Growth and yield of sweet corn in response to the liquid organic fertilizer derived from *Tithonia diversifolia* and *Ageratum conyzoides*

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Abstract. Sweet corn is a popular alternative vegetable among Indonesians. Because the majority of its growing area is alternated with other vegetable crops, a strategy for managing the source of fertilizer is required to ensure efficiency and sustainability. This research aims to determine an optimum dose of LOF derived from *T. diversifolia* and *A. conyzoides* for increasing sweet corn growth and yield. A completely randomized block design was used to set up five levels of fertilizer application: 750 mL LOF without *T. diversifolia* and *A. conyzoides* as fresh materials, 750 mL LOF, 1.500 mL LOF, 2.250 mL LOF, derived from *T. diversifolia* and *A. conyzoides* as fresh materials, and a standard dose of inorganic fertilizer. The findings revealed that LOF derived from *T. diversifolia* and *A. conyzoides* had a significant effect`on plant height, stem diameter, ear length, ear diameter, and ear weight, as well as on ear weight per plot. When compared to the LOF treatment without *T. diversifolia* and *A. conyzoides*, plants nutrients obtained from standard inorganic fertilizer or LOF of *T. diversifolia* and *A. conyzoides* of 2.250 mL had a higher average for all observed variables, including plant height, stem diameter, ear length, ear diameter, ear weight, and ear weight per plot. Based on the current research, adding liquid organic fertilizer made from *T. diversifolia* and *A. conyzoides* at a rate of 2.250 mL per plant led to the best growth and yield of sweet corn. The findings confirm the possibility of replacing inorganic fertilizer with LOF from local plants like *T. diversifolia* and *A. conyzoides*.

1 Introduction

Sweet corn (*Zea mays* L. var. *saccharata*) is the commonly consumed types of corn due to its freshness and nutritional value. Sweet corn is rich in protein, carbohydrates, and beta-carotene (provitamin A) [1]. Sweet corn contains 5 to 6 % sugar, 10 to 11 % starch, 3 % water-soluble polysaccharides, and the rest is water. It also contains a reasonable amount of protein [2]. Growers are shifting their focus to sweet corn to increase yields and create employment opportunities as sweet corn also has a big market [3].

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Overusing fertilizer in intensive farming could harm the environment. A study estimated nitrogen losses in BMP-compliant vegetable crop production systems [4]. Using recommended fertilizer rates on crop residues can reduce N losses. Sweet corn requires a lot of fertilizer, both inorganic and organic. Nitrogen (N) determines crop size and yield formation [5, 6]. A side-dressing of 120 kg ha^{-1} nitrogen at V6 increased seed yield and kernel protein content [7]. In addition, phosphorus, potassium, and nitrogen can increase corn yields by promoting silking [8]. According to [9], N, P, and K starter fertilizers increased corn yield in no-till conditions. Over-application of NPK fertilizer did not increase yields and could be bad for the environment, so it is important to find the best NPK application rate.

Inorganic fertilizers can harm the soil's physical, chemical, and biological properties [10]. Combining inorganic fertilizers with organic fertilizers and Plant Growth Promoting Rhizobacteria (PGPR) can improve inorganic fertilizer effectiveness [11-13]. One kind of organic fertilizer (LOF) commonly used for sweet corn is liquid organic fertilizer [14-16]. LOF contains nutrients in a solution that plants can easily absorb and apply to plants by spraying on the leaves or stems. Microorganisms in LOF play an essential role in substrate degradation during the fermentation process, resulting in the production of growth regulators such as auxins, cytokinins, and organic acids [17]. Vermicompost, cow urine, EM4, dirt, and leaf waste are all organic elements of a LOF mix. By combining soil and leaf waste, [14] demonstrate that LOF can provide nitrogen while promoting vegetable growth. Solid organic fertilizer improves soil porosity, permeability, and plant growth when combined with LOF [18, 19].

According to [20], using LOF in sweet corn increased growth and yield. *Tithonia diversifolia* (local Indonesian name is Paitan) and *Ageratum conyzoides* (local Indonesian name is Bandotan) are wild plants that are abundant in the tropical highlands. Even though *T. diversifolia* and *A. conyzoides* plants have many macronutrients and can be used to make liquid organic fertilizer, their utilization in agriculture is still rare. The N-total content of *T. diversifolia* is 3.5-4.0 %, the P content is 0.35-0.38 %, the K content is 3.5-4.0 %, the Ca content is 0.59 %, and the Mg content is 0.27 % [21].The N-total content of *A. conyzoides*, on the other hand, is 0.17 %, the P content is 31.660 mg/100 g, and the K content is 22.715 mg/100 g [22]. *A. conyzoides* also has secondary metabolites such as flavonoids, alkaloids, coumarins, essential oils, sterols, and tannins [23]. The possibility of using LOF based on *T. diversifolia* and *A. conyzoides* in sweet corn is rarely contemplated, it is important to study the effect of LOF made from *T. diversifolia* and *A. conyzoides*to the growth and yield of sweet corn.

2 Materials and method

The study was conducted at the Agricultural Research Station of the Faculty of Agriculture, Bengkulu University, in Rejang Lebong Regency, Bengkulu Province, Indonesia, at 102° 36' 54.96" E and 3° 27' 34.26" S, at an altitude of 1,054 masl.

2.1 Experimental setup

In the experiment, we used a G4xG7 genotype of sweet corn, LOF without *T. diversifolia* and *A. conyzoides,* LOF with *T. diversifolia* and *A. conyzoides*, Urea, SP36, and KCl. The LOF, which had been developed by the CAPS Agricultural Research Station, was utilized in the study [24]. In this study, *T. diversifolia,* hereinafter called *Tithonia,* and *A. conyzoides,* hereinafter will be called *Ageratum.*

Table 1 summarizes the treatment, which was divided into five experimental units and replicated five times. The experimental design was a completely randomized block design with 20 plants in each experimental unit, five of which were chosen at random as sample

plants and spaced 70 cm x 25 cm apart. The common sweet corn cultivation method was used for crop management.

Table 1. The level of treatment, schedule and volume of LOF given to plants (per plant basis).

Level of Treatment	Scheduled (in days after planting) and given LOF volume (mL)								Total dosage
	0 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP	56 DAP	
P1	-	25	50	75	100	150	150	200	750 mL
P2	-	25	50	75	100	150	150	200	750 mL
P3	-	50	100	150	200	250	350	400	1.500 mL
P4	-	100	150	250	350	450	450	500	2.250 mL
P5	1,9 g urea	1,9 g Urea 1,9 g SP-36 1,9 g KCl	-	-	-	-	-	-	3,8 g urea 1,9 g SP-36 1,9 g KCl

Note: P_1 (LOF without *Tithonia* and *Ageratum*); P_2, P_3, and P_4 (LOF derived from *Tithonia* and *Ageratum* at different dosage); P_5 (Inorganic Fertilizer)

2.2 Data collection and analysis

The variable measurements were based on five randomly selected plant samples from each plot and included plant height, stem diameter, number of leaves, ear length, ear diameter, ear weight, and ear weight per plot. All variables were analysed for variance using the Statistical Analysis System at a $P<0,05$ significance level. Multiple comparisons of the effects of different LOF sources on the measured variables were conducted using Duncan's test with a probability of 5%.

3 Results and discussion

During the period of study (November 2020 to February 2021), the monthly precipitation, air temperature, relative humidity, and duration of sunshine were 368 mm, 23.9 °C, 86%, and 2.8 hours, respectively. The climate data was suitable for sweet corn plants, which require monthly temperatures between 23 and 27 ºC and 200 to 300 mm of precipitation [25]. Time of harvest was delayed because plants respond by storing heat as they develop to determine their current developmental stage.

3.1 The influence of LOF concentration on the growth of sweet corn

At 49, 56, 63, 70, and 77 DAP, the treatment of LOF made from *Tithonia and Ageratum* had a significant effect on the height of sweet corn plants. The average plant height of plants aged 49 to 77 DAP did not differ significantly between treatments 2.250 mL LOF and inorganic fertilizer, but differed between treatments 750 mL without *Tithonia* and *Ageratum* and 750 mL with *Tithonia* and *Ageratum* (table 2).

Table 2. Sweet corn plant height (cm) after LOF *Tithonia and Ageratum* applications at various growth stages.

Treatment			Days after planting		
	49	56	63	70	77
P_1	61,52^{b}	80,32^{b}	91,96^{c}	104,60^{c}	113,68^{c}
P_2	69,72^{ab}	85,84^{ab}	98,16^{bc}	108,96^{bc}	118,2^{bc}
P_3	71,48^{ab}	88,48^{ab}	101,36^{abc}	111,76^{abc}	121,56^{bc}
P_4	81,28^{a}	101,60^{a}	114,20^{ab}	124,64^{ab}	134,16^{ab}
P_5	82,64^{a}	104,48^{a}	117,08^{a}	127,72^{a}	139,52^{a}

Note: The mean value followed by different letters indicates that the treatment is significantly different at the 5% level, according to Duncan's test. P_1 (LOF without *Tithonia and Ageratum*); P_2, P_3, and P_4 (LOF with *Tithonia and Ageratum* at various dosages); P_5 (Inorganic Fertilizer)

In comparison to other treatments, the dosage of 2,250 mL (P_4) produced the highest average plant height, while the dosage of 750 mL (P_1) produced the lowest average plant height. In another study, [26] looked at how different doses of LOF affected sweet corn plants and found that the 800 mL dose produced the best results in terms of plant growth and development. It is hypothesized that the increase in the height of sweet corn plants was due to the development of a root system that was actively absorbing the nutrients contained in the 2,250 mL of LOF *Tithonia and Ageratum*. Thechlorophyll compounds, nucleic acids, and enzymes will accelerate vegetative growth, such as the formation of shoots and stems. Lack of nitrogen stunts plant growth by impeding cell division and expansion.

LOF affected sweet corn stem diameter at 63, 70, and 77 DAP. The average stem diameter of 56-77 DAP plants did not differ between treatments 2.250 mL LOF and inorganic fertilizer, but did differ significantly between treatments 750 mL with and without *Tithonia* and *Ageratum* (table 3).

Table 3. The stem diameter of sweet corn plants (in cm) after LOF *Tithonia* and *Ageratum* application at different growth stages.

Level of Treatment	Day after planting				
	49	**56**	**63**	**70**	**77**
P_1	1,08	1,34^{b}	1,61^{b}	1,75^{b}	1,89^{b}
P_2	1,18	1,41^{b}	1,66^{b}	1,79^{b}	1,89^{b}
P_3	1,24	1,43^{ab}	1,61^{b}	1,72^{b}	1,84^{b}
P_4	1,38	1,63^{ab}	1,95^{a}	2,06^{a}	2,21^{a}
P_5	1,45	1,74^{a}	1,91^{a}	2,07^{a}	2,22^{a}

Note: The mean value followed by different letters indicates that the treatment is significantly different at the 5% level, according to Duncan's test. P_1 (LOF without *Tithonia and Ageratum*); P_2, P_3, and P_4 (LOF with *Tithonia and Ageratum* at various dosages); P_5 (Inorganic Fertilizer)

As shown in table 3, when the amount of LOF was increased to 2.250 mL it started to compete with the inorganic fertilizer. Nitrogen helps plants grow and makes stems bigger [20] as also found by [27] with organic fertilizer of farmyard and [28] with LOF from goat manure. On the other hand, [29] found that LOF did not increase stem of coffee seedlings.

LOF had no effect on the number of leaves during vegetative growth (figure 1) as also found by [14]. On the other hand, [16] found that LOF and vermicompost caused the sweet corn much taller.

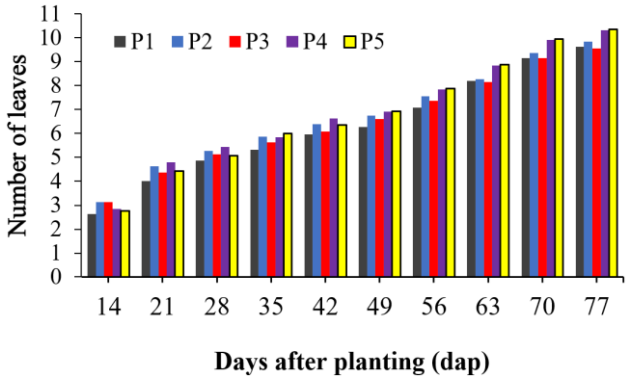

Figure 1. The leaf growth of sweet corn during the vegetative phase at varying levels of LOF.

3.2 The effect of LOF concentration on sweet corn yield

LOF of *Tithonia* and *Ageratum* had a significant effect on the weight, length, and diameter of sweet corn ears (figure 2a to figure 2d). The average length of ears of sweet corn fertilized with 2.250 mL LOF was comparable to ears fertilized with inorganic fertilizer but significantly different from ears fertilized by 750 mL LOF with or without *Tithonia* and *Ageratum*, and 1.500 mL LOF with *Tithonia* and *Ageratum* (figure 2a). The addition of 2.250 mL LOF resulted in the greatest average ear diameter and ear weight, despite being comparable to that of inorganic fertilizer, whereas 750 mL LOF without *Tithonia* and *Ageratum* resulted in the smallest average ear diameter, comparable to treatment levels of 750 mL LOF and 1500 mL LOF with *Tithonia* and *Ageratum* (Figure 2b and Figure 2c).

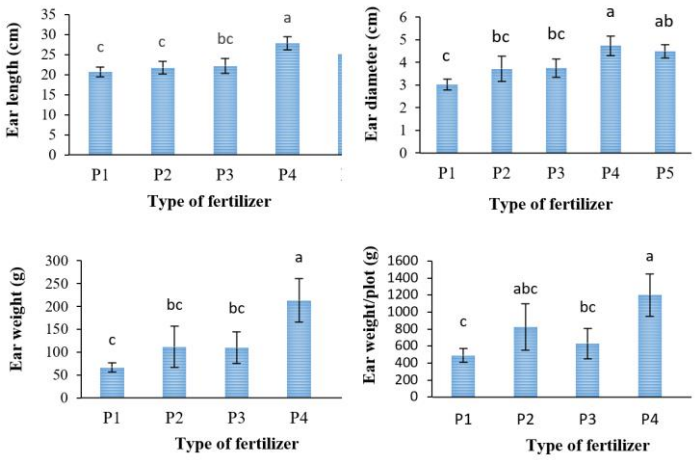

Figure 2. The effect of LOF concentration on sweet corn yield.

During the generative phase, the nutrients in LOF *Tithonia* and *Ageratum* or inorganic fertilizer were used to increase the length and width of sweet corn ears. The highest dose of LOF for *Tithonia* and *Ageratum* had provided more nutrients, as also reported by [25]. This is due to the phosphate-making ATP, which gives the plant the energy for growing. Meanwhile, K is a nutrient that supports the plants' ability to make carbohydrates and store them. Plants that make a lot of carbohydrates also need potassium. [17] found that the addition of vermicompost and LOF increased the uptake of nitrogen, phosphorus, and

potassium by sweet corn, whereas the addition of LOF alone only affected the uptake of nitrogen [15]. The recent study found that the macronutrient needs of the sweet corn were met by adding 2.250 mL of LOF or by inorganic fertilizer alone.

LOF *Tithonia* and *Ageratum* affect the ear weight per plot. The average weight of sweet corn ears per plot in 2.250 mL LOF was comparable to ears fertilized with inorganic fertilizer but significantly different from ears fertilized with 750 mL LOF without *Tithonia* and *Ageratum* (Figure 2d). Sweet corn plants of 2.250 mL LOF produced the heaviest ear weight per plot, while those in LOF without *Tithonia* and *Ageratum* produced the lowest average ear weight per plot, even though not significant to 750 mL LOF and 1.500 mL LOF with *Tithonia* and *Ageratum*.

Recent research indicates that an inorganic fertilizer can be replaced with LOF containing material ingredients from *Tithonia* and *Ageratum* at a rate of 2.250 mL per plant throughout the plant's growth and development (grain filling). However, less than 2,250 mL of LOF from *Tithonia* and *Ageratum* or even 750 mL of LOF without *Tithonia* and *Ageratum* was insufficient to stimulate the growth and yield of sweet corn. Therefore, the highest dose of LOF combined with *Tithonia* and *Ageratum* will able to reduce the use of inorganic fertilizers, and will improve soil quality and productivity.

4 Conclusion

The optimal dose of LOF derived from *T. diversifolia* and *A. conyzoides* was identified as 2.250 mL per plant for sweet corn. Meanwhile, a dosage of even 750 mL of LOF without *T. diversifolia* and *A. conyzoides*, or less than the above-mentioned dosage, was insufficient to stimulate sweet corn growth and yield. The current research finding confirms that the possibility of substituting inorganic fertilizer with LOF based on local plants such as *T. diversifolia and A. conyzoides* is promising. The quality and density of LOF should be improved in the future.

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