

## Growth and Yield Responses of Three Sweet Corn (*Zea mays* L. var. Saccharata) Varieties to Local-based Liquid Organic Fertilizer

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**Abstract**— Solid organic fertilizing for organically sweet corn production should be combined with foliar application to improve fertilizing effectiveness. Each sweet corn variety had different response to particular liquid organic fertilizer (LOF). This experiment aimed to determine growth and yields of three sweet corn varieties to local-based LOF was conducted at CAPS research station (950 m above sea level) from March to June 2015, arranged in a factorial completely randomized block design with three replicates. The first factor was three sweet corn varieties, *i.e.* Talenta, Jambore and Asian Honey, and the second factor was five LOF concentrations, *i.e.* 0, 25, 50, 75, and 100 ppm, respectively. Results indicated that sweet corn varieties significantly affected plant height, plant leaf-area, root fresh-weight, weight of husked ears, weight of unhusked ears, but did not affect diameter of unhusked ear and shoot fresh-weight. LOF concentrations did not affect all observed parameters. So did the interaction between varieties and LOF concentrations, except on shoot fresh-weight. Asian Honey variety had the highest plant height, plant leaf-area, roots fresh-weight, weight of husked ears, and weight of unhusked ears. There were no different in plant diameter and shoot fresh weight among the tested varieties. Further research should be focused on the use of higher concentration of local-based LOF to provide effective complementary organic fertilizing in sweet corn production.

**Keywords**— organic sweet corn; variety responses; liquid organic fertilizer.

### I. INTRODUCTION

Sweet corn (*Zea mays* L. var. Saccharata) has been widely considered more beneficial than maize production due to the shorter growing seasons and higher cropping index, which later suppresses production costs and eventually increases farmers' income. In addition, its economic values might be double when it is organically grown due to increasing consumer's demands and limited product availability. It is estimated that the retail values of organic industries by the year of 2015 around US\$100 billion, more than threefold higher than in 2005 which was accounted for US\$30 billion [1].

The use of solid organic fertilizer has been widely practiced for nutrient supply in organic sweet corn production. Nevertheless, solid organic fertilizer takes longer time to mineralize than crop life-cycles. *i.e.* within 90 days only after solid organic fertilizer application, there were

only 50% of its N, P, and K get mineralized [2]. Another report confirmed that most composts mineralized <10% of initial N content in the 4 to 6 months after the application into the soil [3]. Research conducted [4] concluded that compost application has a residual effect on the soil nutrient and sweet corn yield. This slow-release characteristic endorses the application of liquid organic fertilizer (LOF) through leaves to fulfill nutrient required for organic sweet corn production. Foliar application is very effective to support growth and yield of maize plants [5].

Previous research concluded that the quality of LOF, *i.e.* nutrient compositions, is determined by type of raw material, decomposer microorganisms, and the production process [6]. Proper organic vegetable production is eventually conducted in a closed production system. Organic vegetable production is a system approach, where the production was intentionally designed to promote biodiversity, biological cycles, and soil biological activities [7]. The use local materials, therefore, is an essential part of organic vegetable production practices.

Plant parts, local microorganisms as well as plant and animal wastes available around the production areas should be further incorporated in LOF production. Researchers at Closed Agriculture Production Systems Research Center, Faculty of Agriculture University of Bengkulu have developed local-based LOF, composed from topsoil, cattle manure, weed (*Tithonia diversifolia* (Hamsley) A. Gray), effective microorganism, urine of cattle, and water [8].

Effective foliar application of fertilizer is determined by the crop species, fertilizer form, concentration, frequency of application and the stage of plant growth [7]. Genetic factor also determines the successfulness of organic vegetable production, such as in wheat, tomato, broccoli [9], and in cowpea [10]. Various effects of local-based LOF have been previously documented in many vegetables, such as in lettuce [11], [12], Chinese green cabbage [13], cauliflower [14], kaelan [15], potato [16], tomato [17], sweet corn [18] and peach plants [19].

This research aimed to determine (1) the optimum concentration of local-based LOF for growth and yield of organic sweet corn production and (2) the most responsive sweet corn variety to local-based LOF.

## II. MATERIALS AND METHODS

This experiment was conducted at CAPS research station (950 m above sea level) from March to June 2015, arranged in a factorial completely randomized block design with three replicates. The first factor was three sweet corn varieties, *i.e.* Talenta, Jambore and Asian Honey, and the second factor was five LOF concentrations, *i.e.* 0, 25, 50, 75, and 100 ppm.

Local-based LOF was made of 10 kg cattle's feces, 20 l cattle's urine, 5 kg of topsoil, 10 kg of *Tithonia diversifolia* (Hamsley) A. Gray), 20 l solution of 24-hour incubated 20 ml EM 4+0.25 kg white sugar. All these materials were then mixed and added with water in the blue plastic container to reach a volume of 200 l and aerobically fermented for three weeks [8].

Experimental site was cultivated, harrowed and 15 soilbeds of 5m x 1m in each block were constructed two weeks before planting. The experimental plots were separated by 0.5 m within the block and 1 m between the blocks. Sweet corn seeds were planted at a spacing of 0.7 m x 0.2 m. A week before planting, each soilbed was fertilized with 7.5 kg of vermicompost (equals to 15 ton/ha). Manual control of weeds were bi-weekly controlled. At the time of weeding, soil around the stem was raised to prevent up-rooting.

Each plant received 25, 50, 100, 150, 250 and 250 ml LOF, respectively at 2, 3, 4, 5, 6, 7 and 8 weeks after planting, respectively. Application was conducted during calm day and no rain using knapsack sprayer. Sweet corns were harvested at 70 days after planting. Crop responses to treatments were measured by means of plant diameter (cm), plant height (cm), plant leaf area (cm<sup>2</sup>), shoot fresh weight (g), weight of husked ear (g), length of unhusked ear (cm), weight of unhusked ear (g), and diameter of unhusked ear (cm). Analysis of variances were calculated using SAS 9.1.3. Means of varieties' responses were compared using Least Significantly Different Test at 95% level of confidence.

## III. RESULT AND DISCUSSION

Sweet corn varieties significantly affected plant height, plant leaf-area, root fresh-weight, weight of husked ears, weight of unhusked ears, but did not affect diameter of unhusked ear and shoot fresh-weight (Table 1). However, LOF concentrations did not affect all observed parameters. So did the interaction between varieties and LOF concentrations, except on shoot fresh-weight.

Asian Honey variety had the highest plant height, plant leaf-area, root fresh-weight, weight of husked ears, weight of unhusked ears compared to other varieties (Table 2). There were no difference in plant diameter and shoot fresh weight among the tested varieties. Among the tested varieties, it was generally concluded the Asian Honey was the best, followed by Talenta and Jambore variety. Previous report has documented that genetic factor determined crop responses to LOF [6]. Researchers also developed particular variety of organically grown vegetables, such as wheat, tomato, broccoli [9] and cow pea [10].

This experiment indicated that the use of LOF did not influence growth and yield of sweet corn (Table 1). The effects of LOF to all observed parameters are presented in Table 3. This finding was not similar to previously reported where LOF concentration significantly effect, for example, the weight of husked ears [20] and unhusked ear [21] of sweet corns. Since effectiveness of crop responses to LOF is also determined by its concentration [7], it is presumably that LOF concentration used in this experiment was not sufficient enough to support growth and yields of sweet corn. A laboratory analysis indicated that LOF used in this experiment contained 3.36 %, 146 ppm, and 0.0325 % of N, P, and K, respectively. Nitrogen content of this LOF complied with Indonesian Standardization Board (SNI 19-7030-2004) for organic fertilizer where total N should be >0.4 %. However, this was not true for the case of P and K which must be >0.10 % (P<sub>2</sub>O<sub>5</sub>) and >0.20 % (K<sub>2</sub>O), respectively. Low content of P (146 ppm) and K (0.0325 %) might have presumably limited LOF effects on sweet corn growth and yields. Our results were generally lower than previously reported [20] where the length of unhusked ears, diameter of unhusked ears, and weight of unhusked ear were 19.7 cm, 4.6 cm and 219.2 g, respectively. The difference might be due to the nature of LOF used in their experiments. These features, however, were somehow comply with variety descriptions of Talenta sweet corn (length of unhusked ear, weight of husked ear and diameter of unhusked ear were 19.7-23.5 cm, 221.2-336.7 g and 4.5-5.4 cm, respectively). There were two major components of this local LOF used in this experiment, *i.e.*, cattle's feces and green mass of *Tithonia diversifolia* (Hamsley) A. Gray). Manipulating these two components would be one of possible ways to have better nutrient compositions of LOF that will further increase growth and yields of sweet corn. Another way that might be possible to have better effects of LOF on growth and yields of sweet corn is by applying higher concentration. Applying higher LOF concentration, however, might be carefully implemented since higher concentration of LOF could delay nutrient uptake by plant, *i.e.*, Chinese mustard [22].

Another reason might be related to less effective of LOF to promote growth and yield of sweet corn in this experiments was due to the absence of surfactant during the application of LOF. The use of surfactant was designed to improve liquid foliar fertilizing [23]. The use of surfactant has been reported to somehow improve muskmelon quality [24]. Less response of sweet corns to LOF might be related to the fact that this crop has narrow leaf morphology, since foliar fertilization is more effective in broad leaves than narrow leaves [25]. Our previous reports confirmed that the use of LOF through foliar applications did not significantly improve yields of carrots, a narrow leaf crop [8]. The use of local based LOF has been reported to successfully increase yields of broad-leaf vegetables such as in tomato [17], pechay plant [19] and marrow [25].

There were interaction effects between variety and LOF concentration in growth and yields of sweet corn, except in shoot fresh weight (Table 1). However, Asian Honey variety received 100 ppm LOF generally had better growth compared to other combinations (Table 4). Shoot fresh weight of Asian Honey received 100 ppm and Jambore received 0 ppm were the highest among other treatment combinations, although it was not significantly different with those of Talenta 50 ppm, Talenta 75 ppm, Talenta 100 ppm, Jambore 25 ppm, Jambore 75 ppm, Asian Honey 25 ppm, and Asian Honey 75 ppm. The lowest fresh weight was attributed to Talenta 0 ppm, Talenta 25 ppm, Jambore 50 ppm, Jambore 100 ppm, Asian Honey 0 ppm and Asian Honey 50 ppm. It seemed that these significances were not proportionally to weights of husked ear and unhusked ear. Growth disturbances during the later course of sweet corn development might have brought about such phenomenon.

These results confirmed previous results that effectiveness of use of organic fertilizers was also determined by crop species and LOF concentration [7]. This finding also implied that there was a need to develop organic vegetable, including sweet corn, variety to have successful organic vegetable production. Indeed, our colleagues have been developing a breeding program to find superior variety of sweet corn for organically grown in our experimental site since 2012. This program has successfully identified 7 promising genotypes (out of 18 genotypes) that will be further screened for organic sweet corn variety. It is expected by the year of 2018, a suitable hybrid for closed production system is successfully released to the farmers.

#### IV. CONCLUSIONS

The concentration of tithonia-based liquid organic fertilizer did not increase growth and yields of organically grown sweet corn. Sweet corn of Asian Honey had the best responses to local-based liquid organic fertilizer, followed by Talenta and Jambore.

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TABLE I

F>PROB. VALUES OF SOURCE OF VARIANCES OF PLANT DIAMETER (PD), PLANT HEIGHT (PH), PLANT LEAF AREA (PLA), SHOOT FRESH WEIGHT (SFW), WEIGHT OF GREEN EAR (WGE), LENGTH OF EAR (LE), WEIGHT OF DEHUSK EAR (WDE), DIAMETER OF DEHUSK EAR (DDE) OF SWEET CORNS

Source of variances	Variables (F> Prob 5 %)								
	PD	PH	PLA	SFW	RFW	WGE	LE	WDE	DDE
Model	0.0444	0.0001	0.0001	0.0577	0.0595	0.0069	0.0056	0.0007	0.0072
Variety	0.6235	0.0001	0.0326	0.4684	0.0018	0.0001	0.0001	0.0001	0.0001
Concentration	0.5166	0.1018	0.4202	0.5000	0.2206	0.3567	0.5855	0.2456	0.3769
Variety*Concentration	0.0822	0.1049	0.0452	0.0243	0.4151	0.4757	0.9187	0.3455	0.8477
Block	0.0052	0.0687	0.0001	0.1122	0.7702	0.0385	0.0032	0.0303	0.0096
Coefficient Variation	8.63	5.05	13.83	22.67	34.41	21.32	11.30	23.80	8.12
Linear	0.2141	0.0183	0.4045	0.7973	0.2018	0.3528	0.2357	0.1785	0.1289
Quadratic	0.7940	0.7364	0.9591	0.2192	0.2940	0.2909	0.4846	0.2180	0.3812
Cubic	0.2889	0.8304	0.9547	0.7723	0.6620	0.2011	0.3623	0.2976	0.4135

TABLE II

EFFECT OF VARIETIES ON PLANT DIAMETER (PD), PLANT HEIGHT (PH), PLANT LEAF AREA (PLA), SHOOT FRESH WEIGHT (SFW), WEIGHT OF GREEN EAR (WGE), LENGTH OF EAR (LE), WEIGHT OF DEHUSK EAR (WDE), DIAMETER OF DEHUSK EAR (DDE) OF SWEET CORNS

Variety	Variables								
	PD (cm)	PH (cm)	PLA (cm <sup>2</sup> )	SFW (g)	RFW (g)	WGE (g)	LE (cm)	WDE (g)	DDE (cm)
Talenta	1.71 a	150 b	3560 ab	189 a	22.1 b	171 a	15.3 b	111 b	4.15 b
Jambore	1.76 a	151 b	3406 b	204 a	18.7 b	128 b	13.6 c	77 c	3.82 c
Asian Honey	1.76 a	169 a	3903 a	209 a	30.3 a	192 a	16.8 a	137 a	4.45 a

Means in the same column followed with the same letter are not significantly different according to Least Significantly Different Test at 5%

TABLE III

EFFECT OF LIQUID ORGANIC FERTILIZER ON PLANT DIAMETER (PD), PLANT HEIGHT (PH), PLANT LEAF AREA (PLA), SHOOT FRESH WEIGHT (SFW), WEIGHT OF GREEN EAR (WGE), LENGTH OF EAR (LE), WEIGHT OF DEHUSK EAR (WDE), DIAMETER OF DEHUSK EAR (DDE) OF SWEET CORNS

Concentrations	Variables								
	PD (cm)	PH (cm)	PLA (cm <sup>2</sup> )	SFW (g)	RFW (g)	WGE (g)	LE (cm)	WDE (g)	DDE (cm)
Control	1.67 a	151 a	3458 a	202 a	21.5 a	157 a	14.8 a	102 a	4.04 a
25 ppm	1.76 a	154 ab	3521 a	189 a	21.2 a	163 a	15.2 a	104 a	4.09 a
50 ppm	1.72 a	156 ab	3598 a	184 a	21.2 a	147 a	14.8 a	97 a	4.05 a
75 ppm	1.78 a	161 a	3644 a	209 a	26.8 a	179 a	16.0 a	122 a	4.21 a
100 ppm	1.77 a	160 a	3895 a	218 a	28.0 a	173 a	15.4 a	117 a	4.31 a

Means in the same column followed with the same letter are not significantly different according to Least Significantly Different Test at 5%

TABLE IV  
INTERACTION EFFECT OF VARIETY AND CONCENTRATION OF LIQUID ORGANIC FERTILIZER ON PLANT DIAMETER (PD), PLANT HEIGHT (PH),  
PLANT LEAF AREA (PLA), SHOOT FRESH WEIGHT (SFW), WEIGHT OF GREEN EAR (WGE), LENGTH OF EAR (LE), WEIGHT OF DEHUSK EAR  
(WDE), DIAMETER OF DEHUSK EAR (DDE) OF SWEET CORNS

Treatment Combinations	Variables								
	PD (cm)	PH (cm)	PLA (cm <sup>2</sup> )	SFW* (g)	RFW (g)	WGE (g)	LE (cm)	WDE (g)	DDE (cm)
Talenta, 0 ppm	1.62	143	3127	150 b	18.2	151	14.9	96.6	4.06
Talenta, 25 ppm	1.69	143	3301	167 b	17.8	160	15.1	100.4	4.01
Talenta, 50 ppm	1.75	153	3755	201 ab	23.0	175	15.4	115.3	4.20
Talenta, 75 ppm	1.78	157	3608	210 ab	23.5	192	16.3	128.9	4.38
Talenta, 100 ppm	1.72	151	4011	216 ab	28.2	180	15.1	114.2	4.12
Jambore, 0 ppm	1.83	152	3812	273 a	20.3	137	13.5	85.7	3.77
Jambore, 25 ppm	1.83	153	3572	209 ab	19.5	141	13.9	84.4	3.83
Jambore, 50 ppm	1.76	150	3406	181 b	18.1	112	13.1	63.6	3.56
Jambore, 75 ppm	1.75	151	3275	191 ab	20.3	139	14.4	86.5	4.11
Jambore, 100 ppm	1.62	147	2965	165 b	15.5	110	12.9	64.7	3.85
Asian Honey, 0 ppm	1.60	159	3436	183 b	25.9	182	16.2	122.7	4.29
Asian Honey, 25 ppm	1.78	166	3692	189 ab	26.4	188	16.6	128.1	4.46
Asian Honey, 50 ppm	1.65	165	3632	171 b	22.5	155	16.0	113.2	4.39
Asian Honey, 75 ppm	1.82	174	4048	227 ab	36.5	205	17.3	149.5	4.45
Asian Honey, 100 ppm	1.98	182	4709	273 a	40.3	230	18.1	170.8	4.67

\* Means in the same column followed with the same letter are not significantly different according to Duncan's Multiple Range Test at 5%