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Response of Growth Citronellal Grass (Cymbopogon nardus L) by Acaulospora sp Mycorrizha and Different Water Treatments in Ultisol

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Abstract

Citronella grass (*Cymbopogon nardus* L) is one of the essential oil-producing plants from the Gramineae group. This research was conducted in the Greenhouse of the Faculty of Agriculture, Andalas University, Padang from August 2017 until January 2018. This study aimed to determine the effect of *Acaulospora sp* and different water treatments on the growth of citronella grass in ultisol. A completely randomized design with two factors was used. The first factor was treatment with or without *Acaulospora sp*. The second factor was the water supply which consisted of three treatments (saturated, three quarters saturated and half saturated soil). Every treatment was repeated three times. Data were analyzed by analysis of variance using the F-test at the 5% level. Significant differences were further tested using Duncan's New Multiple Range Test also at the 5% level. Treatment with *Acaulospora sp* and 75% saturated soil gave the best number of leaves and canopy to root ratio. Treatment with *Acaulospora sp* showed the best results for the number of tillers, stem diameter, root dry weight, and dry weight of the citronella plants. *Acaulospora spp* promote the growth of citronella grass.

Keywords: Citronella grass, water supply, mycorrhizae,

1. Introduction

Citronella plant (*Cymbopogon nardus* L) is one of the essential oil-producing plants belonging to the Gramineae (grass) family. The essential oil produced by citronella from Indonesia in the world of trade is known as Citronellal Oil of Java, which comes from the Mahapengiri type. This plant produces essential oils which are better known as etheric oils or flying oils.

The percentage of citronella and geraniol content is an important component that must be the quality standard of traded essential oils, because essential oils are important raw materials for various types of industries. In general, essential oils are used as raw materials for disinfectants, soap fragrances, perfumes, cosmetics, increasing octane fuel oil, and flavoring agents. If both percentages of these compounds are low, then they cannot be exported abroad. According to Somaatjaya (1973), the quality of the essential oil produced by the Mahapengiri type has met the Indonesian National Standard (SNI) 06-3953-1995 with a minimum content of citronellal 35% and a minimum of 85% geraniol.

In Indonesia, the area of citronella plantations is still very small. According to BPS data (2015), of the total dry land area in Indonesia, only 19,000 ha or about 0.012% are planted with citronella. The wide area of dry land in Indonesia makes citronella cultivation a good potential to be cultivated into agricultural land with economic value.

Citronella plants which are cultivated on dry land, are only able to produce essential oil yields of around 0.6-1.2%, indicating that the yields produced by citronella are still low compared to essential oil yields produced by patchouli plants of 2-1.2 %. 4.23% (Yuhono and Sintha, 2006), kaffir lime leaves 13.39% (Safaatul and Prima, 2010) and clove flowers 8.6% (Henny et al., 2013). This condition occurs because the citronella root system is only able to grow and develop around the top layer of soil. Besides that, dry land which is a place to grow this plant also has many limiting factors such as low water content and nutrients available to plants that will inhibit plant growth.

Dry land is one of the marginal lands in Indonesia. Dry land has so many problems that it becomes a limiting factor for planting in Indonesia. One type of soil which is the widest part of dry land in Indonesia is ultisol soil. Ultisol is a type of soil in Indonesia which has an area of 45,794,000 ha or about 25% of the total land area of Indonesia (Prasetyo and Suriadikarta, 2006). Efforts to increase the growth and yield of plants cultivated on ultisol land have been carried out, such as increasing the dose of manure that is input into the soil. The application of synthetic chemical fertilizers such as SP-36, Urea, KCL as well as the application of lime, is considered ineffective and efficient until now

One of the efforts to increase growth and yield of citronella plant is the use of Arbuskulaa Mycorrhizal Fungi (AMF). AMF is a symbiosis between soil fungi and plant roots, in which fungi are unable to grow and reproduce when they are not present or in symbiosis with host plants (Obligate) (Smith and Read, 1997). Mycorrhizal fungi can produce phosphatase enzymes, which can dissolve P that is bound in the soil, P (Phosphate) is an essential macro nutrient needed by plants in large quantities. If the availability of P is little in the soil, this will be something that causes the low ability of plants to grow and develop. Brundet et al (1996) stated that mycorrhizae will form a network of external hyphae that are able to grow and develop more widely in the soil, from this hyphal network the process of water and nutrient absorption will occur.

Each type of mycorrhizal found has different characteristics so that the ability to adapt to the environment and host plants is also different. According to Tommerup (1994) these differences in characteristics will affect the number of spores, physical properties, soil pH and the ability to infect host plant roots). Mycorrhizal species Acaulospora sp is tolerant of acid soils and high aluminum (Al). Mycorrhizae of Acaulospora sp are more common in acid soils (Clark, 1997). From the characteristics of the level of adaptation, Acaulospora sp has the ability to be developed on ultisol soils. According to Gonzalo and Miguel (2006), the association between mycorrhizal fungi and plant roots is mutual, that is, both are mutually beneficial. Mycorrhizal fungi can utilize plant root exudates as a source of carbon and energy, while plants more easily absorb nutrients, especially P (Preston, 2007).

2. Materials and Methods

Place and time

This research was conducted in the greenhouse of the Faculty of Agriculture, Andalas University, Padang with an altitude of ± 250 meters above sea level.

Materials and tools

The materials used in this experiment were citronella plant seeds of G3 variety (Appendix 2), ultisol soil, 100 spores of Arbuscula mycorrhizal fungi inoculants in 76 grams in the form of a mixture of sand and plant roots, aquades, 10% KOH, 2% HCl, and 0.05% Tryphan blue in lactofenol. The tools used are polybag size 35 x 25 x 30 cm, plastic bag, rubber, tape measure, hoe, standard pole, analytical scale, 10 kg scale, caliper, object glass, cover glass, beaker glass, newsprint, paper label, film tube, 5 L bucket, scissors, knife, stapler, tweezers, camera phone, water barrel, gallon, hygrometer, stationery.

Experimental design

The design used in this experiment is a factorial pattern in a completely randomized design (CRD) which consists of 2 factors. The first factor was the provision of mycorrhizae with two levels of treatment, namely: No AMF (F0), Acaulospora sp AMF (F1). The second factor is the level of water supply with three levels of treatment, namely: 100% field capacity (11.4 kg) (C1), 75% field capacity (11.1 kg) (C2) and 50% field capacity (10.7 kg) (C3). The data were analyzed by using fingerprint, if Fcount > Ftable, then continued with the DNMRT test at the 5% level.

3. Results and Discussion

Root Colonization By AMF (%)

Observational data on the percentage of colonization were analyzed descriptively. Table 1 below explains that with the administration of mycorrhizae root infection occurs. While without mycorrhizae, root infection does not occur.

Table 1. Mycorrhizal colonization on roots of 12 WAP plants treated with mycorrhizae and the level of water application.

Giving mycorrhizae	Giving rate			Average
	100 % %	75%	50%	
Non Mycorrhizae	0	0	0	0
Mycorrhizae *Acaulospora sp*	56,67	63,33	66,67	62,22

From the table above, it can be seen that the percentage of root colonization infected by mycorrhizal species Acaulospora sp in the treatment with a water application rate of 50% field capacity was the highest percentage of infection compared to other treatments. When the plant is stressed, more mycorrhizal spores are formed. The symbiosis between AMF and plants will help host plants to survive in conditions of water supply, more AMF spores are formed during drought stress (Husin et al., 2012). According to Smith and Read (1997) the compatibility between AMF species and host plants will be a determining factor for the formation of symbiosis. Therefore, the percentage of colonies between fungi and host plants will be influenced by these factors.

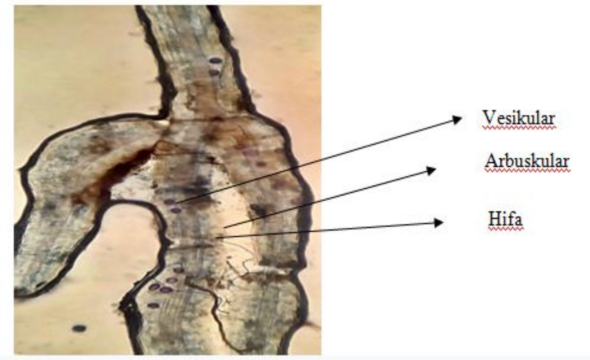

Figure 2. Roots of citronella plant (Cymbopogon nardusL) infected by mycorrhiza Acaulospora sp

Figure 2 explains that the roots of citronella plants infected by AMF are characterized by the presence of vesicular, arbuscular and hyphae. Vesicular is an egg-shaped fungal structure with a size of 30-50 m to 80-100 m originating from swelling of internal hyphae containing fatty compounds that make it an organ for storing food reserves and in certain circumstances can become spores or a tool that is able to maintain fungal life. Brundrett, 2004).

In addition to vesicular, the observations also found arbuscular structures found in the roots of the citronella plant. Arbuscular is a smooth branching of hyphae formed from repeated dichotomous branching so that it resembles a branch (tree) contained in the host cell (Brundrett, 2004). Arbuscular growth and development occurs within the cortical cells of the subapical branches present in the internal hyphae. The arbuscular acts as a place for the exchange of nutrients between the host plant and the fungus

Hyphae are morphological structures found in mycorrhizal fungi that can increase the cruising ability of host plant roots. These hyphae help plant roots expand their absorption area, so that the ability of host plant roots to absorb nutrients and water becomes wider. Hyphae are divided into two, namely internal hyphae and external hyphae. According to Husin et al (2012) internal hyphae play a role in providing nutrients from within or from outside the AMF tissue. External hyphae play a role in expanding the cruising range of the root surface, so that the roots of the host plant are able to absorb the nutrients and water needed by the host plant in greater quantities.

Plant Height

The results of statistical analysis showed that there was no interaction between the provision of mycorrhizae and the level of water supply to plant height. Likewise for the two single factors, each of which did not have a significantly different effect on the height of the citronella plant. The average plant height data can be seen in Table 2.

Table 2. The height of citronella plants at the age of 12 WAP treated with mycorrhiza and the level of water supply

Treatment Mycorrhizae	Water feeding rate			Average
	100 %	75%	50%	
	Cm			
Non Mycorrhizae	114,33	115,83	105,83	111,99
Mycorrhizae *Acaulospora sp*	118,33	119,83	121,17	119,77
Average	116,33	117,83	113,5	
Coefficient diversity = 6,29%				

Description: The numbers in the same column and row are not significantly different according to the 5% level F test

From Table 2 above, it can be seen that the provision of mycorrhizae and the level of water supply did not affect the plant height (cm) of citronella. The effect of giving mycorrhizal species Acaulospora sp with the level of water supply has not been seen in the increase in height of citronella. The average plant height ranged from 105.83-121.17 cm. From Puslitbangbun data (2005), the height of the citronella plant with the type of Mahapengiri variety G3 ranges from 114.4-159.6 cm. The height of citronella plants without mycorrhizal treatment ranged from 105.83-115.83 cm, while with mycorrhizal treatment the height ranged from 118.33-121.17. It can be concluded that the provision of Acaulospora sp AMF tends to have a better effect on plant height. This is thought to be due to the role of mycorrhizae given to citronella

Amount of Leaves

The results of statistical analysis showed that there was an interaction between the provision of mycorrhizae and the level of water supply to the increase in the number of leaves. The average number of leaves can be seen in Table 3.

Table 3. The number of leaves of citronella plants at the age of 12 WAP that were given treatment mycorrhizae and water supply rate.

Treatment Mycorrhizae	Giving rate		
	100 %	75%	50%
	Sheet		
Non Mycorrhizae	14,83 B a	13,17 B b	11,17 B c
Mychorryzhae *Acaulospora sp*	17,33 A a	17,83 A a	17,83 A a
Coefficient diversity = 6,08%			

Description : Numbers followed by different capital letters in the same column and the numbers followed by different lowercase letters in the same row are significantly different according to the DNMRT test at the 5% level

Table 3 shows that in the treatment without mycorrhizae the best level of water administration was 50% for the number of leaves. In the treatment of Mycorrhizae Acaulospora sp, the effect of the level of water application was the same on the number of leaves. Furthermore, at the level of water supply, either 100%, 75% or 50%, the treatment of Mycorrhizae Acaulospora sp was better than without Mycorrhizae. The symbiosis between AMF and the host plant will affect the ability of the host plant to grow and develop. In accordance with the opinion of Husin et al (2012) that AMF and plants will help host plants to survive in conditions of water shortage, more AMF spores are formed during drought stress. The use of mycorrhizae can help the plant root system in absorbing the elements needed by plants. According to (Brundet et al., 1996) states that mycorrhizae will form a network of hyphae that are able to grow and develop more widely in the soil, from this hyphae the process of uptake of water and nutrients will occur.

Number of tillers

The results of statistical analysis showed that there was no interaction between the provision of mycorrhizae and the level of water supply to the number of citronella plant tillers. The treatment level of giving water was not significantly different to the number of tillers of citronella plant (Cymbopogon nardus L). The number of tillers of fragrant lemongrass (Cymbopogon nardus L) was significantly influenced by the mycorrhizal feeding factor. The average number of tillers can be seen in Table 4.

Table 4. The number of tillers of citronella plants at the age of 12 WAP that were treated with mycorrhizae and the level of water supply.

Treatment Mycorrhizae	Give Rate			Average
	100 %	75%	50%	
	Batang			
Non Mycorrhizae	2,50	2,67	2,17	2,44 B
Mycorrhizae *Acaulospora sp*	3	3,17	3,33	3,13 A
Average	2,75	2,92	2,75	
Coefficient diversity = 9,44%				

Description: The numbers in the same column and row are not significantly different according to the 5% level F test

It can be seen from Table 5 that, the average number of citronella saplings that were given treatment using mycorrhizae was better than the treatment without using mycorrhizae. Lemongrass using mycorrhizae can optimize its ability to absorb the elements needed to grow and develop with the help of external hyphae found in mycorrhizae which are in symbiosis with the roots of the citronella plant. Sieverding (1991) explained that the external hyphae of the AMF in symbiosis with the roots of the host plant were able to increase the uptake of other nutrients such as N, K, Mg, Zn, Cu, B and Mo.

True Rod Diameter

The results of statistical analysis on the true stem diameter of citronella citronella showed that there was no interaction between the administration of mycorrhizae and the level of water administration, as well as the treatment level of water administration did not affect the true stem diameter of citronella citronella. The true stem diameter of citronella is significantly affected by mycorrhizal administration. The average increase in true stem diameter can be seen in Table 5.

Table 5. The true stem diameter of citronella at the age of 12 WAP treated with mycorrhizae and the level of water supply.

Treatment Mycorrhizae	Giving Rate			Average
	100 %	75%	50%	
	mm			
Non Mycorrhizae	9,57	9,70	9,30	9,52 B
Mycorrhizae *Acaulospora sp*	9,83	9,93	9,90	9,88 A
Average	9,7	9,81	9,6	
Coefficient diversity = 3,57%				

Description : Numbers followed by different capital letters in the same column and the numbers followed by different lowercase letters in the same row are significantly different according to the DNMRT test at the 5% level

From Table 5 above, it can be seen that in general the growth of stem diameter of citronella plants treated with mycorrhizal type Acaulospora sp was better than the growth of stem diameter of citronella plants that were not treated with mycorrhizae. According to Munir (1996) Ultisol soil is a soil that has many problems in its utilization, one of which is the low content of N, P and K. This will be a factor that can reduce the ability of plants to grow properly.

The presence of mycorrhizae in symbiosis with plant roots will be able to expand the range of nutrient and water absorption in the ultisol soil. In addition, mycorrhizae also produce phosphatase enzymes that are able to decompose bound P in the soil. P which was initially unavailable becomes available P which can be absorbed and utilized by plants for the process of growth and development.

Plant Canopy Dry Weight

The results of statistical analysis of dry weight of citronella plant canopy dry weight showed that there was no interaction between mycorrhizal administration and the level of water administration. For the single factor of each treatment, it gave a significantly different effect on the increase in dry weight of the citronella plant canopy. The average dry weight of the citronella canopy can be seen in Table 6.

Table 6. Dry weight of citronella plant crown at the age of 12 WAP treated with mycorrhiza and the level of water supply.

Treatment Mycorrhizae	Give Rate			Average
	100 %	75%	50%	
	Gram			
Non Mycorrhizae	17,29	17,99	16,79	17,35 B
Mycorrhizae *Acaulospora sp*	19,76	23,51	21,69	21,65 A
Average	18,52 b	20,75 a	19,24 b	
Coefficient diversity =5,07%				

Description : Numbers followed by different capital letters in the same column and the numbers followed by different lowercase letters in the same row are significantly different according to the DNMRT test at the 5% level

Treatment with mycorrhizal type Acaulospora sp gave the dry weight of the citronella plant canopy which was significantly better than the dry weight of the citronella plant crown that was not treated with mycorrhizae. . This is in line with the higher number of tillers and number of leaves from plants treated with mycorrhizae. The dry weight of the plant is the net result of the CO2 assimilation process that the plant accumulates during the growth and development process of the plant (Larcher, 1975). So the better the growth and development of a plant, the dry weight of a plant will also increase. According to Gardner et al (1991) the dry weight of the plant is an illustration of the accumulation of photosynthetic plants. The dry weight of the plant is strongly influenced by the elements needed by the plant and the light received by the plant to carry out photosynthesis.

In the single factor treatment, the level of water given to citronella plants, the best results were obtained at the treatment level of 75% of field capacity with an average value of 20.75 grams. The condition of the water supply level of 75% field capacity, showed that mycorrhizal species Acaulospora sp was able to help the root system of citronella plants to optimally absorb the nutrients needed in the growing media. Mycorrhizal hyphae that are well developed in the planting medium are able to optimize the absorption of nutrients and water needed by citronella plants in the process of growth and development.

Root Dry Weight

The results of statistical analysis showed that there was no interaction between mycorrhizal administration and the level of water administration. For each factor gave a significantly different effect on the dry weight gain of citronella root. The average dry weight of citronella root (Cymbopogon nardus L) can be seen in Table 7 .

Table 7. Dry weight of citronella root at the age of 12 WAP treated with mycorrhizae and the level of water application.

Treatment Mycorrhizae	Water Feeding Rate			Average
	100 %	75%	50%	
	Gram			
Non Mychorrhizae	9,57	10,51	8,98	9,68 B
Mychorrhizae *Acaulospora sp*	11,10	11,45	10,66	11,07 A
Average	10,33 b	10,98 a	9,82 c	
Coefficient diversity =2,90%				

Description : Numbers followed by different capital letters in the same column and the numbers followed by different lowercase letters in the same row are significantly different according to the DNMRT test at the 5% level

The table above explains that the treatment with mycorrhizal species Acaulospora sp showed a better effect on the dry weight of citronella plant roots than the dry weight of plant roots without mycorrhizal treatment. The hyphae produced from mycorrhizae in symbiosis with the roots of the citronella plant can increase the ability of the citronella plant roots to absorb the elements needed for the citronella plant growth process. Arbuscular mycorrhizal fungi are able to absorb water and nutrients, especially P. One of the functions of P for plants is to encourage the formation of young roots in the early stages of growth and play a role in the formation of chlorophyll for plants. According to Brundet et al. (1996) if the availability of P in the soil is not sufficient for plant needs, it will cause the plant's ability to grow and develop is low.

In the treatment factor of the level of water given to citronella plants, the best dry weight of the roots was obtained at the treatment level of water supply of 75% field capacity. It means that citronella plants do not like moist media, thus citronella plants can be an alternative commodity in acid dry land.

Ratio of Roots

The results of statistical analysis showed that there was an interaction between the administration of mycorrhizae and the level of water given to the ratio of citronella root crown, the average ratio of citronella root crown can be seen in Table 8.

Table 8. The ratio of citronella root crown at the age of 12 WAP treated with mycorrhiza and the level of water supply.

Treatment Mycorrhizae	Give Rate		
	100 %	75%	50%
Non Mycorrhizae	1,81 A a	1,77 B a	1,87 B a
Mycorrhizae *Acaulospora sp*	1,78 A b	2,05 A a	2,03 A a
Coefficient diversity = 3,76%			

Description : Numbers followed by different capital letters in the same column and the numbers followed by different lowercase letters in the same row are significantly different according to the DNMRT test at the 5% level

From table 8 above, it can be explained that the best root crown ratio was found in the treatment using mycorrhizal Acaulospora sp and the water application rate was 50% field capacity, and the experiment without using mycorrhizal showed the best increase in the root crown ratio in the treatment with water application level of 50% field capacity.

The root crown ratio is the ratio between the dry weight of the crown and the dry weight of the plant roots. Hidayat (2004) explained that the root crown ratio is a growth parameter of a plant from which it can be seen how the assimilate distribution pattern in plants. The amount of the root crown ratio will be influenced by the species, age and environmental conditions of the growing plants. The more optimal the absorption of the elements needed by plants from the growing environment, the greater the ability of plants to grow and develop properly.

4. Conclusions

Based on the results of the research that has been carried out, it can be concluded that:
Providing mycorrhiza type Acaulospora sp and a water application level of 50% of field capacity showed more influence on the number of leaves and root crown ratio of citronella plants. Application of the mycorrhizal type Acaulospora sp showed better results in the number of tillers, stem diameter, root dry weight, and shoot dry weight of citronella plants. A water level of 50% of field capacity provides better results for the growth of citronella plants.

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