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The effect of Arbuscular Mycorrhizal Fungi (AMF) on agronomic characteristics of clove seedlings of superior local variety of East Halmahera

Pengaruh Jamur Mikoriza Arbuskula (JMA) terhadap karakteristik agronomi bibit cengkeh varietas unggul lokal Halmahera Timur

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Abstrak

Tanaman cengkeh (Syzygium aromaticum *L.*) *memiliki akar tunggang namun pada musim kemarau sering mengalami kekeringan. Peningkatan luas permukaan perakaran tanaman sejak di pembibitan sangat penting dilakukan untuk menghasilkan tanaman cengkeh dengan akar yang memiliki daya serap tinggi terhadap air dan nutrisi dari dalam tanah. Penelitian ini bertujuan untuk mengetahui pengaruh jamur mikoriza arbuskula (JMA) terhadap bibit cengkeh unggul lokal dan kinerja usaha pembibitannya. Penelitian dilaksanakan di pembibitan cengkeh di Desa Telaga Jaya, Kecamatan Wasile Selatan, Kabupaten Halmahera Timur, Maluku Utara mulai Mei sampai Oktober 2020. Penelitian menggunakan Rancangan Acak Kelompok Lengkap (RAKL), terdiri dari satu faktor yaitu JMA dengan taraf 4 dosis yang diulang 3 kali. Empat dosis JMA yaitu 0 g, 25 g, 50 g, dan 75 g per polybag. Hasil penelitian menunjukkan bahwa pemberian JMA meningkatkan tinggi tanaman, jumlah cabang, jumlah daun, diameter batang, panjang akar, dan bobot basah akar. Usaha pembibitan cengkeh unggul lokal Halmahera Timur mendapatkan keuntungan lebih tinggi bila menggunakan JMA dibandingkan tanpa JMA.*

[Kata kunci: jamur mikoriza arbuskula, pembibitan, karakteristik agronomis, cengkeh, Syzygium aromaticum]

Abstract

Cloves (*Syzygium aromaticum* L.) have taproots but during the dry season the plants often suffer from drought. Increasing the surface area of plant roots in the nursery is very important to produce clove plants with roots that have a high absorption of water and nutrients from the soil. The aim of this study was to determine the effect of arbuscular mycorrhizal fungi (AMF) on the growth of clove seedlings in the nursery and their nursery business. The research was conducted at a clove nursery in Telaga Jaya Village, South Wasile District, East Halmahera Regency, North Maluku from May to October 2020. The study used a Completely Randomized Block Design consisting of 4 treatments and three replications. The treatments were AMF doses: 0 g, 25 g, 50 g, and 75 g on each polybag. The results showed that the application of AMF increased plant height, number of branches, number of leaves, stem diameter, root length, and fresh weight of roots. East Halmahera clove nursery business had higher profits when using AMF than without AMF application.

[Keywords: arbuscular mycorrhizal fungi, nursery, agronomic characteristic, clove, *Syzygium aromaticum*]

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Introduction

Clove (*Syzygium aromaticum* L.) is one of the main plantation commodities in Indonesia and is known to have many varieties, one of which is the local superior clove from East Halmahera. This local clove variety has morphological characters similar to Afo clove and is widely cultivated by farmers in East Halmahera (Cahyaningrum et al., 2021). Conditions in the field show that many plants are old and damaged, so rejuvenation is required. Superior and sufficient quality seeds are the determining factors in the success of clove production. So far, to increase clove production, farmers use an-organic fertilizers, but its continuous use will lead to a decrease in soil and environmental quality (Mahulette et al., 2021). Another limiting factor is drought stress, which reduces growth and photosynthesis (Taiz & Zeiger, 2003). This abiotic stress can be a problem for plants in the dry season. Factors affecting root dispersal are soil temperature, aeration, mechanical barriers, water availability and nutrient availability (Lakitan, 1993). One way to overcome the problem of abiotic stress and rooting conditions in clove plants is by increasing the root surface area since the seedling has a high absorption of water and nutrients to grow well.

Nutrients are available in the soil and can be used for plants to grow and develop properly. The use of arbuscular mycorrhizal fungi (AMF) biological agents can increase the efficiency of water and nutrients absorption by roots. Mycorrhiza is a form of symbiotic mutualism between fungi and the root system of higher plants. This symbiosis can increase the ability of plants to absorb nutrients, especially P, Cu, and Zn and make plants more tolerant to metal poisoning, root disease infection, drought, and other abiotic stresses by increasing root surface area and nutrient transmission (Laksono et al., 2013; Mahulette et al., 2021). AMF can also increase plant growth on soils with low fertility levels or on degraded land and help root function in nutrient absorption (Parihar et al*.,* 2020). The application of AMF during the seedling phase will result in a better symbiosis between the plants and AMF (Putri et al*.,* 2016).

AMF belongs to a group of obligate biotrophic soil fungi which cannot grow separately from their host plants (Simanungkalit et al*.,* 2006). AMF mainly consists of hyphae, vesicle in roots, hyphae and spores in soil (Chen et al*.,* 2017). AMF can form a large network of hyphae in the rhizosphere of plants which increase nutrient and water absorption capacity, promote plant growth and yield, improve soil physical and chemical properties, and improve plant nutritional status by absorption and translocation of nutrients and minerals in the soil outside the root system of the plant (Chen et al., 2017; Putri et al., 2016). Endomycorrhizae are present in more than 86% of plant species and when the hyphae penetrate the cortical cells of the plant roots, they form intracellular arbuscles (Varma et al*.,* 2017).

Utilization of AMF on nursery has been widely carried out. AMF inoculation on pepper seedlings is known to increase the number of leaves (Putri et al., 2016), whereas in coconut nurseries, mycorrhizae increase the volume and dry weight of roots (Ilangamudali & Senarathne, 2016). In oil palm, the provision of AMF alone or in combination has been shown to increase the growth of oil palm seedlings (Rini et al*.,* 2022a). The combination of AMF and *Trichoderma* increase the number and length of clove leaves (Sutarman et al*.,* 2019). AMF also has the potential to act as a biocontrol agent. AMF increase sugarcane growth as well as increase the resistance of sugarcane clone 6239 from moderate susceptible to moderate resistant against orange rust infection (Ismayanti, 2013; Swastiningrum, 2015). In cocoa seedling, AMF reduce the disease intensity of leaf spot disease caused by *Colletotrichum gloeosporoides*. The disease intensity and rate development of purple blotch disease caused by *Alternaria porii* were lower on shallots plant inoculated with AMF than the control (Sari, 2016).

Information on the use of mycorrhizae on local superior clove varieties has not been widely carried out. The use of AMF in clove nurseries is expected to have a better effect on the growth of seedlings include the effect of pathogen infection at the nursery. Therefore, it is important to carry out this research with the aim of knowing the interaction effect of AMF on local superior clove nurseries to obtain the best dosage for the growth of local superior clove seedlings and the feasibility of their farming busines.

Materials and Methods

The research was conducted in Talaga Jaya Village (0°51'45''N, 127°41'54''E), South Wasile District, East Halmahera Regency, North Maluku Province from May to October 2020. The research used a completely randomized block design, consisting of 4 treatments with 3 replications. The treatments were AMF doses, namely 0 g/polybag, 25 g/polybag, 50 g/polybag, and 75 g/polybag. There were 12 experiment units, each unit consisted of 10 seedlings, bringing the total number of 120 seedlings. Each treatment consisted of 3 replications, so there were 360 plants in total.

The clove seedlings used in this research were from a local superior variety of East Halmahera, aged 5 months. The seeds were planted in polybags (20x30 cm), using a planting medium consisting of soil and goat manure with ratio 1:1 (v/v). The mycorrhizal inoculums used were purchased from the market, consisting of a mixture of various types of mycorrhizae, such as *Glomus* sp., *Gigaspora* sp., *Acaulospora* sp., *Laccaria* sp., *Rhizopogon* sp. in zeolite media containing 33 spores/gram. AMF inoculation was done by mixing the inoculums with the planting media and placed them in a polybag. Soil was put into polybags with a volume of about 60% of the size of the polybag. Furthermore, AMF inoculum was sown evenly on the soil surface. The clove seeds were placed on top of the AMF inoculum, covered with soil and watered sufficiently.

Observations were made on the agronomic characteristics of the clove seedlings, the intensity of clove leaf spot disease, and the percentage of root colonization by AMF. Observations on agronomic character parameters included plant height, number of branches, number of leaves, stem diameter, root length, and root fresh weight. Measurement of vegetative growth of clove seedlings began on 14 days after transferring the seedlings to polybags and was then repeated every month until the seedlings was 17 months old and ready to be transplanted. Observations of root length, root fresh weight and AMF colonization were carried out at the end of the observation.

Observation of cloves leaf spot disease intensity was carried out on clove leaves in each sample. The disease intensity of cloves leaf spot disease observed was the fungus that naturally infects the clove seedlings. Calculations were made by categorizing disease attacks on each leaf observed using a category-based scale from Putri et al. (2016) (Table 1).

The intensity of cloves leaf spot disease was calculated based on the equation according to Herwidyarti et al. (2013) as follows:

$$I = \frac{\Sigma\,(n\,x\,v)}{Z\,n\,N}\,x\,100\%$$

Notes:
I : disease intensity (%)
n : number of plants per attack category
v : score of attack category score
Z : highest score of attack category score
N : number of plants observed

Tabel 1. Leaf spot disease category
Tabel 1. Kategori penyakit bercak daun

Score *Skor*	Category *Kategori*	Indication *Gejala*
0	Healthy	No spot
1	Very light	Leaf spot > 0 – 10%
2	Light	Leaf spot > 10 – 20%
3	Rather severe	Leaf spot > 20 – 40%
4	Severe	Leaf spot > 40 – 60%
5	Very bad	Leaf spot > 60%

Observation of AMF colonization in the roots of clove seedlings was carried out by calculating the percentage of AMF colonization in the roots of clove seedlings determined by the clearing and staining method according to Kormanik et al. (1982) at the Phytopathology Laboratory, Faculty of Agriculture, Gadjah Mada University, Yogyakarta. The percentage of AMF colonization was calculated based on the equation according to Suryati (2017) as follows:

$$\text{AMF colonization} = \frac{\Sigma\,number\,of\,root\,infection}{\Sigma\,number\,of\,root\,observed}\,x\,100\%$$

The data obtained were then analyzed by analysis of variance (ANOVA), if there was a significant effect of treatment detected, the data was analyzed with the Duncan Multiple Range Test (DMRT) at the 5% level. Periodic developmental data of agronomic characters of clove seedlings were analyzed descriptively.

The rate of return to the total cost of clove nursery business was measured by using the ratio of revenue to production costs (R/C ratio) and profit balance (B/C ratio). Agribusiness profits are said to be financially feasible if the R/C ratio is more than 1 (Soekartawi, 2006).

Results and Discussion

Effect of AMF on clove seedling growth

Observations showed that the growth of clove seedlings inoculated with AMF was better than those of without AMF. The application of AMF affected significantly plant height, stem diameter, number of leaves, and number of branches (Table 2). Based on Table 2, there were no differences of plant height and stem diameter among the three AMF treatments used (25, 50, and 75 g mycorrhiza). For the number of leaves and the number of branches, the highest results were on M1 (25 g) treatment. Plant height and number of branches showed no significant difference among the three mycorrhizal dose treatments. Agronomic characteristics of clove seedlings in accordance with RI Minister of Agriculture No. 315/Kpts/KB.020/10/2015 concerning Guidelines for Certification, Distribution and Monitoring of Clove Seedlings (*Syzygium aromaticum*) are a minimum height of 40 cm, uniform seed growth, green leaves and a minimum number of 4 branches per plant (Kementerian Pertanian, 2015). This is in line with the results of Asmayanti (2021) and Putri et al. (2016) who showed that the growth of clove seedlings inoculated with AMF in polybags was better than the control, AMF 15 g increased leaf area, while AMF 10 g increased leaf area, root volume and length of clove seedlings. The application of mycorrhiza 20 g/pot tended to increase the

Table 2. The effect of AMF on the growth of clove seedlings
Tabel 2. Pengaruh JMA terhadap pertumbuhan bibit cengkeh

AMF (g/polybag) *JMA (g/polibag)*	Plant height *Tinggi tanaman (cm)*	Stem diameter *Diameter batang (mm)*	Number of leaves *Jumlah daun*	Number of branches *Jumlah cabang*
0	54.00 a*)	4.37 a	44.00 a	5.43 a
25	60.45 b	5.44 b	83.29 d	7.73 b
50	62.99 b	5.29 b	76.65 c	8.90 c
75	62.88 b	5.34 b	64.03 b	7.47 b

*) Notes: The same letters in the same column show no significant difference with the DMRT test at the 95% level of confidence
*) *Keterangan: Angka dengan huruf yang sama pada kolom yang sama menunjukkan tidak berbeda nyata dengan uji jarak berganda Duncan pada tingkat kepercayaan 95%*

growth and yield of maize (Rusmana et al., 2022). AMF addition also affected the growth of cocoa seedlings (Sariasih et al., 2012). Mycorrhiza at 8 grams/polybag was able to increase the number of tillers of sugarcane by 6.6-folds. AMF was also reported in sorghum and other plants with an enhancement of plant height, number of leaves, biomass, and uptake of total nitrogen, phosphorus, and potassium (Diagne et al*.,* 2020).

The linkage between plants and AMF is described as a reciprocal relationship and a mutually beneficial symbiotic association. The symbiosis between mycorrhizae and plants increases the absorption of nutrients from the soil, especially phosphorus to plants, while mycorrhiza obtains organic carbon from its host plants (Broadley et al., 2012). Carbohydrates are supplied by plants for fungal metabolic activities, while fungi supply nutrients and water for plant growth (Basu et al., 2018). Mycorrhizal protein rich in cysteine (MISSP7) that plays an important role in facilitating mutual interactions between mycorrhizal fungi and host plants (Kang et al*.,* 2020). The treatment without the application of AMF (control) had the lowest stem diameter and the least number of branches and leaves at the 7th week of observation (Figure 1b, 1c, and 1d). This control treatment also had the lowest plant height at 12th week of observations (Figure 1a).

The growth of clove seedlings was slowed down because the nutrients provided were not maximally absorbed by the roots that had not been treated with AMF. In this study the distribution of roots was not observed, but based on the results of the previous research, AMF increased the root surface area which plays a role in the absorption of nutrients from the soil. Astiko et al (2013) stated that the application of AMF plays a role in improving the quality of growth media and the absorption of nutrients N, P, K, Ca, and other microelements. Mycorrhizal mycelium can penetrate the soil core to seek and absorb orthophosphate (Pi) and be delivered to the plant cortical cells. The ability of mycorrhizal fungi to store P in the polyphosphate form enables the fungi to maintain relatively low internal Pi concentrations and efficient P transfer (Bücking & Kafle, 2015). The P element plays a role in the process of cell formation, reproduction, metabolism and energy use. Plant height is strongly influenced by the dose of AMF (Lala et al., 2021). Available N that is absorbed by roots affects the biomass of roots, stems, branches and plant height (Adetya et al., 2019). If there is a deficiency of N, the plant height, root diameter, carotene and chlorophyll content in the leaves will decrease (Lala et al., 2021).

Effect of AMF on leaf spot disease intensity

Leaf spot disease on clove seedlings is caused by *Phyllosticta* sp. The observed attack symptoms were black spots surrounded by a thin red line on the leaves, the leaves became dry, malformations occurred, then the leaves fell and the plants became bare. The disease intensity on the plants observed ranged from 2.63% to 5.28%. The application of AMF in this study had no effect on leaf spot disease infection in the observed plants (Table 3). This can happen because the pathogen is not virulent enough to cause the disease, besides that environmental factors such as the microclimate at the nursery site may not be suitable for the growth requirements of the pathogen.

However, AMF play an important role as an agent that helps build plant resistance against pathogenic infections (Broadley et al, 2012). The mechanism of protection by AMF was improvement of plant host nutrients, competition with pathogens for photosynthates and infection sites, changes in root anatomy and morphology, and activation of host defense mechanisms (Putri *et al.,* 2016).

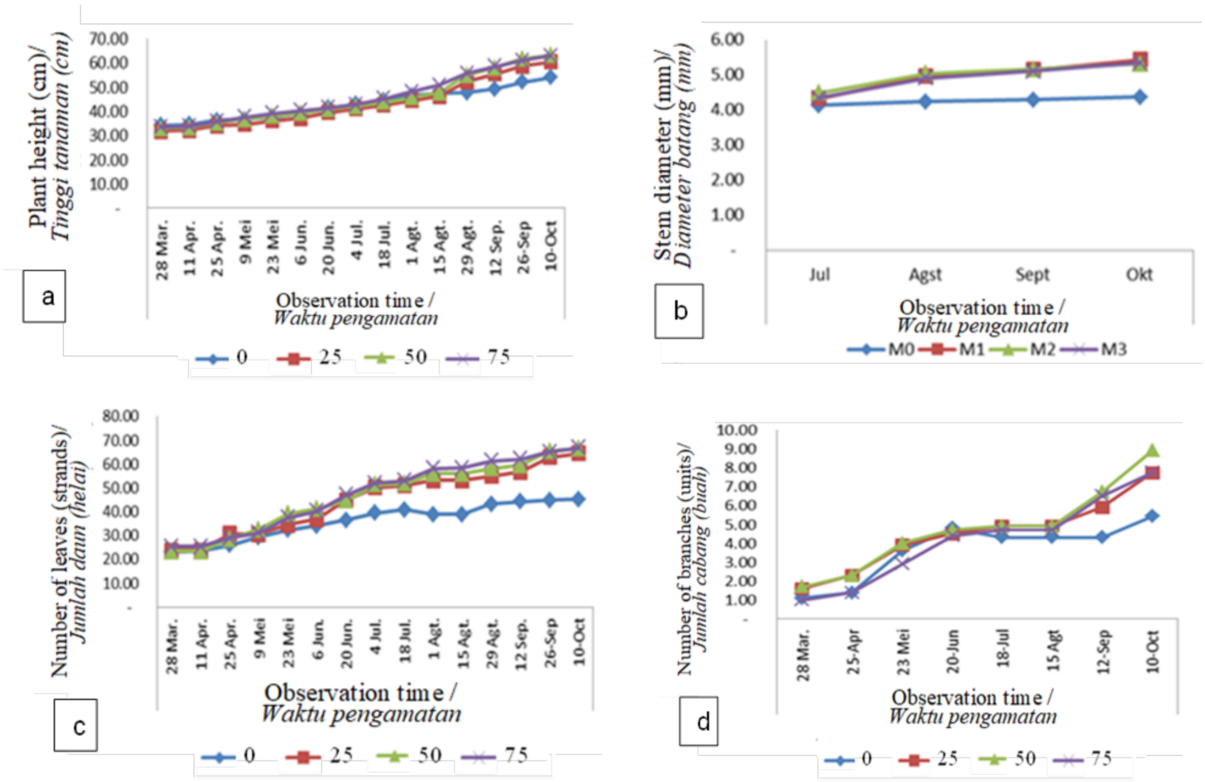

Figure 1. The effect of AMF on the growth of clove seedlings
Gambar 1. Pengaruh JMA terhadap pertumbuhan bibit cengkeh

Table 3. Effect of AMF on cloves leaf spot disease intensity
Tabel 3. Pengaruh JMA terhadap intensitas penyakit bercak daun cengkeh

AMF (g/polybag) *JMA (g/polibeg)*	Disease intensity (%) *Intensitas penyakit (%)*
0	3.67 a*)
25	2.63 a
50	2.67 a
75	5.28 a

Notes: The same letters in the column show no significant difference with the DMRT test at the 95% level of confidence.

Keterangan: Huruf yang sama pada kolom menunjukkan tidak berbeda nyata dengan uji jarak berganda Duncan pada tingkat kepercayaan 95%.

AMF, which belong to the endomycorrhizal group, can increase resistance to pests and diseases. In certain plants, AMF are able to penetrate the cortical cells in the roots to form intra-cellular arbuscular forms. This structure helps the formation of plant resistance by synthesizing phenolic and other compounds and facilitates detoxification of soil organic and inorganic pollutants that interfere with plant productivity (Dwivedi & Ram, 2015; Youssef & Eissa, 2014). AMF enhance the mineral nutrient uptake and photosynthesis of host plants, decrease disease invasion, induce tolerance to extreme temperature changes, reduce heavy metal toxicity, and improve drought stress tolerance (Spinoso-Castillo et al., 2023).

Effect of AMF on clove seedling root

The effect of AMF on clove seedling roots was observed by measuring root length, root fresh weight, percentage of AMF colonization in the roots, and AMF association on plant roots. The results showed that AMF treatment at all doses increased root length and root fresh weight (Table 4). This result is a calculation of a representative sample of plant roots from each treatment without repetition. All treatments showed that AMF colonization in clove roots was from 12-75%. The highest colonization was obtained from mycorrhizal inoculation with a dose of 75 g. AMF infection was also observed in the control with 12% colonization in the roots. This is presumably because the planting medium used already contains local (indigenous) mycorrhizae.

The results of staining on the roots showed that there was an association of AMF in the observed plant roots. The structures observed were external and internal hyphae of the fungi present in the roots of the plants (Figure 2). There were no vesicular and arbuscular structures were found in the roots of the plants observed. Mycorrhizal plant roots would produce internal hyphae, external hyphae, and spores. Root staining causes the vesicular structure to have a bluish color because the structure absorbs the dye solution (Cahyaningrum et al., 2020).

Association of AMF with plant roots will be able to form vesicles and arbuscles. A type of AMF whose hyphae network penetrates into the cortical cells, forming a distinctive oval-shaped structure (vesicles) or branching (arbuscules) is included in the endomycorrhizal group (Musfal, 2010). The structure of the vesicles and arbuscles are specific structures formed by AMF as a sign that AMF colonization has occurred in plant roots (Cahyaningrum et al., 2020).

AMF plays an important role in increasing plant growth by increasing the absorption of plant nutrients through expanding the surface area of absorption on low soil fertility, degraded land and helping to expand the function of the root system in obtaining nutrients (Nurhalimah et al., 2014; Parihar et al., 2020). This growth stimulation is linked to the fact that AMF extends the absorbing network beyond the nutrient depletion zones of the rhizosphere, which allows access to a larger volume of soil. AMF hyphae are much thinner than roots and are able to penetrate smaller pores and uptake more nutrients (Diagne et al., 2020).

There are six genera of fungi that have been shown to form mycorrhizal associations with plant roots, namely *Glomus*, *Acaulospora*, *Gigaspora*, *Sclerocystis*, *Entrophospora* and *Scutellospora* (Lala et al., 2021). Of the six genera of AMF that are commonly found associated with plant roots is *Glomus* sp. This assumption is based on information that around 60-70% of AMF of the *Glomus* sp. infect plant roots. One type of AMF can be in symbiosis with various types of plants, and *vice versa*, one type of plant can be in symbiosis with various types of AMF (Cahyaningrum et al., 2020).

Table 4. Effect of AMF dose on clove seedling rooting
Tabel 4. Pengaruh dosis JMA terhadap perakaran bibit cengkeh

Treatment (g/polybag) *Perlakuan (g/polibeg)*	Root length (cm) *Panjang akar (cm)*	Root fresh weight (g) *Berat basah akar (g)*	AMF root colonization percentage (%) *Persentase infeksi akar JMA (%)*
0	27.0	10.0	12.0
25	46.0	14.9	54.0
50	53.0	14.9	35.0
75	60.0	18.2	75.0

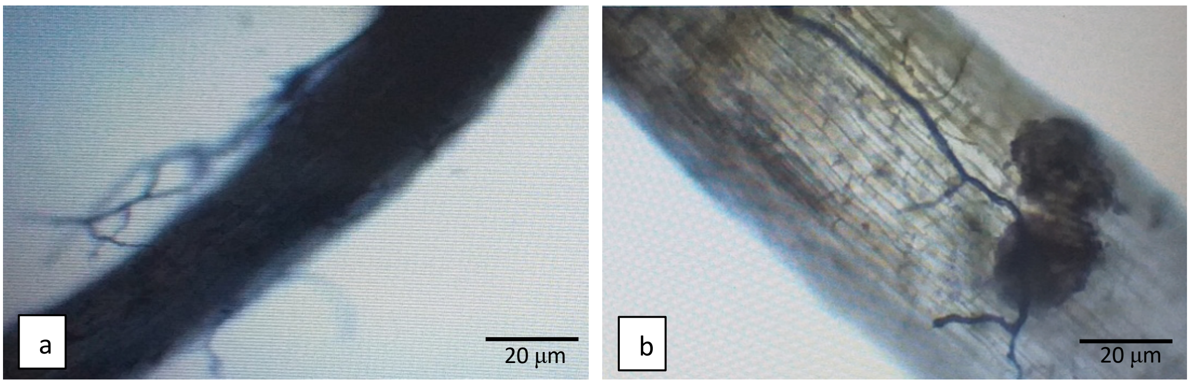

Figure 2. Structure of AMF on clove seedling roots: (a) external hyphae, (b) internal hyphae
Gambar 2. Struktur FMA pada akar bibit cengkeh: (a) hifa eksternal, (b) hifa internal

Analysis of clove seed farming in Talaga Jaya Village, East Halmahera

Clove seedlings treated with AMF showed better morphology than without AMF treatment. Seedlings with mycorrhiza showed optimal growth, plant height and stem diameter, and the number of branches was more than 6 and produced more leaves. Based on the morphological appearance and these various advantages, it can be sold at a higher price, which is IDR 12,500 per seedling. Seedlings without AMF treatment are usually sold for IDR 5,000 per polybag (Table 5). Apart from the advantages mentioned above, the increase in the selling price of mycorrhizal clove seeds was also caused by the increase in production costs for nurseries, including increasing soil volume, polybag size, purchasing compost and mycorrhizae. According to Rini et al. (2022b) AMF application is able to reduce 50% of the need for compound fertilizer in oil palm nurseries, which means it can reduce production costs.

Table 5. Clove nursery financial analysis with AMF in Talaga Jaya Village, East Wasile, East Halmahera
Tabel 5. *Analisis finansial pembibitan cengkeh dengan FMA di Desa Telaga Jaya, Wasile Timur, Halmahera Timur*

No *No*	Description *Keterangan*	Unit *Satuan*	Conventional seedling (without AMF) *Bibit konvensional (tanpa FMA)*			AMF application *Penambahan AMF*		
			Vol *Vol*	Price (IDR) *Harga (Rp)*	Cost (IDR) Biaya *(Rp)*	Vol *Vol*	Price (IDR) *Harga (Rp)*	Cost (IDR) *Biaya (Rp)*
I	Production input							
A	Production facilities							
	a. Clove seeds	kg	12		600,000	12	50,000	600,000
	b. Manure	sack	-	50,000	-	360	20,000	7,200,000
	c. Mycorrhiza	kg	-	-	-	180	75,000	13,500,000
	d. Antracol	kg	1	-	140,000	-	-	-
	e. Defagrid	jar	1	140,000	50,000	-	-	-
	f. Gandasil D	packet	1	50,000	40,000	-	-	-
	g. Green tonic	jar	1	40,000	40,000	-	-	-
	h. Soil	m^3	5	40,000	300,000	-	-	-
	i. Polybag (7 x 12 cm)	packet	15	60,000	600,000	-	-	-
	j. Polybag (15 x 20 cm)	packet	-	40,000	-	60	40,000	2,400,000
	k. Paranet	roll	1	-	1,700,000	2	1,700,000	3,400,000
	l. Hoe	pcs	1	1,700,000	120,000	1	120,000	120,000
	m. Shovel	pcs	1	120,000	100,000	1	100,000	100,000
	n. Bamboo	packet	1	100,000	200,000	1	500,000	500,000
	o. Sprayer	pcs	1	200,000	1,100,000	-	-	-
	p. Water	tank	1	1,100,000	300,000	1	300,000	300,000
	q. Water sprayer	pcs	1	300,000	55,000	1	55,000	55,000
	Total A			55,000				28,175,000
B	Labor expenses (HOK)							
	a. Clove seeds	kg	1	100,000	100,000	1	100,000	100,000
	b. Manure	sack	2	100,000	200,000	2	100,000	200,000
	c. Mycorrhiza	kg	7	100,000	700,000	7	100,000	700,000
	d. Antracol	kg	2	100,000	200,000	-	-	-
	e. Defagrid	jar	11	100,000	1,100,000	11	100,000	1,100,000
	f. Gandasil D	packet	4	100,000	400,000	4	100,000	400,000
	g. Green tonic	jar	3	100,000	300,000	3	100,000	300,000
	h. Soil	m^3	4	100,000	100,000	4	100,000	400,000
	Total B			3,400,000				3,200,000
C	Certification fees and more							
	a. Seeds certification		-	-	-	-	-	-
	b. Other expenses		-	-	-	-	-	-
	Total C		-	-	-	-	-	-
	Total expenses A + B + C			8,745,000				31,375,000
II	Production output							
	a. Production quantities	seeds	7,500			7,500		
	b. Selling price	IDR		5,000			12,500	
	c. Revenue	IDR			37,500,000			93,750,000
III	R/C Ratio				4.29			2.99
	Profit	IDR			28,755,000			62,375,000
	Benefit cost ratio				3.29			1.99

The results of the calculation analysis of clove nursery farming with AMF treatment showed an R/C ratio of 2.99 and a B/C ratio of 1.99 with a profit of IDR 62,375,000 (Table 5). These results indicate that clove seed farming with AMF treatment is feasible to develop. Financially, clove nurseries with mycorrhizae provide a higher level of profit compared to conventional seedling patterns. With a difference in price of IDR 7,500 per seedling, will be very profitable for farmers because the price of seeds will increase by 150%. Seedling buyers can accept this price on the basis that the price is in accordance with the quality of the seedlings.

Conclusion

All doses of AMF application increased the performance of local superior clove seedlings in East Halmahera in term of plant height, stem diameter, number of leaves, number of branches, root length, and root fresh weight. The clove nursery business, with the addition of AMF has the good opportunity to be developed with an R/C ratio of 2.99 and a B/C ratio of 1.99.

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