of organic C. Once it is used as major LOF component, the *Leucaena* leaf-based LOF is expected to increase growth and yield of several crops mainly due to its high N contents.

It was reported that *Leucaena* leaf-based LOF contained N, P, K, Ca, and Mg as much as 3.84%, 0.20%, 2.06%, 1.31%, and 0.33%, respectively (Palimbungan *et al*., 2006 In Jeksen and Mutiara, 2017). However, Jeksen and Mutiara (2017) found much lower nutrient contents of *Leucaena* leaf-based LOF which are accounted for 0.057% of N-total, 0.029% of P, 0.180% of K, 0.014% of Ca and 0.017 of Mg. Variation in nutrient contents of *Leucaena* leaf -based LOF could have been related to the different in composing materials and method of incubation. Nevertheless, the use of *Leucaena* leaf-based LOF increased growth and yield of several vegetable crops, such as sweet corn (Hasan *et al*., 2021), tomato (Septirosya *et al*., 2019), and pak choi (Hidayat and Suharyana, 2019). It appeared that LOF effectiveness in promoting growth and yield of particular vegetable is not only determined by crop species, frequency of application and the stage of plant growth, but also by the concentration of LOF. This experiment aimed to determine the best concentration of *Leucaena* leaf-based LOF on growth and yield of pak choi (*Brassica rapa* Subsp. Chinensis).

MATERIALS AND METHOD

This experiment was conducted from January to March 2020 at Field Laboratory of Faculty of Agriculture University of Bengkulu, in Bengkulu City at altitude of 20 m above sea level. This single factor experiment was laid out in Randomized Complete Design with seven replicates. Various concentrations of *Leucaena* leaf-based LOF served as treatments which consisted of (1) 0%, (2) 25%, (3) 50%, (4) 75%, and (5) 100%. There were three polybags for each experimental unit.

The production of *Leucaena* leaf-based LOF was conducted by mixing 5 kg of chopped *Leucaena* leaves, 5 kg of cattle feces, 2.5 kg of fertile top soil, 10 L solution of 24-hour incubated 10 mL EM 4+0.25 kg white sugar. These mixtures were added with water in plastic container to reach a volume of 100 L and aerobically fermented for four weeks (Fahrurrozi et al., 2015). After that, the liquid portion of the mixture was sieved through a white cloth and then considered as 100 % in concentration. Laboratory analysis indicated that N, P_2O_5, K_2O, organic C, and pH of this *Leucaena* leaf-based LOF were 1.54%, 0.32%, 1.32%, 4.58% and 7.84, respectively.

Growing media of pak choi used fertile topsoil and placed into black polyethylene polybag. Four weeks old seedlings of pak choi (*cv*. Nauli F1) were transplanted into the polybags (contained 8 kg absolute soil dry weight). Each polybag served as experimental unit, and arranged in the distance of 0.3 m x 0.3 m between the polybags. Each polybag was fertilized with vermicompost at the rate of 10 Mg ha^{-1}. This vermicompost contained 2.15 % of total N, 0.24 % of P, 0.55 %, and 25.6 % of organic C (Muktamar *et al*., 2017).

Every single plant in each experimental unit sprayed with a total of 500 mL *Leucaena* leaf-based LOF according to treatments and was applied uniformly to plants at 2, 3, 4 and 5 weeks after transplanting with 50 mL, 100 mL, 150 mL, and 200 mL. When there was no precipitation, plants were manually watered until the growing media reached field capacity. Weeds and pests that presence in the polybags were physically removed their existences.

Growth responses of pak choi to *Leucaena* leaf-based LOF were evaluated by measuring the shoot length, leaf number, leaf area, leaf greenness. All pak choi were harvested at 42 days after transplanting by carefully removing it from the growing media, water-cleaned and weighed to determine shoot and root fresh weight. Samples were dried in oven at 75 ^oC for 24 hours until reaching the constant weight before shoot and root dry weight were weighed.

Before doing an analysis of variance using Statistical Analysis System (P≤0.05), data were homogeneously tested. The Least Significantly Different test (P≤0.05) was used to compare mean values of treatment effects.

RESULTS AND DISCUSSION

Responses of Pak Choi

Results from this experiment indicated that treatment (concentration of *Leucaena* leaf-based LOF) significantly influenced the shoot length, leaf area and leaf greenness, but not leaf number of pak choi. The effects treatments on shoot length, leaf area, leaf number and leaf greenness of pak choi are presented in Table 1.

Table 1 suggested that the use of *Leucaena* leaf-based LOF increased the shoot length, leaf area and leaf greenness, but not the leaf number. The higher LOF concentration, the higher shoot length, leaf area and leaf greenness of pak choi. Generally, using 50% in concentration of *Leucaena* leaf-based LOF was able to increase these variables. Such increases might have been attributed to nitrogen content of *Leucaena* leaf-based LOF (1.54%) which particularly effect the early stage of plant growth development. The amount of nitrogen was also supplied by nitrogen contained in vermicompost (2.15 %). Serving as the primary macronutrient needed by plants, nitrogen is involved in all metabolic

Table 1. Effects of LOF concentration on shoot length, leaf area, leaf number and leaf greenness of Pak Choi

LOF concentration	Shoot length (cm^2)	Leaf area (cm^2)	Leaf number (leaves)	Leaf greenness (SPAD index)
0 %	16.21 b	65.42 bc	8.00 a	46.65 b
25%	19.43 a	47.41 c	10.00 a	44.52 b
50%	19.00 a	69.95 ab	9.00 a	47.55 ab
75%	18.71 ab	73.04 ab	8.00 a	50.67 a
100%	20.00 a	89.40 a	8.00 a	46.98 ab

Note: Means in the same column followed with the same letter are not significantly different according to Least Significant Difference P≤0.05.

activities, including in cell elongation and multiplication during the vegetative growth (Hawkesford, 2012), including maintaining the chlorophyll content of plants. In addition, nitrogen is a key component of the chlorophyll molecule and enhances the quality and amount of dry matter in green plants (Uchida, 2000).

The leaf greenness in this experiment was comparable to that of reported by Hardiansyah *et al*. (2019) who reported that using *jiringa* hulls-based LOF produced the leaf greenness of pak choi as much as 48.48 (SPAD index). Although the treatments on leaf number of pak choi was similar, the number of leaves of pak choi in this experiment was higher than that of reported by Mohammad *et al*. (2022), who found that the number leaves of pak choi fertilized with vermicompost produced only seven leaves plant^{-1}. However, the number of leaves of pak choi in this experiment was much lower to that of reported by Hardiyansyah *et al*. (2019) where *jiringa* hulls-based LOF produced 15 leaves plant^{-1}.

This experiment also indicated that the effect of treatment was insignificant on shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of pak choi. The effects of *Leucaena* leaf-based LOF on shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of pak choi are presented in Table 2.

Insignificant effects of treatments on shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of pak choi was less expected. It is recognized that shoot fresh of pak choi is the most important traits for commercial purposes. Shoot fresh weight of pak choi from this experiment weighed less than 30 g (Table 2). Results from this experiment were contrary to those had been reported by Purbajanti and Setyowati (2020) who concluded that the used of *Leucaena* leaf-based LOF increased the effectiveness of solid organic fertilizer in increasing shoot fresh weight of pak choi. Ramadhani and Koesriharti (2022) found that the used of biourine-based LOF increased the shoot fresh weight of pak choi. Previously, Hardiansyah *et al*. (2019) reported that the use LOF made from *jiringa* hulls produced shoot fresh weight of 68.85 g plant^{-1}. The only explanation might be related to high precipitation during the course of experiment. According to Shoemaker (1991), during the courses of growth and development, this group of vegetable requires 12 to 17 inches (equals to 305 to 431 mm). However, rain fall recorded at the nearest climatological station the months during of January, February and March were continued to increase 344 mm/ months, 351 mm/months and 406 mm/months (or in total of 1.101 mm). High precipitation experienced by the crops in this experiment might have leached the nutrients in the polybag which eventually suppressed growth of pak choi. According to Yao *et al*. (2021) the intensity of rainfall intensity induced the leaching of soil nutrients including nitrogen, phosphorus and potassium. Such leaching disallowed plants roots to effectively uptake the nutrients since the nutrients dripped down to bottom of the polybags.

CONCLUSION

On the basis of this experiment, the uses of *Leucaena* leaf-based liquid organic fertilizer

Table 2. Effects of LOF concentration on shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of pak choi

LOF concentration	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
0 %	18.81 a	0.92 a	1.92 a	0.39 a
25%	20.09 a	1.43 a	1.44 a	0.25 a
50%	23.59 a	1.54 a	2.07 a	0.33 a
75%	25.61 a	1.54 a	1.70 a	0.32 a
100%	29.75 a	1.75 a	2.21 a	0.72 a

Note: Means in the same column followed with the same letter are not significantly different according to Least Significant Difference P≤0.05.

(LOF) increased shoot length, leaf area and leaf greenness pak choi. The use *Leucaena* leaf -based LOF with 50% in concentration was able to increase these variables. However, the application of *Leucaena* leaf-based LOF did not increase the leaf numbers, shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of pak choi.

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