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The effect of enriched compost and nitrogen fertilizer on the growth and yield of sweet corn *(Zea mays* L.)

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Abstract

The integrated use of enriched plant compost and nitrogen fertilizers are one of the main considerations in improving sweet corn productivity in the tropics. Experiment was conducted to determine the effects of enriched compost and nitrogen fertilizer on the growth, yield and mineral nutrients uptake of sweet corn. The treatments involved two enriched compost (rice straw and empty fruit bunches of oil palm each 20 t ha^{-1})) subjected to three levels of nitrogen fertilizer (0, 75, 150 kg N ha^{-1}). The 6 treatment combinations were laid out in a factorial experiment and fitted into a complete randomized block design with three replication. Compost was enriched by adding chicken manure and dolomite. Growth parameters, nutrient uptake and yield attributes were assessed. Result of experiment showed that enriched rice straw compost showed better vegetative and yield than enriched oil palm empty fruit bunch compost. The application of full recommended nitrogen fertilizers had the higher yield as compared with other treatments. This implied that the use of enriched rice straw compost and recommended nitrogen fertilizers could be advisable to be applied for the small scale agriculture cultivation in the red acid Ultisol soil.

Key words: rice straw compost, oil palm empty fruit bunch compost, Urea, ear quality, nutrient uptake

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INTRODUCTION

To maintain soil fertility, agricultural waste must be returned to the soil in the form of compost. The use of compost as a natural fertilizer has increased lately, especially with the development of organic agriculture and the increasing demand for organic food. Types of basic materials for compost abundant around the agricultural community in tropical regions are rice straw and oil palm empty fruit bunch.

The palm oil industry generates an abundance of oil palm biomass such as empty fruit bunch. Processing and utilization empty fruit bunches by palm oil mill is still very limited. In addition to that, processing and utilization of rice straw is still also very rare. After the harvest is completed, the farmers are burning rice straw.

Oil palm empty fruit bunches contains various macro and micro nutrients essential for plant growth, among others : 42.8 % C ; 2.9 % K2O ; 0.8 % N ; 0.22 % P2O5 ; 0.30 % MgO , 23 ppm Cu and 51 ppm Zn (Singh et al 1989). Rice straw is a rich source of organic fertilizer nutrients. Rice straw consists of Si (4-7%), K (1,2 -1,7%), N (0,5-0,8%) dan P (0,07-0,12) (Dobermann dan Fairhurst, 2000).

According to Palm et al. (2001) application of organic matter play a critical role in both of short-term nutrient availability and longterm maintenance of soil organic matter in farming systems in tropical agro ecosystems. This experiment used the basic ingredients of empty fruit bunches of oil palm and rice straw which have been enriched with chicken manure and dolomite, so that each becomes the enriched oil palm empty fruit bunches compost (EOPEFBC) and enriched rice straw compost (ERSC). Composted organic material from plants will more quickly decompose when coupled with enrichment materials. Enriched compost will increase soil fertility and improve the productivity of sweet corn.

Nutrients nitrogen, phosphorus and potassium are a major limiting factor in the productivity of sweet corn. Sweet corn response to nitrogen is influenced by several factors such as the use of organic materials. Organic material is the key to improving the productivity of soil and fertilizer efficiency (Barker, 2010). The objective of the experiment is to study the effects of enriched compost and nitrogen fertilizer on the growth, yield and mineral nutrients uptake of sweet corn.

MATERIALS AND METHODS

A field study was conducted at the farmer field, Kota Sepang, Bandar Lampung, Indonesia. The experiment was factorial design within Randomized Complete Block Design (RCBD) with three replication. The treatments consist of two type of enriched compost i.e. enriched rice straw compost and enriched oil palm empty fruit bunches compost combined each 20 t ha^{-1} with three nitrogen levels i.e. N0 = 0 kg N ha^{-1}; N1 = 75 kg N ha^{-1}; N2 = 150 kg N ha^{-1} (recommended dose).

Enriched compost was prepared from oil palm empty fruit bunch (60%) or rice straw (60%), chicken manure (30%), dolomite (10%), rice bran, crushed paddy husk, and fermented EM solution (5 mL of EM + 10 ml molasse + 1985 mL of dechlorinated water and mixed solution was kept at room temperature to ferment for 3 days). Compost was mixed and sprayed with fermented EM solution until the

moisture content of compost reach to 50%. After 14-21 days the fermented compost was ready to be used.

Sweet corn hybrid ("Jambore") was used in this study. The plant distance was 70 cm x 20 cm, and block treatment was 3 m x 3 m. N, P and K were applied in the form of Urea, SP36 and KCL respectively. The entire quantity of P_2O_5 (75 kg ha^{-1}) and K_2O (50 kg ha^{-1}) was applied as basal at the time of sowing and N was applied in three splits, as basal, at knee-high and tasseling stages.

The study was conducted on Ultisols. Soil and compost were analyzed at Soil and Plant Laboratory, Lampung University. The soil characteristics of the experimental site were pH (6,23), organic matter (1,45%), N total 0,15%, available P 5,31 ppm, available K 19,70 ppm. The soil is loamy soil in texture. The chemical characteristics of ERSC were pH 8,18, C-Organic 25,33 %, N-tot 1,69%, P-tot 0,08%, K-tot 0,88%, Ca : 2.15%, and Mg 0.40%; whereas the chemical characteristics of EOPEFBC were pH 7,51, C-Organic 16,66 %, N-tot 1,87%, P-tot 0,47%, K-tot 1,62%, Ca 1.95%, and Mg 0.30%.

All the recommended cultural practices were used for the management of the experiment. There was no serious incidence of pests and diseases or nutrient deficiencies. Fields were kept weed free by hand weeding at 20–25 day intervals. The observations plant height, number of leaves, brix, length of ear, diameter of ear, ear weight with and without husk, production, chlorophyll content (by Model SPAD 502, Minolta, Japan), the uptake of N, P, K from leaf were recorded. The collected data was analyzed statistically by using Fisher's analysis of variance technique and individual treatment means were separated by using least significant difference (LSD) test at 5 percent probability level.

RESULTS AND DISCUSSION

The interaction effect between types of enriched compost and levels of nitrogen was found non-significant on all parameters observed. Data presented on the main effect of each factor.

The application of enriched compost and nitrogen fertilizers had significant effect on the mean plant height and chlorophyll content (Table 1). However, there was no significant differences on the number of leaves. Enriched rice straw compost (ERSC) showed higher significantly differences over enriched oil palm empty fruit bunch compost (EOPEFBC). This showed that enriched straw compost used promotes the vegetative growth of sweet corn. This finding is similar to that of other researcher who reported better vegetative growth of paddy rice (Barus, 2012) with rice straw compost addition. This confirmed the role of ERSC in promoting vigorous vegetative growth in sweet corn.

The chlorophyll content is an estimate of the N status. The significantly higher chlorophyll content of ERSC treatment than EOPEFBC could be due to differences in nitrogen uptake (Table 4). The greater chlorophyll values in sweet corn leaves is of importance because photosynthetic activity and crop yield may increase with increased chlorophyll content of leaves (Ofosu-Anim and Leitch, 2009).

Table 1. Effects of application of enriched compost and different nitrogen fertilizers rates on vegetative growth of sweet corn

Treatment	Height (cm)	Number of leaves	Chlorophyll content (SPAD)
Enriched rice straw compost	234.91 a	12.87	53.39 a
Empty fruit bunch compost	219.98 b	12.51	49.38 b
LSD	8.74	ns	2.16
N 0 kg ha^{-1}	214.00 a	12.53	48.56 a
N 75 kg ha^{-1}	231.07 b	13.05	51.84 b
N 150 kg ha^{-1}	237.27 b	12.50	53.76 b
LSD	10.70	ns	2.65

There are no statistical differences among the treatments having the same letter at 0.05 level according to LSD test. ns = not significant

The growth vegetative parameters (height and chlorophyll content) increased significantly as the nitrogen rate increased from 0 to 150 kg ha^{-1}. This is due to enhanced availability of nitrogen in the soil which increased leaf area, and consequently resulting in higher photo assimilates and in more dry matter accumulation. These results are supported by the findings of Mullins et al. (1999).

There were significant effects of different enriched compost treatments on ear quality (Table 2) yield and yield attributes (Table 3) of sweet corn. With exception for ear length, application of ERSC significantly improved ear diameter, ear weight with husk, ear weight without husk, soluble solid (Table 2), dry weight matter yield, harvest index with and without husk of sweet corn (Table 3).

The higher dry weight of nitrogen treated plants (Table 3) could be connected with the positive effect of nitrogen in some important physiological processes such as promoting shoot growth and protein synthesis (Barker, 2010) . On the other hand Squire (1990) established that the main effect of N fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by canopy. Better crop growth and development observed under N recommended dose (150 kg ha^{-1}) suggest that increasing crop fertilization to an optimum rate enables the plants to produce their potential vegetative and generative growth, and consequently enhance plant photosynthetic activities and hence more dry matter is produced (Akanbi and Togun, 2002).

Table 2. Effects of application of enriched compost and different nitrogen fertilizers rates on ear components of sweet corn

Treatment	Ear diameter (cm)	Ear length (cm)	Ear weight with husk (kg)	Ear weight without husk (kg)	Soluble solid (^{0}Brix)
Enriched rice straw compost	4.80 a	17.88	0.38 a	0.30 a	14.30 a
Enriched empty fruit bunch compost	4.46 b	16.82	0.32 b	0.26 b	13.21 b
LSD	0.07	ns	0.04	0.02	0.27
N 0 kg ha^{-1}	4.52 a	16.90	0.32	0.26 a	12.63 a
N 75 kg ha^{-1}	4.61 b	17.19	0.36	0.29 ab	13.70 b
N 150 kg ha^{-1}	4.76 c	17.79	0.38	0.30 b	14.93 c
LSD	0.09	ns	ns	0.03	0.33

There are no statistical differences among the treatments having the same letters at 0.05 level according to LSD test. ns = not significant

Table 3. Effects of application of enriched compost and different nitrogen fertilizers rates on yield and harvest index of sweet corn

Treatment	Dry weight matter (g)	Production (ton ha^{-1})	Harvest index with husk	Harvest index without husk
Enriched rice straw compost	135.00 a	15.03 a	0.35 a	0.30 a
Empty fruit bunch compost	126.33 b	10.04 b	0.32 b	0.28 b
LSD	4.44	1.26	0.02	0.02
N 0 kg ha^{-1}	119.83 a	10.89 a	0.33	0.30
N 75 kg ha^{-1}	128.18 b	12.53 b	0.34	0.30
N 150 kg ha^{-1}	143.99 c	14.18 c	0.33	0.29
LSD	5.44	1.54	ns	ns

There are no statistical differences among the treatments having the same letter at 0.05 level according to LSD test. ns = not significant

Enriched rice straw compost application improved soil physical and biological properties and consequently increased sweet corn yields and nutrient availability. These results might be due to the effective use of the applied ERSC soil amendment compared to EOPEFBC. In this experiment, use of enrichment material i.e. chicken manure and dolomite in both compost enhanced soil-nutrient status and organic matter content (Ogboghodo et al., 2005).

Sweet corn yields from ERSC treatment were significantly increased by 49,74% over EOPEFBC treatment. Therefore, regular application of organic amendments, such as rice straw compost which is available abundantly in the small scale agriculture, can sustain soil fertility and increase sweet corn yields.

The yield and yield components (Table 3) and ear quality (Table 2) produced by sweet corn plants were significantly affected by the nitrogen treatments (Table 2 and 3). These yield attributes increased as the nitrogen fertilizer rates increased from 0 to 150 kg ha^{-1}. It might be due to improved nutrients availability and enhanced growth of plant. This is in line with research in corn by Walsh et al. (2012). Mullins et al. (1999) also reported that nitrogen fertilization slightly increased plant growth and ear size of sweet corn.

Application of 150 kg N ha^{-1} not only enhanced the sweet corn yield but also improved the quality of grain as shown in higher sucrose content (as indicated by Brix Table 2). Grain sucrose content, which is the primary sugar in developing sweet corn grain, is closely related to the sweetness in sweetcorn (Reyes et al., 1982; Wong et al., 1994).

The uptake of N, P, and K at maximum vegetative stage is presented in Table 4. There is no significant differences were observed in the nutrient uptake among the enriched compost. Table 4 showed that ERSC application showed higher nutrient uptake value than EOPEFBC application, except on K uptake. The effect of nitrogen fertilizer on plant N, P, K uptake was significant. At all applied N levels plant nutrient uptake was in the order of 150 kg > 75 kg > 0 kg N ha^{-1} (Table 4). This growth parameters advantage that was achieved through greater nutrient uptake by sweet corn plant resulting increased height (Table 1), chlorophyll content (Table 1), ear quality (Table 2) and dry weight matter (Table 3) which eventually increased yield of sweet corn. This is in agreement with results by Berradaa and Halvorson (2012).

Table 4. Effects of application of enriched compost and different nitrogen fertilizers rates on N, P, K leaf uptake

Treatment	N uptake (%)	P uptake (%)	K uptake (%)
Enriched rice straw compost	2.27	0.31	4.53
Enriched empty fruit bunch compost	2.24	0.29	4.56
LSD	ns	ns	ns
N 0 kg ha^{-1}	1.95 a	0.26 a	4.15 a
N 75 kg ha^{-1}	2.17 b	0.30 b	4.39 a
N 150 kg ha^{-1}	2.64 c	0.33 c	5.09 b
LSD	0.22	0.02	0.54

There are no statistical differences among the treatments having the same letter at 0.05 level according to LSD test. ns = not significant

Composting and fertilizer Nitrogen does not provide significant interaction effect on all parameters. This is presumably because the time of application of compost and fertilizer nitrogen that is not the same.

CONCLUSION

The enriched paddy straw compost was better than enriched oil palm empty fruit bunch compost in improving the growth and yield of sweetcorn. The vegetative growth, yield and uptake of N, P, and K at recommended 150 kg Nitrogen ha^{-1} was improved over the control. Hence, we recommend the use integrated of enriched rice straw compost and inorganic fertilizers for improving sweet corn yield and soil fertility restoration.

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