

Growth and yield of chili on post-mine sandpits treated by Arbuscular Micorhizal fungi and organic matter

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Abstract. Post mining soil with its low fertility can be used for crop cultivation through application of Arbuscular Micorhizal Fungi (AMF) and organic matter. The aim of the research was to know the effect of AMF and organic matter on the growth and yield of Chilli pepper (*Capsicum annum* L.) on post-mine sandpits soil. A field-polybag trial had been carried out using a randomized block design two factors with factorial pattern and three replications. The first factor was the type of AMF i.e. *Glomus* sp and *Gigaspora* sp each of 15 g polybag⁻¹. The second factor was the type of organic matter (chicken manure, *Tithonia diversivolia* compost, and guano each of 30 t ha⁻¹). The results showed there was interaction effect of AMF and organic material on root infection degree percentage and short root ratio. Application of *T. diversivolia* compost 30 t ha⁻¹ gave significant effect on plant height and fresh fruit weight. The experiment indicated that combination of *Gigaspora* and *T. diversivolia* compost equal to 30 t ha⁻¹ produced low root infection degree that can not be used to stimulate growth and yield of chilli crop. Only addition of *T. diversivolia* compost equal to 30 t ha⁻¹ can be used in crop cultivation on post-mine sandpits soil and need further for the success of AMF inoculation need to consider population size beside AMF species.

1. Introduction

Post-mine sandpits has limiting factors for plant cultivation. Ramadhan et al [1] found the top soil lost and remaining the sub soil with low C-organic (0,35%) and dominated with sand (75 %). Post mining soil with heavy metal has low AMF, decreased AMF spore number and mycorrhizal colonization [2], and resulting plant growth and microbial activity of soil microorganisms that are extremely reduced [3].

Application of AMF and organic matter is the key factors for the improvement of degraded soil. AMF is ubiquitous soil microorganism in nature and being a good biological “bacterial manure”[4] and associated with 250 000 plant species [5]. AMF inoculation significantly increased the acid phosphatase activity and the content of available phosphorus in the rhizosphere [4]. Compost addition stimulates soil microbial communities [6], plant performance and improved soil quality in post mine soil [7]. Addition of organic amendments in the degraded soils improved soil quality and net primary, including the mechanism of phosphorus release [8]. Plant grown in the compost amended substrate inoculated with AMF showed increased plant biomass [9].

In contrast with previous research which used perennial plant on post mine soil, in this study we used edible-annual crop, also utilized different AMF species with one of the organic matter source



originated from weed. The aim of the research was to know the effect of AMF and organic matter on the growth and yield of *Capsicum annum* L. on post-mine sandpits soil.

2. Materials and method

A polybag-trial at 720 m a.s.l. and Am climate type according to Koppen Climate classification was carried out from December 2016 to July 2017. The materials used were post-mine sandpits soil from Ngamprah Batujajar (06.88956 °S, 107.50721°E), AMF (*Glomus* sp. and *Gigaspora* sp.), EM₄, chili seed var Tanjung-2, chicken manure, *T. diversivolia* compost, and guano.

The experiment used was randomized block design two factors with factorial pattern and three replication. The first factor was AMF namely: m₀= without AMF inoculum, m₁= 15 g *Glomus* sp polybag⁻¹, m₂= 15 g *Gigaspora* polybag⁻¹. The second factor was manure namely: p₀ = without organic matter, p₁= chicken manure 240 g polybag⁻¹ (equivalent 30 t ha⁻¹), p₂= *T. diversivolia* compost 240 g polybag⁻¹ (equivalent 30 t ha⁻¹), and p₃= guano 240 g polybag⁻¹ (equivalent 30 t ha⁻¹). Post mine-sandpits soil from 20 cm depth sieved and inserted in 40 cm x 60 cm polybags. All organic matter per treatment were applied 2 weeks before planting by mixing it with post-mining sandpits soil. *Glomus* sp. and *Gigaspora* sp. were applied at planting time of chili seeds. Basic fertilizations of Urea 0.402 g polybag⁻¹, 0.0912 g TSP polybag⁻¹ (50% of recommended dosage), and 0.3192 g KCl polybag⁻¹ were given 2 weeks before planting. Continued fertilization was given at 3 weeks after planting (WAP) and 7 WAP each of 30 percent at the recommended dosage. Pest and disease control was done by mechanical method and harvesting at 11 WAP.

The parameters observed were plant height measured at 2,3,4, and 5 WAP. Leaf width, shoot root ratio, and fresh chili fruit weight were measured at the time of harvest. To analyze the data, F test at 5 % level was used and continued with Duncan Multi Range Test at 5 % level.

3. Result and discussion

3.1. Root infection degree

The application of AMF and organic matter gave significant effect on root infection degree of chili. Inoculation of *Gigaspora* sp. with *T.diversivolia* compost and *T.diversivolia* without AMF showed the highest root infection degree, but categorized as low root infection degree (Table 1).

Table 1. The effect of AMF and organic matter on root infection degree of chili.

Treatments	Root infection degree			
	Organic Matter			
AMF	p ₀	p ₁	p ₂	p ₃
m ₀	0.00 a A	0.00 a A	10.0 a B	2.00 a B
m ₁	5.00 b B	1.00 b A	2.33 a AB	3.00 a B
m ₂	2.00 b A	1.33 b A	10.0 a B	3.33 a AB

Remarks : Numbers followed by same small letter (vertical) and same capital letter (horizontal) are not significantly different based on Duncan's Multiple Range Test at 5% level.

Root infection degree is depending on several factors. Soil texture determines the success of AMF infecting plant root. Sandy soil texture with large pore is suitable for *Gigaspora* which has large spore diameter. Data on Table 1 shows that *Gigaspora* inoculation along with organic matter resulted in higher root infection degree than *Glomus* plus organic matter. *T diversivolia* compost had the highest C-organic than the other treatments. Organic matter provides a carbon source for AMF activity including infecting plant root especially *Gigaspora* that can live in sandy soil texture, but root

infection degree in this research was categorized as low related to a low number of AMF spores. At low population sizes, invader AMF will be easily outcompeted by native AM fungi [10].

3.2. Plant height

The inoculation of *Glomus* sp. and *Gigaspora* sp. had no effect on plant height from 2 - 5 WAP. On the other hand application of organic matter enhanced plant height starting from 3 WAP (Table 2).

Based on data from Table 1, AMF inoculation resulted in low root infection degree. With low root infection degree AMF, nutrients absorption could not be maximum causing any effect on plant height. Low soil nutrients made AMF suppressing plant growth by competing with the plant for nutrient [10], particularly when developing AMF create significant carbon sink for young plants [11]. Plant performance was depending on density of infective propagule [12].

Table 2. The effect of AMF and organic matter on plant height.

Treatments		Average of plant height (cm)			
AMF	2 WAP	3 WAP	4 WAP	5 WAP	
m ₀	12.26 a	14.33 a	15.60 a	16.45 a	
m ₁	14.09 a	17.32 a	18.37 a	19.04 a	
m ₂	13.41 a	15.92 a	16.80 a	17.27 a	
Organic Matter					
p ₀	12.36 a	14.21 a	14.48 a	14.84 a	
p ₁	13.84 a	17.31 b	18.55 b	18.95 b	
p ₂	13.97 a	17.46 b	18.98 b	20.28 b	
p ₃	12.84 a	14.45 a	15.66 a	16.26 a	

Remarks : Numbers followed by same small letter are not significantly different based on Duncan's Multiple Range Test at 5% level.

Chicken manure and *T. diversifolia* compost addition increased plant height due to its N content. Positive vegetative response to biochar application in disturbed mine substrate attributed to increased sorption [13] and nutrient bioavailability[14]. Organic matter added to sandy soil improved plant growth [9].

3.3. Plant height

Application of AMF and organic matter showed significant effect on shoot root ratio. The value of shoot root ratio varied from 3.03 to 13.27. Application of *T. diversifolia* compost significantly increased shoot root ratio when applied with *Gigaspora* sp. Meanwhile, when these AMF were applied together with the guano the shoot root ratio decreased (Table 3).

Table 3. The effect of AMF and organic matter on shoot root ratio.

Treatments	Average of shoot root ratio			
	Organic Matter			
AMF	p ₀	p ₁	p ₂	p ₃
m ₀	5.50 a	6.08 a	3.75 a	4.92 a
	A	A	A	A
m ₁	3.57 a	5.09 a	5.44 a	4.56 a
	A	A	A	A
m ₂	3.80 a	4.76 a	13.27 b	3.03 a
	A	A	B	A

Remarks : Numbers followed by same small letter (vertical) and same capital letter (horizontal) are not significantly different based on Duncan's Multiple Range Test at 5% level

AMF inoculation along with *T. diversivolia* compost produced the highest shoot root ratio (Table 3). This indicates that *Gigaspora* increased the absorption of N, P, and K contained in *T. diversivolia* compost. AMF has mycelium that makes soil contact area of the host plant roots is expanded, resulting in improvement of nutrient and water absorption of plant [15]. This result corresponds with Kinany [9] reporting that planlet trasplanted into compost amended substrate inoculated with AMF showed plant biomass increase. Plant shoot and root biomass were increased by AMF inoculation [12]. Organic matter according to Abbasi [16] plays an important role in P solubilization through chelation mechanisms resulting greater P available to be used by plants.

3.4. Fruit weight

AMF inoculation had no effect on fresh fruit weight, while application of organic matter, ie. chicken manure and *T. diversivolia* compost increased fresh fruit weight, but guano produced fresh fruit weight lower than control (Table 4).

Table 4. The effect of AMF and organic matter on fresh fruit weight and harvest index.

AMF	fresh fruit weight (g)
m ₀	62.36 a
m ₁	85.68 a
m ₂	68.21 a
Organic Matter	
p ₀	47.22 a
p ₁	59.50 a
p ₂	151.63 b
p ₃	30.00 a

Remarks : Numbers followed by same small letter are not significantly different based on Duncan's Multiple Range Test at 5% level

Data Table 4 shows that application of *T. diversivolia* compost gave the highest fresh fruit weight. It is related with Phosphorus as one of nutrients needed for fruit development. Phosphorus content in *T. diversivolia* compost (4.1 %) is higher than chicken manure (3.21%) so it can supply more for the plants. Guano has the highest P content (22 %), but P in guano is in the unavailable form. The positive effect of compost was approved by Hossein [17] who concluded that organic wasted provided essential plant nutrients and maintain soil fertility and stimulate crop growth and yield.

4. Conclusion

Inoculation of *Gigaspora* along with application of *T. diversivolia* compost 30 t ha⁻¹ produced low root infection degree implied to limited influence on plant growth and yield of *C. annum* L. on post-mine sandpits. Addition of *T. diversivolia* compost equal to 30 t ha⁻¹ can be used in crop cultivation on post-mine sandpits soil and for the success of AMF inoculation need to consider population size beside AMF species.

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