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Submission date: 04-Jul-2023 11:14AM (UTC+0800)
Submission ID: 2126258294
File name: ubaedah_2022_IOP_Conf._Ser.__Earth_Environ._Sci._1083_012024.pdf (465.97K)
Word count: 3255
Character count: 16589

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Abstract

This study was conducted to analyze the effect of organic matter application on mycorrhizal inoculated soil on the percentage of AMF infection and the availability of phosphorus nutrients for the growth of mung beans. The research was conducted at the Green House, Universitas Muslim Indonesia, and in the Microbiology laboratory of the Environmental and Forestry Research Institute, Makassar, which was carried out from May to August 2021. This research was conducted in an experimental form based on a completely randomized design consisting of four treatments with three replications. The treatments tested were planting media, namely sand + soil (without organic matter), sand + soil + husk, sand + soil + husk charcoal, and sand + soil + husk + husk charcoal. Parameters observed in this study were total soil P nutrient content, available P content, percentage of mycorrhizal infection, plant height, number of leaves, root length, and root volume. The results showed that the percentage of root infection with the application of organic husk material obtained the percentage of root infection up to 83.67%. Plant growth and nutrient levels of total P and available P were higher with the application of husk organic matter and husk charcoal.

Keywords: organic matter, mung bean, mycorrhizal, root infection

1. Introduction

In Indonesia, mung beans (*Vigna radiata* L) are one of the most important legumes, after soybeans and peanuts [1]. Mung beans contain high enough nutrients [2, 3] causing mung beans to be in great demand by the public to be used as vegetables, snacks, or as industrial raw materials, especially in the beverage industry. This causes the need for mung beans to continue to increase, while the production of mung beans is still very low. Based on data from the Central Statistics Agency in 2018, the national mung bean production reached 235,000 tons, while its demand reached 304,000 tons [4]. The level of national needs continues to increase every year. To cover supply shortages, the perpetrators also import them from several countries.

The productivity of mung beans in Indonesia is still low at 1.19 t/ha [4], while the potential for mung bean production can reach 2.5 tons/ha [5]. The low production of mung beans in the country is due to the development of mung beans generally on marginal dry lands which are faced with low soil

fertility and limited soil water content. Many efforts have been made to increase production in the marginal dry land, for example by using high doses of inorganic fertilizers, but this excessive use creates several environmental risks [6] that will threaten the sustainability of the agricultural system. Besides that, marginal dry land is characterized by low soil organic matter content which will reduce soil biological activity [7], so that the fertilizer applied cannot be absorbed by plants. Therefore, efforts are needed to improve soil fertility in marginal dry land to improve growth and increase the production of mung beans.

One of the efforts that can be done to improve the growth of mung bean plants, so that it can increase their production is to improve soil fertility through the addition of organic matter. Soil organic matter contains all the nutrients necessary for plant growth [8]. [9] suggested that increasing soil organic matter would increase the growth and production of mung beans. Various types of organic matter can be used for planting media such as husks and husk charcoal. The use of husk and husk charcoal as a mixture of planting media will obtain a pivoting planting medium so that the development of plant roots runs optimally and also the ability of husk charcoal to increase the availability of nutrients for plants [10]. The results of the research [11] showed that the use of husk charcoal gave the best results for plant growth rate and leaf area of corn plants. Meanwhile, in lettuce, the use of husk charcoal increases the weight of lettuce biomass [12]. In addition to providing organic matter, soil fertility can also be improved by applying biological fertilizers, such as mycorrhizae. Mycorrhizae or arbuscular mycorrhizal fungi are types of fungi that benefit plant growth, especially on marginal lands faced with abiotic stress problems [13; 14; 15]. Mycorrhizae with plants form a symbiotic relationship of mutualism with the roots of higher plants.

AMF infects plant roots and then produces hyphae intensively so that mycorrhizal plants will be able to increase their capacity to absorb nutrients [16]. Hyphae in mycorrhizae can absorb phosphate elements bound in the soil and become elements available to plants [17]. In addition, the use of mycorrhizae can also protect plants from drought stress, and soil salinity and protect plants from various soil pathogens [18]. Mycorrhizal activity in infecting plant roots is influenced by soil organic matter [19]. Therefore, it is necessary to conduct a study to analyze the effect of the application of organic matter husks and husk charcoal on mycorrhizal inoculated soil on the level of root infection for the growth of mung bean plants.

2. Materials and Methods

This study was conducted at the Green House of the Universitas Muslim Indonesia and in the Microbiology laboratory of the Environmental and Forestry Research Institute, Makassar, Indonesia.

This study was designed with a completely randomized design consisting of four treatments with three replications. The treatment is as follows:

M0 = Sand + soil (without organic matter)
M1= Sand + soil + husk
M2= Sand + soil + husk charcoal
M3= Sand + soil + husk + husk charcoal

The research begins with the preparation of planting media consisting of sand, soil, husks, and husk charcoal. The planting medium is sterilized first. After the media is sterilized, then the media is mixed using a volume ratio by the treatment provisions, namely for planting media sand + soil with a volume ratio of 1:1 (M0), media sand + soil + husk with a volume ratio of 1:1:1 (M1), media of sand, soil, husk charcoal with a volume ratio of 1:1:1 M2) and media of sand, soil, husks, and husk charcoal with a volume ratio of 1:1:1/2:1/2 (M3). The mixed planting media is then put in a polybag of 6 kg/polybag.

Planning of mung bean seeds as many as 3 seeds per polybag and then thinning by maintaining two plants per polybag. The application of mycorrhizal isolates was carried out after the green bean plants were 1 week old by inserting a 10 g/polybag. The maintenance carried out included watering and fertilizing with leaf fertilizer which was given three times with a concentration of 2 g/l of water.

Maintenance is done until the plant flower. The parameters observed in this study included the percentage of root infection, total soil P-content, available P, plant height, number of leaves, root length, and root volume.

3. Result and Discussion

3.1. P-total and P-available of The Soil

The results of soil analysis showed that the application of various types of organic matter significantly affected the total and available P levels. The results of the BNT test in Table 1 show that the application of husk organic matter and husk charcoal (M3) obtained the highest total P content of the soil, namely 14.71 mg/100 g of soil, and significantly different from the treatment without organic matter (M0) and also significantly different from the treatment M1, and M2. Similarly, the available P level parameter showed that the treatment of the application of organic matter husks and husk charcoal (M3) obtained the highest available P of 7.29 ppm, while the treatment without application of organic matter (M0) obtained the lowest available P of 6.15 ppm.

Table 1. P -total and P-available of the soil in Different Types of Organic Matter

Treatment	*P-total (mag/100g)*	*P-available (ppm)*
M0: Sand+soil	13.14 d	6.15 b
M1: Sand+soil+ hus	15.51 c	6.68 b
M2: Sand+soil+ hus charcoal	14.08 b	7.06 a
M3: Sand+soil+ husk+ husk charcoal	14.71 a	7.29 a
LSD 0.05	**0.27**	**0.23**

Note: Numbers followed by different letters in the same column mean that they are significantly different based on the LSD test with a level of 0.05

3.2. Percentage of AMF Infections in Mung Bean Roots

The results of the analysis of the percentage of AMF infection in mung bean roots showed that the percentage of AMF infection in the roots was influenced by the type of organic matter. The results of further tests in Table 2 show that the treatment without the addition of organic matter (M0) obtained a high percentage of AMF infection, namely 86.67%, and significantly different from the treatment of the application of organic matter of husk charcoal and a mixture of husk and husk charcoal (M2 and M3), but not significantly different from the addition of husk organic matter (M1) with a percentage of root infection of 83.89%.

Table 2. Percentage of Mung Bean Root AMF Infection with Various Types of Organic Matter

Treatment	*Infection of Root (%)*	*LSD 0,05*
M0: Sand+soil	86.67 a	22.95
M1: Sand+soil+ husk	83.89 ab	
M2: Sand+soil+ husk charcoal	63.37 b	
M3: Sand+soil+ husk+ husk charcoal	74.45 b	

Note: Numbers followed by different letters mean that they are significantly different based on the LSD test with a level of 0.05

3.3. Plant Height, Number of Leaves, Root Length and Root Volume

The results of observations of plant height, number of leaves, root length and root volume at the age of 6 weeks after planting showed that the application of organic matter significantly affected leaf number and root length of mung bean, but had no significant effect on plant height and root volume

parameters. The average number of leaves of mung bean plants in Table 3 shows that the treatment of application of husk and husk charcoal (M1, M2 and M3) obtained a higher number of leaves, which was between 14.70-15.37 strands and was significantly different from the number of leaves obtained. without the addition of organic matter (M0). he root length parameter showed that the application of husk charcoal organic matter (M2) resulted in a significantly longer root that was 36.33 cm compared to the treatment without organic matter (M0) and the treatment of husk organic matter (M1).

Table 3. Effect of Types of Organic Matter on Plant Height, Number of Leaves, Root Length and Root Volume of Mung Beans at 6 WAP

Treatment	Plant Height (cm)	Number of Leaves (sheet)	Root Length (cm)	Root Volume (ml)
M0: sand + soil	31.67	10.00 b	21.33 c	1.67
M1: sand + soil + husk	33.00	15.37 a	24.33 bc	2.67
M2: sand + soil + husk charcoal	33.97	15.33 a	36.33 a	2.33
M3: sand + soil + husk+ husk charcoal	34.40	14.70 a	31.00 ab	2.00
LSD 0.05	ns	1.73	10.22	ns

Note: Numbers followed by different letters in the same column mean that they are significantly different based on the LSD test with a level of 0.05 Ns = not signifikan

3.4. Discussion

The addition of organic matter to the growing media will increase the availability of nutrients. The results of research on the use of organic matter from husks and husk charcoal increase the nutrient content, especially available phosphorus which can be absorbed by plants. The decomposed organic matter will produce organic acids which form chelation bonds with Al and Fe ions thereby releasing the adsorbed P so that the availability of P increases [20]. According to [21], the addition of organic matter will increase fertilization efficiency, because the decomposition of organic matter produces organic acids that can provide nutrients for plants. The increase in available P-nutrient levels was also due to the increase in the percentage of mycorrhizal infections in mung bean roots. Mycorrhizal fungus infection produces a phosphatase enzyme that is released due to mycorrhizal activity which is ultimately able to release P which is fixed by Al and Fe ions so that soil P nutrient levels increase [22]. [23] and [24] also reported an increase in P-total and P-available levels in mycorrhizal inoculated soil with the addition of organic matter.

The percentage of AMF infection in the roots of mung bean plants was highest in the treatment without the addition of organic matter but was not significantly different from the provision of husks with the percentage of AMF infection greater than 80%. This indicates that the provision of husks has a positive effect on the activity of mycorrhizal in infecting the roots of mung bean plants. This is by the results of the research by [25] which showed that the highest percentage of AMF infections was obtained by administering organic matter (manure). The high percentage of AMF infections resulted in better plant growth and this was supported by the availability of nutrients, especially phosphorus, which is a macronutrient needed for plant growth [26]. AMF works by infecting the root system of plants to produce hyphae that grow expansively and penetrate the subsoil layer, which will increase the ability of roots to absorb nutrients and water, thereby increasing plant growth.

The increased availability of P nutrients and the high level of AMF infection in mung bean roots encourage better plant growth. The better plant growth was supported by the significantly higher number of leaves and long roots in the media with husk charcoal and a mixture of husk and husk charcoal. The use of husk charcoal in rice was also reported by [27] and found that the administration

of husk and husk charcoal increased the growth and production of rice plants. This is because the addition of husk and husk charcoal to the growing media makes the growing medium more porous, so that root development is freer, besides that husk and husk charcoal are rich in carbon and other primary nutrients [28].

4. Conclusion

The use of organic material in the form of rice husks obtained a percentage of root infection by AMF of 83%. Nutrient levels of total P-total and P-available were higher in the application of a mixture of husk organic matter and husk charcoal so that the growth of mung beans was better.

Acknowledgements

Thanks are conveyed to the Directorate General of Higher Education for providing research funding assistance through the Higher Education Leading Research Scheme for the 2021 Fiscal Year.

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