Response of the Sweet Corn (*Zea Mays* L. *Saccharata*) to Different Types and Timing of the Organic Fertilizer Application

Yulian Abdullah[1], Setyono Yudo Tyasmoro[2], Titin Sumarni[3]

[1, 2, 3]Brawijaya University, Postgraduate Program of Magister, Faculty of Agriculture,
Veteran Road, Malang 65145, Indonesia

Abstract: ***Objectives of this research are (1) establishing the appropriate timing of organic fertilizer application to increase production of the sweet corn production, (2) recognizing types of organic fertilizer that could increase growth and yield of the sweet corn. The research was conducted in Malang, East Java of Indonesia from May – September 2013. By using Split Plots Design as the main plot by 4 (four) types of organic fertilizer (P) : P_1 = cow's compost; P_2 = Tithonia diversifolia; P_3 = cow's compost + (EM-4); P_4 = Tithonia diversifolia + (EM-4), and the son plot (SP) is the application timing (T) by 4 (four) levels : T_1 = 0 week (during the initial planting); T_2 = 1 week before planting; T_3 = 2 weeks before planting; T_4 = 3 weeks before planting, which comprise of 16 combinations of treatment by 3 replications. Result of the research, which was based on different types of organic fertilizer along with the appropriate timing of application, showed different results on variables of dry weight at 34 dap, percentage of the increasing for about 54.40% and 44.76%; the growth rate of the crop at 24 – 34 dap have increased 50.70% and 58.18%, respectively; chlorophyll of the leaf at 24 dap; diameter of the ear without husk during harvest time.***

Keywords: Cow's compost, *Tithonia diversifolia*, EM-4 (*Effective Microorganism*-4), sweet corn.

1. Introduction

Sweet corn (*Zea mays* L. *saccharata*) has been grown commercially and plays strategic role in national economy, whereas it has multipurpose, as source of foods, feeds, and raw material of industry. The increasing demand of sweet corn in the market is expected to be able to develop the farm operations of sweet corn in order to fulfill the increasing demand of sweet corn in the market. In order to obtain optimal yield, appropriate breeding is required including in selecting superior and qualified seeds, proper fertilizer application and intensive maintenance [1]. The expanded farming area is one of efforts to increase the national corn production, particularly by utilizing the existed dry soil, in which total area is 52.4 million hectare that spread over the entire areal in Indonesia [2].

Most of the farming areas in Indonesia have low organic material content, less than 1%, particularly in dry soil. The increasing productivity of corn in dry soil can be done by combining the technology application, such as superior varieties, balanced fertilizing, and extensive planting area [3], [4]. Farming intensification through fertilization is done to increase the crop yield. Such organic fertilizer application is an alternative that should be concerned in order to increase the yield and can be used as organic material source as nutrient provider for the plants, as well as to improve physical, chemical, and biological characteristics of the soil [5], [6]. Besides that, slow release of such organic material requires large amount of low nutrients and consider the right timing of the application. Diverse content of nutrients within the organic materials depend on type and age of the animals, feeds, and duration of the storage in relation to mineralization and decomposition process, which would be gradually absorbed by the crop, as well as to maintain stability of the farming products and environment in the future [7], [8], [9]. Based on the above description, the application of organic fertilizer to maintain soil productivity, nutrient provider, and improving soil fertility toward crop production by reviewing different types and appropriate timing of organic fertilizer application without inhibiting and reducing production and quality of the sweet corn yields.

2. Materials and Methods

2.1. Location of the Research

The research was conducted from May to September 2013 in Balittas Karangploso, Malang that lies on the altitude of 515 m above the sea level, and the daily temperature is about 22 – 31°C, in Inceptisol soil by C-organic content 1.43%.

2.2. Materials of the Research

Materials of the research included sweet corn seeds of *bisi sweet boy,* cow's compost, *Tithonia diversifolia*, EM-4 (*Effective Microorganism*-4).

2.3. Design of the Research

The research used Split Plots Design as the main plot by 4 (four) types of organic fertilizer (P) that included : P_1= Cow's compost; P_2= *Tithonia diversifolia;* P_3= Cow's compost + (EM-4); P_4= *Tithonia diversifolia* + (EM-4), and the son plot (SP) was timing (T) of the application that comprised of 4 (four) levels : T_1= 0 week (during the planting time); T_2= 1 week before planting; T_3= 2 weeks before planting; T_4= 3 weeks before planting, which included 16 treatments as combination of 4 treatments of organic fertilizer types and 4 treatments of application timing by 3 replications.

2.4. Stages of the Research

Soil cultivation must be done two weeks pre-application treatment. Then make plots, 2.8 m x 3.5 m, 30 cm height,

inter-plots space of 50 cm and inter-block space of 100 cm. Application of the organic fertilizers must be conformed to the treatment. Treatment using cow's compost and *Tithonia diversifolia* that was mixed with EM-4 before applied. Dosage of each organic fertilizer is based on recommendation of N ha^{-1} urea fertilizer for the sweet corn of *bisi sweet boy* and N content in the soil, therefore dosage for cow's compost fertilizer is 24 ton ha^{-1} and *Tithonia diversifolia* 6.16 ton ha^{-1}.

In order to find out the effect of treatment, an observation has been done on components of the crop's growth: leaf area (cm^2), dry weight of the crop (g $plant^{-1}$), leaf area index (LAI), crop growth rate (CGR), chlorophyll of the leaf, that has been observed once in 10 days starting from 14 days after planting to 44 days after planting, as well as the yield component of the crop: fresh weight of the ear with and without husk per plant (kg), diameter of ear (mm), length of ear without husk (cm), being observed during harvest time.

3. Results

3.1. Leaf Area of the Crop

Result of the analysis of variance on leaf area showed that it had no significant influence on treatment application of the organic fertilizer types and the organic fertilizer application.

Table 1: Mean of leaf area (cm^2) along with type and timing of organic fertilizer application

Treatment	14	24	34	44
Cow's compost	55,14	341,44	2.433,97	4.656,17
T. diversifolia	51,18	327,61	1.872,67	4.611,64
Cow's compost + EM-4	56,79	421,36	2.452,80	4.529,99
T. diversifolia + EM-4	55,97	346,04	2.154,14	4.660,54
SSD 5%	insig	insig	insig	insig
0 week at planting time	59,86	372,29	2249,05	4979,89
1 week before planting	52,33	372,68	2052,63	4313,50
2 weeks before planting	48,56	318,62	2277,09	4827,34
3 weeks before planting	58,32	372,85	2334,82	4337,61
SSD 5%	insig	insig	insig	insig
Notes :	insig = insignificant; dap = days after			

3.2. Dry Weight of the Crop

Result for the scrunity of variance showed that organic fertilizer types had significant influence on dry weight of the sweet corn at 34 days after planting.

Table 2: Mean of dry weight of the plant (g $plant^{-1}$) and types of organic fertilizer

Types of Fertilizer	Dry weight of plant at the age of observation (dap)			
	14	24	34	44
Cow's compost	0,59	3,45	24,16 b	57,77
T. diversifolia	0,54	3,60	16,69 a	55,78
Cow's compost + EM-4	0,56	4,09	25,77 b	55,69
T. diversifolia + EM-4	0,59	3,64	19,37 ab	57,81
SSD 5%	insig	insig	6,56	insig
Notes :	Numbers followed by the same letter in the same column have no significant difference on t =0,05; sig = significant; dap = days after planting			

Table 2 shows that treatment of cow's compost and cow's compost + EM-4 gave better yield than *Tithonia diversifolia* on dry weight of the sweet corn. Also, percentage of dry weight has increased 54.40% under the treatment of cow's compost + EM-4 and *Tithonia diversifolia*, as well as 44.76% by the application of cow's compost and *Tithonia diversifolia*.

3.3. Leaf Area Index (LAI)

Result of the scrunity of variance on leaf area index showed no significant influence on treatment for types of the organic fertilizer and timing of the organic fertilizer application.

Table 3: Mean of the leaf area index in accordance with types and timing of the organic fertilizer application

Treatment	Leaf Area Index at the age of observation (dap)			
	14	24	34	44
Cow's compost	0,039	0,244	1,739	3,326
T. diversifolia	0,037	0,234	1,338	3,294
Cow's compost + EM-4	0,041	0,301	1,752	3,236
T.diversifolia + EM-4	0,040	0,247	1,539	3,329
SSD 5%	insig	insig	insig	insig
0 week (planting time)	0,043	0,266	1,606	3,557
1 week before planting	0,037	0,266	1,466	3,081
2 weeks before planting	0,035	0,228	1,626	3,448
3 weeks before planting	0,042	0,266	1,668	3,098
SSD 5%	insig	insig	insig	insig
Notes :	insig = insignificant; dap = days after planting			

3.4. Crop Growth Rate (CGR)

Result of the scrunity of variance on crop growth rate showed significant influence on treatment of types of the organic fertilizer at the age of observation 24 - 34 daps.

Table 4: Mean of crop growth rate ($g.m^{-2}.day^{-1}$) by types of organic fertilizer

Types of Fertilizer	Crop growth rate at the age of observation (dap)		
	14 - 24	24 - 34	34 - 44
Cow's compost	2,04	14,79 b	24,01
T. diversifolia	2,18	9,35 a	27,92
Cow's compost + EM-4	2,52	14,09 b	21,38
T. diversifolia + EM-4	2,18	11,24 ab	27,45
SSD 5%	insig	4,43	insig
Notes :	Numbers followed by the same letter in the same column have no significant difference on t =0,05; sig = significant; dap = days after planting		

Table 4 shows that treatment using cow's compost and cow's compost + EM-4 gives better yield in comparison with *Tithonia diversifolia,* during the observation at 24 – 34 dap toward crop growth rate. Percentage of the crop growth rate has increased 58.18% under the treatment of cow's compost + EM-4 in comparison with *Tithonia diversifolia*, then 50.70% using cow's compost and *Tithonia diversifolia*.

3.5. Chlorophyll of the Leaf

Result of the scrunity of variance on leaf's chlorophyll showed that organic fertilizer has significant influence on leaf's chlorophyll of the sweet corn at the age of 24 dap.

Table 5: Mean of the leaf's chlorophyll (unit) by organic fertilizer

Types of Fertilizer	Number of leaf's chlorophyll at the age of observation (dap)			
	14	24	34	44
Cow's compost	31,17	38,71 a	47,84	47,94
T. diversifolia	28,58	36,86 a	47,27	48,54
Cow's compost + EM-4	31,53	41,23 b	49,02	49,13
T.diversifolia + EM-4	30,66	38,96 ab	47,93	48,54
SSD 5%	insig	2,48	insig	insig
Notes :	Numbers followed by the same letter in the same column have no significant difference on t =0,05; insig = insignificant; dap = days after planting			

Table 5 shows that cow's compost + EM-4 has better influence in comparison with treatment using cow's compost and *Tithonia diversifolia* on leaf's chlorophyll during observation at the age of 24 days after planting.

3.6. Fresh Weight of Ear With and Without Husk

Result of the scrunity of variance on fresh weight of ear with and without husk in sweet corn showed no significant influence of the organic fertilizer and timing of the organic fertilizer application.

Table 6: Mean of fresh weight of ear (kg plant^{-1}) with and without husk at the harvest time

Treatment	Fresh weight of ear at the harvest time	
	With husk	Without husk
Cow's compost	0,318	0,224
T.diversifolia)	0,313	0,220
Cow's compost + EM-4	0,312	0,226
T.diversifolia + EM-4	0,315	0,227
SSD 5%	insig	insig
0 week at planting time	0,312	0,222
1 week before planting	0,318	0,227
2 weeks before planting	0,312	0,222
3 weeks before planting	0,316	0,225
SSD 5%	insig	Insig
Notes :	insig = insignificant; dap = days after planting	

3.7. Diameter of Ear Without Husk

Result of the scrunity of variance showed significant influence in relation to treatment of organic fertilizer at the harvest time on diameter of ear without ear of the sweet corn.

Table 7: Mean for diameter of ear (mm) without husk at harvest time

Types of Fertilizer	*Timing of Application*							
	0 week (at planting time)		*1 week before planting*		*2 weeks before planting*		*3 weeks before planting*	
Cow's compost	39,98	B	39,69	B	38,38	A	38,96	AB
	ab		a		a		a	
T. diversifolia	39,14	A	39,79	AB	39,64	AB	40,52	B
	a		a		b		b	
Cow's compost + EM-4	39,45	A	39,77	AB	40,86	B	39,01	A
	ab		a		c		a	
T. diversifolia + EM-4	40,29	A	40,55	A	39,57	A	39,86	A
	a		a		b		ab	
SSD 5%	1,12							

Notes:

- Mean values followed by the same capital letters in the same rows or followed by the same small letters in the same column have no significant difference in t = 0,05.
- Mean values in the same row compare between the timing of application and the same type of fertilizer.
- Mean values in the same column compare between types of fertilizer and the same

Table 7 shows that under treatment of 0 week (at the planting time) and 1 week before planting by cow's compost have given better yields in comparison with timing of application of 2 weeks before planting. As well as under treatment of 3 weeks before planting by *Tithonia diversifolia*, it has given better yield in comparison with application of 0 week (at planting time). Then, during the application of 2 weeks before planting by cow's compost + EM-4, it has given better yield in comparison with 0 week (at planting time) and 3 weeks before planting. For all treatments, timing of application by *Tithonia diversifolia* + EM-4 has not given any yield on diameter of ear without husk at the harvest time. Then, for treatment using all types of organic fertilizer by timing of application 0 week (at the planting time) and 1 week before planting, has not shown any difference toward diameter of ear without husk at the harvest time. However, under treatment of cow's compost + EM-4 by timing of application 2 weeks before planting, has given the best yield in comparison with the cow's compost, *Tithonia diversifolia*, *Tithonia diversifolia* + EM4. As well as *Tithonia diversifolia* by the application of 3 weeks before planting, which has given better yield in comparison with treatment using cow's compost, cow's compost + EM4 .

3.8. Length of Ear Without Husk

Result of the scrunity of variance showed that ear's length of the sweet corn has no significant influence on treatment of various types of organic fertilizer and different timing of application.

Table 8: Mean of ear's length without husk (cm) at the harvest time

Treatment	Ear's length of the sweet corn at the harvest time
Cow's compost	18,21
T.diversifolia	18,13
Cow's compost + EM-4	18,00
T.diversifolia + EM-4	18,11
SSD 5%	insig
0 week at planting time	18,10
1 week before planting	18,09
2 weeks before planting	18,14
3 weeks before planting	18,14
SSD 5%	tn
Notes :	insig = insignificant; dap = days after planting

4. Discussion

Growth is defined as a process of life in plant that causes change in size and determines the yield. The increasing size of the plan as a whole is a result of the increasing size of the plant's parts due to the development of cell tissues [10], [11]. The increasing organic material is not only important as nutrient, but also as agent to increase nutrient value, which is given to the plant [12].

The application of organic fertilizer will be able to provide macronutrient (N, P, K) and micronutrient for the plant. The content of nitrogen (N) in organic fertilizer is an essential component that includes amino acid, nucleic acid, nucleotide, and chlorophyll. Nitrogen increases the protein level in plant, improve quality of the plant that produces leaves, increase the development of microorganism in the soil, and protein formation [13].

Besides N, macronutrient of K plays its role in photosynthesis because it gets involved in ATP synthesis, production in photosynthetic enzymes activities (such as RuBP carboxylase), CO_2 absorption, through stomata and keeps the electrical balance during photophosphorylation within the chloroplast, transporting the photosynthetic yields (assimilate) from leaf to phloem through reproductive organ tissues and storage (fruit, seed, tuber, and etc.). K plays in protein synthesis in order to push nitrate conversion into protein, which will increase efficiency of N fertilizing. P plays an essential role and function in the process of growth and development of the plant. P is the essential part in photosynthetic process and carbohydrate metabolism process as regulator in distributing the photosynthetic yields between the sources and reproductive organs, cell nucleus formation and the transferring of hereditary traits. Phosphate compounds, which are rich of energy, adenosine triphosphate (ATP) and adenosine diphosphate (ADP), get involved in various biosynthetic reactions within plant, such as photosynthesis, protein synthesis, and almost in all aspects of growth and metabolism within the plant starting from initial growth to floral formation and seed, as well as the maturity [14].

Salisbury & Ross [15] suggested that leaf, which is related to the amount of chlorophyll, is a factor that determines the amount of sunray's energy accepted by leaf and the amount of the resulted photosynthate. The photosynthate highly determines yield of the seeds due to a part of the photosynthates are accumulated in the seeds and during the seed's filling, the increasing accumulated dry matter and lack of nutrient in this period will cause the seeds could not completely develop. Organic fertilizer contains complete nutrients and other organic compounds required by the plants, such as humic acid, fulphate acid, and other organic compounds. Humic acid and fulphate acid play their roles as hormone that could stimulate growth of the plant. Nugroho *et al*., [16]; Arianto [17] suggested that the increasing weight of ear along with the increasing efficient photosynthetic process as well as photosynthate translocation rate to the ear part. Photosynthesis rate and high biomass product (dry weight of the crop) due to adequate availability of N, P, K will accelerate the change of hexose sugar, which has polymerization into starch (flour) and the structural component, such as cellulose, hemycellulose can be changed into polysaccharide (as food reserves) or the formed sucrose that enters the cell respiratory system and then exposed to produce energy for development and enlargement of ears as well as seed filling. Result of the research by Yuwono [18] showed that the application of organic fertilizer *T. diversifolia* resulted better growth and higher yield in comparison with the application of anorganic fertilizer by the same dosage of application 80 kg N ha^{-1}, the yield of sweet potato was 22.12 ton ha^{-1} and fertilizing by *T. diversifolia* produced 29.39 ton ha^{-1}. Also, research by Khadijah [8] suggested that treatment using diverse green manure *T.diversifolia* and *C.odorata* have affected on numbers of leaf, branches, and dry weight of legumes.

The increasing production of crops can be done by improving nutrient synchronization, using and providing the nutrients just in time and in a proper amount. Quality of organic material toward decomposition could increase synchronization and efficient use of the nutrients. Availability of nutrients and the requirements (*matching)* in accordance with time will lead to nutrient deficiency, if the availability of nutrients do not match, which implicate to growth and the crop. High qualified organic materials as well as quicker in providing the required nutrients will affect faster to the growth, but loss of nutrients might occur through washing as well. Slower decomposed organic material will result to slower in providing nutrients and, of course, it will less affect the crops immediately but gives higher residues. Handayanto and Ariesusilaningsih [19] suggested that if the nutrient availability does not "match", both deficiency and excessive nutrients will occur. No synchronization occurs due to: a) if the availability is slower than the required ones, and b) if the availability occurs earlier than what the crop needs, in which the available nutrients beyond the required by the plant at that time are susceptible to loss or conversed into unavailable forms. Such synchronization can be fixed by a) regulating what the the plants need for nutrients, by setting the planting time and crop selection, b) regulating the nutrient release pattern from organic material input through observation of timing and application, or c) changing the quality of organic materials. The synchronization levels are determined by decomposition rate (weathering) and mineralization (releasing nutrients) of organic materials. Research by Yuwono [18] showed that biomass from *T. diversifolia* has quickly decomposed after being applied into the soil and considered as effective source of N, P and K. The peak of mineralization *T. diversifolia* occurs at 4 (four) weeks post-treatment. As research by Nugroho [20] showed the fact that the application of green manure *Tithonia diversifolia* 10 ton ha^{-1}, which was given 2 weeks before transferred on lettuce crop, will be able to increase growth and get higher yield as a result of better synchronization.

5. Conclusion

1. The use of different types of organic fertilizer requires different timing of application as well, and has different influence on growth and yield of the sweet corn.
2. Implication of the study are reduce the impact of the use of inorganic fertilizers and the use of local biomass resources as a source of organic material for the plant in order to improve plant nutrient and environmental

References

[1] H. Budiman. Organic Corn Farming. (The most wanted new variety). Pustaka Baru Putra Yogyakarta. 2012
[2] Research and Development Center on Soil and Agroclimate. Map of Potential Land for Corn Development in Indonesia. Bogor: Puslittan Bogor. 2005
[3] E.Y. Nasution, Nasrez A., Warnita. The Influence of Manure Types and Planting Space on Growth and Yield

of the Sweet Corn (*Zea mays saccharata* Sturt.) . Jerami, IV (2). pp. 109-118, 2011.
[4] K. Hairiah, Widianto, Utami S.R., Suprayogo D., Sunaryo, Sitompul S.M., Lusiana B., Mulia R., Noordwijk M. V. and Cadisch G. Management of Acid Soil Biologically. Reflection of Experience from North Lampung. ICRAF SEA. SMT Grafika Desa Putera, Jakarta. 2000.
[5] E. Handayanto. Managing the Soil Fertility Biologically for Continuous Agricultural System. Habitat, X (104), pp. 1-7, 1998
[6] L. Agustina 2011. Green Technology in Organic Agriculture to Continuous Agriculture. University of Brawijaya Press. 2011
[7] A. A. A. S. Trisnadewi, T. G. O. Susila and I W. Wijana. 2012. The Influence of Type and Dosage of Manure on Growth and Production of the Sweet Corn (*Zea mays* L. *saccharata*). Pastura Journal, I (2), pp: 52 – 55, 2012.
[8] Khadijah. The Influence of Types and Dosage of Green Manure on Growth and Yield of Legume (*Vigna sesquipedalis* L. Fruwirth). Thesis. Postgraduate Program on Faculty of Agriculture. University of Brawijaya. Malang. 2007
[9] Tini. Root Fertilizer. Published by Swadaya. Jakarta. 2002
[10] M.L. Srivastava. Plant Growth and Development: Hormones and Environment. Academic Press. California. USA. 2002.
[11] S.M. Sitompul and Guritno B. Analysis on Plant Growth. Gadjah Mada University Press. Yogyakarta. 1995
[12] R. Sutanto. Organic Agriculture. Leading to Continuous and Alternative Agriculture. Kanisius. Yogyakarta. 2002
[13] H.S. Hardjowigeno. Soil Science. Akademika Presindo. Jakarta. 2003
[14] J.L. Havlin, Beaton J. D., Nelson S.L., Nelson W.L. Soil Fertility and Fertilizers. An Introduction To Nutrient Management. New Jesey. Pearson Prentice Hall. 2005
[15] F.B. Salisbury, F. B. and C. W. Ross. Plant Physiology; 4th edition, Wadsworth Publishing Co., A division of Wadsworth, Inc. 1992
[16] A. Nugroho, N. Basuki and M. A. Nasution. 1999. The Influence of Manure and Kalium Application on Quality of the Sweet Corn in Dry Soil. Habitat, X (5), pp.33-38, 1999.
[17] S.E. Arianto. Improving the Quality of Cow's Fertilizer and Its Application on Sweet Corn (*Zea mays saccharata Sturt*). Journal on Science and Technology, IV (2), pp.164-176, 2011.
[18] M. Yuwono. 2003. Growth and Yield of Sweet Potato (*Ipomea batatas* L) in Different Types and Dosage of Organic Fertilizer on Anorganic Fertilizers. Postgraduate Program of Brawijaya University.. 2003.
[19] E. Handayanto and E. Ariesusilaningsih. Local Floral Biomass as Organic Material for Healthy Agriculture in Dry Soil. Habitat, XV (3), pp. 11-149, 2004.
[20] Y.A. Nugroho and E.M.N. Ningsih. Dynamic Model as Attainment Effort of Nitrogen Synchronization at Lettuce Cultivation with Green Manure Paitan. Soil Trop Journal, XIV (2), pp. 127-134, 2009

Author Profile

Yulian Abdullah received a degree in agriculture in 1997 from the Faculty of Agricultural Sam Ratulangi University and a master's degree from the Faculty of Agriculture Brawijaya University in 2014. Since 2006 he is lecturer at the State Agricultural Polytechnic in East Nusa Tenggara. Kupang, Indonesia.

Dr. **Setyono Yudo Tyasmoro**, lecturer at Brawijaya University, Department of Agronomy, Faculty of Agriculture since 1986 interest in sustainable development of organic farming

Dr. Titin Sumarni, lecturer at Brawijaya University, Department of Agronomy, Faculty of Agriculture since 1987 interest in the development of organic farming