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Improvement Soil Physic Properties and Yield of Chilli by Dual Soil Microorganism

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Abstract. *The aim of the research was to know the effect of Arbuscular Mycorrhizal Fungi (AMF) and rhizobacteria on the soil physic properties and yield of Chilli (Capsicum annum L.). A field-polybag trial had been carried out at 750 m above sea level using a randomized block design two factors with factorial pattern and three replications. The first factor was the type of AMF (control, Glomus sp, Gigasporasp, Acaulospora sp. Glomus sp+ Gigasporasp+ Acaulosporasp). The second factor was the type rhizobacteria (control, Pseudomonas diminuta, Bacillus alvei). The results showed that AMF and rhizobacteria independently did not influenced soil bulk density, soil water content, and soil aggregate stability index. Gigasporasp increased harvest index and fruit fresh weight.*

Keywords: *AMF, rhizobacteria, chili, soil physic, yield.*

INTRODUCTION

Chili is a horticultural products widely used by the people of Indonesia as a seasoning herb ingredient cooking, traditional medicine, and the material mix in the food industry as well as drinks. Chilli ranks top among the eighteen types of vegetables that are cultivated commercially in Indonesia over the past few years [1], due to the wide market, high economic value, and has high adaptation to various conditions of the area [2]. For farmers in West Java chili become the most preferred commodity so determined as the leading commodities in West Java [3].

Inceptisolthat widely spread can be used for chili development in West Java. On the other hand this soil has poor soil chemical properties, even very low P because it is adsorp by Al and Fe forming Al-P and Fe-P [4] so it is not available to plants.

Arbuscullar Mycorrhiza Fungi (AMF) has external hypha to improve P absorption. AMF inoculation significantly increased the acid phosphatase activity and the content of available phosphorus in the rhizosphere [5]. Rhizobacteria also has role in improving P absorption through activity of phosphatase enzyme which change P not available to P available, so the two microbes can be used to address the question of the lack of the P element. However, AMF and rhizobacteria not only improve soil chemistry fertility, but also soil physics as well. Rhizobacteria involved as gluing in the formation of micro-aggregates and AMF is involved in the formation of the macro-aggregate that will affect the soil pores. With porus soil, then plant roots can be expanded to take the nutrient contained in the soil to support plant production.

The aim of the research was to know the effect of AMFand rhizobacteria on soil physic properties and yield of *Capsicum annum* L.

MATERIALS AND METHODS

A polybag-trial at 750 m above sea level at BalaiPengembanganBenihHortikulturadan Aneka Tanaman (Institute of Development Horticulture Seed and various Plants) Pasir Banteng Sumedang with Inceptisols, rain intensity 1600 mm year^{-1} and C climate type had been carried out from February to June 2013. The materials used were: chili seed varKencana, AMF (*Glomus sp., Gigaspora sp., and Acaulospora* sp.),

rhizobacteria(*Psedomonasdiminuta and Bacillus alvei)*Inceptisol, fertilizer (Urea, TSP, KCl), polybag 50 cm x 50 cm, KOH, HCl, Aquades, tryphan blue and pesticide.

The experiment used was randomized block design two factors with factorial pattern and three replications. The first factor was AMF namely: m_o=without AMF inoculum, m_1 =*Glomus*sp 5 g polybag^{-1}, m_2 =*Gigaspora*sp 5 g polybag^{-1}, m_3= *Acaulospora*sp 5 g polybag^{-1}, and m_4=Glomus sp + *Gigaspora*sp + *Acaulospora*sp 5 g polybag^{1}).The second factor was rhizobacteria namely: r_o = without rhizobacteria, r_1= *Psedomonasdiminuta*, r_2= *Bacillus alvei.* Sterilized soil that contained soil and manure 1:1 inserted in 50 cm x 50 cm polybags. *P. diminuta* + *B alvei* poured evenly in the soil as much as 60 ml suspension with a density of 10^6 CFU ml^{-1}. Spores of the AMF (*Glomus sp., Gigaspora sp.,* and *Acaulospora sp.*) a total of 10 g is placed as deep as 5 cm in the midst of polybag fit treatment. Chili seeds were planted one seedling per hole with a distance of 5 cm from the AMF spores . Basic fertilizations was 1.25 g KCl plant^{-1}, continued fertilization was given at 3,6,9 Weeks After Planting (WAP) using Urea 1.875 g crop^{-1}dan SP-36 1.875 g crop^{-1}. Pest and disease control was done when serious damage occured. The parameters observe were aggregate stability indeks, soil bulk density, soil water conten, harvest index, and fruit weight. To analyze the data, F test at 5 % level was used and continued with Duncan Multi Range Test at 5 % level.

RESULT AND DISCUSSION

Soil Analysis

The soil was used in the study came from station research of BalaiPengembanganBenihHortikulturadan Aneka Tanaman (Institute of Development Horticulture Seed and various Plants) – Pasir Banteng Sumedang and belongs to the order of the inceptysol, wichcharateristic are clay texture (clay 66 %), pH 5.78 , C-organic 1.39% (low), NTotal 0.10% (low), with index C/N 13.90 (medium). Cation exchange capacity (CEC) 10.40 i.e. cmol.kg^{-1} (low). P total 14.26 mg/100 g (very low) and P available 0.80 ppm (low). While the level of saturation of bases of 55.10% and Al saturation 11.92 % that can be categorized medium. For cation composition showed that K 2.26 cmolkg^{1}(very high), whereas Ca, Na and Mg were actegorized low wich value were 2.26 cmol.kg^{-1}, cmol.kg^{-1} 0.22 and 0.99 cmol.kg^{-1} respectively.

Agregate Stability Index (ASI)

Aplication of AMF and rhizobacteria showed no effect on aggregate stability index (ASI) measured at last vegetative phase (Table 1).

TABLE 1: The Effect of AMFdanRhizobacteria on Agregate Stability Index (ASI)

Treatment		ASI
AMF:		
1.	With out AMF	13,95 a
2.	*Glomus* sp.	15,26 a
3.	*Gigaspora* sp.	14,85 a
4.	*Acaulospora* sp.	15,40 a
5.	*Glomus* sp. + *Gigaspora* sp. + *Acaulospora* sp.	15,36 a
Rhizobacteria:		
1.	With outrhizobactera	15,02 a
2.	*Pseudomonasdiminuta*	15,04 a
3.	*Bacillusalvei*	14,84 a

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

AMF inoculation either single or consortium increased ASI value non significantly comparing to with out AMF inoculation and classified as non stable aggregate. AMF is involved in the formation of the macro aggregate through external hypha which bind particles from micro aggregate to form bigger aggregate or macro aggregate [6]. That external hypha secreted glycoprotein called glomalin that glue soil particles [7]. It

seem that external hypha did not develop well due to low root percentage degree (data not mention). There were environmental factors such as low C-organic soil content (1.39%) that cannot support the AMF food needs.

The macro aggregates is a continuation of the process of the formation of micro aggregates. When microaggregates formed properly then its influence continued on the establishment of macro aggregates. Otherwise, once the formation of the aggregate micro did not run well, then going against the negative influence of macro aggregate [8]. Data Table 1 showed that inoculation of *P.diminuta* and *B.alvei*did not improve ASI. Rhizobacteria released the Exopolysacharide (EPS) as a response to the less favorable environment. The release of the EPS is determined also by the soil organic C supply. In this study C soil organic content was low and insufficient to support rhizobacteria activity and temperature was not extreme so that production of EPS slightly and consequently the formation of micro aggregates hampered.

Soil Bulk Density

Inoculation AMF and rhizobacteria decreased soil bulk density and maintain its value in the range of a standard between 0.93-1.11 g cm^{-3}. Bulk density is influenced by soil microbes[9].

TABLE 2: The Effect of AMFdanRhizobacteria on Soil Bulk Density

Treatment	Bulk Density ($g\ cm^{-3}$)
FMA:	
1. With out AMF	0,957 a
2. *Glomus* sp.	0,970 a
3. *Gigaspora* sp.	0,938 a
4. *Acaulospora* sp.	0,921 a
5. *Glomus* sp. + *Gigaspora* sp. + *Acaulospora* sp.	0,927 a
Rhizobacteria :	
1. With outrhizobacteria	0,976 a
2. *Pseudomonasdiminuta*	0,918 a
3. *Bacillusalvei*	0,934 a

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

AMF and rhizobacteria were used in this experiment seem did not work optimum. Rhizobacteria need neutral pH, whereas soil pH was 5.7 (acid). Temperature effect on root colonization by AMF. Root colonizatin was followed by external hypha septate. The temperature needed by *Gigaspora*sp was 25 – 35 ^{o}C and 18 – 20 ^{o}C for *Glomus sp*. Temperatur during the experiment was 21.3 – 33.0 ^{o}C. Temperature range in accordance to *Gigaspora*sp and its influence can be seen at the bulk density decline (Table 2).

Soil Water Content

The inoculation of AMF and rhizobacteria had no effect on soil water content (Table 3).

TABLE 3: The Effect of AMFdanRhizobacteria on Soil Water Content

Treatment	Soil Water Content (% volume)

FMA:		
1.	With out AMF	43,24 a
2.	*Glomus* sp.	43,40 a
3.	*Gigaspora* sp.	41,93 a
4.	*Acaulospora* sp.	40,37 a
5.	*Glomus* sp. + *Gigaspora* sp. + *Acaulospora* sp.	43,21 a
Rhizobacteria :		
1.	With outrhizobacteria	42,71 a
2.	*Pseudomonasdiminuta*	41,72 a
3.	*Bacillusalvei*	42,86 a

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

Water content has correlation with ASI. Data from Table 1 showed that soil has low ASI low then the aggregate will be easily dispersed into a single chip. The results of the dispersion will clog the pores and reduced macro-pore and continuity of pore. Soil pore blockage reduces the speed of the movement of the water so that water distribution is slow. Aggregate dispersion indirectly reduces total soil pore due to the results of a prior dispersion cover macropore so the macro pore became smaller and would reduce the movement of water into the lower layers of soil.

AMF has external Hypha which is capable to increase water uptake. External Hypha is also capable to bind the soil particles and prevent soil particle dispersion. In this study the external Hypha were not well developed due to the low root infection degree. Likewise with rhizobacteria did not produce EPS maximum due to the low soil organic matter. Rhizobacteria can metabolize soil organic matter to produce EPS which was used as a binding agent for micro-particles.

Harvest Index

AMF inoculation increased harvest index, but rhizobacteria inoculation had no effect.

TABLE 4: The Effect of AMFdanRhizobacteria on Harvest Index

Treatment		Harvest Index
AMF:		
1.	With out AMF *Glomus*	0,33 ab
2.	sp.	0,27 a
3.	*Gigaspora* sp.	0,40 c
4.	*Acaulospora* sp.	0,32 ab
5.	*Glomus* sp. + *Gigaspora* sp. + *Acaulospora* sp.	0,38 bc
Rhizobacteria		
1.	With outrhizobacteria	0,36 a
2.	*Pseudomonasdiminuta*	0,34 a
3.	*Bacillusalvei*	0,33 a

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

Harvest index has corelation with photosynthate partition. This process is influenced by P and K elements. *Gigaspora*sp has longer external hypha than *Glomus* and *Acaulospora* [10]. The function of *Gigaspora*sp should

increase ion that diffuse low like P and K and hypha development and external hypha become determinant factor in low diffuse nutrients absorption efficiency [11].The existence of elements of P and K in the plant tissue promoted photosynthate partition to harvest organ larger. The success of the *Gigaspora* role has not been perfect because harvest index under 50 percent.

Fruit Fresh Weight

Inoculation single AMF *Gigasopra*sp and *Acaulosporasp*increased fruit fresh weight significantly. The highest fruit fresh weight showed by *Gigaspora*sp inoculation. Whereas *P.diminuta* and *B.alvei* increased fresh fuit weight non significant.

TABLE 5: The Effect of AMFdanRhizobacteria on Fruit Fresh Weight

Treatment	Fruit Fresh Weight (g)
AMF:	
1. With out AMF	80,78 a
2. *Glomus* sp.	73,83 a
3. *Gigaspora* sp.	132,17 c
4. *Acaulospora* sp.	113,28 bc
5. *Glomus* sp. + *Gigaspora* sp. + *Acaulospora* sp.	92,56 ab
Rhizobacteria :	
1. With outrhizobacteria	89,30 a
2. *Pseudomonasdiminuta*	98,23 a
3. *Bacillusalvei*	108,03 a

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

Fruit fresh weight parameter is correlated with harvest index that showed *Gigaspora*sp which more extensive extermal hypha than other AMF species absorbed more P and K. P and K elements stimulate photosynthate to harvest organ, so fruit fresh weight become bigger. External hypha add root absorption zone and shorten the distance of the phosphate ions diffusion that accelerate the diffusion process [12]. The increased uptake of P by *Gigaspora*sp stimulated the formation of flowers and fruit. Physiological K specifically prevents loss of flowers that will affect the fruit is formed. AMF not only improve un mobile elements absorption, but also mobile element like Nitrogen (N) as founded [8]. N is important for vegetative growth.

CONCLUSION

Dual inoculation of AMF and rhizobacteria did not improve soil physical properties like soil aggregate stability, bulk density, and soil water content. Inoculation of *Gigaspora*sp increased harvest indeks with the value below 50 percent and fruit fresh weight.

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