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Mud cake composting by *Trichoderma viride* APT01 to improve growth and productivity of apple

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Abstract

Market's demand of apple from Batu is increase, but productivity of apple plants is decrease over time. In others hand, farmers always use inorganic fertilizers to soil and countinously plant it to reach target of the productivity. This activity will cause deficiency of organic matterials until < 1%, whereas ideal organic materials in soil is > 3%. So, this research was conducted to know more information about effect of mud cake composting (APT01 compost) on productivity (quality and quantity) of apple plants in apple farm area, Gabes, Tulungrejo Village, Bumiaji Sub-District, Batu. APT01 and Bokashi compost (positive control) as much as 10 and 20 kg per tree was added to 4,0 - 4,5 years old apple plants the day after defoliation. After 3 (SR3) and 4 (SR4) months defoliation and harvest time (SPN) receive such treatments, the production of fruit (number and weight) were calculated. Furthermore, the data was processed by analysis of variance (ANOVA). The results showed that 20 kg APT01 compost addition gave the best result to improve quality and quantity productivity of apple plants than Bokashi compost in SPN. The 20 kg APT01 compost addition supressed the fruit loss until 13.85% and improve fruit weight until 49.11%.

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Introduction

Apple farm area in Batu is increasingly narrow over time which causes less productivity of apple plants. It is supported by data from Agriculture Department of Batu whom shows that apple farm area is 600 ha in 2009 which is planted by only 2,506,546 apple plants (Bintariadi, 2011). From those number, apple plants are only produced 24,625 ton per year or 10.8 ton per Ha. It means that every tree only produces 9.8 kg which can be an indicator of acceleration extinction of apple in Batu.

Increasing of apple production and productivity are the most important action to supply market's demand. Farmers always use inorganic fertilizers to soil and countinously plant it to reach target of the productivity. In other hand, this activity will cause deficiency of organic matterials until < 1%, whereas ideal organic materials in soil is > 3%. Based on result of soil analysis from Bumiaji-Batu, we know that organic matterial contents is about 0.79%. It shows that soil does not have ability to support growth of apple plants and to support agroecosystem.

Improving of soil fertility and organic matterials can be done much better by adding compost than by adding inorganic fertilizer. Source of organic matterials for compost production comes from agricultural crop residues, livestock waste, municipal waste, and industrial waste using agricultural materials. The addition of organic matter (manure) into soil to improve the quality of physical and chemical impact on improving soil porosity, pH, soil organic carbon and nitrogen as well as capable of maintaining soil fertility (Eche *et al.*, 2013). One type of industrial waste produced by sugar mills which has 30% organic material contents (mainly is polysaccharide in crystalin form such as cellulose) are mud cake. The percentage content of its organic materials adequate to improve soil fertility in apple farm area. Sugar production in Indonesia is increased by 122,000 ton per year and sugar production in 2007-2012 is about 2.2 million tons (Hairani *et al.*, 2013). There is continuous and increasing availability of mud cake as compost material.

Development of composting strategy at this time can not be separated from decomposition process by decomposers especially microoorganism whom will excelerate the decomposition process of mud cake and determine availability of organic matterials. Microorganisms require energy for the growth and protein synthesis whom are derived from carbon and nitrogen present in organic matterials (C/N ratio). Previous research find that *Trichoderma* sp. is potential for regulating the C/N ratio because it is producer of cellulose enzymes to degrade cellulose for being glucose (Budiono *et al.*, 2015a; Boediono *et al.*, 2015b).

Application of mud cake for apple plant should be conducted continously, because mud cake is well known as source of organic materials and continously available in large quantity. Our previous research shows that first application of mud cake composting by *Trichoderma viride* APT01 after defoliation can improve number of fruit (58.57- 67.14%) and weight of fruit per tree (74.51-135.91%) compared to controls (Budiono *et al.*, 2013). Those productivity can still need to increase. So, the second application of mud cake should be conducted to get more information about effect of mud cake composting continously on productivity (quality and quantity) of apple plants in apple farm area, Gabes, Tulungrejo Village, Bumiaji Sub-District, Batu.

Materials and methods

This research was conducted in 400 m^2 "Anna" apple farm area, Gabes, Tulungrejo Village, Bumiaji Sub-District, Batu and during January-Juni 2013. We used 4.5-5 years apple plant and distance between plants was 2-3 m. Design of research was full factorial design with triplicate whom has two factors, including type of treatments and compost volume. There were three treatments; without compost (negative control), 10 and 20 kg Bokashi compost addition (positive control), also10 and 20 kg filter cake filter compost APT01 addition (treatment). Compost was added to the same plants in first period (Budiono *et al.*, 2013) and was added one day after defoliation.

Composting Mud Cake

Mud cake from sugar cane mills and cow manure was air-dried. It would be mixed by using ratio 25 (filter cake):77 (cow manure) to get 10 kg compost. Those mixture was flushed by aquades whom contained conidia *Trichoderma viride* strain APT01. It had 107 conidia/mL and the flushed would be done up to 60% humidity. The mixture would be placed in plastic barrel and was incubated for a month at room temperature (Budiono *et al.*, 2013; Budiono *et al.*, 2015a; Boediono *et al.*, 2015b).

Observation Parameters

There was observation to generative growth, quantity (total) and weight of apple(s) per plant in two observation periods. The observation was done for six months after compost addition until harvesting. Observations made during fruit growth 3 and 4 months after giving compost (SR3 and SR4) and at harvest (SPN).

Data Analysis

Data from generative growth parameters were analyzed by using Analysis of Varian (ANOVA) (α = 5%). It was done to determine impact of compost to apple plants growth.

Results

Age of the plants in this research was ranged from 4.5 to 5.0 year, it means that the plant in second period is 6 months older than in first period (Budiono *et al.*, 2013). In second period, we added 10 and 20 kg composts per plant one day after defoliation period. The observations of quantitative parameters are presented in Table 1.

Table 1. Number and weight of apple from all treatment.

		Parameter					
		Number of fruit (fruits)			Weight of fruit (kg)		
Type of compost	Weight of compost (kg)	SR3	SR4	SPN	SR3	SR4	SPN
Without compost	0	45	38	35	1.05	1.35	2.39
APT01 Compost	10	56	50	46	1.25	2.22	3.97
APT01 Compost	20	59	55	51	1.43	2.81	4.91
Bokashi Compost	10	59	51	47	1.17	2.17	3.81
Bokashi Compost	20	59	52	46	1.36	2.60	4.76

Note : SR3 = 3 months after defoliation; SR4 = 4 months after defoliation and SPN = when harvest period.

This table show that there is an increase of total apple in plant which were fostered by composts. Initially, total of apples before compost addition was 45 and it increased significantly to 46-51 after compost addition (ρ <0.05). Increasing number of apple had an impact on fruit production tonnage. The average initial production (without compost) per plant was 1.05 kg, then it also increased significantly to 3.81 - 4.91 kg after compost addition (ρ <0.05). The addition of APT01 compost as much as 20 kg was significantly able to further increase number and weight of apple (51 fruits and 4.91 kg) than others compost addition (ρ <0.05). In the second period, we knew that number and weight of apple in 10 kg APT01 compost addition was similar with Bokashi compost addition (ρ >0.05), but different amount of compost gave different result to number and weight of apples (ρ <0.05).

Fruit loss and weight of fruit percentage are showed by Figure 1. The fruit loss percentage in this research for without compost treatment was 22.22%, but this percentage could be minimized significantly by 10 and 20 kg APT01 compost addition to be 17.55 and 13.85% (ρ <0.05). Bokashi addition as much as 10 and 20 kg only decreased fruit loss about 20.33 and 23.03%. Either APT01 compost or Bokashi addition increased significantly weight of apple, but percentage of fruit weight from 20 kg APT01 compost addition was highest among others (49.11%). It means that APT01 compost give better result than Bokashi compost. Bokashi and APT01 had different effect to

productivity of apple plants. The greater APT01 addition caused the greater productivity, but the greater Bokashi addition caused the lower productivity.

Discussions

Addition of compost in this research increased number and weight of apple which was compared with SR3. Compost addition to productive age apple plant gave positive result to increase weight of fruit and to bear out tissue especially fruit tissue. Periodic addition of compost also gave periodic increase in weight of fruit(s). An increase percentage of fruit number during SR3, SR4 and SPN showed a tissue strength on generative phase of fruit stalk. This was evidenced by lower percentage of fruit loss during SPN than SR3 and SR4. Previous research also shows that addition of compost in first period increases productivity of apple (number and weight of fruit) (Boediono *et al.*, 2013). Increase in fruit production due to the addition of compost is also investigated by Adebayo *et al.* (2013) which states that addition of compost, as much as 10 tonnes per ha, on Okra plants are able to raise number and weight of fruit production significantly. Kasiran also reports that addition of organic matter, as much as 5.0 and 10.0 tonnes per ha can improve soybean production from 28.9% to 33.1% and from 38.6 % to 54.9% (Kasiran, 2008).

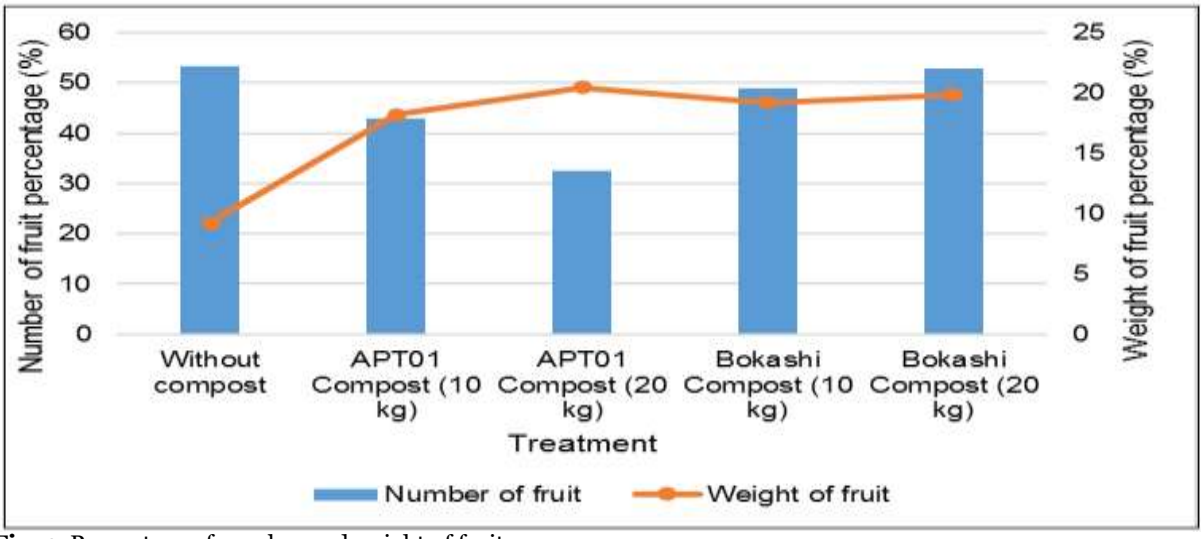

Fig. 1. Percentage of number and weight of fruit.

Increase productivity growth in quantity and quality is strongly influenced by availability of nutrients in environment. In this study, availability of nutrients in APT01 compost more adequate than Bokashi to support strength of plants tissue and fruit development. Another research shows that significant increase of nutrients (such as nitrogen (N), potassium (K) and phosphorus (P)) and number of microorganisms in the soil causes accelerating growth and roots strength of plants (Liu *et al.*, 2013). Mud cake, main material of APT01 compost, has potential to improve soil physical properties, in particular increase water holding capacity and decrease rate of leaching (Afshar *et al.*, 2014). Bougnom *et al.* (2010) states that compost, contains a lot of cellulose such as mud cake, is useful as aggregate structure forming of soil that can improve efficiency of water in the soil, nutrient content (phosphor (P) and potasium (K)) and level of soil fertility. Those facts cause that APT01 compost is better to be applied to apple farm than Bokashi.

Nutrients contained in APT01 compost have different effects on plants. Nitrogen (N) plays a key role in vegetative growth of plants. P plays an important role in synthesis of enzymes, proteins, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA), as well as contribute to growth and development of

flowers and fruit. Research conducted by Devi *et al.* (2012) report that P is important for ATP formation and many other phosphorylated compounds. P is important to increase photosynthetic activity, root growth and crop production. In addition, the availability of sufficient P will significantly affect on number of flowers (Idowu *et al.*, 2013). K acts as a regulator of plant physiological processes such as photosynthesis, carbohydrate transport and regulating water distribution into tissues and cells. Addition of K in plant not only increase number and diameter of fruit but also strengthen and enlarge plant tissue. K in cell tissue can increase formation and translocation of carbohydrates to stem of plant. The formation and translocation causes stem growth bigger and stronger (Colpan *et al.*, 2013). Chemical analysis to mud cake by Cifuentes *et al.* (2013) show that levels of inorganic elements are 1.83% N, 3.69% P, 0.76% K, 7.80% Ca. While other researchers find that organic waste, mud cake, contains various macro and micro nutrients such as 0.11% N, 50.86% Ca and 0.01% K whom are needed for plant growth (Afshar *et al.*, 2014). The greater amount of APT01 compost addition, the greatest availability amount of K, Ca and P. Giving APT01 compost into soil can not all be absorbed directly by roots. This is evidenced by the growing strength of fruit stalk during 4 months that is stronger than 3 months. Strengthening the fruit stalk as the impact of the elements K and Ca absorption by plants. P and Ca, positive ions, tend to be bound by negatively charged organic compounds to form bioavailability compounds for plants. These elements play a role in strengthening the tissue of plants such as flowers and fruit, so it does not easily fall out (Boediono *et al.*, 2013). Therefore, at second period the value of fruit loss in compost addition treatment is lower than without compost addition.

Amount of nutrients in the fertilizer is not only influenced by basic material of fertilizer, but also by presence of biocatalysts and other microorganisms. The results of chemical analysis show that addition of biocatalysts to compost can significantly increase the content of N, P and K ($p < 0.05$) (Jusoh *et al.*, 2013). Biocatalyst is produced by microorganisms in the form of protein or enzyme which can accelerate breakdown of organic materials. *T. viride* produce cellulase enzymes which will accelerate or catalyze the breakdown of cellulose in mud cake into glucose as a source of nutrients for apple plants (Li *et al*, 2010; Boediono *et al.*, 2015a; Boediono *et al.*, 2015b). Microorganism community structure in fertilizer is different than in soil that is caused by differences in nutrient availability. The existence of antagonistic microorganisms in compost is also able to suppress growth of pathogenic soil microorganisms (Fediala *et al.*, 2015).

This research is further research from Budiono *et al.* (2013) as second addition or second treatment of compost. The addition of fertilizer in soil can improve the availability of nutrients in soil and the physical properties of biological soil. In the second addition of compost, physical and biological properties of soil are predicted in good condition as a result of the compost addition in first period. Treatment in second period not only can improve physical, cheical and biological properties of soil but also productivity of apple plants (quality and quantity). It means that sustainable addition of compost will increase the production of fruit and physical, biological and chemical properties of soil.

Production of 5 years old apple plants in this research can produce 9-12 tons fruits per ha. Previous production in first period shows that 4.5 years old apple plants can produce 6-8 tons fruit per ha (Budiono *et al.*, 2013). The greater amount of compost addition, the greatest productivity of apple plants. From those results can be concluded that twice addition of 20 kg APT01 compost can increase fruit production from 6-8 tons to 9-12 tons per hectare.

Conclusion

The results showed that 20 kg APT01 compost addition gave the best result to improve quality and quantity productivity of apple plants than Bokashi compost in harvest period (SPN). The 20 kg APT01 compost addition supressed the fruit loss until

13.85% and improve fruit weight until 49.11% whom were compared to its SR3.

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References

Bintariadi B. 2011. Musnahnya Maskot Kota Batu. http://www.beritalingkungan.com/ berita/2011-04/, Acessed February 19, 2012.

Eche NM, Iwuafor ENO, Amapui IY, Victoria Bruns MV. 2013. Effect of application of organic and mineral soil amendments in a continuous cropping system for 10 years on chemical and physical properties of an Alfisol in Northern Guinea Savanna zone. International Journal of Agricultural Policy and Research **1(4),** 116-123.

Hairani RI, Aji JMM, Januar J. 2013. Analisis trend produksi dan impor gula serta faktor-faktor yang mempengaruhi impor gula Indonesia. Berkala Ilmiah Pertanian **1(4)**, 77-85.

Budiono A, Suharjono, Santoso I, Soemarno. 2015. Composting mud cake by *Trichoderma viride* Apt01. International Journal of Agricultural and Environmental **1(5)**, 26-29.

Budiono A, Suharjono, Santoso I, Soemarno. 2015. Effect of isolate of *Trichoderma* sp. and incubation period to glucose production. International Journal of Engineering Science **5(8)**, 21-25.

Budiono A, Suharjono, Santoso I, Soemarno. 2013. Application compost of mud cake by *Trichoderma viride* APT01 to apples to increase production in Bumiaji Batu. International Journal of Engineering Science **3(2),** 17-20.

Adebayo AG, Shokalu AO, Akintoye HA. 2013. Effect of compost mixes on vegetative development and fruit yield of okra (*Abelmoscus esculentus*). IOSR Journal of Agriculture and Veterinary Science **3(1)**, 42-48.

Kasiran. 2008. Konservasi lahan melalui penerapan teknologi budidaya lorong alley cropping di daerah transmigrasi Kuro Tidur, Bengkulu. Jurnal Teknologi Lingkungan **9(2)**, 205-210.

Liu CH, Liu Y, Fan C, Kuang SZ. 2013. The effects of composted pineapple residue return on soil properties and the growth and yield of pineapple. Journal of Soil Science and Plant Nutrition **13(4)**, 433-444.

Afshar PG, Honarvar M, Gharachorloo M, Eshratabadi P, Bazyar B. 2014. Investigation of the physico-chemical properties of press mud: a sugar industry. Advances in Environmental Biology **8(13)**, 1053 –1058.

Bougnom BP, Knapp BA, Elhottová D, Koubová A, Etoa FX, Insam H. 2010. Designer compost with biomass ashes for ameliorating acid tropical soils, effects on the soil microbiota. Applied Soil Ecology **45(3),** 319-324. http://dx.doi.org/10.1016/j.apsoil.2010.05.009

Devi TC, Bharathalakshmi M, Kumari M, Naidu NV. 2012. Effect of sources and levels of phosphorus with zinc on yield and quality of sugarcane. Sugar Tech **14(2),** 195–198. http://dx.doi.org/10.1007/s12355-012-0144-2.

Idowu GA, Oyewale RO, Yusuf ST, Isah AS, Bello LY. 2013. Effect of phosphorus application on growth, yield and yield components of snake tomato *Trichosanthes cucumerina* L. World Journal of Agricultural Sciences **1(3),** 088 – 093.

Colpan E, Zengin M, Ozbahce A. 2013. The effects of potassium on the yield and fruit quality components of stick tomato. Horticulture, Environment, and Biotechnology **54(1),** 20 -28. http://dx.doi.org/10.1007/s13580-013-0080-4

Cifuentes R, Leo'n RD, Porres C, Rolz C. 2013. Windrow composting of waste sugar cane and press mud mixtures. International Journal of Sugar Crops and Related Industries **15(4)**, 406-411. http://dx.doi.org/10.1007/s12355-013-0217-x

Jusoh MLC, Manaf LA, Latiff PA. 2013. Composting of rice straw with effective microorganisms EM and its influence on compost quality. Iranian Journal of Environmental Health Science & Engineering **10(1),** 1-9. http://dx.doi.org/10.1186/1735-2746-10-17.

Li H, Pei JB, Wang JK, Li SY, Gao GW. 2013. Organic carbon density and storage of the major black soil regions in Northeast China. Journal of Plant Nutrition and Soil Science **13(4),** 883-893.

Fediala W, Mosa AE, Paszt LS, Frac M. 2015. The role of biofertilization in improving apple productivity? a review. Advances in Microbiology **5(1),** 21-27. http://dx.doi.org/10.4236/aim.2015.51003