# SPINACH (*Amaranthus tricolor L.*) GROWTH USING ORGANIC FERTILIZER FROM *Trichoderma harzianum* DECOMPOSITION RESULT

**Azwir Anhar, Linda Advinda, Rival Mulyadi, Irdawati and Irma Leilani**

*Biology Department, Faculty of Mathematics and Natural Science, Universitas Negeri Padang*
*Jl. Prof. Dr. Hamka Air Tawar Barat, Padang, West Sumatera Indonesia*
*Email: azwiranhar@fmipa.unp.ac.id*

## ABSTRACT

Long term period of using fertilizers is not beneficial for soil fertility due to decreasing soil organic matter content. Otherwise, the source of organic matter widely available as waste in the environment are not used optimally because the naturally decomposition quite long time. This problem can be overcome by utilizing various types of microbes, such as Trichoderma. This research conducted to determine the effect of organic fertilizer from the decomposition result of *T. harzianum* in enhancing growth of spinach plant. This study used a completely randomized design (CRD) with 6 treatments and 4 replications. The treatments were doses variation of decomposition of organic material; 0 g, 15 g, 30 g, 45 g, 60 g and 75 g. Data were analyzed with ANOVA and continued with Duncan New Multiple Range Test (DNMRT). The results showed that the application doses of organic fertilizer from decomposition result influences height, number of leaves, leaf area, fresh weight and dry weight of spinach plants. Optimal dose for all growth is 45 grams/polybag.

Key words: spinach, organic, fertilizer, *Trichoderma harzianum*, decomposition

## INTRODUCTION

Spinach is favorite ones of vegetable leaves by consumer because it contains a variety of nutrients. Spinach not only contains carbohydrate, lipid and protein, but also minerals and vitamins. Carbohydrate, lipid and protein in 100 grams fresh spinach are 4.02, 0.33 and 2.46 gram respectively. Its minerals include Ca (215 mg), K (611 mg) and Mg (55 mg). It also has content of vitamin C, A and K 43.3 mg, 2917 IU and 1140 mg (USDA, 2016) respectively.

To fulfill the needs of plants nutrition, vegetable producers generally use synthetic inorganic fertilizers as nutrient sources. The use of inorganic fertilizers which contain high amounts of macronutrients, when used in the long time period is not beneficial for soil fertility. The residual of inorganic fertilizer affect the inhibition of organic matter decomposition by soil microbes (Suriadikarta and Simanungkalit, 2016). In addition, the use of inorganic fertilizers can also lead nutrients deficiency (Atmojo, 2003). Residues of synthetic fertilizers are one of the main factors that cause hardening of agricultural lands. This condition also resulted in decreased of soil porosity; plant oxygen availability; and soil microbes' quantity, the distribution of the roots disturbed thereby inhibiting the growth of plants (Suriadikarta and Simanungkalit, 20016).

To prevent the impact of synthetic fertilizer to fulfill the nutritional needs of the crop is by giving organic fertilizer. Organic fertilizer is the fertilizer that is largely or entirely composed of organic material derived from plants or animals that have been through the engineering process, in the form of solid or liquid that is used to supply organic matter to

improve the physical, chemical, and biological soil (Permentan, 2006).

Utilization of organic fertilizer as a source of plant nutrients has several advantages. The addition of organic matter will improve the ability to retain water, so the ability to provide ground water for plant growth increases. The addition of organic matter will improve soil infiltration as the result of rising soil macro pores and declining its micro pores. (Atmojo, 2003). Improvement of water infiltration capacity will reduce runoff, so that erosion is reduced. The other positive effect of the addition of organic matter is the effect to plant growth. On the ground, there is auxin compound as growth stimulant and vitamins that influence plant growth. Those compounds derived from plant exudates, manure, compost, crop residues and also from the results of microbial activity in the soil (Stevenson, 1982). Therefore, mineralization of organic material not only produce macronutrients N, P, K, Ca, Mg and S, but also contribute various micronutrients which are essential for plant growth.

Various organic wastes originating from agricultural cultivation environment or the rest of vegetables that come from market and households potential used as organic fertilizer because it contains various minerals needed by plants. Atmojo (2003) reported that the municipal solid waste as bokashi compost containing 1.68% N, 3.29% P, and 2.92% K. Handayani *et al* (2015), shows that the local microorganisms with the raw material cabbage before fermented contains 0.11% N, 245.03 ppm P, 147.17 ppm K, 153.46 ppm Ca, Mg 1387.16 ppm, Fe 5.41 ppm, Zn 0.92, Mn 3.02 ppm with a C/N ratio 176.18.

Organic raw materials have high C/N ratio. If it directly distribute into the ground will affect negatively toward the availability of soil nutrients. Those organic materials will directly utilized by microbes to obtain energy. Thus, microbes and plants compete each other for nutrients. As a result, the nutrients in the soil become unavailable to plants because it turns into microbial organic compound (Atmojo, 2003). Therefore, the organic material with a high C/N ratio takes long time for mineralization process.

The decomposition process can be accelerated by adding selected microorganisms. Sugito *et al.* (1995) stated that one of the microorganisms which have been developed to accelerate the decomposition is *Trichoderma sp*. Suryanti *et al.,* (2003) states that the biocontrol agent *Trichoderma sp* able to decompose lignin, cellulose and chitin from organic matter into nutrients that are readily absorbed by plants. *T. harzianum* could improve the growth and yield, because of its ability to degrade compounds that are difficult degraded such as lignocelluloses (Affandi, 2001). *Trichoderma* is very important in giving a signal of auxin and stimulate plant growth (Nurahmi, 2012).

The administration of organic matter as a decomposition result of *Trichoderma sp* able to accelerate the number of stems and plant growth (Bertham *et al*., 1996). Doni *et al* (2014) reported that the application of *Trichoderma* can improve rice seed germination and vigor. Application of *Trichoderma* also promote growth and development, plant productivity, resistance to abiotic stress factors, absorption and utilization of nutrients, increases the solubility of phosphate, increase the shoots biomass of *Avicennia marina* up to 33% (Saba *et al*., 2012; Saravanakumar *et al*., 2013). Utilization information of waste vegetables as the base material of organic fertilizer using *T.harzianum* as decomposers and their effect on growth of spinach is still limited.

## METHODS

This experimental study conducted from December 2015 to February 2016 in the Wire House and Plant Physiology Laboratory of Biology Department, Universitas Negeri Padang. The research design used a completely randomized design with 6 treatments and 4 replications. The treatments were organic fertilizer doses from decomposition of *Trichoderma harzianum* namely; 0 (control), 15, 30, 45, 60 and 75 grams.

*T.harzianum* isolates obtained from BPTPH Laboratory Padang, West Sumatera in the cooked rice medium. Furthermore, Amaranth seeds (*Amaranthus tricolor* L.) were obtained from the Institute for Seeds of West Sumatra. Organic material in the form of waste vegetable cabbage, collards and kangkong were taken from the central market in Padang city. Garden soil has been cleaned used as planting medium with 1kg weighed and put in the polybag 18 x 25 cm.

Organic fertilizer made by preparing waste of vegetable cabbage, collards, and kangkong 5 kg each other. Furthermore, the wastes is cut into pieces with approximately 2 cm size. Next, 15 kg of chicken manure added with 5 kg sawdust and 1.5 kg *T.harzianum.* All the material was mixed until homogeny. To maintain humidity water added. Every week bokashi is somersaulting to mature the compost which characteristic colored between dark brown and black (Kasli, 2008).

Polybag that contain the planting medium is mixed with organic fertilizer according to treatments. Furthermore, amaranth seed planted 3 seeds per polybag. Spacing was done at the age of 21 weeks by leaving healthy spinach and the remaining cut with scissors at ground level. Watering is done once a day in the late afternoon with water 200 ml per polybag. All weeds removed and disposed from the polybag. Observations did toward plant height by measuring from the base of the stem to the point of growing every week until fourth week. The number of leaves observed in the first and fourth week. Leaf area was measured using Leaf Area Meter and carried out during harvest time in the fourth week. Wet and dry weight plants were observed at harvest time. Planting medium pH was observed at the beginning and the end of the study. The data obtained were analyzed by analysis of variance followed by Duncan test (Steel and Torrie, 1991).

## RESULTS AND DISCUSSION

### Height of Spinach Plants

The results showed that plant height at one week is not affected by application or dose of organic fertilizer. In contrast, plant height at 3 weeks until the end of observation at the age of 4 weeks showed that application of neither organic fertilizer nor doses affects spinach plants. Although application and dose increased plant height, but doses exceeding 45 grams of organic fertilizer is precisely no able to increase plant height significantly. Even increasing doses exceeding 45 grams had lower plant height as show in Table 1.

Table 1. The influence of organic fertilizer from *Trichoderma harzianum* decomposition toward spinach plant average height

| Treatment | Average of plant height (cm) | | | |
|---|---|---|---|---|
| | I WAP | II WAP | III WAP | IV WAP |
| A (0 g) | 7,25 | 7,82[a] | 8,62[a] | 9,00[a] |
| B (15 g) | 7,25 | 7,77[a] | 10,25[b] | 15,75[b] |
| C (30 g) | 7,00 | 9,45[a] | 11,25[b] | 19,12[bc] |
| D (45 g) | 7,75 | 12,32[c] | 20,5[d] | 31,75[e] |
| E (60 g) | 7,25 | 7,65[a] | 10,62[b] | 21,75[d] |
| F (75 g) | 7,50 | 9,57[b] | 14,37[c] | 25,37[e] |

The number followed by the same letters in the same column not significant at 5% level according DNMRT test.

Based on Table 1 in the first week, plant height are the same in all treatments. It is thought to relate to the adaptation of plants to reviews their environment. As we know, early

growth of crops, crop nutrient needs are still fulfilled by existing food reserves in the seed plants. Although the roots and the leaves have started to grow but still in a small size, so it is not optimal yet to absorb and utilize the nutrients provided in the medium. In contrast, in the second week and so on plant height is higher than the control due to the growing root growth and increasing of nutrients supply that contributed by organic fertilizers, including nitrogen. The nitrogen content of cabbage reached 3.6% (Diaz *et al*., 2007), it is estimated to have contribution to the availability of nitrogen in the organic fertilizer treatment given

Nitrogen roles accelerate the growth of apical meristem so that the plant is higher than the control. Nugroho (2011) states that plant height is much more influenced by Nitrogen. Nitrogen element is the main component of many important substances in the plant. Nitrogen needed in relatively large quantities on plant growth, especially in the vegetative stage. Junialdi (2013) also states that the most responsible nutrient for increased plant height is Nitrogen. Jumin (2002) explains that the addition of Nitrogen serves to stimulate plant height. Lingga and Marsono (2001) stated nitrogen in sufficient numbers plays in accelerating the growth of the plant as a whole, especially stem and leaf. Nitrogen deficiency causes the plants become stunted (Sudarmi, 2003).

Increasing doses exceeding 45 grams did not add height of plants is estimated as nutrient for plant growth needs to be sufficient. Thus, the dose is already an optimal dose for spinach plants. Plants also have a certain limit in absorbing nutrients.

**Number of Leaves**

Organic fertilizer administration not only influences the number of leaves, but also the dose of application affect the number of leaves produced. These results concretely showed at the end of the fourth week observation. Lowest number of leaves found in control and different when compared with the treatments of organic fertilizer. Even the lowest dose of organic fertilizer (15 g) still higher leaves amount compared with the control. The dose of organic fertilizer up to 75 grams was still able to increase the number of leaves of the plant as shown in Table 2.

Table 2. Effect decomposition by *Trichoderma harzianum* toward the number of spinach leaves

| Treatment | Average number of spinach leaves | |
|---|---|---|
| | I<br>Week after planting | IV<br>Week after planting |
| A (0 g) | 4,00[a] | 6,25[a] |
| B (15 g) | 4,50[c] | 10,25[b] |
| C (30 g) | 4,75[d] | 9,50[b] |
| D (45 g) | 4,25[b] | 12,00[b] |
| E (60 g) | 4,00[a] | 16,00[c] |
| F (75 g) | 4,00[a] | 21,50[d] |

The number followed by the same letters in the same column not significant at 5% level according DNMRT test.

Leaf is an organ that is essential for the plant as a place for photosynthesis. The more leaves causes photosynthesis to be active. Nitrogen contained in organic fertilizers caused the leaves become larger and greener. In addition, the magnesium element contained in cabbage 55 mg (USDA, 2016) is a necessary macronutrients plant as an element to create chlorophyll (Lingga and Marsono, 2008). With the increasing availability of these elements would directly affect a number of leaves. Lakitan (1996) states that the plants which do not get additional nitrogen will grow stunted and leaves formed will be little, while plants get

enough nitrogen element the leaves are formed will be more.

**Total Area of Spinach Leaf**

Spinach plant leaf area was influenced by the administration of organic fertilizer from decomposition. In addition, the dose of organic fertilizer also can increase the area of the leaf. Nonetheless, application of doses exceeding 45 g was not able to increase the area of the leaves, but it resulted in leaf area reduced. Leaf area on the controls just 1.64 $cm^2$ increased to 20.27 $cm^2$ at a dose of 45 g, but its decline into 14.17 $cm^2$ by applying 60 g of organic fertilizers (Table 3).

Table 3. Effect of organic fertilizer from decomposition by *Trichoderma harzianum* toward average area of spinach leaves

| Treatment | Average of spinach leaves area ($cm^2$) |
|---|---|
| A (0 g) | 1,64[a] |
| B (15 g) | 6,36[b] |
| C (30 g) | 11,24[c] |
| D (45 g) | 20,27[e] |
| E (60 g) | 14,17[d] |
| F (75 g) | 9,03[c] |

The number followed by the same letters in the same column not significant at 5% level according DNMRT test.

The availability of nutrients for the growth of spinach leaves were already optimally up to 45 grams. One nutrient that plays an important role in the growth of leaves is Nitrogen. According to Zhang (1996), a plant that grows at high nutrient supply will produce more leaves than with low nutrient supply. One of the nutrients needed in large quantities is Nitrogen. The nutrient availability that reached 55 mg on the cabbage (USDA, 2016) coupled with *T.harzianum* role in increasing nutrient uptake and utilization (Saba *et al*., 2012) resulted in higher plant growth. Plants growing on a limited nitrogen supply resulted in the leaves become smaller compared with plants grown in the optimal nutrient supply. This condition affected by its influence on the size and number of meristem cells (Terry, 1970). Nitrogen plays role to increase vegetative growth, so the plant leaves becomes wider (Wahyudi, 2010). Application of liquid or solid organic fertilizer can stimulate the increase of leaf area (Ratna 2002).

**Plant Wet Weight**

Organic fertilizer as *T. harzianum* decomposition affects the wet weight of spinach plants. It can be known from the wet weight of control was the lowest ones and different compared to all doses. In addition, dose also affects the plant fresh weight. Increasing the dose of organic fertilizers up to 45 g increases wet weight linearly, but the increase next dose make the lower wet weight of spinach plants (Table 4).

Table 4. Effect of organic fertilizer from *Trichoderma harzianum* decomposition toward fresh plant weight

| Treatment | Average of fresh plant weight (gram) |
|---|---|
| A (0 g) | 1,50[a] |
| B (15 g) | 17,00[c] |
| C (30 g) | 26,25[d] |
| D (45 g) | 23,00[d] |
| E (60 g) | 15,25[bc] |
| F (75 g) | 12,50[b] |

Number followed by the same letter not significant according to DNMRT at 5% level.

Gardner *et al*. (2008), states that 80% of plant wet weight consists of water. Fresh weight of plants depends on the water content in plant tissue (Lakitan (2008). Furthermore, organic fertilizer can act as "binder" primary granules into secondary ground grains in the formation of stable aggregates. This situation highly influences the porosity, storage and water supply, soil aeration, and soil temperature (Simanungkalit *et al.*, 2006). Thus, water supply is higher when compared with control, so that affect the fresh weight of the plant. However, the adequacy of water supply is optimal at a dose of 45 g of organic fertilizer. Excess water is just not profitable for plant because it can reduce the supply of oxygen required for root respiration. Kirani (2011) states that the fresh weight of plants affected by the absorption of nutrients absorbed by plants fulfilled and will be utilized for the plant photosynthesis process that will ultimately affect the plant fresh weight. According to Nurshanti (2009), fresh weight of the plants is affected by the nitrogen content that widely available in the plant body. This causes the water in the stem, not evaporate and will cause these parts remain wet. Fresh weight of the plants affected by plant height; leaf number; the higher the plant, the more number of plants leaves, the fresh plants weight is higher (Prasetya, *et al*., 2009)

**Spinach plant dry weight**

The dry weight of plants as a result of plant photosynthesis was also influenced by the organic fertilizer from decomposition. In fact, the rate given also affect plant dry weight of spinach. The lowest dry weight was found in the control and the highest obtained at the dose of 45 g of organic fertilizer. Increasing the dose exceeds 45 g do not give a higher dry weight, but have resulted in plant dry weight is lower (Table 5).

Tabel 5. Effect of organic fertilizer from *Trichoderma harzianum* decomposition toward spinach plant dry weight

| Treatment | Average of plant dry weight (gram) |
|---|---|
| A (0 g) | 0,15[a] |
| B (15 g) | 1,85[c] |
| C (30 g) | 2,60[e] |
| D (45 g) | 1,87[d] |
| E (60 g) | 1,70[bc] |
| F (75 g) | 1,37[b] |

Number followed by the same letter not significant according to DNMRT at 5% level.

According to Mungara *et al.* (2013), plant dry weight increasing demonstrated by an increase of plant growth and development. Increasing of dry weight is an indicator of plant growth and development. The dry weight of the plant is also associated with the leaf surface area. Plants that have broader leaves at the beginning of the growth will be faster growth because of the ability to produce higher photosynthetic. The greater photosynthetic allow to form plant organs larger, and then produce of drying matter increases.

Ratna (2002), states that the provision of neither liquid nor solid organic fertilizer can stimulate the increase of leaf area. Increased leaf means the ability to receive and absorb sunlight, therefore photosynthetic and the energy produced is also higher. According to Fisher and Goldsworthy (1985), the addition of the leaf area is an efficiency of each unit leaf

area to do photosynthesis to increase plant dry weight.

## CONCLUSION

Organic fertilizer from *T. harzianum* decomposition affects the height growth of spinach plants. Fertilizer given dose also affects plant growth. Optimal dose for all growth components in terms of height, number of leaves, leaf area, fresh weight and dry weight of spinach plants is 45 grams/polybag. Increasing the dose exceeds it resulted in lower plant growth.

## REFERENCES

Affandi M, Ni'matuzahroh and A Supriyanto. 2001. Diversity and Visualization Character Fungi Associated with Degradation Process Litter in Mangrove Environmental. *Medika Ekstra.* 2 (1) : 39-52

Atmojo SW. 2003. Role of Organic Matter and Soil Fertility Efforts Against Their Management. *Inauguration Speech of Professor in Sciences Soil Fertility.* Universitas Sebelas Maret. Surakarta

BethamYH ,H Bustaman AD, Nusantara E, Inoriah dan Riwandi. 1996. The ability Gliocladium, Trichoderma in Mereput Paceilomyces and Upland Rice Straw. *OPF Project Report.* Bengkulu: Universitas Bengkulu.

Doni F, I Anizan, CMZ. Che Radziah, AH Salman, MH Rodzihan and WMW Yusoff. 2014. Enhancement of Rice Seed Germination and Vigour by *Trichoderma spp*. Res. *J. App. Sci. Eng. Technol*., 7(21): 4547-4552

Diaz LF, M de Bertoldi and W Bidlingmaier. 2007. *Compost Science and Technology*. Elsevier. Tokyo.

Fisher NM. dan Goldsworthy. 1985. *Cultivation Crop Physiologi of Tropical*. Gajah Mada University Press. Yogyakarta

Gardner FP, RB Pearce dan RL Mitchell. 2008. *Physiology of Cultivation crop.* (Terjemahan: Susilo). Universitas Indonesia Press. Jakarta

Handayani SH, A Yunus dan A Susilowati. 2015. Liquid Organic Fertilizer Quality Testing of Various Local Microorganisms (Mol). *EL-VIVO* Vol.3, No.1:54–60. http:// jurnal.pasca.uns.ac.id.

Jalil AAK. 2004. *Microbial Enzyme and Material Selloluse Decomposision. Enzim Mikroba dan Bahan Penguraian Berselulosa.* Biology Department. Jakarta

Jumin HB. 2002. *Basic of Agronomy.* Rajawali. Jakarta

Junialdi R. 2013. Effect of Bokashi (*Ageratum conyzoides* L.) on Growth and quality of tomatoe nutrient (*Lycopersicum esculentum* Mill.). *Thesis.* Universitas Negeri Padang. Padang

Kasli. 2008. Fertilizer Biological Results Decomposers Some Organic Waste with Their Decomposer. *Jerami* vol 1 No. 3.

Lakitan B. 1996. Growth Physiology and Plants Development. PT Raja Grafindo Persada. Jakarta

Lingga P dan Marsono. 2001. Guidence of Fertilizer use. Penebar Swadaya. Jakarta

Mungara E, Indradewa D, dan Rogomulyo R. 2013. Growth analysis and rice yield (Oryza sativa) in Conventional Farm system, Organic transision and Organic. *Vegetalika* Vol.2 No.3. p. 18-20

Nugroho DS. 2011. Study of organic fertilizer water hyacinth on Growth and Yield of white Amaranth and red amaranth. *Thesis.* Universitas Sebelas Maret. Surakarta

Nurahmi E, Susanna dan R Sriwati. 2012. Effect of Trichoderma on Seed Germination and Growth of Cocoa, tomatoes, and soybeans. *Floratek* 7 (1) : 57 – 65

Steel RGD & Torrie JH. 1991.*Principles and Procedures of Statistics: An Approach Biometrics* (Translate by: Bambang Sumantri). Jakarta: PT. Gramedia

Stevenson FT. 1982. *Humus Chemistry.* John Wiley and Sons, New York

Sudarmi. 2003.Importance of Micro Nutrient For Crop Growth. Widyatama.Vol. 22.No. 22:178-183

Permentan. 2006. no.2/Pert/HK.060/2/2006 about Organic Fertilizer and Soil restoration

Prasetya B, S Kurniawan, dan M Febrianingsih. 2009. Effect of Dose and Frequency of Fertilizer Against N Uptake and Sawi Growth (Brassica juncea.L.) Pada Entisol. *AGRITEK* VOL. 17 NO. 5

Ratna DI. 2002. Effect of Biological Fertilizer Concentration Combination with Organic Liquid Fertilizer on the Quality and Quantity of Crop Tea (Camellia sinensis.L.) gambung clone 4. *Ilmu Pertanian.*10 (2): 17-25

Saba H, Vibhash D, Manisha M, Prashant KS, Farham H. & Tauseff A. 2012. Trichoderma A Promising Plant Growth Stimulator and Biocontrol Agent. *Mycosphere* 3(4):524-531. http://www.mycosphere.org/pdf/ MC3_4 _No14. Pdf

Saravanakumar K, Shanmuga AV & Kathiresan K. 2013. Effect of Trichoderma on soil phosphate solubilization and growth improvement of Avicennia marina. Aquatic Botany 104: 101-105

Sugito Y, Nuraini Y dan Nihayati E. 1995. Organic Farming System. Faperta Unibraw. Malang

Suriadikarta DA. dan Simangkulangit RDM. 2006. Organic fertilizer and Bio fertilizer (Ed.Simanungkalit dkk). Center for Agricultural Land Resources. Agency for Agricultural Research and Development

Suryanti, Martoedjo T, Tjokrosoedarmono AH, dan Sulistyaningsih E. 2003. Wine Red Root Disease Control with Trichoderma spp. Proc. *National Congress XVII and National Seminar FPI*, Bandung, 6-8 Agustus

Terry N. 1970. Developmental physiology of sugar-beet. II. Effect of temperature and nitrogen supply on the growth, soluble carbohydrate content and nitrogen content of leaves and roots. *Journal of Experimental Botany* 21, 477-496

USDA. 2016. Full Report (All Nutrients) 11003, Amaranth Leaves, Raw. https:// ndb. nal. usda.gov.

Wahyudi A. 2010.`Practical Guide to Planting Vegetables. Agromedia Pustaka. Jakarta

Zhang J. 1996. Interactive Effects of Soil Nutrients, Moisture and Sand Burial on the Development, Physiology, Biomass and Fitness of Cakile edentula. *Annals of Botany* 78: 591-598, http:// aob.oxfordjournals.org /content/78/5/ 591 .full.pdf