Application of Organic Manure and Mycorrhizal for Improving Plant Growth and Yield of Temulawak (*Curcuma xanthorrhiza* Roxb.)

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***Abstract*- Problems encountered in the development of herbal medicine industry is that most of the raw materials (80%) came from the forest or natural habitats and the rest (20%) of the results of traditional cultivation. Provision of raw materials still rely on the natural occurrence of genetic erosion has resulted in some important medicinal plants such as ginger, turmeric, temulawak, and kencur. This research was conducted in the District of Karanganyar, Central Java. The research is focused to improve cultivation techniques of temulawak plants (*Curcuma xanthorrhiza* Roxb.) by using various types of organic manure (chicken, goat, and cow) combined with various dose levels of arbuscular mycorrhizal fungi (AMF) application. The purpose of this research is to gain a steady cultivation technology through the use of organic nutrients and arbuscular mycorrhizal fungi so as to increase the production of temulawak plants. The results showed that goat manure can significantly increase the growth and yield of temulawak on every variable except plant height compared with other manure (chicken and cow). Mycorrhizal treatment at a dose of 10 g/plant capable of improving growth in a variable of leaves number, fresh weight of plant, dry weight of plant, and fresh weight of rhizomes. No interaction between organic manure application and mycorrhizal treatment dose on all observation variables growth and yield of temulawak.**

***Index Terms*—Temulawak, *Curcuma xanthorrhiza*, organic manure, arbuscular mycorrhizal fungi.**

I. INTRODUCTION

Potential of medicinal plants in Central Java is quite large. Center of medicinal plants such as ginger, turmeric, temulawak, and kencur spread in District of Semarang, Sukoharjo, Karanganyar, Purworejo, Boyolali, Banyumas, Magelang, Wonogiri, Rembang, and Jepara. Production in 2006 to reach 13,401 tons ginger, 13,438 tons turmeric, 3,023 tons temulawak, and 10,438 tons kencur, besides that it still met other products of medicinal plants such as fennel, kapulogo, temukunci, purwoceng, and others.

Curcuma xanthorrhiza Roxb. is a member of the ginger family (Zingiberaceae) and a native Indonesian plant. It is commonly known as "Temu Lawak" in Malaysia, is widely used in South East Asian countries in the traditional treatment of many ailments including migraines, constipation, liver complaints and inflammatory conditions (Devaraj et al., 2013). It is grown in Thailand, Philippines, Sri Lanka and Malaysia. *Curcuma xanthorrhiza* is low growing plant with a root (rhizome) which is similar to ginger with aromatic, pungent odor and bitter taste. *Curcuma xanthorrhiza* is reported to be useful for hepatitis, liver complaints, diabetes, rheumatism, cancer, hypertension and heart disorders. *Curcuma xanthorrhiza* has also shown diuretic, anti-cancer, anti-inflammatory, anti-oxidant, anti-hypertensive, anti-rheumatic, anti-hepatotoxic, anti-dysmenorrheal, antispasmodic, anti-leucorrhoea, anti-bacterial and antifungal effects (Sears, 2005).

Productivity and quality of java turmeric (temulawak) were influenced by many factors, i.e. nutrition availability from fertilizer application. Production and quality of temulawak cultivation is heavily influenced by technology. Production of organic cultivation method is generally lower compared to inorganic farming ways. However, organic farming has more value because it is expected to avoid the contamination of hazardous chemicals (Rahardjo and Ajijah, 2007).

Organic farming is a type of system that involves less intensive use of land by applying cultivation practices which exclude or significantly restrict the use of synthetic chemicals such as pesticides and fertilizers. Organic agriculture focuses on environmental protection and the use of natural resources including the maintenance of soil structure and fertility, water resources and biodiversity. Thus conservation tillage as a sustainable agricultural practice that has the potential to mitigate green house gas effect, improve soil structure, and increase soil water infiltration, soil water holding capacity and enhanced biodiversity (Duruigbo et al., 2013).

To increase the availability of nutrient, also to remedy soil physical condition, organic fertilizer have been developed and widely used in agriculture practices. Organic fertilizer such as bokashi, was composed from crop residues and dung manures by using decomposer microbes (EM4). Present researchs also focuse on using natural phosphate as, fertilizer like the bio phosphate and zeolite. Productivity of temulawak *(Curcuma xanthorrhiza* Roxb) is influenced by fertilizer application. Inorganic fertilizer gave the higher rhizomes production on temulawak (Rahardjo et al., 2009).

Organic agriculture is a production system which avoids or excludes the use of synthetic preparation-artificial fertilizers, pesticides, growth accelerators and fodder additives. As an alternative to these means, organic agriculture applies a number of modern preventive methods to maintain the natural soil fertility and non-chemical control of weeds, pests and diseases. Technical aspects of medicinal plants organic farming shows modern concept and environmentally friendly. By these ways, the economic aspects in the agricultural sector are being better (Raei and Milani. 2014).

Nowadays, organic products are being famous for all people around the world. Due to the great global market demand, production of organic foods has rapidly increased in the past decades. On this basis organic agriculture has become a great choice as means of organic product producing. As a staple product in the world, the high demand on organic medicinal plants has increased in last decades. Problems of the decline in the bio-environmental sustainability due to indiscriminative usage of chemical fertilizers and pesticides in conventional cropping system can solve under organic farming. Organic farming enhances soil organic carbon, available phosphorus content and microbial population/enzymatic activity of soil and thus making it sustainable for organic crop production. Application of different organic amendments in combinations and in a cumulative manner can supply the nutrient requirement of organic medicinal plants cropping system (Raei and Milani, 2014).

The effect of nutrient is very large to the chemical content of the plant because the nutrients in the biosynthesis of secondary metabolites act as precursors (Herbert, 1989). Age of plants has a considerable influence on the chemical content due to the accumulation of secondary metabolites will vary according to the development of a certain age. In *Mentha piperita* L. plants the maximum levels of essential oils of menthol leaves are on the eve of the flowering season, then camphor accumulated in *Campora officinarum* L. wood upon old trees, while *R. serpentina* in India in the harvest at the age of 15-36 months (Sarin, 1982; Tyler et al., 1988).

The use of ruminant farm animals such as cattle, sheep and goats to clear bushes and old stalk residues of harvested crops is an interesting aspect of mixed farming yielding low input technology for land clearing. Low input technologies used in maintaining soil fertility are ashing cattle manure, green manure, mulching, urine-manure slurry and manure tea technology. Some plant nutrients such as copper, zinc, and particularly phosphorus in soils may not exist in sufficient quantity or exist in a state that the crop may have access to them. Vesicular arbuscular mycorrhizae (VAM) which is a typical endomycorrhizal symbiosis is a low input technology to overcome the above problems. They can be grown easily in natural habitats after which their spores will be isolated for use during seed treatments of crops with poor root development such as onions or crops with abundant fine feeder roots and root/hairs but grown on poor soils (Mkpado and Onuoha, 2008).

The P content in shoots and roots significantly increased in all the treated plants as compared to control at the flowering stage of *Gerbera.* The mycorrhized plants have a higher number of flowers, a characteristic which is highly important in ornamental plant production. The positive increment in flower production by the application of bio-fertilizers may be due to the increase in availability of micro and macro nutrients to the plants resulting in enhancement of hormonal activities within the plant (Karishma et al., 2013). The present study suggested that inoculation of fungi was effective in improving the tolerance of wheat genotypes by improving the accumulation of nutrients and soluble solutes that might be responsible for osmotic adjustment of plant to counteract oxidative damage generated by salinity (El-Amri et al., 2013).

Soil microorganisms and their activities play important roles in transformation of plant nutrients from unavailable to available forms and also have many metabolic qualities related to soil fertility improvement (Leaungvutiviroj et al., 2010). Arbuscular mycorrhizal fungi (AMF) are obligate symbionts that colonize the roots of about 80% extant terrestrial plant species. In this relationship, AMF improve the host plant growth by increasing the uptake of water and minerals, especially the uptake of phosphorus (P) which is readily fixed in soil, and in return, they obtain photosynthates from the host plants (Newsham et al., 1995; Clark et al., 1999; Wang and Qui, 2006). Recently, the beneficial effect of AMF on nitrogen (N) uptake by crop has been extensively studied (Guether et al., 2009; Leigh et al., 2009). Consequently, effective AMF utilization would lead to low-input sustainable turmeric cultivation systems.

Microbial-enriched compost tea is a water extract of compost that is amended with nutrient supplements during brewing to enhance their microbial diversity. That the optimal mineral nutrients level (half strength fertigation nutrients) in combination with the weekly foliar application of microbial-enriched compost tea can be used as a biofertiliser and bioprotectant on muskmelons grown under rain shelters without compromising the growth factors and yield quality, thus reducing the dependency on the excessive usage of inorganic fertilisers (Naidu et al., 2013).

Mycorrhiza is one type of fungus that can stabilize soil structure. Formation of good soil structure is capital for the improvement of soil physical properties of the other. Physical properties of soil are improved due to the formation of good soil structure such as improved soil porosity, soil permeability, and soil air. Improvement of soil structure will also directly influence the development of plant roots. Besides having mycorrhizal roots can absorb nutrients in the form of bound and are not available to plants. Mycorrhizal external hyphae can absorb phosphate from the soil element and immediately converted into polyphosphate compounds. A polyphosphate compound then moved into the hyphae and is broken down into organic phosphate that can be absorbed by plant cells. P fertilizer efficiency clearly increased with the use of mycorrhizae (Mosse, 1981).

Arbuscular mycorrhizal fungi (AMF) are soil microorganisms that have establish mutual symbiosis with majority of higher plants roots. It has widely been accepted that AMF have increasing affect on their host plants growth through nutrient uptake enhancement. Smith et al. (1986) reported that the AMF can stimulate plant growth especially in soils with low fertility mainly due to improved phosphorous absorption. In addition, Manoharan et al. (2008) reported that the nitrogen, phosphorus and potassium content increased in vesicular arbuscular mycorrhizal (VAM) fungus treated seedlings compared with non-mycorrhizal tree seedlings. The advantage or disadvantage associated with AMF was affected by three factors: kind of plants, kind of AMF and genetic characters of this symbiosis. Environmental condition (such as elements availability, pH, light etc) can express or

silence some genes in the host plant or AMF, and consequently cause different behavior to appear from this symbiosis (Shirmohammadi and Aliasgharzad, 2013).

Profitable turmeric (*Curcuma longa* L.) production requires adequate nutrients. Arbuscular mycorrhizal fungi (AMF) inoculation resulted in higher biomass production and nutrient uptake of turmeric. Moreover the concentration of curcumin, contained in the rhizome of turmeric, increased in AMF treatment. These results indicate that AMF inoculation has beneficial effects on turmeric growth and curcumin production. AMF inoculation to turmeric field would be effective when indigenous soil populations of AMF are low or native AMF are no longer effective (Yamawaki et al., 2013).

II. Material and Methods

The experiment was conducted in the District of Karanganyar, Central Java on June to November 2013. Laboratory studies conducted at the Laboratory of Plant Physiology and Biotechnology, Faculty of Agriculture Sebelas Maret University (UNS) Surakarta Indonesia. The plant material used in this study is the temulawak rhizomes. Other materials used are polybag, organic fertilizer (chicken manure, goat manure, and cow manure), and arbuscular mycorrhizal fungi (AMF). Equipment used includes tools for land preparation, planting, cultivation, and observations.

This research using completely randomized design (CRD) consisting of two treatment factors with 16 treatment combinations and each repeated 3 times. The first factor is the growing medium, made up of four kinds, namely P0 = soil without organic manure, P1 = soil + chicken manure, P2 = soil + goat manure, P3 = soil + cow manure. The second factor is the arbuscular mycorrhizal fungi (AMF), consisting of 4 levels i.e. M0 = without AMF, M1 = 5 g/plant AMF, M2 = 10 g/plant AMF, and M3 = 15 g/plant AMF. Observations were made of the variables of plant height, number of leaves, number of tillers, plant fresh weight, plant dry weight, and the fresh weight of rhizomes. Data were analyzed using analysis of variance (ANOVA) with F-test at 5% level, and if there is a significant difference followed by Duncan's Multiple Range Test (DMRT) at the 5% level.

III. Results and Discussion

Plant height

Plant height is a very important character in the temulawak plant because it has a direct influence on the character of the rhizome weight per clump (Ajijah et al., 2005). Table 1 show that the use of organic manure significantly affects plant height of temulawak.

Based on the results of analysis of variance, compared with no manure treatment, the application of organic manure can increase plant height of temulawak. But the chicken manure, goat manure, and cow manure was not significantly different. Nitrogen content of manure is a major factor for vegetative growth, stem, and leaves (Munawar, 2011). N is the macro nutrients that most absorbed by the zingiberaceae plant, then followed by K and P nutrient (Rosita et al., 2005). High nitrogen in animal manure can improve the quality and quantity of the chrysanthemum cuttings. Nitrogen serves to accelerate the growth, stimulate germination, especially to improve the quality of protein, a source of food for the microbes around the plant.

Table 2 shows that application of arbuscular micchorhizal fungi (AMF) with various doses (5 g/plant, 10 g/plant, 15 g/plant) were able to increase the plant height of temulawak compared with control, but each other was not significantly different. Mycorrhizal role in the nutrient and water absorption. Advantages of infected plants by mycorrhizal are increases the uptake efficiency of some nutrients such as P, K, Zn, and S (Gianinazzi-Pearson and Diem, 1982).

Number of leaves

Chicken manure, goat manure, and cow manure significantly different compared with the untreated manure to increase the number of temulawak leaves. Table 1 show that organic manure can increase the number of leaves. Results of analysis of variance showed that goat manure have a highly significant difference in the growth of the number of leaves. While the chicken manure and cow manure showed significantly different results compared with no manure application. Goat fertilizer 7.5 kg/m^2 and 15 kg/m^2 are an optimal dose to increase the number of leaves in chrysanthemum (Nasihin, 2012).

Table 2 the results of the analysis of variance showed that the treatment of AMF dosage also significantly affect the number of leaves. Application of 10 g/plant dose gives the best results and significantly different compared with the other AMF dose (5 g/plant and 15 g/plant). Application AMF at a dose of 5 g/plant, 10 g/plant, and 15 g/plant significantly different with without AMF doses treatment.

Table 1. Effect of various types of organic manure on plant height, number of leaves, number of tillers, plant fresh weight, plant dry weight, and rhizomes fresh weight of temulawak

Organic manure treatment	Plant height (cm)	Number of leaves	Number of tillers	Fresh weight of plant (g)	Dry weight of plant (g)	Fresh weight of rhizomes (g)

P0 (without organic manure)	102.30 a	3.84 a	3.00 a	320.28 a	52.08 a	616.90 a
P1 (chicken manure)	110.21 b	5.68 b	4.20 b	550.04 b	74.87 b	815.20 b
P2 (goat manure)	114.22 b	7.00 c	5.87 c	646.12 c	80.00 c	934.87 c
P3 (cow manure)	118.67 b	5.40 b	4.45 b	565.10 b	72.24 b	834.66 b

Values followed by the same letter in the same column are not significant different according to DMRT at 5% level.

Number of tillers

Table 1 show that organic manure can increase the tillers number of temulawak, compared with no manure application. Results of analysis of variance showed that goat manure was highly significant difference in increasing the number of tillers of temulawak. While the chicken manure and cow manure showed significantly different effect compared with no manure application. Manure is applied as fertilizer can increase crop yields higher quality compared with conventional cultivation with the use of inorganic fertilizers. Application of animal manure can increase the uptake of nitrogen, phosphorus, potassium, and sulfur (Ashrafi et al., 2010).

Meanwhile application of AMF doses also affects the growth of temulawak. Table 2 shows that the AMF treatment at a dose of 5 g/plant, 10 g/plant, and 15 g/plant significantly different compared with without mycorrhizal application.

Plant fresh weight

Table 1 show that the application of organic manure can increase the fresh weight of temulawak plants. Results of analysis of variance showed that goat manure highly significant effect compared with other manure treatments (chicken manure and cow manure). However, chicken manure and cow manure significantly different effect with without manure application. The use of manure can increase nutrient uptake that spurred the growth of the roots and results of fresh and dried materials of *Amaranthus viridis* (Awodun, 2007).

Meanwhile in Table 2 it can be seen that the application of AMF with a dose of 10 g/plant gave highly significant effect on the fresh weight of plant compared with other doses treatment (5 g/plant and 15 g/plant). The AMF treatment at doses of 5 g/plant, 10 g/plant, and 15 g/plant give significantly different results compared with the treatment without application of AMF. Application of 500 spores of arbuscular mycorrhizal fungi can increase the fresh weight and dried weight of great white ginger rhizome was 32.6% and 54.65% (Trisilawati et al., 2003).

The combination of organic manure application and the AMF doses treatment provide a positive influence on increase of plant fresh weight. Available nutrients variety in the organic manure and the use of AMF, which help plants in nutrient uptake, it is able to increase the fresh weight of temulawak plants.

Table 2. Effect of various doses of arbuscular mycorrhizal fungi (AMF) on plant height, number of leaves, number of tillers, plant fresh weight, plant dry weight, and rhizomes fresh weight of temulawak

Mycorrhizal doses treatment	Plant height (cm)	Number of leaves	Number of tillers	Fresh weight of plant (g)	Dry weight of plant (g)	Fresh weight of rhizomes (g)
M0 (without mycorrhizal)	104.02 a	3.00 a	3.08 a	365.88 a	51.66 a	652.05 a
M1 (5 g/plant mycorrhizal)	116.45 b	5.30 b	4.25 b	580.29 b	75.75 b	767.34 b
M2 (10 g/plant mycorrhizal)	112.33 b	6.28 c	5.60 c	683.07 c	86.22 c	863.28 c
M3 (15 g/plant mycorrhizal)	116.57 b	5.59 b	4.57 b	540.39 b	74.20 b	764.94 b

Values followed by the same letter in the same column are not significant different according to DMRT at 5% level.

Plant dry weight

Table 1 the results of the analysis of variance showed that goat manure gave the best response in increasing dry weight of temulawak. Goat manure highly significant effect compared to chicken and cow manure. However, chicken manure and cow manure significant effect compared with no manure application. Organic manure can repair the physical, chemical, and biological soil and provide the complete nutrients both macro and micro, and available nutrients absorbed by plants can increase the metabolism of the plant in this case is photosynthesis. Increased photosynthesis will increase photosynthate so plant dry weight also increased.

While application of AMF at a dose of 10 g/plant gives a better response than the other treatments (5 g/plant and 15 g/plant). But basically the treatment of AMF is able to increase the dry weight compared with non-AMF plants (Table 2). The mycorrhizal application of 30 g/pot significantly affect the growth of several components including a canopy diameter, number of midrib, and the length of midrib of purwoceng plant (Djazali, 2011).

Fresh weight of rhizome

Based on Table 1, it can be seen that the organic manure application is able to increase the fresh weight of temulawak rhizome. Table 1 the results of the analysis of variance showed that goat manure application showed the best effect in increasing the weight of temulawak rhizome. The treatment of goat manure significantly different compared with other treatments (chicken manure and cow manure). Moreover the organic manure was significantly affect compared with no manure application. Nutrients contained in organic manure is very complete both macro and micro, such as N, P, K, Ca, Mg, and S, although in small amounts (Oyo, 2010). N nutrient is indispensable in improving the production of rhizomes also can boost the size of the rhizomes are produced. Use of humus and cow and goat manure, significantly affect the growth and production of ginger at least 2 times greater than the control (Gusmaini and Trisilawati, 1998).

While Table 2 shows the AMF is able to increase the fresh weight of temulawak rhizomes. Results of analysis of variance showed that the application of AMF 10 g/plant very different effect markedly increased fresh weight of temulawak rhizome compared with a dose of 5 g/plant and 15 g/plant. Meanwhile, AMF at doses of 5 g/plant, 10 g/plant, and 15 g/plant significantly different effect compared without AMF application.

IV. Conclusion

Goat manure can increase the growth and yield of temulawak on every variable except plant height, compared with other organic manure (chicken manure and cow manure) . Mycorrhizal treatment at a dose of 10 g/plant capable of improving growth of temulawak in a variable number of leaves, plant fresh weight, plant dry weight, and fresh weight of rhizomes. No interaction between organic manure application and mycorrhizal doses treatment on all observation variables of growth and yield of temulawak *(Curcuma xanthorrhiza* Roxb).

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References

[1] Ajijah N, Setiyono RT, Bermawie N. 2005. Kriteria seleksi untuk daya hasil pada tanaman temulawak (*Curcuma xanthorriza* Roxb.). Prosiding Seminar Nasional TOI XXVII. Batu 15-16 Maret 2005.

[2] Ashrafi R, Biswas MHR, Rahman GKMM, Khatun R, Islam MR. 2010. Effect of organic manure on nutrient contents of rice grown in an arsenic contaminated soil. *Bangladesh J. Sci. Ind. Res.* 45(3): 183-188.

[3] Awodun MA. 2007. Effect of goat manure and urea fertilizer on soil, growth and yield of okra (*Abelmoschus esculentus* (L.) Moench*). Int. J. Agric. Res.* 2: 632-636.

[4] Clark RB, Zeto SK, Zobel RW. 1999. Arbuscular mycorrhizal fungal isolate effectiveness on growth and root colonization of *Panicum virgatum* in acidic soil. *Soil Biology and Biochemistry* 31: 1757-1763.

[5] Devaraj S, Ismail S, Ramanathan S, Yam MF. 2013. In vivo toxicological investigations of standardized ethanolic extract of *Curcuma xanthorrhiza* Roxb. rhizome. *J. Nat. Prod. Plant Resour*. 3(1): 67-73.

[6] Djazali M. 2011. Pengaruh pupuk P dan mikoriza terhadap produksi dan mutu simplisia purwoceng. *Buletin Littro* 22(2): 147-156.

[7] Duruigbo CI, Okereke-Ejiogu EN, Nwokeji EM, Peter-Onoh CA, Ogwudire VE, Onoh PA. 2013. Integrated remediation strategies for sustaining agrobiodiversity degradation in Africa. *IOSR Journal of Agriculture and Veterinary Science* 3(4): 16-23.

[8] El-Amri SM, Al-Whaibi MH, Abdel-Fattah GM, Siddiqui MH. 2013. Role of mycorrhizal fungi in tolerance of wheat genotypes to salt stress. *Afr. J. Microbiol. Res*. 7(14): 1286-1295.

[9] Gianinazzi-Pearson V, Diem HG. 1982. Endomycorrhizae in the tropics. *In* Dommergues YR and Diem HG (*Eds*.). Microbiology of Tropical Soils and Plant Productivity. pp 209-251. Martinus Nijhoff. Le Havre.

[10] Guether M, Neuhauser B, Balestrini R, Dynowski M, Ludewig U, Bonfante P. 2009. A mycorrhizal-specific ammonium transporter from *Lotus japonicus* acquires nitrogen released by arbuscular mycorrhizal fungi. *Plant Physiology* 150: 73-83.

[11] Gusmaini dan Trisilawati O. 1998. Pertumbuhan dan produksi jahe muda pada media humus dan pupuk kandang. *Jurnal Penelitian Tanaman Industri* 4(2): 42-48.

[12] Herbert RB. 1989. *The Biosynthesis of Secondary Metabolites.* 2nd ed. Chapman and Hal. New York.

[13] Karishma, Yadav K, Tanwar A, Aggarwal A. 2013. Impact of arbuscular mycorrhizal *f*ungi and *Pseudomonas fluorescens* with various levels of superphosphate on growth enhancement and flowering response of *Gerbera*. *Journal of Ornamental Plants* (*Journal of Ornamental and Horticultural Plants*) 3(3): 161-170.

[14] Leaungvutiviroj C, Piriyaprin S, Limtong P, Sasaki K. 2010. Relationships between soil microorganisms and nutrient contents of *Vetiveria zizanioides* (L.) Nash and *Vetiveria nemoralis* (A.) Camus in some problem soils from Thailand. *Applied Soil Ecology* 46: 95- 102.

[15] Leigh J, Hodge A, Fitter AH. 2009. Arbuscular mycorrhizal fungi can transfer substantial amounts of nitrogen to their host plant from organic material. *New Phytologist* 181: 199-207.

[16] Manoharan PT, Pandi M, Shanmugaiah V, Gomathinayagam S, Balasubramanian N. 2008. Effect of vesicular arbuscular mycorrhizal fungus on the physiological and biochemical changes of five different tree seedlings grown under nursery conditions. *Afr. J. Biotechnol.* 7(19): 3431-3436.

[17] Mkpado M, Onuoha RE. 2008. Refined indigenous knowledge as sources of low input agricultural technologies in sub-saharan Africa rural communities: Nigerian experience. *International Journal of Rural Studies* 15(2): 1-11.

[18] Mosse B. 1981. Vesicular-arbuscular mycorrhiza research for tropical agriculture. *Research Bulletin.* Hawaii Institute of Tropical Agriculture and Human Resources. College of Tropical Agriculture and Human Resources. University of Hawaii. 82 p.

[19] Munawar A. 2011. Kesuburan Tanah dan Nutrisi Tanaman. IPB Press. Bogor.

[20] Naidu Y, Meon S, Siddiqui Y. 2013. Foliar application of microbial-enriched compost tea enhances growth, yield and quality of muskmelon (*Cucumis melo* L.) cultivated under fertigation system. *Scientia Horticulturae* 159: 33-40.

[21] Nasihin Y. 2012. Teknik peningkatan produksi benih krisan dengan aplikasi pupuk kambing. *Bulletin Teknik Pertanian* 17(1): 22-25.

[22] Newsham KK, Fitter AH, Watkinson AR. 1995. Multi-functionality and biodiversity in arbuscular mycorrhizas. *Trends in Ecology and Evolution* 10: 407-411.

[23] Oyo. 2010. Teknik pemberian beberapa jenis pupuk kandang untuk meningkatkan hasil rumput benggala (*Panicum maximum* cv. *Purple guinea*). *Bulletin Teknik Pertanian* 15(2): 66-69.

[24] Raei Y, Milani MA. 2014. Organic cultivation of medicinal plants: a review. *J. Bio. & Env. Sci.* 4(4): 6-18.

[25] Rahardjo M, Ajijah N. 2007. The effect of organic fertilizer on productivity and quality of three promising lines java turmeric (*Curcuma xanthorriza* Roxb.) promising lines, in Cibinong Bogor. *Bul. Littro*. 18(1): 29-38.

[26] Rahardjo M, Ajijah N, Gusmaini, Rizal M. 2009. Response of three promising lines of *Curcuma xanthorrhiza* Roxb on organic and inorganic fertilizer applications. Proceeding of the First lnternational Symposium on Temulawak. Page 108-115.

[27] Rosita SMD, Rahardjo M, Kosasih. 2005. Pola pertumbuhan dan serapan hara N, P, K tanaman bangle (*Zingiber purpureum* Roxb.). Makalah tidak dipublikasikan.

[28] Sarin YK. 1982. Indian row materials for the production of tropane alkaloids. *In*: Atal CK and Kapur BM (*Eds*). *Cultivation and Utilization of Medicinal Plants.* Regional Research Laboratory Jammu-Tawi. New Delhi. India. pp 251-258.

[29] Sears B. 2005. The Anti-Inflammation Zone - Reversing the Silent Epidemic That's Destroying *Our Health.* Harper Collins Publishers. New York. USA. pp 75-87.

[30] Shirmohammadi E, Aliasgharzad N. 2013. Influence of *Glomus etunicatum* and *Glomus intraradices* fungi inoculums and micronutrients deficiency on root colonization and dry weights of tomato and sorghum in perlite bed culture. *Afr. J. of Biotechnol.* 12(25): 3957-3962.

[31] Smith SE, John JB, Smith FA, Bromley JL. 1986. Effect of mycorrhizal infection on plant growth, nitrogen and phosphorous nutrition in glass house grown *Allium cepa* L. *New Phytol.* 103(2): 359-373.

[32] Trisilawati O, Gusmaini, Rohimat I. 2003. Peranan mikoriza terhadap pertumbuhan dan produksi rimpang tiga klon jahe. *Jurnal Ilmiah Pertanian Gakuryoku* 9(1): 85-89.

[33] Tyler VE, Brady LR, Robbers JE. 1988. *Pharmacognosy.* Lee & Febiger. Philadelphia. 519 p.

[34] Wang B, Qui YL. 2006. Phylogenetic distribution and evolution of mycorrhizas in land plants. *Mycorrhiza* 16: 299-363.

[35] Yamawaki K, Matsumura A, Hattori R, Tarui A, Hossain MA, Ohashi Y, Daimon H. 2013. Effect of inoculation with arbuscular mycorrhizal fungi on growth, nutrient uptake and curcumin production of turmeric (*Curcuma longa* L.). *Agricultural Sciences* 4(2): 66-71.