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Full Length Article

Isolation and a Potential Test of Fungal Consortium as Biofertilizer from Mount Lawu, Indonesia

Retno Rosariastuti[1*], Nanda Mutiara Pradiana Wulandari[1], Setya Nugraha[2], Evi Irawan[3], Siti Maro'ah[1] and Sumani[1]
[1]*Department of Soil Science. Faculty of Agriculture, Sebelas Maret University, Surakarta, 57126, Indonesia*
[2]*Department of Geography Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, 57126, Indonesia*
[3]*Department of Agribusiness, Faculty of Agriculture, Sebelas Maret University, Surakarta, 57126, Indonesia*
[*]For correspondence: retnobs@staff.uns.ac.id
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Abstract

The present research aimed to obtain materials for making biological fertilizers in the form of functional fungal consortiums and then test their ability to support plant growth. This was descriptive-exploratory and experimental research with *Brassica rapa* L. as the test plant. Fungi were isolated by culturing soil samples on a potato dextrose agar medium with the spread plate method followed by morphological and physiological observation and molecular identification. Biofertilizer was produced by culturing the fungal consortium in the potato dextrose broth medium. The research used a completely randomized design, with the source of fungal consortium as the treatment. Pakcoy planting in Regosols was used as the medium. Parameters observed were soil pH, C-organic, N-total, P-available, K-available, plant height, leaf number, and dry weight. Four fungal species namely *Aspergillus flavus*, *A. ibericus*, *A. aculeatus* and *Aspergillus* sp. were obtained. The results regarding potential of the fungal consortium as a biofertilizer showed that the forest land fungal consortium treatment had the best result in plant height: 27 cm, which was 35% higher than the control, number of leaves: 10 leaves, which was 42.8% higher than the control, and plant dry weight: 0.42 g which was 50% higher than the control. Forest land fungal consortium increased soil pH from 6.19 to 6.83 (near neutral) and K-available from 0.13 me 100 g^{-1} to 0.30 me 100 g^{-1}. The vegetable garden land fungal consortium could increase N-total from 0.06 to 0.12% and P-available from 1.72 mg kg^{-1} to 2.55 mg kg^{-1}.

Keywords: Biofertilizer; Exploration; Fungi; Land use; Mount lawu

Introduction

Mount Lawu is located on the border of Karanganyar Regency in Central Java, with Ngawi Regency and Magetan Regency in East Java. According to Noviani *et al.* (2020), most of the soil types on Mount Lawu are Andisol soils. Vistoso *et al.* (2021), stated that volcanic soils such as Andisol have low available phosphorus content. According to Poblete-Grant *et al.* (2020), Andisol soils are rich in minerals such as allophane, iron, and aluminium, which cause high phosphorus levels. Different land use will affect the abundance of microorganisms in the soil. Based on the results of research conducted by Moora *et al.* (2014), different types of land use will affect the type and abundance of fungi in the soil. Rosariastuti *et al.* (2023) stated that forest land around the slopes of Lawu Mountain has low diversity of plant species but has a high density, this condition causes the environment at that location to become wet and humid, making it ideal for growth of various organism. This allows functional fungi such as P-solubilizing fungi, K-solubilizing fungi, and nitrogen-fixing fungi to exist in the soil. Hence, the soil in Mount Lawu has the potential to be used as a source of functional fungi isolates.

In general, one of the efforts made by farmers to increase agricultural products is to prioritize the use of inorganic fertilizers because they are considered easier to apply. Guo *et al.* (2021) stated that excessive use of inorganic fertilizers over time can cause serious problems such as soil degradation, greenhouse gas emissions, and food insecurity. An alternative can reduce inorganic fertilizers, specifically biofertilizers that utilize microorganisms such as functional fungi (Javaid and Bajwa 2011). Organic fertilizers can improve soil quality and sustainable crop productivity because they have many agroecosystem functions (Javaid and Mehmood 2010; Hammad *et al.* 2020).

A biofertilizer is a fertilizer that contains one or more microorganisms that can convert unavailable nutrients into more available nutrients for plants (Mohsen *et al.* 2022).

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According to Kumar *et al.* (2017), fungi in biofertilizers can provide plant-available nutrients through biological processes such as nitrogen fixation as well as dissolving K and P. Biofertilizers have advantages compared to chemical fertilizers, such as being more cost-effective (materials available in nature and farmers can make by themselves) and environmentally friendly, as well as ensuring sustainable agricultural production (Javaid 2009; Raimi *et al.* 2021). The utilization of biological technology made from active microorganisms such as functional fungi is one of the efforts that can be made to support sustainable agriculture. Mitter *et al.* (2021) stated that biofertilizers are essential in supporting sustainable agriculture, which has long-term effects on soil fertility. The research aimed to obtain materials for making biological fertilizers in the final fungal consortium and then test their consortiums to support plant growth. Therefore, fungal consortia must be explored to obtain functional fungi isolates that can be used as biofertilizers.

Materials and Methods

Methods

The research was divided into two stages: the exploration of fungal consortia and the testing potential of fungal consortia as biofertilizers. The first stage was descriptive-exploratory, using a survey method to obtain fungal isolates. The next stage used an experimental procedure in a greenhouse using Pakcoy plants, and the design used was a completely randomized design consisting of five treatments, namely NPK fertilizer as a control, paddy fields fungal consortium biofertilizer, forest land fungal consortium biofertilizer, vegetable garden land fungal consortium biofertilizer and residential land fungal consortium biofertilizer. Pakcoy seeds were bought from Infarm Official Shop Surabaya, and fungal isolates from the western slope of Mount Lawu, Central Java, Indonesia, were successfully isolated. All the treatments were done in triplicate, so there were 15 experimental units with a 30 cm between spacing pots. The observation variables consisted of morphological identification of fungi, physiological identification of fungi, molecular identification of fungi, and chemical analysis of soil consisting of soil pH (Electrometry), C-organic (Walkey and Black), N-total (Kjedahl), P-available (Olsen), and K-available (Flamephotometer).

Time and location

This study was conducted from May 2022 to February 2023 on the western slope of Mount Lawu, Karanganyar Regency, Central Java Province, Indonesia, for soil sampling as a source of fungal isolates using the survey method. The survey was conducted on four land uses consisting of paddy fields (7°40'13.58"LS, 111°6'9.45"BT for upper slopes and 7°39'50.07"LS, 111°5'29.72"BT for lower slopes), forest land (7°40'38"LS, 111°8'57.5"BT for upper slopes and 7°40'35.38"LS, 111°8'58. 61"BT for the lower slope), vegetable garden land (7°39'50.42"LS, 111°10'0.87"BT for the upper slope and 7°40'4.68"LS, 111°9'45.93"BT for lower slopes), and residential land (7°40'4.64"LS, 111°7'25.66"BT for upper slopes and 7°39'50.34"LS, 111°5'26.71"BT for lower slopes).

The soil was then brought to the Laboratory of the Faculty of Agriculture, Sebelas Maret University, Central Java, Indonesia, for microbiological and soil chemical analysis. The microbial analysis was conducted at the Soil Biology and Biotechnology Laboratory, while the chemical analysis was performed at the Soil Chemistry Laboratory.

Sampling

Sampling was conducted in May 2022. Soil sampling was carried out around the plant rhizosphere. For each land use type, two samples were taken: one from the upper slope and one from the lower slope. For each point, soil samples were taken at an adequate depth of about 20 cm from the soil surface and a non-effective depth of up to 50 cm.

Fungal exploration

Fungi isolation: Fungi isolation was carried out by growing fungi from four land uses on the western slope of Mount Lawu on a potato dextrose agar medium. The following process was to prepare the isolated source by dissolving 5 g of soil samples in 45 mL of physiological salt and then shaking it until homogeneous and settled. Then, 1 mL of the sedimented solution was taken, put into a reaction tube with 9 mL of physiological salt and labelled with the code 10^{-2}. Serial dilutions were carried out until a 10^{-5} dilution was obtained. The results of each dilution were cultured into a petri dish containing potato dextrose agar medium that had solidified and then incubated at room temperature. After that, a mixed culture was obtained, and purification was carried out by transferring one different fungi colony to a new sterile potato dextrose agar medium until a single culture was obtained.

Identification of fungi morphology and physiology: Morphological identification of successfully isolated fungi was done using macroscopic and microscopic observations. Macroscopic observations included colony surface color, colony edge color and bottom color of fungi colonies. Microscopic observations were made using a microscope, including fungi spores and hyphae. Physiological identification was carried out by growing fungi at different temperatures and pH conditions (Sulistiyono 2017). The temperatures used in the physiological identification were 4°C as the minimum temperature, which is the temperature for the refrigerator, 28°C, which is room temperature, and 40°C as the optimum temperature (Putir *et al.* 2021). According to Hakim *et al.* (2020), some members of the genus *Aspergillus* can grow well at 40°C because the fungi biomass generally increases at that temperature. The pH used was pH 4 as the minimum pH, 7 as the neutral pH and 9 as the alkaline pH.

Molecular identification: Molecular identification of each fungal isolate was done using the polymerase chain reaction method using universal primers ITS1-ITS4, which were sent to PT. Genetika Science Indonesia Laboratory. Molecular identification started with DNA extraction using the Quick-DNA fungal Miniprep Kit (Zymo Research, D6005). The DNA extraction results were amplified with MyTaq HS Red Mix (Bioline, BIO-25048). The amplification results would obtain gene sequences later used as sequencing material. DNA sequencing used a bi-directional sequencing method, and the sequencing results were analyzed using the Basic Local Alignment Search Tool program and phylogenetic tree construction.

Testing the potential of fungal consortium as a biofertilizer

Preparation of liquid inoculum as biofertilizer: Liquid inoculum was prepared by growing each fungal isolate from the four land uses on 100 mL potato dextrose broth liquid medium for each land use. Potato dextrose broth media were made by boiling 250 g of potatoes in 750 mL of distilled water to extract. The extract obtained was then put into an Erlenmeyer, and dextrose was added with 1 g 100 mL^{-1} of potato extract. Then, it was sterilized using an autoclave for 15 min at 121°C. The next step was to put the fungal isolates from each land use into potato dextrose broth media and then shake at 70 rpm for 2 × 24 h. After that, the spore density was calculated using a hemocytometer to determine the dose to be given to plants.

Planting: The process started with preparing planting media by drying the soil taken from the Colomadu sub-district area, Regosol soil, then sieved using a 2 mm sieve. The results of the sieved soil were weighed (3 kg for each pot). The sieved soil was sterilized first by steaming (steam sterilization) for 3 h day^{-1} in three consecutive days. Next, Pakcoy seeds were planted as a test plant to determine the ability of the fungal consortium to be a biofertilizer. After seven days, the seeds were transferred into pots containing sterile soil. The pots were placed according to the experimental design with 30 × 30 cm spacing.

The application of fungal consortium as biofertilizer and NPK fertilizer was done one week after planting to let the plants adjust to the planting media and environmental conditions so they could grow well. The liquid inoculum of the fungal consortium was given as much as 30 mL with a spore density of 10^7 spores mL^{-1} by pouring around the plant roots. The application of NPK compound fertilizer as the control was at the recommended dose of 300 kg ha^{-1}, so the dose for each pot was 0.45 g given directly around the plant. Maintenance activities included daily watering twice a day in the morning and evening, weeding, and controlling pests or diseases. Plant parameters, *i.e.*, plant height and number of leaves, were observed once a week. Harvesting was done 35 days after planting. Harvesting was done by pulling the plants from the pots and weighing the plants to get the fresh weight data. Then, the plants were dried using an oven for 24 h until a constant weight was obtained to obtain the dry weight data. The soil used as the planting media was first analyzed in terms of its chemical characteristics before planting and after harvesting. The observation parameters were soil pH, C-organic, N-total, P-available and K-available.

Data analysis

Data were statistically analyzed using ANOVA (analysis of variance) followed by DMRT (Duncan's Multiple Range Test) and correlation test.

Results

Fungi isolation

Based on the fungi isolation results, the rice fields resulted in 19 fungal isolates, 15 fungal isolates on forest land, 14 fungal isolates on vegetable gardens, and 13 fungal isolates on residential land. The results of the fungal isolates from the four land uses were then selected based on the best colony growth marked by clear colony color and the number of dominant colonies in one petri dish. Based on the screening results, two fungal isolates from paddy fields, four from forest lands, two from vegetable gardens and two from residential lands were obtained.

Morphological identification of fungi colonies

The characteristics of isolate A1 included a greenish-yellow surface on the colony with white edges, a pale bottom, a round spore with a green color and septate hyphae. The isolate S2b(2) had black colony surface, white colony edges, a pale yellow colony bottom, blackish-green spore and septate hyphae. The characteristics of isolate H2a include an orange-red surface on the colony with white edges, reddish back of the colon, a yellow-green spore and septate hyphae. Isolate Y1b had a brownish-black colony surface with white edges, a brownish-with bottom, a green spore, and septate hyphae.

Physiological identification of fungi colonies

According to the identification results of fungi physiology, the fungal isolates found could grow in all pH conditions. Still, they could only grow at 28 and 40°C.

Molecular identification of fungi colonies

Fig. 1 and Fig. 2 show the gene amplification results of isolates A1, S2b(2), H2a and Y1b. Letter M in the

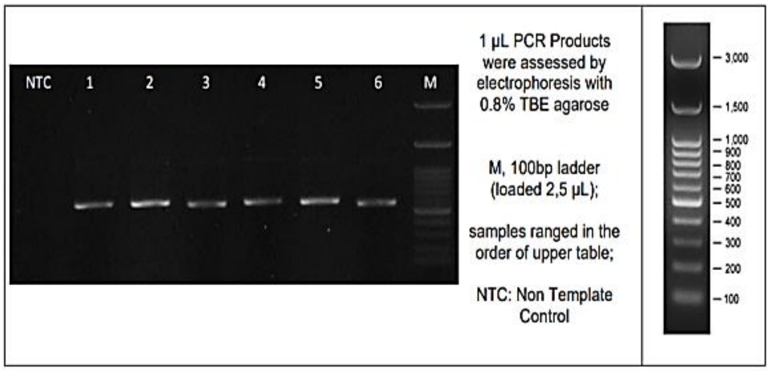

Fig. 1: Amplification results of isolate A1
Number 1 is a DNA band owned by isolate A1

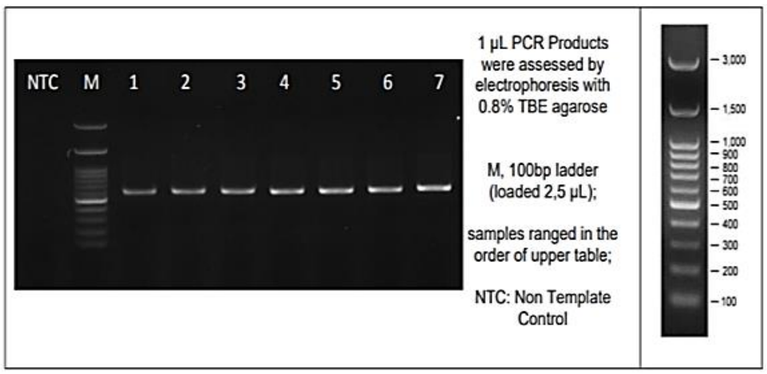

Fig. 2: Amplification Results of Isolates S2b(2), Y1b and H2a
Number 2 is a DNA band belonging to isolate S2b (2), number 5 belongs to isolate Y1b and number 7 belongs to isolate H2a

amplification results above is a marker. Fig. 1 is a DNA band owned by isolate A1 with a DNA molecular weight of about 600 bp. Fig. 2 is a DNA band belonging to isolates S2b (2), Y1b and H2a with a DNA molecular weight of about 700 bp.

Based on the sequencing results, isolate A1 had a DNA length of 589 bp. Based on the results of BLAST analysis and phylogenetic tree construction, it can be concluded that isolate A1 had the most similarity to *A. flavus*. Based on the sequencing results, isolate S2b(2) had a DNA length of 615 bp. Based on the results of BLAST analysis and phylogenetic tree construction, it can be concluded that isolate S2b(2) had the most similarity to *A. ibericus.* Based on the sequencing results, isolate Y1b had a DNA length of 562 bp. The results of phylogenetic tree construction show that isolate Y1b had the closest kinship to *A. aculeatus.* Based on the sequencing results, isolate H2a had a DNA length of 503 bp. Based on the results of BLAST analysis and phylogenetic tree construction, it can be concluded that isolate H2a had the most similarity to *Aspergillus* sp. Based on the results of BLAST analysis and phylogenetic tree construction, it can be concluded that the fungal consortium from each land use is obtained, as shown in Table 1.

Initial soil characteristics of planting media

The initial soil analysis (Table 2) showed that the soil had a slightly acidic pH, which was 6.19. The C-organic content of the soil was low at 1.92%. According to the results of the analysis, the nitrogen and phosphorus content fell in the deficient category, which was 0.06% for soil N-total and 1.72 mg kg^{-1} for soil P-available. The K-available content was also low at 0.13 me 100 g^{-1}. From the preliminary analysis, it can be concluded that the soil still had a low fertility level.

Effect of treatment on final soil characteristics

Soil pH: The treatment generally increased the soil pH compared to the initial soil, with a range of 4.6 to 10.3%. The ANOVA results (Table 3) showed that the application of fungal consortium as biofertilizer significantly affected soil pH ($P < 0.05$). Table 3 shows that the forest land fungal consortium treatment could lead to the highest increase in pH compared to the control and other treatments, which was 10.3%. The soil pH in the forest land fungal consortium treatment was 6.83 (5.6% higher than the control). The results of the DMRT analysis showed that the forest land

Table 1: Fungal consortium from each land use

No	Land Use	Species
1	Rice Field	*A. ibericus* and *A. flavus*
2	Forest Land	*Aspergillus* sp., *A. ibericus*, *A. aculeatus*, and *A. flavus*
3	Vegetable Garden Land	*A. aculeatus* and *A. flavus*
4	Residential	*A. aculeatus* and *A. flavus*

Source: Primary data

Table 2: Results of initial soil characteristics analysis of planting media

No	Parameter	Unit	Result	Classified
1	pH	-	6.19	Slightly acidic
2	C-organic	%	1.92	Low
3	N-total	%	0.06	Very low
4	P-available	mg kg^{-1}	1.72	Very low
5	K-available	me100 g^{-1}	0.13	Low

Source: Primary data

Table 3: Effect of treatment on final soil characteristics

No	Treatments	Parameters				
		pH	C-organic (%)	N-total (%)	P-available (mg kg^{-1})	K-available (me 100 g^{-1})
1	N	6.47a	1.09b	0.09a	2.16a	0.21a
2	LS	6.50a	1.10b	0.09a	2.25b	0.25b
3	LH	6.83c	1.06a	0.11bc	2.32b	0.30c
4	LY	6.63b	1.12c	0.12c	2.55d	0.27bc
5	LP	6.61b	1.11bc	0.10ab	2.33c	0.28bc

Source: Primary Data
N = NPK fertilizer as a control; LS = fungi consortium biofertilizer from paddy fields; LH = fungi consortium biofertilizer from forest land; LY = fungi consortium biofertilizer from vegetable garden land; LP = fungi consortium biofertilizer from residential land

fungal consortium treatment was significantly different from the control and other treatments.

C-organic: In general, treatment of fungi consortium caused a decrease in C-organic content compared to the initial soil, with a range of 41.6 to 44.8%. ANOVA results (Table 3) showed that the application of fungi consortium as biofertilizer interaction significantly affected soil C-organic ($P < 0.05$). The results showed that the highest decrease in C-organics occurred in the treatment of forest land fungi consortium, which amounted to 44.8%, and the C-organic value was 1.06%. The results of the DMRT analysis showed that the consortium treatment from forest land fungi was significantly different from the control and other treatments.

N-total: Generally, the fungal consortium treatment increased soil N-total content compared to the initial soil, with a 50 to 100% range. The ANOVA results (Table 3) showed that the application of fungal consortium as biofertilizer significantly affected soil N-total ($P < 0.05$). Table 3 reveals the highest results were found in treating vegetable garden land fungal consortium. The N-total value in the vegetable garden land fungal consortium treatment was 0.12% (33.3% higher than the control), and the increase was 100%. The DMRT results showed that the treatment of the vegetable garden land fungal consortium was not significantly different from that of the forest land fungal consortium treatment. Still, the difference between the control and the other two treatments was significant.

P-available: The treatment consortium generally increased the soil P-available content compared to the initial soil, with a range of 25.6 to 48.3%. The results of ANOVA (Table 3) showed that the application of fungal consortium as biofertilizer had a significant effect on soil P-availability ($P < 0.05$). The highest was found in the vegetable garden land fungal consortium treatment. The P-available treatment of vegetable garden land fungal consortium was 2.55 mg kg^{-1} (18.1% higher than the control), and the increase was 48.3%. The results of the DMRT analysis showed that the treatment of vegetable garden land fungal consortium significantly differed from the control and the other treatments.

K-available: Generally, the fungal consortium treatment increased the soil K-available content compared to the initial soil, ranging from 61.5 to 130.7%. The ANOVA results (Table 3) showed that the application of fungal consortium as biofertilizer had a significant effect on soil K-available ($P < 0.05$). Based on the analysis, the increase in K-available was highest in the forest land fungal consortium treatment, which was 130.7%, and the value of K-available was 0.30 me 100 $g^{-1,}$ which means 42.9% higher than the control. The DMRT analysis showed that the treatment of forest land fungal consortium showed a significant difference with the power. Still, the difference was not significant with the treatment of vegetable garden land fungal consortium and residential land fungal consortium.

Effect of treatment on plants growth

Plant height: The ANOVA results showed that the treatment of fungal consortium as biofertilizer significantly affected plant height ($P < 0.05$), as shown in Table 4. The results showed that the forest land fungal consortium

Table 4: Effect of treatment on plant growth

No	Treatments	Parameters		
		Plant height (cm)	Number of leaves (strands)	Plant dry weight (g)
1	N	20a	7a	0.28a
2	LS	20a	8a	0.33b
3	LH	27c	10b	0.42c
4	LY	25bc	11b	0.33b
5	LP	22ab	8a	0.34b

Source: Primary Data
N = NPK fertilizer as a control; LS = fungi consortium biofertilizer from paddy fields; LH = fungi consortium biofertilizer from forest land; LY = fungi consortium biofertilizer from vegetable garden land; LP = fungi consortium biofertilizer from residential land

treatment had the highest average plant height, *i.e.*, 27 cm (35% higher than the control). The plant height by the forest land fungal consortium treatment was not significantly different from the vegetable garden land fungal consortium treatment. Still, the difference between the control and the other two treatments was significant.

Number of leaves: The ANOVA results showed that the application of fungal consortium as biofertilizer significantly affected the number of leaves (Table 4). The results of this study revealed that the vegetable garden land fungal consortium treatment resulted in the highest average leaf number. The treatment of vegetable garden land fungal consortium had 11 leaves (57% higher than the control). The number of leaves by vegetable garden land fungal consortium treatment was not significantly different from that of the forest land fungal consortium. Still, the difference between the control and the other two treatments was significant.

Plant dry weight: The ANOVA results showed a significant effect on plant dry weight treating of fungal consortium as biofertilizer (Table 4). The highest results were found in the treatment of forest land fungal consortium. The treatment fungal consortium obtained a dry weight of 0.42 g (50% higher than the control); the dry weight of plants by forest land fungal consortium significantly differed from the control and other treatments.

Discussion

The forest land fungal consortium treatment had the highest pH increase than the other treatments because the forest land fungal portion has the most varied fungi species compared to the fungal consortium from different land uses. The diversity of functional fungi in forest land would decompose soil organic matter because of various base cations that could increase soil pH. An increase in the soil pH to neutral is because soil microorganisms such as fungi decompose soil organic matter. According to Li *et al.* (2022), fungi contribute to the decomposition of organic matter and the carbon cycle. Kaya *et al.* (2017) stated that the decomposition of organic matter will produce basic cations such as Ca^{2+}, Mg^{2+}, K^+ and Na^+, which cause the concentration of OH^- ions, increasing soil pH. The concentration of OH^- ions increases due to the exchange of alkaline cations with other cations on the soil surface, such as H^+. For example, the reaction between calcium ($CaCO_3$) and water (H_2O) from the hydrolysis reaction will release OH^- ions, thus increasing the soil pH (Rini *et al.* 2009). Wan *et al.* (2021) stated that soil pH is a significant factor affecting microbial diversity and activity in the soil.

Based on the results of the study, there was a decrease in the soil C-organic content after being treated. A decrease in the soil C-organic was caused by C-organics undergoing further decomposition by functional fungi to produce base cation. Macias-Benitez *et al.* (2020) stated that soil microorganisms use carbon as an energy source. Nurrohman *et al.* (2014) noted that the decomposition process will produce minerals that are a source of nutrients for plants that would be released by the mineralization process to be used by plants to support their growth. The respiration process in plants and soil can also cause a decrease in C-organic content. Plant and soil respiration will release organic carbon as carbon dioxide (CO_2), thus decreasing the soil's C-organic content. The vegetable garden land fungal consortium treatment, a combination of *Aspergillus aculeatus* and *A. flavus* species, had the highest N-total value compared to the other treatments. Hastuti (2011) stated that the fungus *A. flavus* is included in heterotrophic microorganisms that can produce nitrate. According to Al-Maadhidi and Henriksson (1980), *A. flavus* can increase nitrogen fixation, but its quality is not better than *Trichoderma* because *Aspergillus* species produce more inhibitory substances than *Trichoderma* species. This is in line with the results of this study, which showed that the soil N-total after being treated increased compared to the initial soil, but the results were still relatively low. Some recent studies have shown biocontrol potential of different *Aspergillus* species (Khan and Javaid 2021, 2022).

The treatment of vegetable garden land fungal consortium also resulted in the highest increase in P-available compared to the other treatments. Omomowo *et al.* (2020) stated that *A. flavus* can potentially increase plant growth as a biological fertilizer. *A. flavus* can dissolve phosphate in the soil. The increase in P-available is also influenced by pH. According to Balogun *et al.* (2022), acidic pH usually causes high phosphate dissolution due to the presence of acids that ionize bound phosphate. Still, this species of *Aspergillus* fungi can grow well in neutral soil conditions, so it tends to dissolve more phosphate in neutral conditions. The research results showed that the control treatment with pH 6.47 (slightly acidic) had the lowest P-available content compared to the other treatments whose soil pH was neutral.

According to Ristiari *et al.* (2018), soil microbes such as fungi that dissolve P can also generally dissolve potassium. The fungi species found in the LH fungal consortium treatment namely *A. flavus*, *A. aculeatus* and *Aspergillus* sp. can dissolve P, which means they can dissolve K. According to Li *et al.* (2019), *A. aculeatus* can dissolve insoluble P forms to become available to plants. Li *et al.* (2023) stated that *A. aculeatus* can dissolve K in the soil, encouraging plant growth. According to Sattar *et al.* (2019), fungi dissolve potassium by producing organic acids such as oxalic acid, citric acid, and gluconate, which can damage silicate clay, mica, and feldspar. Based on the study's results, the application of fungal consortium increased K-available in the soil. Plant height is a parameter used to determine the effect of treatment on plant growth. The treatment of forest land fungal consortium resulted in the highest increase in plant height compared to the other therapies, which was 27 cm. Benu *et al.* (2020) stated that the number of biota in the soil affects the soil's physical and chemical properties and plant growth. According to Aulia *et al.* (2016), applying biological fertilizers to plants will cause the formation of functional microbial colonies at the roots to protect the roots from pathogen attacks and break down organic matter to encourage plant growth by increasing the supply of nutrients for plants. The treatment of vegetable garden land fungal consortium resulted in the highest number of leaves compared to the other treatments. Andriani (2017) stated that observations on the number of leaves showed that as the age of the plant increases, the number of leaves also increases. The number of leaves that grow and the age of the plant indicate the activity of vegetative growth in plants.

The highest results were found in the forest land fungal consortium treatment, which obtained a dry weight of 0.42 g. Anjani *et al.* (2022) stated that the number of leaves influences the dry weight of plants because the leaves store photosynthetic products. A more significant number of leaves will increase photosynthesis, which will then be translocated to the plant body. Plant dry weight is also influenced by plant height. According to Pane *et al.* (2014), an increase in plant height will directly affect plant weight.

Conclusion

Four fungal species namely *A.spergillus flavus*, *A. ibericus*, *A. aculeatus*, and *Aspergillus* sp. were obtained from the western slope of Lawu Mountain. The potential test results of the fungi consortium as a biofertilizer showed that the forest land fungi consortium treatment gave the best average results on the yield of *B. rapa* plants.

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Author Contributions

RR, EI, SM, and S designed the research. RR, SN, and NMPW conducted data collection. RR and NMPW conducted analysis and interpretation of the results. RR conducted draft manuscript preparation. All authors reviewed the result and approved the final version of the manuscript.

Conflicts of Interest

No conflicts of interest.

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable to this paper.

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