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The Growth and Yield of Sweet Corn as Affected by Palm-Oil Sludge and Liquid Organic Fertilizer

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ABSTRACT: Organic fertilizer has recently gained popularity as an effective alternative to synthetic fertilizer. The study aimed to find out whether a combination of palm oil sludge and synthetic fertilizer affected sweet corn growth and yield. The study was performed at the Experimental Station of the Agronomy Laboratory, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia in a Completely Randomized Design (CRD). The treatments were K0: Control (without fertilization), K1: 15 tons/ha Palm oil sludge (POS) + 50% Liquid Organic Fertilizer (LOF), K2: 15 tons/ha POS + 100% LOF, K3: 20 tons/ha POS + 50% LOF, K4: 20 tons/ha POS + 100% LOF, K5: 25 tons/ha POS + 50% LOF, K6: 25 tons/ha POS + 100% LOF, K7: 30 ton/ha POS + 50% LOF; K8: 30 tons/ha POS + 100% LOF, and K9: synthetic fertilizer/SF at recommended dosage. Sweet corn fertilized with synthetic fertilizers grew better than control plants (not fertilized). Palm oil sludge + liquid organic fertilizer supplemented with 50% of the recommended synthetic fertilizer dose resulted in similar crop growth and yield as synthetic fertilizer at the recommended dosage. The different application of POS dose and LOF concentration has no significant effect on sweet corn growth or yield of sweet corn. Thus POS and LOF can substitute the role of synthetic fertilizers in providing nutrients for plants.

Keywords- liquid organic fertilizer, organic fertilizer, sludge, sweet corn

I. INTRODUCTION

Farmers have faced some challenges in growing sweet corn, including low agricultural land productivity and the conversion of fertile land to non-agricultural uses. On the other hand, intensive and prolong use of synthetic fertilizer has caused the decline of soil fertility, such as hardened soil, inability to store water, and decreased soil pH, which reduces crop productivity. Organic fertilizer has recently become a popular substitute for synthetic fertilizer.

Palm oil sludge (POS) is a by-product of Crude Palm Oil (CPO) production and could be used as an organic fertilizer. Bengkulu's crude palm oil production increased from 787.05 tons in 2013 to 833.41 tons in 2014. CPO processing plants spreads out throughout Bengkulu Province such as in South Bengkulu, Central Bengkulu, Seluma, Muko-muko, and North Bengkulu, Indonesia [1]. As a result, by product of CPO production continuously increases over the years. Palm oil sludge is a source of an organic fertilizer to provide plant nutrients, improve soil fertility, and ensure environmental quality and production sustainability. On average, 1 ton of POS contains 0.37 % nitrogen (equivalent to 8 kg urea), 0.04 % phosphorous (equivalent to 2.90 kg rock phosphate), 0.91 % potassium (equivalent to 18.3 kg MOP), 0.08 % magnesium (equivalent to 5 kg Kieserite), and 0.91 % potassium (equivalent to 18.3 kg MOP) [2].

Sweet corn variables such as cob length, ear diameter, ear weight per plant, and ear weight per plot provide positive response to the application of solid palm oil waste. Increasing solid oil palm waste rates from 17 tons/ha to 30 tons'/ha increases growth and yield of sweet corn [2]. [3] stated that the combination of palm oil sludge with NPK synthetic fertilizer; LS 20% + NPK 50%, LS 30% + NPK 50%, and LS 40% + 50% had an equivalent effect on vegetative growth (plant height and leaves number) and yield of mustard with that 100% NPK inorganic fertilizer.

POS can be supplemented with liquid organic fertilizer (LOF) because it contains microorganisms rarely found in soil. LOF also releases plant nutrients more quickly, ensuring that they are available when required, mainly during growth stages. The addition of LOF will maintain the high productivity of plants grown in low-organic-matter soils. A study by [4] (2016) indicates that the increasing rate of LOF has a significant increase in N uptake by sweet corn but not by P and K. Increasing the total volume of LOF to 950 ml per plant resulted in a significant increase in sweet corn N, P, and K concentrations and uptakes [5].

Since the recent findings of studies show that solid and liquid organic fertilizers have positive effects on sweet corn growth and yield, further research is necessary to determine the combination of their impact. The purpose of the study was to compare the growth and yield of sweet corn as affected by a combination of palm oil sludge and synthetic fertilizer.

II. METHODOLOGY

The study was conducted at the Experimental Station of the Agronomy Laboratory, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia arranging in Completely Randomized Design (CRD) with ten treatments and repeated three times. The treatment consisted of palm oil sludge doses (POS) in combination with liquid organic fertilizer concentration (LOF). The standard concentration is denoted by LOF 100% (not dissolved in water).

The treatments were K_0: Control (without fertilization), K_1: 15 tons/ha POS + 50% LOF, K_2: 15 tons/ha POS + 100% LOF, K_3: 20 tons/ha POS + 50% LOF, K_4: 20 tons/ha POS + 100% LOF, K_5: 25 tons/ha POS + 50% LOF, K_6: 25 tons/ha POS + 100% LOF, K_7: 30 ton/ha POS + 50% LOF; K_8: 30 tons/ha POS + 100% LOF, and K_9: synthetic fertilizer/SF at recommended dosage. The LOF was obtained from the University of Bengkulu's CAPS (Closed Agricultural Production System) Research Station in Air Duku Village, Rejang Lebong, Bengkulu. POS was acquired from PT Bio Nusantara, a Palm Oil Plantation in Central Bengkulu.

The growing media used Ultisols collected at a depth of 0-20 cm from the Faculty of Agriculture Experiment Station in Kandang Limun Village, 15 meters above sea level. Air-dried soil samples were sieved with a 5 mm screen. A week before planting, ten kg of air-dried soil was incorporated with palm oil sludge and placed in the polybags. Polybags were randomly placed at 70x40 cm spacing in the greenhouse. All POS and LOF treatment combinations received a half of the synthetic fertilizer recommendation. TSP and KCl were applied 7 days after planting, while urea was applied twice, at 7 and 35 days after planting. LOF was applied through soil surface closed to the sweet corn stand at weeks 2, 3, 4, 6, and 8, at a rate of 150, 200, 200, 200, and 200 ml per plant, respectively. The total volume of LOF was 950 ml for five applications.

Two sweet corn seeds were planted in polybags at a depth of 5 cm. Thinning was completed two weeks after planting, leaving the healthier plant. The soil was watered to maintain the soil moisture and weed was manually control. The sweet corn was harvested at 80 days after planting, indicated by turning brown of the cob.

Plant height, number of leaves, stem diameter, leaf greenness, leaf area, shoot fresh and dry weight, root fresh and dry weight, husked cob weight, unhusked cob weight, length of unhusked cob, and diameter of unhusked cob were all observed variables. The data were analyzed using the analysis of variance (ANOVA) F test (5%). The treatment means were separated using a contrast test with a 95% confidence level. For some treatments, a contrast test was performed.

III. RESULTS AND DISSCUSSION

Rainfall during the study was between 172.1 - 670.8 mm/month with an average of 378.06 mm. During the study, the average monthly rainy day was 12.6 days. Sweet corn requires between 200 and 600 mm of rain per month to grow [6]. During the study, therefore, the rainfall met plant growth requirements. Insecticides were used to control the small grasshopper Oxya chinensis, ants, woodchoppers, and red black ladybugs at 4 and 8 weeks, respectively, while fungicides were used to control leaf blight. Sweet corn's growth and development were hindered by pests and diseases.

The treatment significantly affected almost all observed variables, both vegetative and generative variables (Table 1). Orthogonal contrast was performed on several treatments to distinguish the effect of the combination treatment on each observed variables.

Table 1. Analysis of variance of the variables observed

Variables	F-calculated	Notation
Plant height	9,14	**
Number of leaves	9,58	**
Stem diameter	21,8	**
Leaves greenes	3,24	*
Leaf area	5,22	**
Root fresh weights	5,35	**
Plant fresh weight	11,41	**
Root dry weight	11,15	**
Plant dry weight	10,78	**

Cob weight with husk	1,79	ns
Cob weight	1,63	ns
Cob diameter	2,75	*
Cob length	4,37	**

note: * = significant,** = highly significant, ns = not significant

The contrast test revealed a significant difference in the treatment of non-fertilized plants versus plants fertilized with synthetic fertilizers. Plant height, number of leaves, stem diameter, leaf greenery, leaf area, root dry weight, plant dry weight, cob diameter, and cob length were better in fertilized plants than control (Table 2).

Table 2. Contrast tests of plants not fertilized (P0) and fertilized with synthetic fertilizers (P9) on various plant variables

Variables	Contrast Treatment		F-calculation	Notation
	P_0	P_9		
Plant height	75,72	119,04	25,43	**
Number of leaves	5,11	7,77	37,12	**
Stem diameter	9,94	16,96	74,24	**
Leaves greenes	23,02	30,56	22,22	**
Leaf area	2230,94	6183,96	11,90	*
Root dry weight	1,61	7,96	66,12	**
Plant dry weight	9,49	30,79	29,82	**
Cob diameter	16,37	30,61	13,36	**
Cob length	4,81	11,86	21,40	**

note:* = significant,** = highly significant, ns = not significant

According to this study, synthetic fertilizers can provide plants with the N, P, and K required for plant growth and development. Nitrogen is an essential nutrient for plant growth and development [7], and it is required to increase plant height and weight [8]. Nitrogen produces greener plants, accelerates plant growth in plant height, number of tillers, number of branches, and increases the plant protein content [9]. Application of P (phosphorus) and K (potassium) improves growth, production, and yield quality of plant [10]. The formation of corn cobs is supported by P, while the filling of corn seeds is bolstered by K.

Plant height, leaf greenery, and leaf area were significantly different in the combination of palm oil sludge (POS) + liquid organic fertilizer (LOF) vs. synthetic fertilizers but not significantly different in the number of leaves, stem diameter, and length and diameter of the cob (Table 3). These findings suggest that POS in combination with LOF can effectively replace urea, TSP, and KCl fertilizers. As a result, POS and LOF can be used to reduce the amount of synthetic fertilizer used.

Table 3. Contrast test of a combination of palm oil sludge (POS) + liquid organic fertilizer (POC) vs. synthetic fertilizer (SF)

Variables	Value		F-calculation	Notation
	POS+LOF	SF		
Plant height	132,96	119,04	4,56	*
Number of leaves	7,72	7,77	0,021	ns
Stem diameter	18,31	16,96	3,67	ns
Leaves greenes	27,84	30,56	5,10	*
Leaf area	7973,86	6183,96	4,33	*
Root dry weight	6,97	7,96	1,84	ns
Plant dry weight	37,25	30,79	4,92	*
Cob diameter	29,23	30,61	0,15	ns
Cob length	11,62	11,86	0,03	ns

note: POS = * = significant, ns = not significantly different

Compared to those fertilized with synthetic fertilizers, organic fertilizer produces taller sweet corn, greener leaves, broader leaves, and higher plant dry weight. This vegetative growth, on the other hand, was not followed by sweet corn yields. The combination of POS + LOF yielded cob diameter and cob length similar to the recommended dosage of SF (Table 3). As a result, POS and LOF can substitute synthetic fertilizers by 50%. The soil analysis results bolstered the findings of this study after treatment, which showed that soil treated with organic fertilizer was able to increase soil pH, organic matter availability, and plant nutrients N, P, and K. When used with synthetic fertilizers, organic fertilizers can increase soil productivity. The effect of organic fertilizers will last for a long time, enhancing soil quality and leaving no residue on crop [11]

Table 4 featured the effects of POS 300 g + 100 percent LOF (LS + LOF) on sweet corn growth and yield. Sweet corn grew and yielded better with the combination of LS+LOF than with the control treatment (P_0).

Table 4. Contrast test of the POS (30 ton/ha) + 100% LOF vs the control treatment (P_0)

Variables	Value		Increased (%)	F-calculation	Notation
	POS +LOF	P_0			
Plant height (cm)	134,72	75,52	78,39	46,95	**
Number of leaves	7,55	5,11	47.75	37,12	**
Stem diameter (mm)	18,44	9,94	85.51	105,22	**
Leaves greenes	28,16	23,02	22.33	9,88	**
Leaf area (cm2)	7736,05	2230,94	246.76	23,02	**
Root dry weight (mg)	8,28	1,61	414.28	73,26	**
Plant dry weight (g)	41,19	9,49	334.06	67,10	**
Cob diameter (mm)	29,43	16,37	79.78	11,56	**
Cob length (cm)	11,72	4,81`	143.66	21,40	**

note: * = significant,** = highly significant, ns = not significant

According to the findings of this study, POS (30 tons/ha) + LOF (100 percent) can provide nutrients for sweet corn growth and development. The results were supported by post-treatment soil analysis. Application of POS at 30 ton/ha and LOF (100 %) increased P, K, and soil pH but not N and C-organic. soil P enhanced from 0.32 to 0.72 ppm, soil K boosted from 0.20 to 0.54 me/100g, and soil pH risen from 4.6 to 5.4. Oil palm waste can improve soil fertility and serve as a source of nutrients for plants [12]. Even though total soil nitrogen after treatment, the availability of N for plant in control is similar to that POS and LOF treatment, the availability of N to plant is lower in control than POS + LOF. This result is associated with the availability of N from LOF. Nitrogen is easily available from LOF, leading to more efficient metabolic process. According to [13], plants lacking nutrients will disrupt metabolic processes, inhibiting plant growth and [14] stated that nitrogen directly affects carbohydrate synthesis in plants' cells and acts as a constituent of chlorophyll, which results in green leaves. Plants require sufficient amounts of N, P and K nutrients in both the vegetative and generative stages.

In comparison to recommended synthetic fertilizer (SF), Table 5 showed the growth and yield of sweet corn fertilized with 30 ton/ha POS + 100% LOF are similar to those of plants fertilized with synthetic fertilizers at the recommended dose.

Table 5: Contrast test of the POS (30 ton/Ha) + LOF (100%) vs synthetic fertilizer (SF)

Variables	Value		F-calculation	Notation
	POS+LOF	SF		
Plant height	134,72	119,04	3,27	ns
Number of leaves	7,55	7,77	0,00	ns
Stem diameter	18,44	16,96	2,69	ns
Leaves greenes	28,16	30,56	2,47	ns
Leaf Area	7736,05	6183,96	1,83	ns
Root dry weight	8,28	7,96	0,18	ns
Plant dry weight	41,19	30,79	7,46	**
Cob diameter	29,43	30,61	0,07	ns
Cob length	11,72	11,86	0,00	ns

note: * = significant, ** = highly significant, ns = not significant

The findings revealed that POS and LOF both played a role in supplying nutrients to plants. Palm oil sludge and LOF contain sufficient N for sweet corn plant growth, resulting in higher dry biomass weight than synthetic fertilizers (Table 5). The dry weight of a plant is a measure of its growth. Better plant growth will increase plant dry weight [15]. This study's findings are similar to those of [16] that applying palm oil sludge to Ultisol can increase dry canopy weight and P uptake in corn plants. In general, the two treatments produce corn plants that are similar growth and yield. These findings show that synthetic fertilizers can be replaced with organic fertilizers derived from POS or LOF. Both of these organic fertilizers can enhance plant growth by raising soil pH and increasing the availability N, P, K and organic matter.

The addition of organic matter to the soil through the use of organic fertilizer has a positive impact on soil properties, nutrient levels in the soil, and the long-term viability of agricultural land. Continuous application of 100% synthetic fertilizer can degrade the soil's chemical, biological, and physical properties and the substitution of synthetic fertilizer by 25% with organic fertilizer can preserve soil and maintain plant growth [17].

Table 6 shows the comparison of the lowest organic fertilizer combination (K1= POS 15 ton/Ha + LOF 50%) with the highest combination (K8= POS 30 ton/Ha + LOF 100%), the lowest dosage of palm oil (K1= POS 15 ton/Ha + LOF 50%) with the highest dosage of palm oil (K7= POS 30 ton/Ha + LOF 50%), and the lowest LOF concentration. Sweet corn growth and yield were unaffected by differences in POS dose and LOF concentration. Therefore, at low doses of POS and LOF concentrations, sweet corn can receive N, P, and K required for growth and development. In addition, an additional 50% of the synthetic fertilizer used as a basic fertilizer can supply nutrients, increasing the availability of nutrients in the planting media and allowing sweet corn plants to absorb them directly.

Table 6. Contrast test between treatments on variable root and plant dry weight, and diameter and length of the cob

Variables	Average value	F-calculation	Notation
Root dry weight			
K_1 vs K_8	6,76 vs 8,28	2,93	ns
K_1 vs K_7	6,76 vs 7,41	0,73	ns
K_1 vs K_2	6,76 vs 6,68	0,00	ns
Plant dry weight			
K_1 vs K_8	49,45 vs 41,19	2,63	ns
K_1 vs K_7	49,45 vs 34,17	1,43	ns
K_1 vs K_2	49,45 vs 36,00	0,03	ns
Cob diameter			
K_1 vs K_8	29,71 vs 29,43	0,00	ns
K_1 vs K_7	29,71 vs 29,33	0,03	ns
K_1 vs K_2	29,71 vs 31,27	0,18	ns
Cob length			
K_1 vs K_8	13,65 vs 11,72	1,11	ns
K_1 vs K_7	13,65 vs 11,55	1,11	ns
K_1 vs K_2	13,65 vs 10,94	2,83	ns

note: * = significant,** = highly significant, ns = not significant

Sweet corn plants grown with 15 tons/ha of palm sludge have similar growth and yield as those grown with 30 tons/ha of sludge. Thus, 15 ton/ha POS is sufficient to supply nutrients for sweet corn growth. The findings of this study are consistent with those of [18], who concluded that the lowest combination of fertilizer provided the best response for corn growth and yield. Plant height, dry biomass weight, and the weight of 100 corn seeds were all affected by NPK Mutiara fertilizer 150 kg/ha + 20 tons/ha POS. In general, the uptake of N, P, and K is higher in the combination of oil palm ash + palm oil sludge waste with a 40 percent composition than in the treatment with a higher percentage [19].

Sweet corn grown at a 50% LOF concentration produced the same growth and yield as sweet corn grown at a 100% POC concentration. The findings of this study differ from those of [20] where the application of 100% LOF combined with 25 tons/ha vermicompost in a total volume of 950 ml/plant increased N, P, and K uptakes by sweet corn. Plants will not achieve maximum growth and yield without nitrogen, phosphorus, and potassium [21]. [22] reported that combining organic ingredients with synthetic fertilizers increased the levels and uptakes of N, P, and K by plants, resulting in increased sweet corn production.

IV. CONCLUSIONS

Sweet corn fertilized with synthetic fertilizers grew better than control plants (not fertilized). Palm oil sludge + liquid organic fertilizer + 50% of the recommended synthetic fertilizer dose resulted in similar crop growth

and yield as synthetic fertilizer at the recommended dosage. The different application of palm oil sludge dose and liquid organic fertilizer concentration has no significant effect on sweet corn growth or yield of sweet corn. Thus palm oil sludge and liquid organic fertilizer can substitute the role of synthetic fertilizers in providing nutrients for plants.

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