Proceeding International Conference on Green Agro-Industry
Volume 4, 2020 | Pages : 404-413

The Effects Of Mycorrhizae And Organic Matters Application On Soil P Availability Of Limestone Post Mining And The Growth Of Maize In Karangdawa Village, Tegal Regency

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Abstract.

Limestone post mining soil had high levels of calcium carbonate and pH, this condition causing a lack of soil P availability, so that the application of mycorrhizae and organic matter is necessary. This study aims to determine the effect of mycorrhizae and types of organic matter, and the best combination of mycorrhizae and types of organic matter on soil P availability of limestone post mining and growth of maize. This study was conducted at the Greenhouse in Taman Teknologi Pertanian Lebaksiu, Tegal Regency, Central Java, from February to May 2019. This study used a Completely Randomized Design (CRD) with two factors. The first factor was the dose of mycorrhizae, namely without mycorrhizae (M0), mycorrhizae 10 g / pot (M1), and mycorrhizae 20 g pot (M2). The second factor was thr type of organic matter, namely without organic matter (B0), cow manure 20 tons / ha (B1), corn litter 20 tons / ha (B2), and legumes liter 20 tons / ha (B3). Each treatment was repeated 3 times. The result shows that the aplication of mycorrhizae had a significant effect on the increasing C-organic soil, Cation Excange Capacity (CEC), plant height and plant dry weight, but it did not significantly affect on P-available, Ca and Mg. The application of various types of organic matter had a significant effect on the increasing P-available, C-Organic soil, CEC, plant height, and plant dry weight, and decreasing soil pH (H_2O) and Ca, but it did not significantly affect on Mg. There was an interaction between mycorrhizae doses and kinds of organic on the increasing plant dry weight of 6 WAP.

Keywords: Mycorrhizae, Organic Matters, Limestone Post Mining Soil, P-Availability, Growth of Maize.

1. Introduction

Type of mining that has potential in Tegal Regency is limestone mining. limestone mining activities mining activities can cause changes in land topography, damage to soil structure, porosity, erosion, reduction in soil organic matter content, declining population and activity of soil microorganisms and plant growth. The topsoil that is lost causes a reduction in essential nutrients, like Nitrogen and Phosphorus. Limestone post mining has a pH above 7 with the highest mineral content is calcium carbonate. On alkaline soils, calcium carbonate can cause phosphate deposition, because the available phosphate will react with Ca which is difficult to dissolve in the soil and is in an unavailable form. The most optimum and more available form of P occurs in the pH range of 6 to 7. Most of the P in the soil is bound by Ca so it is not available by plants (Winarso, 2005).

Cow manure, Corn litter, and Legume litter is an abundant source of organic material and has the potential as ameliorant material to improve soil properties in limestone post mining. Organic matter provides carbon as an energy source for soil organisms for decomposition and mineralization of organic matter, and the application of organic matter can increase the availability of P in soil. The effect of organic matter on the availability of P can be directly through the mineralization process or indirectly by assisting the release of fixed P.

Vesicular-Arbuscular Mycorrhiza (MVA) is a type of soil microbe that can increase plant growth through increased availability and absorption of nutrients in the soil. MVA can be associated with plant roots to form hyphae that have a larger area than plant roots that are not associated with MVA. MVA Hyphae can increase the ability to absorb nutrients like phosphorus. Mycorrhiza hypha produces the enzyme phosphatase which can release the element of phosphorus which is bound by other elements, into nutrients that can be available by plants (Suparno, 2008). The application of organic matter can increase energy and food sources for MVA activity in carrying out metabolism and absorption of nutrients, while the application of MVA can improve the process of mineralization and decomposition of organic matter, because the production of phosphatase enzymes and organic acids from MVA metabolic activities of and can increase corn growth. Corn plants have adaptability and easy to cultivate. Based on these things, research is needed to determine the effect of a combination of MVA and organic matter will increase soil fertility, availability of phosphorus, and can increase the growth of corn in limestone post mining soil.

2. Method

This research was conducted in the greenhouse of Taman Teknologi Pertanian Lebaksiu, Tegal Regency, Central Java, from February until May 2019.

This study used a Completely Randomized Design (CRD) with two factors. The first factor was the dose of mycorrhizae, namely without mycorrhizae (M0), mycorrhizae 10 g / pot (M1), and mycorrhizae 20 g pot (M2). The second factor was thr type of organic matter, namely without organic matter (B0), cow manure 20 tons / ha (B1), corn litter 20 tons / ha (B2), and legumes liter 20 tons / ha (B3). Each treatment was repeated 3 times. Each treatment was repeated three times and consisted of 12 combinations, so that in total there were 36 experimental unit units. The experimental results were analyzed with an Analysis of Variance of 5%. If the treatment has a significant effect, it will be further tested with the 5% DMRT Test (Duncan Multiple Range Test).

Growing media from the limestone post mining of KOPINKRA ‘Sentra’ Karangdawa Limestone, the soils are air-dried and sieved with a size of ⌀2mm of 10 kg of absolute dry soils or equivalent to 12.3 kg of dry wind weight. Organic material that has been dried aerated, chopped and filtered at a size of ⌀2mm. Corn litter selected have golden yellow that has been dried aerated, while litter beans have dark green that has been dried aerated.

Soil that has been sifted, mixed with organic matters in accordance with the treatment that is without organic matter, 20 tons of cow manure/ha is equivalent to 86.52

grams/pot, 20 tons of fresh corn litter/ha is equivalent to 86.52 grams/pot, and 20 tons/ha of legume litter is equivalent to 86.52 grams/pot, then put in polybag. Soil and organic matter in polybags incubated for 1 month with maintained at field capacity conditions.

After incubation, one third of the MVA dose is placed in the planting hole, which is two thirds mixed / glued covering 3 corn seeds, then covered with soil. After the plants are 1 week after planting (1 WAP), thinning is carried out and the best corn plants are left. Fertilization using urea at the recommended dosage of 350 kg / ha is equivalent to 1.3 gram / pot, and KCl at a dose of 75 kg / ha is equivalent to 0.2798 gram / pot (Anonymous, 2018). Watering every day and cleaning the weeds that grow in polybags. After the age of 2 WAP, soil analysis is carried out by taking soil samples which are then analyzed in the laboratory.

3. Result

Preliminary Soil Analysis Results

Table 1. Preliminary Soil Analysis Results

No.	Parameter		Percentage	Value*
		Silt %	45 %	
1	Soil Texture	Clay %	22,5 %	Loam
		Sand%	32,49 %	
2	P-Available Olsen (ppm)		27,40	Low
3	C-Organic(%)		0,77	Very Low
4	pH H_2O		8	Slightly Alkalis
5	CEC (cmol(+).kg^{-1})		22,92	Medium
6	Ca^{2+} dd (me%)		12,24	High
7	Mg^{2+} dd (me%)		0,53	Low

Based on the results of the analysis it can be seen that, the soil used in the study has a loam soil texture. The chemical properties of these soils have low available P levels of 27.4 ppm. The low content of P-available due to the limestone post mining has a pH of H2O of 8 so it is rather alkaline. Calcium carbonate levels found in post mining can cause phosphate precipitation, because the phosphate will react with Ca ions which are difficult to dissolve in the soil and it in an unavailable form. In alkaline soils, Ca reacts with P so that P becomes less available by plants (Winarso, 2005). The C-Organic content is very low at 0.77%, the soil CEC with a medium value of 22.92 cmol (+), kg-1, the Ca2 + dd content of 12.24 with a high value, and the Mg2 + dd content with a low value of 0.53 (me%).

Quality of Organic Matter

Table 2. Results of Analysis of Organic Matter

Parameter	Organic Matters		
	Cow Manure (B1)	Corn Litter (B2)	Legume Litter (B3)
N-Total (%)	0,28	0,25	2,81
P-Total (%)	2,82	0,28	1,03
C-Organic (%)	15,98	19,02	23,48
C/N	57	76	8,36
pH H_2O	8	7,6	7,4
Ca^{2+} dd (me %)	19,04	10,62	9,85
Mg^{2+} dd (me %)	3,24	4,15	2,45

Soil properties After experiment

pH H_2O

Table 3. Effects of application of Mycorrhiza and Organic Matters on the average of pH H_2O

Treatment	Organic Matters				
Mycorrhiza Dose	**B0**	**B1**	**B2**	**B3**	**Average**
M0	7,33	7,27	7,50	7,13	7,30 **p**
M1	7,23	7,37	7,33	7,03	7,24 **p**
M2	7,50	7,17	6,93	6,90	7,13 **p**
Average	7,36 **a**	7,27 **a**	7,26 **ab**	7,02 **b**	**(-)**

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 3 shows the results of variance in the parameters of pH H_2O levels that the application of legume litter 20 tons / ha (B3) significantly different in decreasing the pH H_2O compared to other treatments, however, the mycorrhiza treatment did not show any significant difference to the pH H_2O parameter. The legume litter decomposition process produces organic acids that can reduce pH. Organic acids produced from organic matter will release H^+ ions from the roots thereby reducing pH in the root region (Troeh and Thompson, 2005 in Agustina, 2014).

The mycorrhiza treatment did not show any significant difference to the pH parameter because of mycorrhiza activity in producing organic acids has not been able to increase the concentration of H^+ ions in the soil so that it has not been able to produce significantly different results in reducing the pH. Mycorrhiza plays a role in increasing ion absorption with low levels of mobility, such as phosphate (PO_4^{3-}) and ammonium (NH^{4+}) (Suharno and Santosa, 2005).

C-Organic

Table 4. Effects of application of Mycorrhiza and Organic Matters on the average of pH C-Organic

Treatment	Organic Matters				
Mycorrhiza Dose	**BO**	**B1**	**B2**	**B3**	**Average**
M0	0,86	1,57	1,62	1,87	1,48 **q**
M1	1,22	1,65	1,75	2,11	1,68 **pq**
M2	1,23	1,81	1,96	2,20	1,80 **p**
Average	1,10 **c**	1,67 **b**	1,78 **ab**	2,06 **a**	**(-)**

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Based on analysis of variance, it is known that the application of 20 tons / ha (BK) legumes litter and 20 g / pot (M2) mycorrhiza gives a significant difference to the soil C-Organic content compared to other treatments (Table 4). The treatment of legumes litter 20 ton / ha (B3) gave the highest average C-Organic content of 2.06%. In the process of decomposition of legumes litter release carbon compounds (C), so it increase the levels of C-Organic soil. This is in accordance with the opinion of Bertham (2002) in Morgo, et al., (2015) which states that organic material that has undergone decomposition will produce carbon compounds such as CO_2, CO_3^{2-}, HCO^{3-}, CH_4 and C.

In mycorrhiza treatment, the application of mycorrhiza 20 g / pot (M2) gives the best average C-Organic content of 1.80%. This is due to mycorrhiza can add organic carbon from the production of glycoprotein or glomalin which is a source of carbon.

Glycoproteins or glomalines are relatively resistant to decomposition so that these compounds as carbon sources and aggregate holders, as well as fungal cell walls that contain lots of chitin that are resistant to weathering are also carbon sources (Jastrow et al., 2007 in Musafa, et al., 2015).

CEC Soils

Table 5. Effects of application of Mycorrhiza and Organic Matters on the average of CEC Soils (cmol(+).kg^{-1})

Treatment	Organic Matters				
***Mycorrhiza* Dose**	**BO**	**B1**	**B2**	**B3**	**Average**
M0	18,56	24,05	28,10	29,93	25,16 **q**
M1	22,19	33,62	20,34	34,50	27,66 **q**
M2	24,53	29,42	31,43	36,83	30,56 **p**
Average	21,76 **c**	29,03 **b**	26,62 **b**	33,75 **a**	**(-)**

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 5 shows the results in the parameters of soil CEC levels that the application of legume litter 20 tons / ha (BK) and the application of mycorrhiza 20 g / pot gives a significant difference in increasing soil CEC compared to other treatments. The application of legume litter 20 tons / ha (B3) gave the highest average CEC content with 33.75 cmol (+) kg^{-1}. Legume litter increases soil CEC levels because it produces organic compounds so that it causes humus (organic colloids) as a source of negative charge soil is also high, so the positive charge (cations) in the soil that can be exchanged is also higher so that it can increase CEC soil.

According to Mokolobate and Haynes, (2002) in Wahyudi (2009) stated that the addition of organic matter will be able to increase soil CEC. The amount of contribution of organic matter to the increase in soil CEC is caused by the high carboxyl (-COOH) and hydroxyl (-OH) compounds which if hydrolyzed will produce / increase the negative charge of the soil. This is indicated by increasing levels of C-Organic (Table 4) so that it can increase soil CEC.

The application of mycorrhiza 20 g / pot gives the best average of CEC soil with 30.56 cmol (+). Kg^{-1}. The application of mycorrhiza can accelerate the decomposition process because mycorrhiza produces organic acids and phosphatase enzymes in its activity, so that it can accelerate the decomposition of organic matter. Humus as a result of the decomposition of organic matter is the result of synthesis of microorganisms and mycorrhiza activity.

The application of mycorrhiza increases soil CEC levels due to the direction of increased levels of C-Organic (Table 4). These results are consistent with research conducted (Syib'li, et al, 2013) that the cation exchange capacity (CEC) in the soil increases with increasing number of AMF spores. The involvement of MVA in the process of absolute decomposition can increase CEC in the soil.

P-Available

Table 6. Effects of application of Mycorrhiza and Organic Matters on the average of P- Available (ppm)

Treatment	Organic Matters				
Mycorrhiza Dose	BO	B1	B2	B3	Average
M0	23,24	45,16	48,90	74,88	48,04 **p**
M1	44,49	56,36	52,53	39,75	48,28 **p**
M2	28,03	73,45	58,76	78,55	59,70 **p**
Average	31,92 **b**	58,32 **a**	53,39 **ab**	64,39 **a**	(-)

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 6 shows that the application of various kinds of organic matter was significantly different from the P-available, but there was no significant difference in the mycorrhiza treatment. The treatment of giving of legume litter 20 tons / ha (B3) litter gives the highest average available P content, this is due to the direct contribution of the P element contained in the legume litter, so P in the soil increases.

The increase in P-available was also influenced by a decrease in soil pH in the treatment of giving legume litter 20 tons/ha to neutral values (Table 3), where if the pH of the soil was at neutral levels, the availability of P would increase. Stevenson (1982) explains the availability of P in the soil can be increased by the addition of organic matter by reducing phosphate sorption because humic acid and fulvic acid function to protect sesquioxide by blocking exchange sites and forming phospho-humic and phospho-fulvic complexes that can be exchanged and are more available for plants, because phosphate is weakly absorbed in organic matter, thus increasing levels of p-available. These results are in accordance with the research of Morgo et al. (2015) who found that giving legume bokashi was significantly different from other treatments (bokashi johar, bokashi goat manure, bokashi cow manure, bokashi chicken manure, and control) which were able to increase the availability of P.

Mycorrhiza application is not significantly different from the P-available, this is because mycorrhiza has not been able to produce the maximum phosphatase enzyme so that it does not affect the organic P mineralization process into more available elements for plants. Mycorrhiza does not affect the P-available soil but rather the P uptake of the host plant, because its external hyphal tissue plays a role in expanding the absorption capacity of nutrients so that plants get enough phosphorus nutrients for plant growth and production. This is in accordance with Yusra's (2005) study that mycorrhiza administration had no significant effect on the total P, available P and Ultisols soil pH.

Ca^{2+} and Mg^{2+}

Table 7. Effects of application of Mycorrhiza and Organic Matters on the average of Ca^{2+} dd (me %)

Treatment	Organic Matters				
Mycorrhiza Dose	BO	B1	B2	B3	Average
M0	7,82	7,19	7,60	6,17	7,14 **p**
M1	9,37	6,43	6,37	6,75	7,23 **p**
M2	7,50	7,03	6,74	5,81	6,84 **p**
Average	8,28 **a**	6,88 **b**	6,91 **b**	6,25 **b**	(-)

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 8. Effects of application of Mycorrhiza and Organic Matters on the average of Mg^{2+} dd.

Treatment	Organic Matters				
Mycorrhiza Dose	BO	B1	B2	B3	Average
M0	1,07	1,14	1,12	1,23	1,14 **p**
M1	1,15	1,29	1,27	1,35	1,26 **p**
M2	1,24	1,02	1,35	1,16	1,19 **p**
Average	1,15 **a**	1,15 **a**	1,25 **a**	1,25 **a**	**(-)**

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 7 shows the results of the variance that the application of legume litter 20 tons / ha (B3) was significantly different in reducing the Ca2 + dd parameter. compared to other organic materials, but the mycorrhiza treatment did not show any significant difference in Ca^{2+} dd levels. The level of Ca^{2+} dd from the results of the initial soil analysis that is equal to 12.76 me% has a high level, there is a decrease after the treatment of various kinds of soil organic matter. The application of legume litter 20 tonnes/ha (B3) gives the lowest Ca^{2+} dd yield. This is because the legume litter is an organic material that has a low C / N ratio which causes the decomposition process to run faster. This is shown by increasing levels of C-Organic (Table 4), decomposed organic material will produce organic acids that increase cation exchange capacity (Table 5), but reduce base saturation and pH (Table 3). Organic matter which is rich in functional carboxyl (COOH) and phenolate (OH) functional groups plays a role in chelating and decreasing Ca^{2+} activity in soil solution which further promotes the dissolution of natural phosphate so that phosphate becomes available (Table 6). This is in accordance with research Tambunan, et al., (2014) corn plants at the age of 14 DAP showed the treatment of the combination of 20 t / ha biochar corn litter and 40 t / ha sugarcane litter (Fresh Organic and Biochar) which was the best in reducing Ca -dd soil that is equal to 18.75%.

The mycorrhiza treatment did not show any significant difference to the parameters of Ca^{2+} dd levels. This is because mycorrhiza in maize aged 2 MST has not been able to produce more organic acids so that it does not increase the concentration of H^+ ions, namely by showing that there is no significant difference in soil pH (Table 3) so it has not been able to replace / hydrolyze Ca^{2+} cations dd in the ground.

The parameters of Mg2 + levels showed that the application of organic matter and mycorrhiza treatment did not show any significant difference to the parameters of Mg2 + dd. This is because the soil organic matter and mycorrhiza are still unable to further mineralize, so it does not add more Mg2 + concentrations in the soil. Whereas the administration of mycorrhiza plays a role in increasing nutrient uptake compared to the availability of Mg, plant roots inoculated with AMF besides being able to increase the absorption of nutrients P, also able to increase the absorption of other nutrients such as N, Ca, Mg, M, N and Zn (Pan and Cheng, 1988 in Sartini, 2004).

Parameter Plant Growth

Plant Height

Table 9. Effects of application of Mycorrhiza and Organic Matters on the average of Plant Height (cm)

Treatment	Organic Matters				
Mycorrhiza Dose	BO	B1	B2	B3	Average
M0	43,33	122,67	95,67	124,33	96,50 **q**
M1	70,33	151,67	98,67	189	127,42 **p**

M2	97	144	128,67	183	138,17 **p**
Average	70,22 **c**	139,44 **a**	107,67 **b**	165,44 **a**	**(-)**

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Table 9 shows the results of variance in the parameters of the height of maize plants aged 6 MST that the application of 20 tons / ha (B3) Peanut litter was significantly different in increasing the height of corn plants which was higher at 165.44 cm, compared with other treatments. The provision of bean litter can increase the levels of C-Organic (Table 4) and increase the level of P-available (Table 6) so that it can supply nutrient requirements for plants to grow better than without the application of organic matter. Darmawan and Baharsyah (1983) stated that the availability of sufficient and balanced nutrients would affect the metabolic processes in plant tissue better.

The treatment of mycorrhiza 10 g / pot (M1) gives a real difference in increasing the height of the best corn plant that is 127.42 cm, compared with other treatments. Giving mycorrhiza in plants will cause infected roots to have hyphae. Mycorrhiza external hyphae can increase the surface area of contact with the soil, thereby increasing the area of root absorption which makes it easier to access nutrients in the soil. Hifa plays a role in helping plant roots absorb phosphate, nitrogen, sulfur, zinc, and other essential elements (Smith and Read, 2008 in Agustin, 2011). This is in accordance with (Riza, et al, 2015) which states that the combined treatment concentration of 60 mL of tempe / 100 mL water, industrial wastewater and 20 g / plant mycorrhiza given the highest plant height (cm) parameters compared to other treatments.

Plant Dry Weight

Table 10. Effects of application of Mycorrhiza and Organic Matters on the average of Plant Dry Weight 6 WAP (gram)

Treatment	**Organic Matters**				
***Mycorrhiza* Dose**	**BO**	**B1**	**B2**	**B3**	**Average**
M0	2.67 **a** **(p)**	17.24 **a** **(p)**	5.84 **a** **(r)**	13.23 **a** **(r)**	**9.74**
M1	3.63 **b** **(p)**	30.90 **a** **(p)**	8.74 **b** **(q)**	44.75 **a** **(q)**	**22.00**
M2	8.96 **b** **(p)**	24.61 **b** **(p)**	21.12 **bc** **(p)**	59.07 **a** **(p)**	**28.44**
Average	**5.08**	**24.25**	**11.90**	**39.02**	(+)

Description: The (-) sign indicates there is no interaction. The average row and column followed by the same letter shows no significant difference in Duncan's Multiple Range Test of 5%.

Based on Table 10, it is known that the combination treatment of mycorrhiza application 20 g / pot + giving 20 tons / ha Peanut litter (M2B3) has the highest dry weight compared to other types of organic and mycorrhiza combination which is 59.07 grams. Application of organic matter in the soil causes the development of mycorrhiza getting better because of the availability of energy and food sources available by organic matter, while mycorrhiza can modify the physiological roots so as to excrete organic acids and acid phosphatases into the soil. The presence of mycorrhiza activity in roots, helps speed the process of mineralization of organic matter, so that organic material can be decomposed faster with the help of mycorrhiza activity.

The combination of M2B3 treatment can provide a higher dry weight of corn because the application of nut litter has the highest nutrient content compared to other organic matter (Table 2). Good quality organic material can supply the needs of plants for their metabolism. Nitrogen functions as a constituent of amino acids, a protein component of chlorophyll pigments that are important in the process of photosynthesis. According to the research of Yetti, et al (2012) the application of organic matter in the form of mixed compost showed better dry weight of the plant (97.75%), followed by rice straw (91.22%), long bean stover (70.95%), stover Corn (53.82%) when compared to sawdust compost 26.53%. Mycorrhiza infection causes plants to get nutrients more easily than without mycorrhiza, because they have external hyphae that function as root expansion and shorten the distance of nutrient diffusion, especially P elements that are immobile in the soil, so the diffusion process becomes faster. According to Musfal's research (2008) and Kabirun (2002) reported that plants infected with MVA can absorb higher P elements than uninfected plants

4. Conclusion

Application of mycorrhizal dosage has an effect on increasing soil C-Organic, soil cation exchange capacity, and dry weight of plants, but does not affect the levels of P-Available, Ca dd and Mg dd. Application of various types of organic matter has an effect on increasing P-Available, C-Soil Organic, Soil Cation Exchange Capacity, and dry weight of plants, as well as reducing soil pH (H2O) and Ca dd levels, but does not affect Mg dd. Giving mycorrhizal doses and kinds of organic matter interact in increasing the dry weight of plants aged 6 MST and there is no interaction with P-Available, pH, C-Organic, CEC, and Ca & Mg in the soil.

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