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Journal of Tropical Agricultural Science

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays L. Var. saccharata)

Journal:	*Journal of Tropical Agricultural Science*
Manuscript ID	JTAS-1698-2019.R1
Manuscript Type:	Regular Article
Scope of the Journal:	Crop nutrition < Crop and pasture production < AGRICULTURAL SCIENCES
Keywords:	liquid organic fertilizers, sweet corn
Abstract:	The objective of the research was to investigate the effect of concentration and doses of liquid organic fertilizers (LOF) derived from the extract mixture of lamtoro leaves, banana humps, and coconut fibers on growth, yield, quality and nutrient uptake of sweet corn. Two experiments were conducted using Randomized Complete Block Design with 3 replications. Experiment 1 composed of 6 treatments namely control without LOF, recommended inorganic fertilizers, LOF concentration of 15 ml l-1, 30 ml l-1, 45 ml l-1, 60 ml l-1. Experiment 2 consisted of 5 treatments namely recommended inorganic fertilizers, LOF doses of 25 l ha-1, 50 l ha-1, 75 l ha-1, 100 l ha-1. Results showed that LOF consistently increases the growth and yield of sweet corn. Application of LOF with a concentration of 60 ml l-1 or a dose of 100 l ha-1 showed the highest yield compared to other treatments. The quality of sweet corn increased markedly. Application of LOF improved the nutrient absorption. It was concluded that LOF could be applied as an alternative technique to inorganic fertilizers in the sweet corn organic farming in the tropics.

Liquid organic fertilizer extracts improves yield of sweet corn

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. Saccharata*)

List of Tables

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. Saccharata*)

ABSTRACT

The objective of the research was to investigate the effect of concentration and doses of liquid organic fertilizers (LOF) derived from the extract mixture of *lamtoro* leaves, banana humps, and coconut fibers on growth, yield, quality and nutrient uptake of sweet corn. Two experiments were conducted using Randomized Complete Block Design with 3 replications. Experiment 1 was composed of 6 treatments namely control without LOF, recommended inorganic fertilizers, LOF concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1}. Experiment 2 consisted of 5 treatments namely recommended inorganic fertilizers, LOF doses of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1}, 100 l ha^{-1}. Results showed that LOF consistently increased the growth and yield of sweet corn. Application of LOF with a concentration of 60 ml l^{-1} or a dose of 100 l ha^{-1} showed the highest yield compared to other treatments. The quality of sweet corn increased markedly. Application of LOF improved the nutrient absorption. It was concluded that LOF could be applied as an alternative technique to inorganic fertilizers in the sweet corn organic farming in the tropics.

Key words: banana hump, coconut fiber, leucaena leaf, nutrient uptake, organic farming

INTRODUCTION

Sweet corn (*Zea mays* L. Var. Saccharata) is one type of vegetable that is preffered by the community because of its relatively high sugar content. Organic sweet corn production needs to be improved by improving fertilization techniques. Fertilizing sweet corn can be given in the form of solid fertilizer or liquid fertilizer. The characteristics of solid organic fertilizer are the process of Nitrogen nutrient mineralization and the Carbon takes place very slowly (Hartz, Mitchell, & Giannini, 2000; Johnson et al., 2012). Another alternative in organic tropical agriculture is the use of liquid organic fertilizers.

One of the cultivation techniques to increase growth and yield of sweet corn grown organically is the use of liquid organic fertilizers (LOF) made from the waste of many plant materials available around the farmer's garden. The application of fertilizer through leaves has been successfully carried out on corn plants (Amanullah et al., 2014). Similarly, the application of LOF was carried out on various vegetable crops such as sweet corn (Fahrurrozi et al., 2016) and tomatoes (Zhai et al., 2009). Hartz, Smith, & Gaskell, (2010) proved that the application of LOF can function the same as conventional fertilization of solid fertilizers. Furthermore, the researchers stated that Nitrogen derived from liquid organic fertilizer is more readily available and the nitrification process takes place faster.

There is still lack scientific basis about utilization of plant extracts as LOF. Plant wastes such as *lamtoro* (*Leucaena leucocephala*) leaves, banana humps, and coconut husk are widely available around farmers' gardens. *Lamtoro* leaves are often used as animal feed. *Lamtoro* leaves contain lots of nitrogen, protein, vitamins, and minerals (Farinu, Ajiboye, & Ajao, 1992; Meulen et al., 1979). Liquid organic fertilizer from the leaves of lamtoro is a source of nitrogenous nutrients for plants. Banana humps contain microbial decomposers of organic matter, such as *Bacillus* sp., *Aeromonas* sp., and *Aspergillus nigger* (Suhastyo, 2011). These microbes are able to decompose organic matter. The main content of coconut fibers is cellulose, hemi-cellulose, and lignin (Arsyad et al., 2015). If the coconut fiber is soaked and fermented with water, the nutrient K contained in coconut fiber will dissolve in soaking water so that the liquid fertilizer coconut husk is high in K nutrients.

The purpose of this study was to determine the effect of concentration and dose of liquid organic fertilizer made from an extract mixture of *lamtoro* leaves, banana humps and coconut fibers on the growth, production, quality and nutrient uptake of sweet corn plants.

MATERIALS AND METHODS

This research was carried out in Kota Sepang experimental station, Bandar Lampung, Indonesia with the coordinates between 105 ° 15 '23' 'and 105 ° 15' 82 " E and between 5 ° 21' 86 " S. The study area classified as Ultisol soil. Field study was set up in RCBD (Randomized Complete Block Design) and replicated three times. The experiment consists of 2 sub-experiments. Experiment 1 (April to June 2016) consisted of six treatments, namely control (k0), recommended inorganic fertilizer (k1), application of LOF with a concentration of 15 ml l^{-1} (k2), 30 ml l^{-1} (k3), 45 ml l^{-1} (k4), 60 ml l^{-1} (k5). Experiment 2 (April to June 2017) consisted of five treatments namely recommended inorganic fertilizer (d0), application of LOF with a dose of 25 l ha^{-1} (d1), 50 l ha^{-1} (d2), 75 l ha^{-1} (d3), and 100 l ha^{-1} (d4).

The research began with making plant extract LOF following a procedure developed by Astuti (2014). *Lamtoro* leaves, banana humps, and coconut husks were cut into small pieces and then put into containers, then brown sugar and rice washing water were put and stirred evenly. Then EM-4 was added, after which the container was closed and then fermented for 21 days and filtered. Liquid organic fertilizer from *lamtoro* leaves, banana humps, and coconut fibers mixed with a ratio of 1: 1: 1. All plots were hand hoed before planting. The area of each plot was 3 m × 3 m, and the row spacing was 70 cm × 20 cm.

The application of liquid fertilizer was carried out by spraying evenly on the upper and lower part of leaves. The application of LOF was carried out once a week from the age of 2 to 7 weeks after planting (WAP). Inorganic recommended fertilizers were given included Urea 300 kg ha^{-1}, SP-36 150 kg ha^{-1}, and KCl 100 kg ha^{-1}. Agronomic practices in this study included watering, growing, control of weeds, and preventing pests and diseases organically. Harvesting was conducted at 70 days after planting.

The variables observed in this study were the number of leaves, stem diameter, plant height, leaf area index (LAI), SPAD value, the weight of husked ear, the weight of unhusked ear, ear length, ear diameter, shoot dry weight, ºBrix value, yield, and N, P and K nutrient uptake. Statistical analysis of the data was conducted using MINITAB v. 16.0 software. The ANOVA (analysis of variance) and the least significant difference (LSD) test were conducted at the 5% probability level.

RESULTS AND DISCUSSION

Results

The LOF application affects vegetative variables of plants. Leaf number and stem diameter were greater in LOF applied plant than control plant (Table 1). The results of the variance analysis showed that the application of liquid LOF extract increased the number of leaves and stem diameter. The number of leaves and stem diameter treated with concentrations of 15, 30, 45, and 60 ml l^{-1} were not significantly different (Table 1).

The LOF application had affected on vegetative variables of plants. The plant height, leaf number, stem diameter, LAI and SPAD value greater in LOF applied plant than control plant (Tables 1 & 2). Plant height, leaf number, stem diameter and LAI increased with increasing concentration of LOF till 45 ml/L and 76 l/ha followed by not significant increased. The lowest number of leaves, plant height, stem diameter and SPAD value were recorded in control plant.

The LOF application increases plant height, leaf area index and the greenness of the leaves (Table 2). Plant height and leaf area index with a dose of 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences (Table 2). The greenness level of leaves in the 100 l ha^{-1} treatment was the highest than the other treatments, while between doses of 50 l ha^{-1} and 75 l ha^{-1} was not significantly different.

The results of the variance analysis indicated that the LOF application increased weight of unhusked ears and weight of husked ears (Table 3 and 4). Weight of unhusked ear and weight of husked ear in the LOF treatment were significantly higher than the control treatment, and not significantly different from inorganic fertilizer treatment (Table 3). The lowest of weight of unhusked ear, weight of husked ear, ear length, and ear diameter were recorded in control plant (Table 3).

The LOF application increased ear length (Tables 3 and 4). The lowest ear length and ear diameter were recorded in control plant (Table 3). Ear length of the concentration of 30, 45, and 60 ml l^{-1} was not significantly different from the treatment of inorganic fertilizer (Table 3), while ear length between doses of 50 l ha^{-1} and inorganic recommendation did not show any significant differences (Table 4). The ear length between doses of 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1} did not show any significant differences (Table 4).

The application of LOF increased the ear diameter (Tables 3 and 4). The lowest ear diameter was recorded in control plant (Table 3). The diameter of the ear between a concentration of 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1} (Table 3) and between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 4) were not significantly different.

The LOF application increased sugar content (Tables 5 and 6) indicated by ºBricks value. The lowest sugar content was recorded in control treatment (Table 5). The sugar content between all concentrations of LOF (Table 5) and between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 6) were not significantly different. The application of LOF increased the shoot dry weight (Table 6).

The application of LOF consistently increased sweet corn yields (Tables 5 and 6). The yield of sweet corn at all concentrations (Table 5) were not significantly different. The lowest yield was recorded in control treatment. The highest yield was obtained at a concentration of 60 ml l^{-1} (Table 5) and doses 100 l ha^{-1} (Table 6).

Application of LOF plant extracts increased plant nutrient uptake (Table 7). Nutrient uptake of P and K in the LOF treatment were significantly higher than those treated with inorganic fertilizer. In addition, nutrient uptake of N, P, and K between doses of 25 l ha^{-1} and 50 l ha^{-1} as well as between doses 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences.

The weight of husked ear and the weight of unhusked ear in the LOF treatment were significantly higher than the control treatment, and not significantly different from inorganic fertilizer treatment (Table 3). The results of the variance analysis indicated that the LOF application increased the weight of husked ears and the weight of unhusked ears.

The weight of unhusked ears between the doses of 75 l ha^{-1} and 100 l ha^{-1} did not show any significant difference (Table 4).

The LOF application increased ear length (Tables 3 and 4). The ear length in the control treatment was significantly lower than those treated by LOF, while the ear length of the concentration of 30, 45, and 60 ml l^{-1} was not significantly different from the treatment of inorganic fertilizer (Table 3). The ear length on the LOF treatment was significantly higher than that of inorganic recommendation, while the ear length between doses of 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1} did not show any significant differences (Table 4).

The application of LOF increased the ear diameter (Tables 3 and 4). The diameter of the ear on the LOF treatment was higher than the control treatment (Table 3) and from inorganic fertilizers (Table 4). The diameter of the ear between a concentration of 30 ml l^{-1}, 40 ml l^{-1}, 60 ml l^{-1} (Table 3) and doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 4) were not significantly different.

The LOF application increased sugar content (Tables 5 and 6) as indicated by ºBricks value. The sugar content in the control treatment was significantly lower than those treated with LOF, while the sugar content of all concentrations of LOF (Table 5) and doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 6) were not significantly different.

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Discussion

The results of the laboratory analysis of LOF showed that extract N content in lamtoro leaves was 763.01 ppm, P was 55.11 ppm, and K was 125.81 ppm. Banana humps extract had N nutrient content of 238.04 ppm, P was 63.88 ppm, and K was 88.21 ppm. Coconut fibers extract had N nutrient content of 133.12 ppm, P was 8.95 ppm, and K was 192.11 ppm. The high content of N, P, K nutrients in LOF means that the application of liquid organic fertilizer is sufficient to meet the basic needs of N, P and K nutrients for sweet corn plants.

Vegetative growth of plants is represented by the variable number of leaves, stem diameter, and plant height. The best vegetative results are indicated by the treatment of concentrations of 45 m l^{-1} and 60 ml l^{-1}. At the beginning of growth, plants can absorb nutrients from LOF and are used by plants to support growth. The N element is a key element for cell division which will support plant growth in both size and volume (Ohyama, 2010).

Liquid organic fertilizer ~~increases~~ increased the leaf area index so that the leaf surface will be wider to capture sunlight. Fageria et al. (2009) stated that foliar application requires high LAI. The leaf greenness variable showed that the application of LOF at a dose of 100 l ha^{-1} gave a high yield compared to the other treatments. According to Nugroho (2015) the function of nitrogen, in addition to stimulating plant growth, also ~~gives~~ gave the green color of the leaves. The darker the green color of leaves on corn plants shows the higher the nitrogen element absorbed by plants.

The application of LOF ~~gives~~ gave positive results on generative growth of plants. The results showed that the concentration of 60 ml l^{-1} gave the best results on variable the weight of husked ear and the weight of unhusked ear and treatment with a dose of 100 l ha^{-1} gave the highest ear diameter and the heaviest weight of the cob. It can be inferred that the higher the dose or concentration of LOF given will increase the generative growth of plants. According to Zafar, Abbasi, & Khaliq, (2013) enlargement of ear diameter is related to the availability of P elements. P nutrients greatly influence the formation of ears. As the component of ATP, P will guarantee the availability of energy for growth so that the formation of assimilates and transport to storage can function well (Amanullah et al., 2009) that causes the growth of a generative plant is activated.

The LOF application ~~can~~ could increase the yield of sweet corn. This means that the contribution of nutrients from liquid organic fertilizer can be an alternative to the recommended solid fertilizer. The results of this study are supported in various other LOF studies. Minardi et al. (2015) found that banana corm extract increased the available P soil. Aini, Sugiyanto, & Herlinawati (2017) stated that the treatment of banana humps ~~has~~ had a significant effect on the growth and yield of soybean. Working with *Gleicheni linearis* plant extract Aulya et al. (2018) showed that the application of 100 mg l^{-1} was the most effective concentration in increasing plant height and leaf area of maize compared to control.

The results showed that the treatment of a dose of LOF 100 l ha^{-1} gave a high N, P, and K nutrient uptake, and this was attributed to the adequate supply of nutrients from LOF. This means that the higher the dose of LOF ~~given~~ applied ~~will~~ increase the nutrient uptake of N, P, and K. Muktamar et al. (2016) showed that increase in rates of LOF significantly raised nitrogen uptake by sweet corn, but not phosphorus and potassium.

The application of N nutrients in plants has a direct role in the formation of amino acids, proteins, nucleic acids, enzymes, nucleoproteins, and alkaloids (Mokhele et al., 2012) which are needed for the vegetative growth process of plants and increase the greenness of leaves. Leaf N nutrient uptake has a close relationship with the leaf greenness level which is characterized by SPAD value. Liquid organic fertilizer also increases nutrient uptake of P and K by plants. Mukuralinda et al. (2010) also showed high P nutrient uptake due to the application of organic fertilizer compared to control. Increasing nutrient uptake of P ~~will~~ encourages the metabolic processes in the plant to become more active. The P element is known as the forming element of ATP for energy sources. In addition to P, nutrient K also plays an important role in improving the quality of plant fruit.

The application of liquid organic fertilizer containing element of K elements from coconut fiber extract improved the quality of sweet corn which is characterized by a higher Brix value. Jifon & Lester (2009) show found that the application of K fertilizer through leaves will increase the sugar content of muskmelon plants. Sweet taste in sweet corn involves potassium nutrients which play a role in the activation of many enzymes that play a role in metabolic processes in plants. Enzymes that play a role in sugar synthesis are activated by K (Prajapati & Modi, 2012)

The research showed that in both experiments, between the concentration (experiment 1) of the LOF and inorganic recommended fertilizers as well as between the doses (experiment 2) of the LOF and inorganic recommended fertilizers gave the same effect on all parameters of growth and yield of sweet corn. It is clear then that sweet corn plants fertilized with LOF had the same growth and yield with those of recommended fertilizers. Therefore, it implied that LOF could be an alternative fertilizer. Some researchers have also succeeded in applying the application of liquid organic fertilizer to sweet corn commodities (Muktamar et al., 2017) and corn (Aulya et al., 2018). From this experiment, it can be recommended to use local plant resources around farmers such as lamtoro leaves, banana humps, and coconut fibers to be used as LOF. The use of liquid organic fertilizer from plant materials can be used as an alternative to complementary fertilization technology in developing organic agriculture. In its application, liquid organic fertilizer needs to be mixed with given a surfactant to increase the efficiency of uptake by plant leaves. The application of liquid organic fertilizer is a cheap and an but effective technology in organic farming. Further research is still needed to determine the appropriate concentration and doses of liquid organic fertilizer for each type of horticulture plant.

CONCLUSIONS

Application of LOF with the concentration of 60 ml l^{-1} or dose 100 l ha^{-1} showed the best growth and yield of sweet corn compared to lower concentration or lower dose. Application of LOF could improved the quality of sweet corn. Sweet corn sprayed with LOF absorbed higher nutrient N, P, and K higher. Research showed that LOF could be an alternative to inorganic fertilizers as sweet corn plants fertilized with LOF had the same growth, yield, and quality with those of recommended fertilizers.

ACKNOWLEDGMENT

This research was funded by the research grant from Faculty of Agriculture, University of Lampung in 2017.

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Table 1.

Effects of liquid organic fertilizer concentration on the number of leaves and stem diameter in sub-experiment 1

Treatments	The number of leaves	Stem diameter (cm)
k_0 (control)	11.33 c	1.60 c
k_1 (inorganic fertilizer)	12.47 b	1.80 b
k_2 (15 ml l^{-1})	12.80 ab	1.93 ab
k_3 (30 ml l^{-1})	13.00 ab	1.89 ab
k_4 (45 ml l^{-1})	13.20 a	2.02 a
k_5 (60 ml l^{-1})	13.47 a	2.00 a
LSD 5%	0.71	0.19

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 2

Effects of liquid organic fertilizers doses on plant height, LAI, and SPAD value in sub-experiment 2

Treatments	Plant height (cm)	LAI	SPAD value
d_0 (inorganic fertilizer)	82.05 bc	3.07 d	44.28 c
d_1 (25 l ha^{-1})	83.31 b	3.64 c	44.91 c
d_2 (50 l ha^{-1})	84.56 b	4.23 b	46.22 b
d_3 (75 l ha^{-1})	93.80 a	5.33 a	46.97 b
d_4 (100 l ha^{-1})	93.45 a	5.51 a	48.15 a
LSD 5%	1.74	0.19	0.99

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 3

Effects of liquid organic fertilizer concentration on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in sub-experiment 1

Treatments	The weight of husked ear (kg)	The weight of unhusked ear (kg)	Ear length (cm)	Ear diameter (cm)
k_0 (control)	1.88 b	1.28 b	18.61 c	3.94 c
k_1 (inorganic fertilizer)	2.33 a	1.77 a	21.03 ab	4.42 b
k_2 (15 ml l^{-l})	2.35 a	1.78 a	20.15 b	4.40 b
k_3 (30 ml l^{-l})	2.30 a	1.97 a	21.14 ab	4.55 ab
k_4 (45 ml l^{-l})	2.63 a	2.08 a	21.85 a	4.71 a
k_5 (60 ml l^{-l})	2.63 a	2.12 a	21.61 a	4.68 a
LSD 5%	0.42	0.41	1.09	0,20

In a column, values having common letter(s) do not differ significantly at p ≤ 0.05 as per LSD

Table 4

Effects of liquid organic fertilizer doses on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in experiment 2

Treatmens	The weight of husked ears (kg)	The weight of unhusked ears (kg)	Ear length (cm)	Ear diameter (cm)
d_0 (inorganic fertilizer)	2.10 e	1.60 c	20,32 a	4.39 d
d_1 (25 l ha^{-1})	2.30 d	1.73 c	20.19 a	4.43 c
d_2 (50 l ha^{-1})	2.57 c	1.80 bc	18.45 b	4.50 b
d_3 (75 l ha^{-1})	3.03 b	2.07 ab	18.12 b	4.58 a
d_4 (100 l ha^{-1})	3.30 a	2.27 a	17.79 b	4.60 a
LSD 5%	0.10	0.27	0.88	0.03

Respective treatment column means followed by different letters are significantly different

Table 5

Effects of liquid organic fertilizers on shoot dry weight, °Bricks value, and yield on Experiment 1

Treatments	Shoot dry weight (g)	°Bricks value	Yield (ton ha^{-1})
k_0 (control)	14.19 a	15.22 c	8.28 b
k_1 (inorganic fertilizers)	19.24 a	15.76 b	11.59 a
k_2 (15 ml l^{-1})	17.16 a	15.85 ab	13.26 a
k_3 (30 ml l^{-1})	18.97 a	16.16 ab	13.24 a
k_4 (45 ml l^{-1})	20.74 a	16.18 a	14.76 a
k_5 (60 ml l^{-1})	21.31 a	16.22 a	14.94 a
LSD 5%	10.36	0.40	5.38

Respective treatment column means followed by different letters are significantly different by LSD at P<0.05

Table 6

Effects of dose of liquid organic fertilizers on shoot dry weight, °Bricks value, and yield in Experiment 2

Treatments	Shoot dry weight (g)	°Bricks value	Yield (ton ha^{-1})
d_0 (inorganic fertilizers)	16.25 d	11.05 b	15.15 c
d_1 (25 l ha^{-1})	17.07 b	11.50 b	15.97 b
d_2 (50 l ha^{-1})	17.43 a	11.56 b	16.21 b
d_3 (75 l ha^{-1})	16.87 c	12.39 a	17.37 a
d_4 (100 l ha^{-1})	17.33 a	12.56 a	17.81 a
LSD 5%	0.15	0.60	0.63

Respective treatment column means followed by different letters are significantly different by LSD at $P<0.05$

Table 7
Effects of liquid organic fertilizers doses on nutrient uptake in Experiment 2

Treatments	N uptake	P uptake	K uptake
d_0 (inorganic fertilizers)	7.70 b	1.97 c	25.14 c
d_1 (25 l ha^{-1})	8.17 b	2.39 b	26.98 b
d_2 (50 l ha^{-1})	8.57 b	2.51 b	29.39 ab
d_3 (75 l ha^{-1})	9.80 ab	2.70 a	32.22 a
d_4 (100 l ha^{-1})	10.10 a	2.72 a	34.74 a
LSD 5%	0.58	0,17	3.76

Respective treatment column means followed by different letters are significantly different by LSD at $P<0.05$

Liquid organic fertilizer extracts improves yield of sweet corn

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. Saccharata*)

List of Tables

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. Saccharata*)

ABSTRACT

The objective of the research was to investigate the effect of concentration and doses of liquid organic fertilizers (LOF) derived from the extract mixture of lamtoro leaves, banana humps, and coconut fibers on growth, yield, quality and nutrient uptake of sweet corn. ~~Two experiments were conducted using Randomized Complete Block Design with 3 replications.~~ Experiment 1 composed of 6 treatments namely control without LOF, recommended inorganic fertilizers, LOF concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1}. Experiment 2 consisted of 5 treatments namely recommended inorganic fertilizers, LOF doses of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1}, 100 l ha^{-1}. Results showed that LOF consistently increases the growth and yield of sweet corn. Application of LOF with a concentration of 60 ml l^{-1} or a dose of 100 l ha^{-1} showed the highest yield compared to other treatments. The quality of sweet corn increased markedly over control. ~~Application of LOF improved the nutrient absorption. It was concluded that~~ LOF could be applied as an alternative technique to inorganic fertilizers in the sweet corn organic farming in the tropics.

Commented [A1]: Not correct, only foliar application of plant extract is not sufficient for plant normal growth and development. It may be applied for additional supplement with ingornation fertilizer

Key words: banana hump, coconut fiber, leucaena leaf, nutrient uptake, organic farming

INTRODUCTION

Sweet corn (*Zea mays* L. Var. Saccharata) is one type of vegetable that is ~~preffered~~preferred by the community because of its relatively high sugar content. Organic sweet corn production needs to be improved by improving fertilization techniques. Fertilizing sweet corn can be given in the form of solid fertilizer or liquid fertilizer. The characteristics of solid organic fertilizer are the process of Nitrogen nutrient mineralization and the Carbon takes place very slowly (Hartz, Mitchell~~,~~ & Giannini, 2000; Johnson et al., 2012). Another alternative in organic tropical agriculture is the use of liquid organic fertilizers.

One of the cultivation techniques to increase growth and yield of sweet corn grown organically is the use of liquid organic fertilizers (LOF) made from the waste of many plant materials available around the farmer's garden. The application of fertilizer through leaves has been successfully carried out on corn plants (Amanullah et al., 2014). Similarly, the application of LOF has been carried out on various vegetable crops such as sweet corn (Fahrurrozi et al., 2016) and tomatoes (Zhai et al., 2009). Hartz et al (2010) ~~, Smith, & Gaskell, (2010)~~ informed ~~prove~~ that the application of LOF can function the same as conventional fertilization of solid fertilizers. Furthermore, the researchers stated that Nitrogen derived from liquid organic fertilizer is more readily available and the nitrification process takes place faster.

There is still lack scientific basis about utilization of plant extracts as LOF. Plant wastes such as lamtoro (*Leucaena leucocephala*) leaves, banana humps, and coconut husk are widely available around farmers' gardens. Lamtoro leaves are often used as animal feed. Lamtoro leaves contain lots of nitrogen, protein, vitamins, and minerals (Meulen et al., 1979;Farinu et al~~, Ajiboye, & Ajao,~~ 1992;~~ Meulen et al., 1979~~). Liquid organic fertilizer from the leaves of lamtoro is a source of nitrogenous nutrients for plants. Banana humps contain microbial decomposers of organic matter, such as *Bacillus* sp., *Aeromonas* sp., and *Aspergillus nigger* (Suhastyo, 2011). These microbes are able to decompose organic matter. The main content of coconut fibers is cellulose, hemi-cellulose, and lignin (Arsyad et al., 2015). If the coconut fiber is soaked and fermented with water, the nutrient K contained in coconut fiber will dissolve in soaking water so that the liquid fertilizer coconut husk is high in K nutrients.

The purpose of this study was to determine the effect of concentration and dose of liquid organic fertilizer made from an extract mixture of lamtoro leaves, banana humps and coconut fibers on the growth, production, quality and nutrient uptake of sweet corn plants.

MATERIALS AND METHODS

This research was carried out in Kotasepang experimental station, Bandar Lampung, Indonesia with the coordinates between 105 ° 15 '23' 'and 105 ° 15' 82 " E and between 5 ° 21' 86 " S. The study area classified as Ultisol soil. The study was designed with randomized block design and three replications consisting of 2 sub-experiments. The experiment I (April to June 2016) consisted of six treatments, namely control (k0), recommended inorganic fertilizer (k1), application of LOF with a concentration of 15 ml l^{-1} (k2), 30 ml l^{-1}(k3), 45 ml l^{-1} (k4), 60 ml l^{-1} (k5). The experiment II (April to June 2017) consisted of five treatments namely recommended inorganic fertilizer (d0), application of LOF with a dose of 25 l ha^{-1} (d1), 50 l ha^{-1} (d2), 75 l ha^{-1} (d3), and 100 l ha^{-1} (d4).

The research began with making plant extract LOF following a procedure developed by Astuti (2014). Lamtoro leaves, banana humps, and coconut husks are cut into small pieces and then put into containers, then brown sugar and rice washing water are put and stirred evenly. Then EM-4 was added, after which the container was closed and then fermented for 21 days and filtered. Liquid organic fertilizer from lamtoro leaves, banana humps, and coconut fibers mixed with a ratio of 1: 1: 1. All plots were hand hoed before planting. The area of each plot was 3 × 3 m, and the row spacing was 70 × 20 cm.

The application of liquid fertilizer was carried out by spraying evenly on the upper and lower part of leaves. The application of LOF was carried out once a week from the age of 2 to 7 weeks after planting (WAP). Inorganic recommended fertilizers given included Urea 300 kg ha^{-1}, SP-36 150 kg ha^{-1}, and KCl 100 kg ha^{-1}. Cultivation techniques in this study included watering, growing, weeds, and preventing pests and diseases organically. Harvesting was conducted at 70 days after planting

The variables observed in this study were the number of leaves, stem diameter, plant height, leaf area index (LAI), SPAD value, the weight of husked ear, the weight of unhusked ear, ear length, ear diameter, shoot dry weight, ºBrix value, yield, and N, P, K nutrient uptake. Statistical analysis of the data was conducted using MINITAB v. 16.0 software. The ANOVA (analysis of variance) and the least significant difference (LSD) tests were conducted at the 5% probability level.

RESULTS AND DISCUSSION

Results

The LOF application had affects on vegetative ~~and generative~~ variables of plants. ~~The results of the variance analysis showed that~~ The plant height, leaf number, stem diamer, LAI and SPAD value were greater in LOF applied plant than control plant (Tables 1 & 2). Plant height, leaf number, stem diameter and LAI increased with increasing concentration of LOF till 45 ml/L and 76 l/ha followed by not significant increased. The lowest number of leaves, plant height, stem diameter and SPAD value were recorded in control plant. ~~the application of liquid LOF extract increased the number of leaves. The number of leaves in the control treatment was significantly lower than those treated with LOF. The number of leaves treated with concentrations of 15, 30, 45, and 60 ml l^{-1} (Table 1) were not significantly different. The results of the variance analysis showed that the application of LOF increased the stem diameter (Table 1), the stem diameter in the control treatment was smaller than the treatment treated with LOF.~~

Commented [A2]: Write like this for other parameters

The LOF application increases plant height and leaf area index. Plant height and leaf area index with a dose of 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences (Table 2). The results of the variance analysis showed that the application of LOF increased the greenness of the leaves (Table 2). The greenness level of leaves in the 100 l ha^{-1} treatment was the highest than the other treatments, while between doses of 50 l ha^{-1} and 75 l ha^{-1} was not significantly different.

The weight of husked ear and the weight of unhusked ear in the LOF treatment were significantly higher than the control treatment, and not significantly different from inorganic fertilizer treatment (Table 3). The results of the variance analysis indicated that the LOF application increased the weight of husked ears and the weight of unhusked ears. The weight of unhusked ears between the doses of 75 l ha^{-1} and 100 l ha^{-1} did not show any significant difference (Table 4).

The LOF application increased ear length (Tables 3 and 4). The ear length in the control treatment was significantly lower than those treated by LOF, while the ear length of the concentration of 30, 45, and 60 ml l^{-1} was not significantly different from the treatment of inorganic fertilizer (Table 3). The ear length on the LOF treatment was significantly higher than that of inorganic recommendation, while the ear length between doses of 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1} did not show any significant differences (Table 4).

The application of LOF increased the ear diameter (Tables 3 and 4). The diameter of the ear on the LOF treatment was higher than the control treatment (Table 3) and from inorganic fertilizers (Table 4). The diameter of the ear between a concentration of 30 ml l^{-1}, 40 ml l^{-1}, 60 ml l^{-1} (Table 3) and doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 4) were not significantly different.

The LOF application increased sugar content (Tables 5 and 6) indicated by ºBricks value. The sugar content in the control treatment was significantly lower than those treated with LOF, while the sugar content of all concentrations of LOF (Table 5) and doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 6) were not significantly different.

The application of LOF consistently increased sweet corn yields (Tables 5 and 6). The yield of sweet corn at all concentrations (Table 5) was not significantly different. The highest yield was obtained at a concentration of 60 ml l^{-1}. The yield of sweet corn at doses 25 l ha^{-1} and 50 l ha^{-1} as well as at doses of 75 l ha^{-1} and 100 l ha^{-1} were not significantly different (Table 6).

Application of LOF plant extracts increased plant nutrient uptake (Table 7). Nutrient uptake of P and K in the LOF treatment was significantly higher than those treated with inorganic fertilizer. In addition, nutrient uptake of N, P, and K between doses of 25 l ha^{-1} and 50 l ha^{-1} as well as between doses 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences.

Discussion

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The results of the laboratory analysis of LOF showed that extract N content in lamtoro leaves was 763.01 ppm, P was 55.11 ppm, and K was 125.81 ppm. Banana humps extract had N nutrient content of 238.04 ppm, P was 63.88 ppm, and K was 88.21 ppm. Coconut fibers extract had N nutrient content of 133.12 ppm, P was 8.95 ppm, and K was 192.11 ppm. The high content of N, P, K nutrients in LOF means that the application of liquid organic fertilizer is sufficient to meet the basic needs of N, P and K nutrients for sweet corn plants.

Commented [A4]: Did not find any Table on nutritional status lamtoro, banana hump extract and Coconut fiber extract. Then why U mention here in Discussion?

Vegetative growth of plants is represented by the variable number of leaves, stem diameter, and plant height. The best vegetative results are indicated by the treatment of concentrations of 45 m l^{-1} and 60 ml l^{-1}. At the beginning of growth, plants can absorb nutrients from LOF and are used by plants to support growth. The N element is a key element for cell division which will support plant growth in both size and volume (Ohyama, 2010).

Liquid organic fertilizer increases the leaf area index might be due increase number of leaves and leaf size.~~so that the leaf surface will be wider to capture sunlight~~. Fageria et al. (2009) stated that foliar application requires high LAI. The leaf greenness variable showed that the application of LOF at a dose of 100 l ha^{-1} gave a high yield compared to the other treatments. According to Nugroho (2015) the function of nitrogen, in addition to stimulating plant growth, also gives the green color of the leaves. The darker the green color of leaves on corn plants shows the higher the nitrogen element absorbed by plants.

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The application of LOF gives positive results on generative growth of plants. The results showed that the concentration of 60 ml l^{-1} gave the best results on variable the weight of husked ear and the weight of unhusked ear and treatment with a dose of 100 l ha^{-1} gave the highest ear diameter and the heaviest weight of the cob. It can be inferred that the higher the dose or concentration of LOF given will increase the generative growth of plants. According to Zafar, Abbasi, & Khaliq, (2013) enlargement of ear diameter is related to the availability of P elements. P nutrients greatly influence the formation of ears. As the component of ATP, P will guarantee the availability of energy for growth so that the formation of assimilates and transport to storage can function well (Amanullah et al., 2009) that causes the growth of a generative plant is activated.ormation *Technology, 7*(2), 602-608.

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Table 1.

Effects of liquid organic fertilizer concentration on the number of leaves and stem diameter in experiment 1

Treatments	The number of leaves	Stem diameter (cm)
k_0 (control)	11.33 c	1.60 c
k_1 (inorganic fertilizer)	12.47 b	1.80 b
k_2 (15 ml l^{-1})	12.80 ab	1.93 ab
k_3 (30 ml l^{-1})	13.00 ab	1.89 ab
k_4 (45 ml l^{-1})	13.20 a	2.02 a
k_5 (60 ml l^{-1})	13.47 a	2.00 a
LSD 5%	0.71	0.19

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per DMRT.

Respective treatment column means followed by different letters are significantly different

Commented [A7]: Make 1 Table from Tables 1 & 3

Table 2

Effects of liquid organic fertilizers doses on plant height, LAI, and SPAD value on experiment 2

Treatments	Plant height(cm)	LAI	SPAD value
d_0 (inorganic fertilizer)	82.05 bc	3.07 d	44.28 c
d_1 (25 l ha^{-1})	83.31 b	3.64 c	44.91 c
d_2 (50 l ha^{-1})	84.56 b	4.23 b	46.22 b

Commented [A8]: Place it Table 1 of 1st column

d_3 (75 l ha^{-1})	93.80 a	5.33 a	46.97 b
d_4 (100 l ha^{-1})	93.45 a	5.51 a	48.15 a
LSD 5%	1.74	0.19	0.99

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD.

Respective treatment column means followed by different letters are significantly different

Table 3

Effects of liquid organic fertilizer concentration on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in experiment 1

Treatments	The weight of husked ear (kg)	The weight of unhusked ear (kg)	Ear length(cm)	Ear diameter(cm)
k_0 (control)	1.88 b	1.28 b	18.61 c	3.94 c
k_1 (inorganic fertilizer)	2.33 a	1.77 a	21.03 ab	4.42 b
k_2 (15 ml l^{-1})	2.35 a	1.78 a	20.15 b	4.40 b
k_3 (30 ml l^{-1})	2.30 a	1.97 a	21.14ab	4.55 ab
k_4 (45 ml l^{-1})	2.63 a	2.08 a	21.85 a	4.71 a
k_5 (60 ml l^{-1})	2.63 a	2.12 a	21.61 a	4.68 a
LSD 5%	0.42	0.41	1.09	0,20

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD.

Respective treatment column means followed by different letters are significantly different

Table 4

Effects of liquid organic fertilizer doses on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in experiment 2

TreatmensTreatments	The wWeight of husked ears (kg)	The wWeight of unhusked ears (kg)	Ear length(cm)	Ear diameter (cm)
d_0 (inorganic fertilizer)	2.10 e	1.60 c	20,32 a	4.39 d
d_1 (25 l ha^{-1})	2.30 d	1.73 c	20.19 a	4.43 c
d_2 (50 l ha^{-1})	2.57 c	1.80 bc	18.45 b	4.50 b
d_3 (75 l ha^{-1})	3.03 b	2.07 ab	18.12 b	4.58 a
d_4 (100 l ha^{-1})	3.30 a	2.27 a	17.79 b	4.60 a
LSD 5%	0.10	0.27	0.88	0.03

Respective treatment column means followed by different letters are significantly different

Commented [A9]: Per plant or per ear? Should specify

Commented [A10]: I am confuse, normally unhusked ear weight is higher than husked ear. But here U mentioned reverse result. What is correct?

Table 5

Effects of liquid organic fertilizers on shoot dry weight, ºBricks value, and yield on experiment 1

Treatments	Shoot dry weight (g)/plant	ºBricks value	Yield (ton ha^{-1})
k_0 (control)	14.19 a	15.22 c	8.28 b
k_1 (inorganic fertilizers)	19.24 a	15.76 b	11.59 a
k_2 (15 ml l^{-1})	17.16 a	15.85 ab	13.26 a
k_3 (30 ml l^{-1})	18.97 a	16.16 ab	13.24 a
k_4 (45 ml l^{-1})	20.74 a	16.18 a	14.76 a
k_5 (60 ml l^{-1})	21.31 a	16.22 a	14.94 a
LSD 5%	10.36	0.40	5.38

Respective treatment column means followed by different letters are significantly different

Table 6

Commented [A11]: Make 1 Table from Table 5 & 6

Effects of dose of liquid organic fertilizers on shoot dry weight, ºBricks value, and yield in experiment 2

Treatments	Shoot dry weight (g)	ºBricks value	Yield (ton ha^{-1})
d_0 (inorganic fertilizers)	16.25 d	11.05 b	15.15 c
d_1 (25 l ha^{-1})	17.07 b	11.50 b	15.97 b
d_2 (50 l ha^{-1})	17.43 a	11.56 b	16.21 b
d_3 (75 l ha^{-1})	16.87 c	12.39 a	17.37 a
d_4 (100 l ha^{-1})	17.33 a	12.56 a	17.81 a
LSD 5%	0.15	0.60	0.63

Respective treatment column means followed by different letters are significantly different

Table 7

Effects of liquid organic fertilizers doses on nutrient uptake on experiment 2

Treatments	N uptake	P uptake	K uptake
d_0 (inorganic fertilizers)	7.70 b	1.97 c	25.14 c
d_1 (25 l ha^{-1})	8.17 b	2.39 b	26.98 b
d_2 (50 l ha^{-1})	8.57 b	2.51 b	29.39 ab
d_3 (75 l ha^{-1})	9.80 ab	2.70 a	32.22 a
d_4 (100 l ha^{-1})	10.10 a	2.72 a	34.74 a
LSD 5%	0.58	0,17	3.76

Commented [A12]: Need unit. In percentage or other unit, mention

Respective treatment column means followed by different letters are significantly different

1

Author's Response to Reviewer's Comments

Paper title: ***Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. saccharata*)***

Title	Reviewer's 1 Comments	Author response	Reviewer's 2 Comments	Author response
Title	OK		OK	
Abstract	a. Comment spelling	a. Spelling has been corrected, changes done in red	a. Delete sentences Two experiments were conducted using Randomized Complete Block Design with 3 replications.	a. Sentences has been deleted
	b Comment verb	b. Verb has been changed. Changes done in red	b. Delete over control	b. "over control" has been deleted
			c. Last sentence: Not correct, only foliar application of plant extract is not sufficient for plant normal growth and development. It may be applied for additional supplement with ingornation fertilizer	c. Last sentence has been changed with a new sentence. Changes done in blue

Introduction	a. Paragraph 2 Has been changed into was	a. verb has been changed. Changes done in red	a. par 1 spelling prefer	a. Spelling has been corrected. Changes done in blue
	b. Par 2 change prove	b. prove has been changed by informed. Changes done in red	b. Par 2 change prove	b. prove has been changed by informed. Changes done in red
			c. Par 2 references using et al	c. references has been followed Journal template style in which all 3 authors written. Changes done in blue
			d. Par 3. References should be in sequence.	d. references has been written in sequence. Changes done in blue
			e. References using et al.	e. references has been followed Journal template style in which all 3 authors written. Changes done in blue
Materials Method	a. Paragraph 1: Revised the sentence: The study was carried out using designed with completely randomized block design (RCBD) and with three replications	a. par1 The sentences has been revised as recommended. Changes done in red. Symbols have been removed.	a. Paragraph 2. The chemical analyses of plant extract put in Table	a. Table 1 has been added. Changes done in blue.

	consisting of 2 sub-experiments.	Changes done in blue.		
	b. Paragraph 2. Wrong verb	b. Verb has been changed from are became were. Changes done in red.		
	c. Par 2. Missing unit	c. Par 3. Unit m and cm has been added. Changes done in red		
	d. Par 3. Wrong verb	d. verb has been corrected. Changes done in red.		
	e. Par 3. Delete cultivation technique.	e. Cultivation technique has been changed into agronomic practices. Changes done in red		
	f. Par 3 preventing removed	f. preventing has been changed into control. Changes done in red		
	G par 3 Missing and	g. and has been added. Changes done in red		
	h. Par 4. Missing test	h. Test has been added. Changes done in red		

Title	Reviewer’s 1 Comments	Author response	Reviewer’s 2 Comments	Author response
Abstract				

Results	a. par 1 Verb affect b. par 2 verb increases c. par 3 Add indicated by SPAD value d. par 9	a. par 1 It has been been changed into affected. Changes done in red b. par 2 It has been been changed into increased. Changes done in red c. par 3 indicated by SPAD value has been added. Changes done in red	All paragraph: Write like this for other parameters	All paragraph has been revised following comments from Reviewer. Changes done in Yellow

	miss as	d. as has been added. Changes done in red		
Discussion	a. par 2 verb increase b. par 2 verb give c. par 3 verb give d. par 4 verb can e. par 4 verb has f. par 5 verb given	a. par 2 Verb has been changed into increased. Changes done in red b. par 2 Verb has been changed into gave. Changes done in red c. par 3 Verb has been changed into gave. Changes done in red d. par 4 Verb has been changed into could Changes done in red d. par 4 Verb has been changed into had. Changes done in red f. par 5 Verb has been changed into applied. Changes done in red	a. The discussion is not up to the mark for publication. b. par 1 Did not find any Table on nutritional status lamtoro, banana hump extract and Coconut fiber extract. Then why U mention here in Discussion? c. par 3 ? d. par 3 requires ?	Discussion has been added with 1 paragraph and some new sentences so that the discussion was in depth, this including 6 new additional references. Changes done in green b. par 1 Information about content of plant extract has been presented in the form of Table 1. Changes done in Yellow c. par 3 Explanation by added Table 2. Changes done in green d. par 3 Explanation has been added. Changes done in green

	g. par 6 ver bwill h. par 6 missing also i. par 7 k element j. par 7 missing improved k. par 7 verb show l. par 8 word then	g. par 6 Verb has been changed into encourages. Changes done in red h. par 6 also has been added. Changes done in red i. par 7 it has been revised into elements of K. Changes done in red j. par 7 improved has been added. Changes done in red k. par 7 Verb show has been changed into found. Changes done in red l. par 8 new word become that sweetcorn. Changes done in red		

	m. par 10 mixed with given, delete given n. par 10 a cheap and an but, delete a and delete but	m. par 10 given has been deleted. Changes done in red n. par 10 a and but has been deleted. Changes done in red		
Conclusion	a. delete could and changed improve b. wrong absorb c. wrong position higher	a. delete has been removed. Verb was corrected to be improved. Changes done In red b. absorbed become absorbed. Changes done in red c. higher has been put properly. Changes done in red	a. plant extract was not an alternative instead a complementary technology	a. Conclusion has been revised as recomenneded. Changes done in blue
References			Follow the style of journal	References has been revised as recommended. 6 References has been added to improve the depth of discussion. References added done in green

Tables			a. delete the sentences: Respective treatment column means followed by different letters are significantly different	a. new sentences become: In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD. Changes done in blue
			b. in every Table delete LSD value	b. LSD value has been deleted as recommnended.
			c. The weight of unhusked and husked were reversed	c. Weight of unhusked and weight of husked has been corrected. Changes done in blue
			d. weight per plant or per ear should be clear	d. weight per plant. Changes done in blue
			e. Table without symbol k1, k2, k3, etc..	e. Table without symbol k1, k2, k3 and without symbol d1, d2, d3, as recommended
			f. Shoot dty weight per plant	f. per plant has been added. Changes done in blue
			f. Unit in Table 7	

				f. Unit in % in Table 7. Changes done in blue
			g. Combine Table 1 and Table 3.	g. If the table merged seems crowded
			h. Combine Table 2 and Table 4.	h. If the table merged seems crowded

NOTE: YOU HAVE ONE CHANCE TO CORRECT YOUR MANUSCRIPT AS PER PERTANIKA'S GUIDELINE

Dear Dr. Pangaribuan,

Your manuscript, JTAS-1698-2019.R1, entitled "Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays L. Var. saccharata)" has been unsubmitted from the Journal of Tropical Agricultural Science. The reason of "unsubmission" is due to the following issue(s):

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Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays L. Var. saccharata)

Journal:	*Journal of Tropical Agricultural Science*
Manuscript ID	JTAS-1698-2019.R2
Manuscript Type:	Regular Article
Scope of the Journal:	Crop nutrition < Crop and pasture production < AGRICULTURAL SCIENCES
Keywords:	liquid organic fertilizers, sweet corn

Abstract:	The objective of the research was to investigate the effect of concentration and doses of liquid organic fertilizers (LOF) derived from the extract mixture of lamtoro leaves, banana humps, and coconut fibers on growth, yield, quality and nutrient uptake of sweet corn. Experiment 1 was composed of 6 treatments namely control without LOF, recommended inorganic fertilizers, LOF concentration of 15 ml l-1, 30 ml l-1, 45 ml l-1, 60 ml l-1. Experiment 2 consisted of 5 treatments namely recommended inorganic fertilizers, LOF doses of 25 l ha-1, 50 l ha-1, 75 l ha-1, 100 l ha-1. Results showed that LOF consistently increased the growth and yield of sweet corn. Application of LOF with a concentration of 60 ml l-1 or a dose of 100 l ha-1 showed the highest yield compared to other treatments. The quality of sweet corn increased markedly. It was concluded that LOF could be applied as an additional supplement to inorganic fertilizers in the sweet corn organic farming in the tropics.

Liquid organic fertilizer extracts improves yield of sweet corn

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var. saccharata*)

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List of Tables

Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays* L. Var *saccharata)

ABSTRACT

The objective of the research was to investigate the effect of concentration and doses of liquid organic fertilizers (LOF) derived from the extract mixture of *lamtoro* leaves, banana humps, and coconut fibers on growth, yield, quality and nutrient uptake of sweet corn. Experiment 1 was composed of 6 treatments namely control without LOF, recommended inorganic fertilizers, LOF concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1}. Experiment 2 consisted of 5 treatments namely recommended inorganic fertilizers, LOF doses of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1}, 100 l ha^{-1}. Results showed that LOF consistently increased the growth and yield of sweet corn. Application of LOF with a concentration of 60 ml l^{-1} or a dose of 100 l ha^{-1} showed the highest yield compared to other treatments. The quality of sweet corn increased markedly. It was concluded that LOF could be applied as an additional supplement to inorganic fertilizers in the sweet corn organic farming in the tropics.

Key words: banana hump, coconut fiber, leucaena extract, nutrient uptake, organic farming

INTRODUCTION

Sweet corn (Zea mays L. Var. Saccharata) is one type of vegetable that is preferred by the community because of its relatively high sugar content. Organic sweet corn production needs to be improved by improving fertilization techniques. Fertilizing sweet corn can be given in the form of solid fertilizer or liquid fertilizer. The characteristics of solid organic fertilizer are the process of Nitrogen nutrient mineralization and the Carbon takes place very slowly (Hartz, Mitchell; & Giannini, 2000; Johnson et al., 2012). Another alternative in organic tropical agriculture is the use of liquid organic fertilizers.

One of the cultivation techniques to increase growth and yield of sweet corn grown organically is the use of liquid organic fertilizers (LOF) made from the waste of many plant materials available around the farmer's garden. The application of fertilizer through leaves has been successfully carried out on corn plants (Amanullah et al., 2014). Similarly, the application of LOF was carried out on various vegetable crops such as sweet corn (Fahrurrozi et al., 2016) and tomatoes (Zhai et al., 2009). Hartz, Smith, & Gaskell, (2010) informed that the application of LOF can function the same as conventional fertilization of solid fertilizers. Furthermore, the researchers stated that Nitrogen derived from liquid organic fertilizer is more readily available and the nitrification process takes place faster.

There is still lack scientific basis about utilization of plant extracts as LOF. Plant wastes such as *lamtoro* (*Leucaena leucocephala*) leaves, banana humps, and coconut husk are widely available around farmers' gardens. *Lamtoro* leaves are often used as animal feed. *Lamtoro* leaves contain lots of nitrogen, protein, vitamins, and minerals (Meulen et al., 1979; Farinu, Ajiboye, & Ajao, 1992). Liquid organic fertilizer from the leaves of *lamtoro* is a source of nitrogenous nutrients for plants. Banana humps contain microbial decomposers of organic matter, such as Bacillus sp., Aeromonas sp., and Aspergillus nigger (Suhastyo, Anas, Santosa, & Lestari, 2013). These microbes are able to decompose organic matter. The main content of coconut fibers is cellulose, hemi-cellulose, and lignin (Arsyad et al., 2015). If the coconut fiber is soaked and fermented with water, the nutrient K contained in coconut fiber will dissolve in soaking water so that the liquid fertilizer coconut husk is high in K nutrients.

The purpose of this study was to determine the effect of concentration and dose of liquid organic fertilizer made from an extract mixture of *lamtoro* leaves, banana humps and coconut fibers on the growth, production, quality and nutrient uptake of sweet corn plants.

MATERIALS AND METHOD

This research was carried out in Kota Sepang experimental station, Bandar Lampung, Indonesia. The study area classified as Ultisol soil. Field study was set up in RCBD (Randomized Complete Block Design) and replicated three times. The experiment consists of 2 sub-experiments. Experiment 1 (April to June 2016) consisted of six treatments, namely control, recommended inorganic fertilizer, application of LOF with a concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1}. Experiment 2 (April to June 2017) consisted of five treatments namely recommended inorganic fertilizer, application of LOF with a dose of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1}.

The research began with making plant extract LOF following a modified procedure developed by Astuti (2014). *Lamtoro* leaves, banana humps, and coconut fibers were cut into small pieces and then put into containers, then brown sugar and rice washing water were put and stirred evenly. Then EM-4 was added, after which the container was closed and then fermented for 21 days and filtered. Liquid organic fertilizer from *lamtoro* leaves, banana humps, and coconut fibers mixed with a ratio of 1: 1: 1. The content of plant extracts was analyzed in Soil Laboratory, Agriculture Faculty, Lampung University (Table 1). All plots were hand hoed before planting. The area of each plot was 3 m × 3 m, and the row spacing was 70 cm × 20 cm.

The application of liquid fertilizer was carried out by spraying evenly on the upper and lower part of leaves. The application of LOF was carried out once a week from the age of 2 to 7 weeks after planting (WAP). Inorganic recommended fertilizers were given included Urea 300 kg ha-1, SP-36 150 kg ha-1, and KCl 100 kg ha-1. Agronomic practices in this study included watering, growing, control of weeds, pests and diseases organically. Harvesting was conducted at 70 days after planting.

The variables observed in this study were the number of leaves, stem diameter, plant height, leaf area index (LAI), SPAD value, the weight of husked ear, the weight of unhusked ear, ear length, ear diameter, shoot dry weight, ºBrix value, yield, and N, P and K nutrient uptake. Statistical analysis of the data was conducted using MINITAB v. 16.0 software. The

ANOVA (analysis of variance) and the least significant difference (LSD) test were conducted at the 5% probability level.

RESULTS AND DISCUSSION

Results

The LOF application affected vegetative variables of plants. Leaf number and stem diameter were greater in LOF applied plant than control plant (Table 2). The results of the variance analysis showed that the application of liquid LOF extract increased the number of leaves and stem diameter. The number of leaves and stem diameter treated with concentrations of 15, 30, 45, and 60 ml l^{-1} were not significantly different (Table 2).

The plant height, leaf number, stem diameter, LAI and SPAD value greater in LOF applied plant than control plant (Tables 2 & 3). Plant height, leaf number, stem diameter and LAI increased with increasing concentration of LOF till 45 ml l^{-1} and 75 l ha^{-1} followed by not significant increased. The lowest number of leaves, plant height, stem diameter and SPAD value were recorded in control plant.

The LOF application increases plant height, leaf area index and the greenness of the leaves as indicated by SPAD value (Table 3). Plant height and leaf area index with a dose of 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences (Table 4). The greenness level of leaves (SPAD value) in the 100 l ha^{-1} treatment was the highest than the other treatments, while between doses of 50 l ha^{-1} and 75 l ha^{-1} was not significantly different.

The results of the variance analysis indicated that the LOF application increased weight of unhusked ears and weight of husked ears (Table 4 and 5). Weight of unhusked ear and weight of husked ear in the LOF treatment were significantly higher than the control treatment, and not significantly different from inorganic fertilizer treatment (Table 4). The lowest of weight of unhusked ear, weight of husked ear, ear length, and ear diameter were recorded in control plant (Table 4).

The LOF application increased ear length (Tables 4 and 5). The lowest ear length and ear diameter were recorded in control plant (Table 4). Ear length of the concentration of 30, 45, and 60 ml l^{-1} was not significantly different from the treatment of inorganic fertilizer (Table 4), while ear length between doses of 50 l ha^{-1} and inorganic recommendation did not show any significant differences (Table 5). The ear length between doses of 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1} did not show any significant differences (Table 5).

The application of LOF increased the ear diameter (Tables 4 and 5). The lowest ear diameter was recorded in control plant (Table 4). The diameter of the ear between a concentration of 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1} (Table 4) and between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 5) were not significantly different.

The application of LOF consistently increased sweet corn yields (Tables 5 and 6). The yield of sweet corn at all concentrations (Table 6) were not significantly different. The lowest yield was recorded in control treatment. The highest yield was obtained at a concentration of 60 ml l^{-1} (Table 6) and doses 100 l ha^{-1} (Table 7).

Application of LOF plant extracts increased plant nutrient uptake (Table 8). Nutrient uptake of P and K in the LOF treatment were significantly higher than those treated with inorganic fertilizer. In addition, nutrient uptake of N, P, and K between doses of 25 l ha^{-1} and 50 l ha^{-1} as well as between doses 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences.

The LOF application increased the quality of sweet corn indicated by sugar content (Tables 6 and 7) as indicated by ºBricks value. The lowest sugar content was recorded in control treatment (Table 6). The sugar content between all concentrations of LOF (Table 6) and between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 7) were not significantly different. The application of LOF increased the shoot dry weight (Table 6 & 7).

Discussion

Vegetative growth of plants is represented by the variable number of leaves, stem diameter, and plant height. The best vegetative results are indicated by the treatment of concentrations of 45 m l^{-1} and 60 ml l^{-1}. At the beginning of growth, plants can absorb nutrients from LOF and are used by plants to support growth. Nitrogen from LOF (Table 1) is needed for vegetative growth. The N element is a key element for producing vegetative biomass on the early growth of maize (Massignam, Chapman, Hammer, & Fukai, 2009).

Liquid organic fertilizer increased the leaf area index might be due increase number of leaves (Table 2). Fageria et al. (2009) stated that foliar application requires higher LAI for absorbing applied nutrient solution in sufficient amount. The leaf greenness variable showed that the application of LOF at a dose of 100 l ha^{-1} gave a high yield compared to the other treatments. According to Nugroho (2015) the function of nitrogen, in addition to stimulating plant growth, also gave the green color of the leaves. The darker the green color of leaves on corn plants shows the higher the nitrogen element absorbed by plants.

The application of LOF gave positive results on generative growth of plants. The results showed that the concentration of 60 ml l^{-1} gave the best results on variable the weight of husked ear and the weight of unhusked ear and treatment with a dose of 100 l ha^{-1} gave the highest ear diameter and the heaviest weight of the cob. It can be inferred that the higher the dose or concentration of LOF given will increase the generative growth of plants. According to Zafar, Abbasi, & Khaliq, (2013) enlargement of ear diameter is related to the availability of P elements. P nutrients greatly influence the formation of ears.

The LOF application could increase the yield of sweet corn. This means that the contribution of nutrients from liquid organic fertilizer can be a complementary to the recommended solid fertilizer. The results of this study are supported in various other LOF studies. Minardi, Hartati, Widijanto, & Wulandari (2015) found that banana corm extract increased the available P soil. Aini, Sugiyanto, & Herlinawati (2017) stated that the treatment of banana humps had a significant effect on the growth and yield of soybean. Working with *Gleicheni linearis* plant extract Aulya et al. (2018) showed that the application of 100 mg l^{-1} was the most effective concentration in increasing plant height and leaf area of maize compared to control.

The results showed that the treatment of a dose of LOF 100 l ha^{-1} gave a high N, P, and K nutrient uptake, and this was attributed to the adequate supply of nutrients from LOF. This means that the higher the dose of LOF applied increase the nutrient uptake of N, P, and K. Muktamar et al. (2016) showed that increase in rates of LOF significantly raised nitrogen uptake by sweet corn, but not phosphorus and potassium.

The application of N nutrients in plants has a direct role in the formation of amino acids, proteins, nucleic acids, enzymes, nucleoproteins, and alkaloids (Mokhele et al., 2012) which are needed for the vegetative growth process of plants and increase the greenness of leaves.

Leaf N nutrient uptake has a close relationship with the leaf greenness level which is characterized by SPAD value. Liquid organic fertilizer also increases nutrient uptake of P and K by plants. Mukuralinda et al. (2010) also showed high P nutrient uptake due to the application of organic fertilizer compared to control. Increasing nutrient uptake of P encourages the metabolic processes in the plant to become more active. The P element is known as the forming element of ATP for energy sources. In addition to P, nutrient K also plays an important role in improving the quality of plant fruit.

The application of liquid organic fertilizer containing element of K from coconut fiber extract improved the quality of sweet corn which is characterized by a higher Brix value. Jifon & Lester (2009) found that the application of K fertilizer through leaves will increase the sugar content of muskmelon plants. Sweet taste in sweet corn involves potassium nutrients which play a role in the activation of many enzymes that play a role in metabolic processes in plants. Enzymes that play a role in sugar synthesis are activated by K (Prajapati & Modi, 2012)

The research showed that in both experiments, between the concentration (experiment 1) of the LOF and inorganic recommended fertilizers as well as between the doses (experiment 2) of the LOF and inorganic recommended fertilizers gave the same effect on all parameters of growth and yield of sweet corn. It is clear that sweet corn plants fertilized with LOF had the same growth and yield with those of recommended fertilizers. Therefore, it implied that LOF could be a compelemetary fertilizer. Some researchers have also succeeded in applying the application of liquid organic fertilizer to sweet corn commodities (Muktamar et al., 2017) and corn (Aulya et al., 2018).

From this experiment, it can be recommended to use local plant resources around farmers such as *lamtoro* leaves, banana humps, and coconut fibers to be used as LOF. The high content of N, P, K nutrients in LOF (Table 1) means that the application of liquid organic fertilizer is sufficient to meet the needs of N, P and K nutrients for sweet corn plants. The mixture of plant residues contained the basic nutrient requirements for plants. *Lamtoro l*eaves has a high content of protein, carbohydrate, and Nitrogen (Devi, Ariharan, & Prasad, 2013). Banana humps contained P and K (Bahtiar et al., 2016). Azospirillum, Azotobacter, *Bacillus sp, Aeromonas sp, and Aspergillus niger* and the other phosphate solubilizing Bacteria were identified in the of banana hump (Minardi, Hartati, Widijanto, & Wulandari, 2015; Suhastyo, Anas, Santosa, & Lestari, 2013). Banana hump had naturally a bioactive compound to be used as plant growth regulators (Ulfa et al., 2013) namely Auxin, Gibberelin and Cytokinin. Coconut fibre had a high P and K (Abad, Noguera, Puchades, Maquieira, & Noguera, 2002). It can be said that application of LOF supplied nutrient, microbe, and hormone leading to a better growth and yield of sweet corn.

The use of liquid organic fertilizer from plant materials can be used as a complementary fertilization technology in developing organic agriculture. However, the nutrient content of plant extract is depend on the the type of organic waste used, the fermentation period, and the storage of plant extract. In its application, liquid organic fertilizer needs to be mixed with a surfactant to increase the efficiency of uptake by plant leaves. The application of liquid organic fertilizer is cheap and an effective technology in organic farming. Therefore, local-based liquid organic fertilizers which contained extract of *lamtoro*, banana hump and coconut fibre has the potential to be a biological fertilizers supporting the organic farming. Further research is still needed to determine the appropriate concentration and doses of liquid organic fertilizer for each type of horticulture plant.

CONCLUSIONS

Application of LOF with the concentration of 60 ml l^{-1} or dose 100 l ha^{-1} showed the best growth and yield of sweet corn compared to lower concentration or lower dose. Application of LOF improved the quality of sweet corn. Sweet corn sprayed with LOF absorbed higher nutrient N, P, and K. It is recommended that LOF could be the complementary fertilization technology in sweet corn organic farming.

ACKNOWLEDGEMENT

This research was funded by the Faculty of Agriculture, University of Lampung Research Grant 2017. The author would like to thank to Rugayah and Y. C. Ginting for scientific discussions during manuscript preparation.

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Table 1.
Content of Plant Extract

Plant extract	N (ppm)	P (ppm)	K (ppm)
Lamtoro leaves	763,01	55,11	125,81
Banana hump	238,04	63,88	88,21
Coconut fibre	133,12	8,95	192,11

Table 2.
Effects of liquid organic fertilizer concentration on the number of leaves and stem diameter in sub-experiment 1

LOF concentration	Number of leaves	Stem diameter (cm)
control	11.33 c	1.60 c
inorganic fertilizer	12.47 b	1.80 b
15 ml l^{-1}	12.80 ab	1.93 ab
30 ml l^{-1}	13.00 ab	1.89 ab
45 ml l^{-1}	13.20 a	2.02 a
60 ml l^{-1}	13.47 a	2.00 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 3
Effects of liquid organic fertilizers doses on plant height, LAI, and SPAD value in sub-experiment 2

LOF doses	Plant height (cm)	LAI	SPAD value
inorganic fertilizer	82.05 bc	3.07 d	44.28 c
25 l ha^{-1}	83.31 b	3.64 c	44.91 c
50 l ha^{-1}	84.56 b	4.23 b	46.22 b
75 l ha^{-1}	93.80 a	5.33 a	46.97 b
100 l ha^{-1}	93.45 a	5.51 a	48.15 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD.

Table 4

Effects of liquid organic fertilizer concentration on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in sub-experiment 1

LOF concentration	Weight of unhusked ear (kg plant^{-1})	Weight of husked ear (kg plant^{-1})	Ear length (cm)	Ear diameter (cm)
control	1.88 b	1.28 b	18.61 c	3.94 c
inorganic fertilizer	2.33 a	1.77 a	21.03 ab	4.42 b
15 ml l^{-1}	2.35 a	1.78 a	20.15 b	4.40 b
30 ml l^{-1}	2.30 a	1.97 a	21.14ab	4.55 ab
45 ml l^{-1}	2.63 a	2.08 a	21.85 a	4.71 a
60 ml l^{-1}	2.63 a	2.12 a	21.61 a	4.68 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD.

Table 5

Effects of liquid organic fertilizer doses on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in sub-experiment 2

LOF doses	Weight of unhusked ears (kg plant^{-1})	Weight of husked ears (kg plant^{-1})	Ear length(cm)	Ear diameter (cm)
inorganic fertilizer	2.10 e	1.60 c	20,32 a	4.39 d
25 l ha^{-1}	2.30 d	1.73 c	20.19 a	4.43 c
50 l ha^{-1}	2.57 c	1.80 bc	18.45 b	4.50 b
75 l ha^{-1}	3.03 b	2.07 ab	18.12 b	4.58 a
100 l ha^{-1}	3.30 a	2.27 a	17.79 b	4.60 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 6

Effects of liquid organic fertilizers concentration on shoot dry weight, ºBricks value, and yield in sub-experiment 1

LOF concentration	Shoot dry weight (g plant^{-1})	ºBricks value	Yield (ton ha^{-1})
control	14.19 a	15.22 c	8.28 b
inorganic fertilizers	19.24 bc	15.76 b	11.59 a
15 ml l^{-1}	17.16 ab	15.85 ab	13.26 a
30 ml l^{-1}	18.97 bc	16.16 ab	13.24 a
45 ml l^{-1}	20.74 c	16.18 a	14.76 a
60 ml l^{-1}	21.31 c	16.22 a	14.94 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 7

Effects of dose of liquid organic fertilizers doses on shoot dry weight, ºBricks value, and yield in sub-experiment 2

LOF doses	Shoot dry weight (g plant^{-1})	ºBricks value	Yield (ton ha^{-1})
inorganic fertilizers	16.25 d	11.05 b	15.15 c
25 l ha^{-1}	17.07 b	11.50 b	15.97 b
50 l ha^{-1}	17.43 a	11.56 b	16.21 b
75 l ha^{-1}	16.87 c	12.39 a	17.37 a
100 l ha^{-1}	17.33 a	12.56 a	17.81 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 8

Effects of liquid organic fertilizers doses on nutrient uptake in sub-experiment 2

LOF concentration	N uptake (g plant^{-1})	P uptake (g plant^{-1})	K uptake (g plant^{-1})
inorganic fertilizers	7.70 b	1.97 c	2.51 c
25 l ha^{-1}	8.17 b	2.39 b	2.69 b
50 l ha^{-1}	8.57 b	2.51 b	2.93 ab
75 l ha^{-1}	9.80 ab	2.70 a	3.22 a
100 l ha^{-1}	10.10 a	2.72 a	3.47 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Pertanika J. Trop. Agric. Sc. 42 (3): (2019)

PERTANIKA
JOURNALS

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Liquid Organic Fertilizer from Plant Extracts Improves the Growth, Yield and Quality of Sweet Corn (*Zea mays* L. var. *saccharata*)

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ABSTRACT

The objective of this research was to study the effect of concentration and dose of liquid organic fertilizer (LOF) derived from an extract mixture derived from *lamtoro* leaves, banana humps, and coconut fibers on the growth, yield, quality, and nutrient uptake of sweet corn. Experiment 1 comprised six treatments, namely a control without LOF, recommended inorganic fertilizers, and LOF at a concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, or 60 ml l^{-1}. Experiment 2 consisted of five treatments, namely recommended inorganic fertilizers, and LOF doses of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1} or 100 l ha^{-1}. Results showed that LOF consistently increased the growth, yield and quality of sweet corn. Application of LOF with a concentration of 60 ml l^{-1} or a dose of 100 l ha^{-1} showed the highest yield compared to other treatments. The quality of sweet corn increased markedly. It was concluded that LOF could be applied as an additional supplement to inorganic fertilizers used for sweet corn organic farming in the tropics.

Keywords: Banana hump, coconut fiber, leucaena extract, nutrient uptake, organic farming

ARTICLE INFO

Article history:
Received: 01 March 2019
Accepted: 10 June 2019
Published:

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INTRODUCTION

The community prefers sweet corn (*Zea mays* L. var. *saccharata*) because of its relatively high sugar content. Organic sweet corn production needs can be improved by improving fertilization techniques. Fertilizers for sweet corn can be given in the solid or liquid form. Solid organic fertilizers tend to be taken up by the crop

ISSN: 1511-3701
e-ISSN: 2231-8542

relatively slowly (Hartz et al., 2000; Johnson et al., 2012). Another alternative in organic tropical agriculture is the use of liquid organic fertilizers (LOF), which are taken up more quickly by crops.

The application of fertilizer into the plants through leaves was successfully carried out on corn plants (Amanullah et al., 2014). Similarly, the application of LOF was carried out on various vegetable crops such as sweet corn (Fahrurrozi et al., 2016) and tomatoes (Zhai et al., 2009). Hartz et al. (2010) reported that the application of LOF could function the same as conventional fertilization with solid fertilizers. Furthermore, the researchers stated that nitrogen derived from liquid organic fertilizers was more readily available and the nitrification process took place faster.

One cultivation technique used to increase growth, yield, and quality of sweet corn grown organically are LOF made from the waste of plant materials available around the farmer's garden. There is still a lack of a scientific basis on the utilization of plant extracts as LOF. Plant wastes such as *lamtoro* (*Leucaena leucocephala*) leaves, banana humps, and coconut husks are widely available around farmers' gardens in tropical areas. *Lamtoro* leaves are often used as animal feed. *Lamtoro* leaves contain significant amounts of nitrogen, protein, vitamins, and minerals (Farinu et al., 1992; Meulen et al., 1979). Liquid organic fertilizer from the leaves of *lamtoro* is a source of nitrogenous nutrients for plants. Banana humps contain microbial decomposers of organic matter, such as *Bacillus* sp., *Aeromonas* sp. and *Aspergillus niger* (Suhastyo et al., 2013). These microbes are able to decompose organic matter. The main content of coconut fibers is cellulose, hemi-cellulose, and lignin (Arsyad et al., 2015). If the coconut fiber is soaked and fermented with water, the potassium contained in coconut fiber will dissolve in soaking water so that the liquid fertilizer coconut husk is high in potassium.

The purpose of this study was to determine the effect of concentration and dose of liquid organic fertilizer made from an extract mixture of *lamtoro* leaves, banana humps and coconut fibers on the growth, production, quality, and nutrient uptake of sweet corn plants.

MATERIALS AND METHODS

This research was carried out in Kota Sepang experimental station, Bandar Lampung, Indonesia. The study area was classified as having Ultisol soil. A field study was set up in RCBD (Randomized Complete Block Design) and replicated three times. The experiment consisted of two sub-experiments. Experiment 1 (April to June 2016) consisted of six treatments, namely an unfertilized control, recommended inorganic fertilizer, and application of LOF with a concentration of 15 ml l^{-1}, 30 ml l^{-1}, 45 ml l^{-1}, or 60 ml l^{-1}. Experiment 2 (April to June 2017) consisted of five treatments, namely recommended inorganic fertilizer, and an application of LOF with a dose of 25 l ha^{-1}, 50 l ha^{-1}, 75 l ha^{-1}, or 100 l ha^{-1}.

The research began with making plant extract LOF following a modified procedure developed by Astuti et al. (2014). *Lamtoro* leaves, banana humps, and coconut fibers were cut into small pieces and then separately put into containers, into which brown sugar and rice washing water were added and stirred evenly. Then EM-4 was added, after which the container was closed and then fermented for 21 days and filtered. Liquid organic fertilizer from *lamtoro* leaves, banana humps, and coconut fibers was then mixed in a ratio of 1: 1: 1. The nutrient content of the plant extracts (Table 1) was analyzed in Soil Laboratory, Faculty of Agriculture, University of Lampung.

Table 1
Content of fermented plant extract

Plant extract	N (ppm)	P (ppm)	K (ppm)
Lamtoro leaves	763.01	55.11	125.81
Banana humps	238.04	63.88	88.21
Coconut fiber	133.12	8.95	192.11

All plots were hand hoed before planting with sweet corn. The area of each plot was 3 m × 3 m, and the row spacing was 70 cm × 20 cm. The application of liquid fertilizer was carried out by spraying evenly on the upper and lower part of leaves. The application of LOF was carried out once a week from 2 to 7 weeks after planting (WAP). The inorganic recommended fertilizers were given included urea at 300 kg ha^{-1}, SP-36 at 150 kg ha^{-1}, and KCl at 100 kg ha^{-1}. Agronomic practices used in this study included watering, growing, control of weeds, pests, and diseases organically. Harvesting was conducted at 70 days after planting.

The parameters observed in this study were the number of leaves, stem diameter, plant height, leaf area index (LAI), SPAD value, the weight of husked ear, the weight of unhusked ear, ear length, ear diameter, shoot dry weight, ºBrix value, yield, and N, P and K nutrient uptake. Statistical analysis of the data was conducted using MINITAB v. 16.0 software. Analysis of variance and least significant difference (LSD) tests was used to test overall treatment effects and between-treatment differences and was conducted at the 5% probability level.

RESULTS AND DISCUSSION

Results

The LOF application affected the vegetative parameters of the plants. Leaf number and stem diameter were greater in LOF-applied plant than the control (Table 2). The results of the analysis of variance showed that the application of LOF increased the number of leaves and stem diameter. The number of leaves and stem diameter treated with concentrations of 15 ml l^{-1}, 30 ml l^{-1}, 45

Table 2
Effects of liquid organic fertilizer concentration on the number of leaves and stem diameter in experiment 1

LOF concentration	Number of leaves	Stem diameter (cm)
Control	11.33 c	1.60 c
Inorganic fertilizer	12.47 b	1.80 b
15 ml l^{-1}	12.80 ab	1.93 ab
30 ml l^{-1}	13.00 ab	1.89 ab
45 ml l^{-1}	13.20 a	2.02 a
60 ml l^{-1}	13.47 a	2.00 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

ml l^{-1}, and 60 ml l^{-1} were not significantly different. The lowest number of leaves and the lowest stem diameter were recorded in the control treatment (Table 2).

The LOF application increased plant height, leaf area index, and the greenness of the leaves (indicated by SPAD value) (Table 3). The plant height, LAI, and SPAD value were greater in LOF-applied plants than with the inorganic fertilizer treatment. Plant height and LAI increased with increasing doses of LOF until 75 l ha^{-1}; above these levels, there was no significant additional increase. The greenness level of leaves (SPAD value) in the 100 l ha^{-1} treatment was higher than in the other treatments, while doses of 50 l ha^{-1} and 75 l ha^{-1} were not significantly different from each other. The lowest plant height, LAI and SPAD value were recorded with the inorganic fertilizer treatment (Table 3).

LOF application also affected the generative parameters of plants. The results of the analysis of variance indicated that the LOF application increased the weight of unhusked ears and weight of husked ears (Tables 4 and 5). Weights of unhusked ears and weight of husked ears in the LOF treatment were significantly higher than the control treatment (Table 4). The lowest weights of unhusked ears, the weight of husked ears, ear length, and ear diameter were recorded in the control plants (Table 4).

The LOF application increased ear length (Tables 4 and 5). Ear lengths at concentrations of 30 ml l^{-1}, 45 ml l^{-1}, and 60 ml l^{-1} were not significantly different from the treatment of inorganic fertilizer (Table 4), while ear length between doses of 25 l ha^{-1} and inorganic fertilizer did not show any significant differences (Table 5). The ear length between doses of 50 l ha^{-1}, 75 l ha^{-1}, and 100 l ha^{-1} did not show any significant differences (Table 5).

Table 3
Effects of liquid organic fertilizers doses on plant height, LAI, and SPAD value in experiment 2

LOF dose	Plant height (cm)	LAI	SPAD value
Inorganic fertilizer	82.05 c	3.07 d	44.28 c
25 l ha^{-1}	83.31 b	3.64 c	44.91 c
50 l ha^{-1}	84.56 b	4.23 b	46.22 b
75 l ha^{-1}	93.80 a	5.33 a	46.97 b
100 l ha^{-1}	93.45 a	5.51 a	48.15 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 4
Effects of liquid organic fertilizer concentration on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in experiment 1

LOF concentration	Weight of unhusked ear (kg $plant^{-1}$)	Weight of husked ear (kg $plant^{-1}$)	Ear length (cm)	Ear diameter (cm)
Control	1.88 b	1.28 b	18.61 c	3.94 c
Inorganic fertilizer	2.33 a	1.77 a	21.03 ab	4.42 b
15 ml l^{-1}	2.35 a	1.78 a	20.15 b	4.40 b
30 ml l^{-1}	2.30 a	1.97 a	21.14 ab	4.55 ab
45 ml l^{-1}	2.63 a	2.08 a	21.85 a	4.71 a
60 ml l^{-1}	2.63 a	2.12 a	21.61 a	4.68 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 5
Effects of liquid organic fertilizer doses on the weight of husked ear, the weight of unhusked ear, ear length, and ear diameter in experiment 2

LOF dose	Weight of unhusked ears (kg plant^{-1})	Weight of husked ears (kg plant^{-1})	Ear length(cm)	Ear diameter (cm)
Inorganic fertilizer	2.10 e	1.60 c	20.32 a	4.39 d
25 l ha^{-1}	2.30 d	1.73 c	20.19 a	4.43 c
50 l ha^{-1}	2.57 c	1.80 bc	18.45 b	4.50 b
75 l ha^{-1}	3.03 b	2.07 ab	18.12 b	4.58 a
100 l ha^{-1}	3.30 a	2.27 a	17.79 b	4.60 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

The application of LOF increased the ear diameter (Tables 4 and 5). The lowest ear diameter was recorded in control plants (Table 4). The diameter of the ear between concentrations of 30 ml l^{-1}, 45 ml l^{-1}, 60 ml l^{-1} (Table 4) as well as between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 5) were not significantly different.

The application of LOF consistently increased sweet corn yields (Tables 6 and 7). The yield of sweet corn at all LOF concentrations (Table 6) was not significantly different. The lowest yield was recorded in control treatment. The highest yield was obtained at a concentration of 60 ml l^{-1} (Table 6) and dosed 100 l ha^{-1} (Table

Table 6
Effects of liquid organic fertilizers concentration on shoot dry weight, ºBricks value, and yield in experiment 1

LOF concentration	Shoot dry weight (g plant^{-1})	ºBrix value	Yield (ton ha^{-1})
Control	14.19 a	15.22 c	8.28 b
Inorganic fertilizers	19.24 bc	15.76 b	11.59 a
15 ml l^{-1}	17.16 ab	15.85 ab	13.26 a
30 ml l^{-1}	18.97 bc	16.16 ab	13.24 a
45 ml l^{-1}	20.74 c	16.18 a	14.76 a
60 ml l^{-1}	21.31 c	16.22 a	14.94 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Table 7
Effects of dose of liquid organic fertilizers doses on shoot dry weight, ºBricks value, and yield in experiment 2

LOF dose	Shoot dry weight (g plant^{-1})	ºBrix value	Yield (ton ha^{-1})
Inorganic fertilizers	16.25 d	11.05 b	15.15 c
25 l ha^{-1}	16.87 c	11.50 b	15.97 b
50 l ha^{-1}	17.07 b	11.56 b	16.21 b
75 l ha^{-1}	17.43 a	12.39 a	17.37 a
100 l ha^{-1}	17.33 a	12.56 a	17.81 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

7). The application of LOF increased the dry shoot weight (Tables 6 and 7). The lowest shoot dry weight was noted in control treatment (Table 6).

Application of LOF increased plant nutrient uptake (Table 8). Nutrient uptake of P and K in the LOF treatment were significantly higher than those treated with inorganic fertilizer. Also, nutrient uptake of N, P, and K between doses of 25 l ha^{-1} and 50 l ha^{-1} as well as between doses 75 l ha^{-1} and 100 l ha^{-1} did not show any significant differences (Table 8).

The LOF application increased the quality of sweet corn as indicated by sugar content (Tables 6 and 7) as indicated by ºBrix value. The lowest sugar content was recorded in control treatment (Table 6). The sugar content between all concentrations of LOF (Table 6) and between doses of 75 l ha^{-1} and 100 l ha^{-1} (Table 7) were not significantly different.

Table 8
Effects of liquid organic fertilizers doses on nutrient uptake in experiment 2

LOF concentration	N uptake (g $plant^{-1}$)	P uptake (g $plant^{-1}$)	K uptake (g $plant^{-1}$)
Inorganic fertilizers	7.70 b	1.97 c	2.51 c
25 l ha^{-1}	8.17 b	2.39 b	2.69 b
50 l ha^{-1}	8.57 b	2.51 b	2.93 ab
75 l ha^{-1}	9.80 ab	2.70 a	3.22 a
100 l ha^{-1}	10.10 a	2.72 a	3.47 a

In a column, values having common letter(s) do not differ significantly at $p \leq 0.05$ as per LSD

Discussion

Vegetative growth of plants is represented by the number of the parameters of leaves, stem diameter, and plant height. The highest number of leaves and stem diameter were seen concentrations of 45 ml^{-1} and 60 ml l^{-1} in experiment 1. At the beginning of growth, plants can absorb nutrients from LOF, which are used by plants to support growth. Nitrogen (Table 1) is needed for vegetative growth. Nitrogen is a key element for producing vegetative biomass on the early growth of maize (Massignam et al., 2009).

The fact that LOF increased the leaf area index might be due to an increase in the number of leaves (Table 3). Fageria et al. (2009) stated that foliar application required higher LAI for absorbing applied nutrient solution in sufficient amounts. Table 3 shows that the application of LOF at a dose of 100 l ha^{-1} gave a higher value of leaf greenness compared to the other treatments. According to Nugroho (2015) nitrogen, in addition to stimulating plant growth, also gives the green color of the leaves. The darker the green color of leaves on corn plants, the higher the amount of nitrogen absorbed by the plants.

The application of LOF gave positive results in terms of the generative growth of plants. The results showed that the concentration of 60 ml l^{-1} gave the best results in terms of the weight of unhusked ears and husked ears, and the treatment with a dose of 100 l ha^{-1} gave the highest ear diameter and the heaviest weight of the ears. It can be inferred that the higher the dose or concentration of LOF given, the higher the generative growth of plants. According to Zafar et al. (2013), enlargement of ear diameter is related to the availability of phosphorus; phosphorus greatly influences the formation of ears.

Liquid organic fertilizer application increased the yield of sweet corn. This means that the contribution of nutrients from LOF can be complementary to the recommended solid fertilizer. The results of this study are supported in various other LOF studies. Minardi et al. (2015) found that banana corm extract increased the available P in soil. Aini et al. (2017) stated that the treatment of banana humps had a significant effect on the growth and yield of soybean. Working with *Gleicheni linearis* plant extract, Aulya et al. (2018) showed that the application of 100 mg l^{-1} was the most effective concentration in increasing plant height and leaf area of maize compared to a control.

The results showed that the treatment of a dose of LOF 100 l ha^{-1} gave a high degree of N, P, and K nutrient uptake, and this was attributed to the adequate supply of nutrients from LOF. This means that the higher the dose of LOF application, the higher the nutrient uptake of N, P, and K; in contrast to Muktamar et al. (2016) showed that increase in rates of LOF significantly raised nitrogen uptake by sweet corn but did not raise phosphorus and potassium uptake. Mukuralinda et al. (2010) also showed high P nutrient uptake due to the application of organic fertilizer compared to control.

The application of N nutrients in plants has a direct role in the formation of amino acids, proteins, nucleic acids, enzymes, nucleoproteins, and alkaloids (Mokhele et al., 2012), which are needed for the vegetative growth process of plants and increase the greenness of leaves. Leaf N nutrient uptake has a close relationship with the leaf greenness level, characterized by the SPAD value. Increasing nutrient uptake of P enhanced the metabolic processes in the plant to become more active. P is known as the forming element of ATP for energy sources. In addition to P, K also plays an important role in improving the quality of plant fruit. The application of liquid organic fertilizer containing an element of K from coconut fiber extract improved the quality of sweet corn, which is characterized by a higher Brix value. Jifon and Lester (2009) found that the application of K fertilizer through leaves increased the sugar content of muskmelon plants. Sweet taste in sweet corn involves potassium nutrients, which play a role in the activation of many enzymes that has a role in metabolic processes in plants. Enzymes that play a role in sugar synthesis are activated by K (Prajapati & Modi, 2012).

The research showed that in both experiments, between the all concentration of the LOF and inorganic recommended fertilizers (experiment 1) as well as between the doses of the LOF and inorganic recommended fertilizers (experiment 2) gave the same effect on all parameters of growth and yield of sweet corn. Sweet corn plants fertilized with LOF had the same growth and yield with those of recommended fertilizers. Therefore, it implied that LOF could be a complementary fertilizer. Many researchers have also succeeded in applying the foliar application of LOF to sweet corn (Muktamar et al., 2017) and corn (Aulya et al., 2018).

From this experiment, it can be recommended to utilize local plant resources around farmers such as *lamtoro* leaves, banana humps, and coconut fibers to be used as LOF. The high content of N, P, K nutrients in LOF (Table 1) means that the application of liquid organic fertilizer is sufficient to meet the needs of N, P, and K nutrients for sweet corn plants. The mixture of plant residues contained the basic nutrient requirements for plants. *Lamtoro* leaves have a high content of protein, carbohydrate, and nitrogen (Devi et al., 2013). Banana humps contained P and K (Bahtiar et al., 2016). *Azospirillum*, *Azotobacter*, *Bacillus* sp., *Aeromonas* sp., and *Aspergillus niger* and the other phosphate solubilizing bacteria were identified in banana humps (Minardi, et al., 2015; Suhastyo et al., 2013). Banana humps naturally had bioactive compounds to be used as plant growth regulators (Ulfa et al., 2013), namely auxin, gibberellin and cytokinin. Coconut fiber had a high P and K (Abad et al., 2002). It can be said that the application of LOF supplied nutrients, microbes, and hormones leading to better growth, yield and quality of sweet corn.

The use of liquid organic fertilizer from plant materials can be used as a complementary fertilization technology in developing organic agriculture. However, the nutrient content of plant extract is dependent on the type of organic waste used, the fermentation period, and the storage of plant extract. In its application, liquid organic fertilizer needs to be mixed with a surfactant to increase the efficiency of uptake by plant leaves. The application of liquid organic fertilizer is an inexpensive and effective technology in organic farming. Therefore, local-based liquid organic fertilizers that contain extracts of *lamtoro*, banana hump, and coconut fiber have the potential to support organic farming. Further research is still needed to determine the appropriate concentration and doses of liquid organic fertilizer for each horticultural and food crop.

CONCLUSIONS

Application of LOF with the concentration of 60 ml l^{-1} or dose 100 l ha^{-1} showed the best growth, yield, and quality of sweet corn compared to lower concentrations or lower doses. Application of LOF improved the agronomic quality of sweet corn. Sweet corn sprayed with LOF absorbed a higher amount of N, P, and K. It is recommended that LOF could be a complementary fertilization technology in sweet corn organic farming.

ACKNOWLEDGEMENT

This research was funded by the Research Grant 2017, Faculty of Agriculture, University of Lampung. The authors would like to thank to Rugayah and Y. C. Ginting for scientific discussions during manuscript preparation.

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Dear Dr. Pangaribuan:

It is a pleasure to accept your manuscript entitled "Liquid organic fertilizer from plant extracts improves the growth, yield, and quality of sweet corn (Zea mays L. Var. saccharata)" in its current form for publication in the Journal of Tropical Agricultural Science.

An official acceptance letter will be sent to you from my office in due course of time.

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Thank you for your fine contribution. On behalf of the Editors of the Journal of Tropical Agricultural Science, we look forward to your continued contributions to the Journal.

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