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Agronomic Responses of Sweet Corn - Peanut Intercropping to Liquid Organic Fertilizer Grown in Different Dosages of Vermicompost

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ABSTRACT

Applying organic fertilizer and intercropping systems are among the techniques for preserving land sustainability in organic vegetable production systems. In organic vegetable production, the use of liquid organic fertilizer has been suggested in addition to the use of solid organic fertilizer. This study evaluates how growth and yields of sweet corn and peanuts grown utilizing row intercropping respond to different vermicomposting dosages. A factorial experiment is arranged using a split-plot design with three replicates. The main plot is vermicomposting dosages; 5, 10, 15, 20, and 25 Mg/ha, and the sub-plot was the applications of liquid organic fertilizer, not fertilized and fertilized with liquid organic fertilizer. Results show that the application of liquid organic fertilizer elevated plant height and leaf area, length, diameter, and weight of husked ears of sweet corn. Vermicomposting increased plant height, husked ear length, husked ear diameter, and husked ear fresh weight of sweet corn. Twenty Mg/ha is the best dosage for producing sweet corn intercropped with peanuts. However, using vermicompost and liquid organic fertilizers did not increase the growth and yields of peanuts. Evaluation of nutrient uptakes by intercropped crops, sweet corn, and peanut, in organic production systems, should be the subject of further study..

INTRODUCTION

Organically grown vegetables, including sweet corn, have been increasingly practiced to increase consumer demand for organic foods globally. A market analysis published in September 2021 indicated that the worldwide organic food industry grew at an annual growth rate of 9.7% in 2021 and is anticipated to develop at a pace of 14.5% in 2025 (Reportlinker, 2021). Golijan and Dimitrijevic (2018) previously estimated that the growing demand for organic fruits and vegetables accounted for 40% of the worldwide organic food market. A steady supply of organic vegetables must be ensured to meet rising market demands without placing land and water resources at risk. According to Khakbazan et al. (2014), organic farming practices have many benefits, including reducing pest infestations, energy inputs, greenhouse gas emissions, and leaching of pesticides into groundwater. This system also improved rhizosphere quality as well as increased employment opportunities. However, organic farming systems might have disadvantages such as being financially risky, increased labor needs costs, and dynamic changes in certification standards. Thus, organic vegetable production practices must deploy sustainable production technologies to provide increased market demands continuously.

In organic vegetable production systems, the cropping system is a crucial strategy to sustain land and water resources that eventually benefit crop growth and yield in the long run. Several types of cropping systems include mono-cropping, crop rotation, sequential cropping, intercropping, mixed intercropping, row intercropping, stir cropping, and relay cropping. Martin-Guay et al. (2018) state that intercropping practices elevate land use efficiency. Indeed, Fung (2019) concluded that intercropping could increase food security and environmental

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sustainability. Intercropping practices must be applied in organic farming since it enables farmers to cultivate at least one high-value crop while allowing the cropping arrangement to control weeds and boost the following crop year's production. Moutier et al. (2021) have created agricultural systems that are more self-sufficient in terms of external inputs, productive, diverse, resilient, and ecologically benign to boost intercropping practices in organic farming. In this system, growing species mixtures is strongly encouraged to address the challenges organic arable cropping faces in the European Union. Such policies covered subsidizing intercropping European farms, regulating relevant and proportionate species in intercropping, and disseminating technical information on organic farming practices for agricultural advisors and farmers. According to Nafziger (2009), intercropping is the practice of planting two or three crops in the same field simultaneously, in which each crop is assigned in a separate row. Under this condition, there will be potential competition between the crops regarding water, nutrient, light, and space utility. Crop selections must be properly considered to establish a mutually symbiotic relationship in intercropping. According to Notaris et al. (2019), proper seeding rate, sowing time, and sowing methods in spring cereal-forage legume intercropping systems determine plant competition. Intercropping practices are generally arranged by combining legume and non-legume crops. It has been commonly reported to produce a higher yield than monocropping, for example, in maize-soybean intercrop (Raza et al., 2019).

Legume crops can have a symbiotic relationship with rhizobium at root nodules which can fixate atmospheric nitrogen. This fixation takes place through the conversion of atmospheric nitrogen (N_2) into ammonium (NH_4^+) or organic nitrogen for plant metabolisms (Foyer et al., 2016). The interaction of intercropping crops is reported to influence crop growth and yield. Research by Liu et al. (2017) concluded that intercropped faba bean with wheat produced higher nodules and dry weight than monoculture faba bean. Increased yields of intercropped crops might have been related to the changes in the plant's ability to uptake nutrients from the root environment. Ramirez-Garcia et al. (2015) concluded that intercropping between barley and legume vetch changes plants' root growth and nitrogen uptakes. Barley has higher root intensity and density than vetch and takes up more nitrogen than vetch. The intercropping also increased nitrogen uptakes of barley but decreased N uptakes by vetch. Intercropping of maize and peanut has been reported to increase yields of maize and land equivalent ratio of intercropped plants (Li et al., 2019). Previously, Zuo et al. (2000) concluded that intercropping of maize and peanut significantly alleviated the competition for land between maize and peanut and increased yields of intercropped crops.

In addition to cropping systems, organic fertilizer is one of the most common methods used to maintain the quality of land resources in organic vegetable production systems. The use of solid organic fertilizers, including vermicompost, has been widely practiced in the production of many vegetables. According to Ramnarain et al. (2019), vermicompost is of solid organic fertilizers produced by composting organic materials (e.g., animal manures) using species of earthworms. Research conducted by Piya et al. (2018) concluded that using vermicompost improved crops' soil quality, growth, yield, and nutritional value. Additionally, Sikder et al. (2017) concluded that potato crops fertilized with vermicompost had higher yields than those grown without vermicomposting. Regardless of this increase, using vermicompost in sweet corn production under organic production systems must be accompanied by the application of liquid organic fertilizer (Muktamar et al., 2017). This complementary requirement was presumably related to solid organic fertilizer (vermicompost) needing a longer time to get available for vegetable crops. Considering these significant benefits of intercropping and the effectiveness of liquid organic fertilizer in increasing yields of vegetables in organic farming systems, it is essential to evaluate how liquid organic fertilizer influences the performances of intercropped sweet corn and peanuts in organic production systems. This research aimed to determine the effects of liquid organic fertilizer on growth and yields of sweet corn-peanuts intercropping grown in different dosages of vermicompost.

MATERIALS AND METHODS

Experimental Site and Design

This experiment was conducted from August to November 2021 at the organic site in Rejang Lebong, Bengkulu, Indonesia (3°, 27', 30.38" South Latitude and 102°. 36', 51.33'' East Longitude), at an elevation of approximately 1,054 m above sea level. The soil type of the experimental site was Inceptisols and has been planted with organic vegetables since 2011.

The experiment was arranged in a Split Plot design with three replicates. Vermicompost with dosages of 5, 10, 15, 20, and 25 Mg/ha served as the main plot, and the sub-plot was the liquid organic fertilizer applications (not fertilized and fertilized with 100% liquid organic fertilizer). The land was harrowed, and 15 plots of 5 m x 5 m in each block were constructed two weeks before planting. Each plot was separated by 0.75 m within and 1 m between the blocks. Vermicompost was applied a week before planting.

Sweet corn hybrid (CAPS 17AxCAPS22) and peanut (cv. Tuban) were planted and arranged in rows intercropping each main plot. Sweet corn rows were separated 0.75 m away, and sweet corn seed was sown at one cm in depth with a spacing of 0.25 m within the row. Meanwhile, the peanut was planted in between sweet corn rows and sown at two cm in depth with a spacing of 0.30 m. Each main plot had 60 sweet corn plants and 80 peanut plants. The main plot was then split into two subplots.

Liquid organic fertilizer was produced incubating the blends of 10 kg of cattle's feces, 20 L of cattle's urine, 5 kg of topsoil, 5 kg of green leaves of *Tithonia diversifolia*, 5 kg of green leaves of *Ageratum conyzoides* L., 20 L of EM-4 solution and 135 L of water for five weeks in a blue plastic container. Following incubation, the mixture was filtered using white cloth and the results of filtering were considered as 100% in concentration. The applications of liquid organic fertilizer (100% in concentration) were conducted at 2, 3, 4, 5, 6, 7, 8, 9, and 10 weeks after planting, respectively, with a total volume of 1700 mL for sweet corn and 1400 mL for groundnut, by uniformly spraying the plants. Weedings were conducted every other week throughout the growing season. To prevent crops from pest and pathogen attacks, bio-pesticide Pestona® and bio-fungicide Glio ® were applied as necessary.

Observed Variables and Data Collections

Crop responses to treatments were evaluated from the average measurement of five sample plants in each subplot. Sweet corn responses to treatments were measured using plant height (cm), plant leaf area (cm^2), shoot to root ratio, husked ear fresh weight (g), length of the unhusked ear (cm), unhusked ear fresh weight (g), and unhusked ear diameter (cm).

To measure plant leaf area (cm^2), equation 1 based on Musa and Hassan (2016) was used:

$Y = (L*W*0.75)*\text{leaf number}$ ....1)

Where: Y = leaf area (cm^2); L = leaf length (cm); W = leaf width (cm); 0.75 = corrrecting coefficien

Meanwhile, peanut responses to treatments were evaluated regarding plant height (cm), shoot-to-root ratio, number of pods per plant, number of filled pods per plant and dry weight per plant (g). Treatment effects of sweet corn and peanut were also determined by measuring chlorophylls (chlorophyll a, chlorophyll b and total chlorophyll). Leaf samples were collected from the upper most-expanded leaves. Chlorophyll from fresh tissue (0.5 g) was extracted using 80% acetone (Yoshida *et al.*, 1976). Absorbances of this extract were determined at 646 nm (A646) and 663 nm (A663) using UV/Visible Spectrophotometer. Calculations of concentration (μmol/l) of chlorophyll a, chlorophyll b, and total carotenoid used equations as recommended by Wellburn (1994). Moreover, the experimental site's weather data, including the average minimum, maximum, and daily temperatures, relative humidity, and rainfall, were collected from Meteorology, Climatology, and Geophysical Agency (ID WMO: 96255).

Statistical Analysis

All data on plant growth, sweet corn, and peanut yields were subjected to a homogenous test before analyzing variance at $P \leq 0.05$. Differences in liquid organic fertilizer effects on each variable were compared using T-test. The vermicompost effect mean was compared using Duncan's Multiple Range Test at $P < 0.05$.

RESULTS AND DISCUSSION

Environmental Conditions

The average daily air temperature recorded from August to November 2021 was 24.2, 24.1, 23.9, and 24.1^{o}C, with the average monthly rainfall of 97, 347, 417, and 228 mm. In addition, during those months, the average relative humidity around the experimental site was 87, 87.6, 87.8, and 85.2 %, respectively. These environmental conditions could support both sweet corn and peanuts growths. Sweet corn growths could flourish under these circumstances. After crop tasselling, sweet corn needs between 101.2 and 152.4 mm of moisture per month to successfully pollinate and produce kernels (Davis, 2019). Average air temperatures during the growing season were probably changed to accommodate sweet corn development and growth. Ideal air temperatures for sweet corn growth, according to Wright et al. (2005), were between 24 and 30^{o}C. However, the hybrid sweet corn used in this experiment was an organic variety created at this growing location. Meanwhile, peanut requires average monthly precipitation of 67 to 110 mm, with optimum air temperatures of 28 to 30^{o}C for optimum growth and yields (Cargill et al., 2014). In addition, peanut grows well at the average daily relative humidity of 75% and soil pH between 6.0 to 6.5.

The pH of the soil one week before planting was 5.03, and measurements (at plot fertilized with 10 Mg/ha vermicompost) taken four and ten weeks following the first planting showed that the pH had increased to 5.32 and 5.42, respectively. This increase was the result. Such an increase was related to vermicompost's ability (10-30 Mg/ha) to reduce soil acidity by increasing soil pH (Muktamar et al., 2017). Vermicompost used in this experiment had 3.06% N, 2.6% P, 1.05% K, 1.79% Ca, 0.59% Mg, and 7.96% C, with a pH of 5.5 (Muktamar et al., 2017). Laboratory analysis of the liquid organic fertilizer used in this experiment indicated that its pH was 7.36, and its N, P_2O_5, K_2O, Ca, Mg, Cu, and Zn were 2.23%, 0.03%, 0.17%, 0.035%, 0.025%, 0.505 ppm, and 2.63 ppm, respectively. The high pH of liquid organic fertilizer (7.36) might have also reduced soil pH as the intercropped crops matured.

Sweet Corn Responses

Using liquid organic fertilizer influenced plant height, plant leaf area, husked ear length, husked ear diameter, and husked ear fresh weight (Table 1). However, it did not affect shoot-to-root ratios, chlorophyll a, chlorophyll b, and total chlorophyll of intercropped sweet corns. In addition, vermicompost had similar effects with liquid organic fertilizer effects on all observed variables. Interactions between liquid organic fertilizer and vermicompost did not affect intercropped sweet corn's growth and yields.

Results indicated that using liquid organic fertilizer increased plant height, plant leaf area, husked ear length, husked ear diameter, and fresh weight of husked intercropped sweet corn (Table 2). Sweet corn fertilized with liquid organic fertilizer had higher plant height and plant leaf area than those not fertilized with liquid organic fertilizer. However, it did not affect the shoot-to-root ratio, chlorophyll a, b, and total chlorophyll. Increased plant height might have resulted from the effect of liquid organic fertilizer to induce stalk elongation. It eventually increased plant height by increasing sweet corn's N and K tissue contents (Muktamar et al., 2021) since both nutrients play important roles in cell divisions and elongations. Although their research was conducted in coastal entisol, the nature of nutrient absorption by sweet corn as affected by liquid organic fertilizer was presumably similar since it deployed similar liquid organic fertilizer and vermicompost. Previously, Pangaribuan et al. (2017), Aulya et al. (2018) as well as Maintang et al. (2021) concluded that the application of liquid organic fertilizer increased the plant height of sweet corn. The presence of liquid organic fertilizer might have induced cell elongation of sweet corn. According to Nielsen (2019), stalk elongation in sweet corn is mainly a result of cell expansion along the internode bases at the intercalary meristems. Ciampitti et al. (2016) also concluded that increased sweet corn height resulted from stalk elongation. Increased leaf area of sweet corn was related to the significant effects of liquid organic fertilizer in increasing the number (P=0.0084) and length (P=0.0060) of sweet corn treated with liquid organic fertilizer. The increase might have resulted from sufficient nitrogen available for sweet corn due to the application of liquid organic fertilizer (2.23%) to induce cell growth and divisions of sweet corn, resulting in higher leaf areas for fertilized sweet corn than those of the unfertilized group.

This experiment also disclosed that applying liquid organic fertilizer increased the length of the husked ear, the diameter of the husked ear, and the weight of the intercropped sweet corn (Table 2). Nutrient contents of liquid organic fertilizer (N, P_2O_5, K_2O, Ca, Mg, Cu, and Zn, were 2.23 %, 0.03 %, 0.17 %, 0.035 %, 0.025 %, 0.505 ppm, and 2.63 ppm, respectively) was presumably the main reason of the differences. Research conducted by Pangaribuan *et al.* (2019) found that using liquid organic fertilizer increased the fresh weight of unhusked ears, fresh weight of husked ears, ear length, and ear diameter. Muktamar et al. (2017) concluded that using liquid organic fertilizer on the growth of organic sweet corn enhanced soil pH, exchangeable K, NO_3-N, and total soil nitrogen.

Table 1. Summary of analysis of variances the effects of liquid organic fertilizer and vermicompost on growth and yields of intercropped sweet corn.

Plant variables	Probability value < 0.05		
	Liquid organic fertilizer (LOF)	Vermicompost (VC)	Interaction (LOF x VC)
Plant height	0.0001	0.0273	0.2084
Plant leaf area	0.0020	0.0583	0.7051
Length of husked ear	0.0118	0.0115	0.8763
Diameter of husked ear	0.0257	0.0001	0.1002
Husked ear fresh weight	0.0024	0.0001	0.1035
Shoot to root ratio	0.4906	0.8973	0.7029
Chlorophyll a	0.9858	0.655	0.9104
Chlorophyll b	0.4651	0.3395	0.9947
Total chlorophyll	0.8512	0.5873	0.9497

Table 2. Effects of liquid organic fertilizer (LOF) on growth and yields of intercropped sweet corn

Plant variables	With LOF	Without LOF
Plant height (cm)	166.84^{a}	152.28^{b}
Plant leaf area (cm^2)	7913^{a}	70.61^{b}
Length of husked ear (g)	24.73^{a}	23.53^{b}
Diameter of husked ear (g)	53.07^{a}	50.77^{b}
Husked earfresh weight (g)	248.52^{a}	211.32^{b}
Shoot to root ratio	6.33^{a}	6.66^{a}
Chlorophyll a (mg/l)	1.85^{a}	2.01^{a}
Chlorophyll b (mg/l)	0.41^{a}	0.49^{a}
Total chlorophyll (mg/l)	2.25^{a}	2.50^{a}

Remarks: Means in the same row followed with the same letter are not significantly different according to t-Test: Paired Two Sample for Means at P < 0.05

Table 3. Effects of vermicompost on growth and yields of intercropped sweet corn

Plant variables	Vermicompost (Mg/ha)				
	5	10	15	20	25
Plant height (cm)	160.73^{ab}	146.87^{b}	150.60^{b}	167.27^{a}	172.33^{a}
Plant leaf area (cm^2)	7398.00^{a}	6461.00^{a}	6863.00^{a}	8554.00^{a}	8161.00^{a}
Length of husked (cm)	24.10^{ab}	22.70^{c}	23.77^{bc}	25.10^{a}	25.00^{ab}
Diameter of husked ear (mm)	50.13^{b}	47.57^{c}	51.59^{b}	54.24^{a}	56.06^{a}
Husked ear fresh weight (g)	199.60^{b}	170.80^{c}	223.90^{b}	271.87^{a}	283.43^{a}
Shoot to root ratio	6.61^{a}	6.99^{a}	6.54^{a}	6.25^{a}	6.10^{a}
Chlorophyll a (mg/l)	1.80^{a}	2.02^{a}	2,24^{a}	1.73^{a}	1.85^{a}
Chlorophyll b (mg/l)	0.38^{a}	0.48^{a}	0.55^{a}	0.47^{a}	0.37^{a}
Total chlorophyll (mg/l)	2.18^{a}	2.50^{a}	2.79^{a}	2.20^{a}	2.22^{a}

Remarks: Means in the same row followed with the same letter are not significantly different according to Duncan's Multiple Range Test at P < 0.05.

Insignificant effects of liquid organic fertilizer on intercropped sweet corn on shoot-to-root ratios, chlorophyll a, chlorophyll b, and total chlorophyll of intercropped sweet corns (Table 2) might have related to the compounding effects of high N content in applied liquid organic fertilizer and continuous application of vermicompost in this experimental site since 2011. In addition, the continued application of organic fertilizers could increase nutrient availability in the rhizosphere (Hou et al., 2020), which might later distort the treatment effects. Similar to the insignificant impact of liquid organic fertilizer, the little effects of vermicompost on the shoot-to-root ratios and chlorophyll contents (Table 3) might have resulted from the residual effect of organic practices in respected growing areas.

Results indicated that sweet corn fertilized with 10 and 25 Mg/ha vermicompost are amongst the highest plant height, though it was similar to those fertilized with 5 Mg/ha. Similarly, fertilizing sweet corn with 20 and 25 Mg/ha produced the highest fresh weight, length, and diameter of husked compared to other dosages (Table 3). According to Li et al. (2022), increased of corn yields in intercropping of corns and legumes (soybean and peanuts) were boosted by the enzyme activity related to nitrogen metabolism in corn. Increased sweet corn growth yields due to vermicompost application in the range of 20 and 25 Mg/ha were related to the sufficient supply of nutrients contained in vermicompost. Vermicompost application at 20 Mg/ha was equal to 600 kg N/ha, 520 kg P/ha, and 210 kg K/ha since vermicompost used in this experiment contained 3.06% N, 2.6% P, and 1.05% K (Muktamar et al., 2017). However, from a farming sustainability perspective, 20 Mg/ha is sufficient for sweet corn production. According to Bellitürk et al. (2021), vermicompost is a natural product made from a straightforward biotechnological composting method that uses specific species of earthworms to speed up the decomposition of organic material into organic nutrients and soil ameliorants. In addition, vermicompost also increased plant nutrient uptakes (Barlas et al. (2018). Similar results of vermicompost effects have also been documented in potatoes (Sikder et al., 2017) and sweet corn (Muktamar et al., 2017). Nevertheless, the insignificant effects of vermicompost in plant leaf area, shoot-to-shoot ratio, chlorophyll a, chlorophyll b, and total chlorophyll of intercropped sweet corns might have resulted from blurring effects of vermicompost, known as residual effects, on organic production systems.

Increased yields of intercropped sweet corn in this experiment, due to the respective effect of liquid organic fertilizer and vermicompost, indicated that sweet corn was superior when it was intercropped with peanut as both treatments increased sweet corn yields (Table 2 and Table 3), but not on peanut yields (Table 4 and Table 5). Similarly, Li *et al.* (2019) found that maize/peanut intercropping increased light transmission into the maize canopy, active photosynthetic duration, dry matter accumulation after silking and photosynthate distribution to the grain of the maize, which eventually increased the weight of maize ears.

Table 4. Effects of liquid organic fertilizer (LOF) on growth and yields of intercropped peanut

Plant variables	With LOF	Without LOF
Plant height (cm)	33.98[a]	29.25[b]
Numbers of pods	20.90[a]	20.65[a]
Numbers of filled pods	10.82[a]	11.38[a]
Shoot to root ratio	3.67[a]	3.65[a]
Pods dry weight (g)	13.17[a]	13.1[a]
Grain yields dry weight (g)	9.61[a]	9.71[a]
Chlorophyll a (mg/l)	1.96[a]	1.93[a]
Chlorophyll b (mg/l)	0.43[a]	0.50[a]
Total chlorophyll (mg/l)	2.38[a]	2.43[a]

Remarks: Means in the same row followed with the same letter are not significantly different according to t-Test: Paired Two Sample for Means at $P < 0.05$.

Peanut Responses

The use of liquid organic fertilizer did not affect plant leaf area, number of pods, number of filled pods, shoot-to-root ratio, pods dry weight, grain yield dry weight, chlorophyll a, chlorophyll b, and total chlorophyll of intercropped peanuts. However, it influenced the plant height of the peanut (Table 6). Likewise, vermicompost application had similar effects on all observed plant variables. Interactions between liquid organic fertilizer and vermicompost had no effect on all observed variables except plant height.

Table 5. Effects of vermicompost on growth and yields of intercropped peanuts

Plant variables	Vermicompost (Mg/ha)				
	5	10	15	20	25
Plant height (cm)	33.26	30.93	28.26	32.03	33.60
Numbers of pods	16.63	23.23	24.16	20.00	19.86
Numbers of filled pods	8.40	12.46	13.46	10.56	10.50
Shoot to root ratio	3.22	3.62	3.76	3.19	4.50
Pods dry weight (g)	9.69	16.72	14.01	12.89	12.36
Grain yield dry weight (g)	7.41	11.75	10.16	9.78	9.21
Chlorophyll a (mg/l)	1.51	2.47	2.00	1.91	1.83
Chlorophyll b (mg/l)	0.29	0.60	0.42	0.46	0.54
Total chlorophyll (mg/l)	1.80	3.07	2.42	2.37	2.37

Table 6. Summary of analysis of variances the effects of liquid organic fertilizer and vermicompost on growth and yields of intercropped peanuts

Plant variables	Probability value < 0.05		
	Liquid organic fertilizer (LOF)	Vermicompost (VC)	Interactions (LOF x VC)
Plant height	0.0001	0.2194	0.0009
Numbers of pods	0.8729	0.2382	0.5618
Numbers of filled pods	0.4343	0.0634	0.4952
Shoot to root ratio	0.9161	0.2590	0.1761
Pods dry weight	0.9444	0.3108	0.9004
Grain yield dry weight	0.8832	0.4149	0.9925
Chlorophyll a	0.9499	0.6792	0.9101
Chlorophyll b	0.5434	0.3559	0.9924
Total chlorophyll	0.9249	0.6185	0.9438

Table 7. Interaction effects of liquid organic fertilizer and vermicompost on plant height of intercropped peanuts.

Vermicompost (Mg/ha)	With Liquid Organic Fertilizer	Without Liquid Organic Fertilizer
5	39.60[a]	26.93[d]
10	32.73[bc]	29.13[cd]
15	28.20[cd]	28.33[cd]
20	32.60[bcd]	31.46[bcd]
25	36.80[ab]	30.40[cd]

Remarks: Values followed with the same letter in the same row are not significantly different according to Duncan's Multiple Range Test at P < 0.05.

Using liquid organic fertilizer increased the plant height of peanuts (Table 6). The effects of liquid organic fertilizer on the growth and yields of intercropped peanuts are presented in Table 6. Increased plant height might have been attributed to sweet corn's shading effects on peanut growth. Although peanut belongs to the group of plants with a C3 photosynthetic pathway, applying liquid organic fertilizer provided nutrients for peanuts competing with sweet corn to have more sunlight, resulting in a higher plant but not a robust stand. The latter was indicated by the insignificant effects of liquid organic fertilizer to shoot to root ratio of peanuts.

Significant interaction effects between liquid organic fertilizer and vermicompost on plant height might have indicated that peanut used more energy from both treatments to compete with sweet corn in acquiring the sunlight. The interaction of liquid organic fertilizer and vermicompost significantly affect the height of peanuts. Five Mg/ha of vermicompost and liquid organic fertilizer had the tallest plant height (Table 7).

Likewise, this experiment revealed that the use of vermicompost had insignificant effects on the growth and yields of peanuts. Insignificant effects of vermicompost (Table 6) might have been due to the inability of peanuts to compete with sweet corn in terms of sunlight in the above-ground surfaces and nutrients in the below-ground surfaces. Hemon et al. (2021), concluded that peanut grown under continuous shade from planting to harvest had lower yield compared to that of grown without shading. Sweet corn had higher plant stands than peanuts which provided more shading effects to peanuts. In addition, according to Goldy (2015), sweet corn is considered a heavy nitrogen remover from the soil environment. Canatoy and Daquiado (2021) concluded that about 98–99% of total biomass of sweet corn was determined by its nutrient uptakes, including nitorgen. Regardless of the ability of peanuts to fixate nitrogen from the atmosphere, the inferiority of peanuts to sweet corn brought about fewer responses of peanuts to applied treatments. These environmental conditions might have explained why the effects of liquid organic fertilizer and vermicompost were insignificant in all observed variables except the plant height of peanuts.

The use of legume species in crop rotation of organic sweet corn production systems is inevitably practiced to maintain the quality of land resources and sweet corn productivity. Although cereal-legume intercropping is a typical planting strategy for diversification that has been developed to accomplish the double objectives of high output and low greenhouse gas emissions (Yao et al., 2023), more cereal-legume intercropping research needs to be conducted, especially in organic vegetables production system. A challenge specific to sweet corn–peanut intercropping under organic production systems is ensuring both sweet corn and peanut benefit from this cropping system. The fact that sweet corn is classified as a high-nutrient consumer crop, especially nitrogen, and peanut is legume species known as nitrogen suppliers to the soil environment must be further understood by carefully planning the model of intercropping as well as the plants – nutrients relationships between intercropped plants. Evaluation for sweet corn–peanut intercropping might include the plant spacing, planting dates, sources and time of organic fertilizer. Meanwhile, evaluating plants – nutrients relationships might include the nutrient use efficiency of sweet corn and peanut, especially nitrogen. These are some challenges to sustainable organic sweet corn production by improving the availability of nitrogen (and other nutrients) and long-term soil fertility to establish a yield stabilization effect over time for sweet corn.

CONCLUSION AND SUGGESTION

Under organically sweet corn-peanut intercropping, applying liquid organic fertilizer increased plant height and leaf area, length, diameter and weight of husked ears of sweet corn. Vermicomposting increased plant height, husked ear length, husked ear diameter, and husked ear fresh weight of sweet corn. Using 20 Mg/ha is considered the best dosage to support the growth and yield of sweet corn. However, peanuts' growth and grain yields were not increased due to the application of liquid organic fertilizers and vermicompost. Further research should be addressed on intercropped sweet corn and peanut nutrient uptakes.

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