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Effect of Mycorrhizal Provision at Different Watering Levels and Frequency on Nutrient production of Sorghum (*Sorghum bicolor* (L.) Moench)

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ABSTRACT.
Sorghum is a cereal crop that has the potential to be developed as an animal feed crop. This study aimed to determine the effect of giving mycorrhizal fungi at different levels (0, 10 grams, and 20 grams/plant) and different watering frequencies (every day, 4 days, 8 days) on the morphology and the production of forage nutrients of sorghum. This research was carried out in the Greenhouse of Faculty of Animal Science, Universitas Gadjah Mada. This study used a completely randomized design with a 3 x 3 factorial pattern. The variables observed were sorghum morphology, fresh production, and forage nutrient production (DM, OM, CP, CF, and CL). The results showed that the highest sorghum nutrients production (DM, OM, CP, CF, and CL) was found in the mycorrhizal treatment of 10 g/plant and the highest-fiber production was in the treatment without mycorrhizal. The frequency of daily watering did not have a significant effect on sorghum nutrients production. From the study results, the administration of mycorrhizal fungi with different levels increased sorghum nutrients production and reduced crude fiber production. The best treatment was giving mycorrhizae 10 grams/polybag (M10). Different watering frequencies did not have a significant effect on sorghum nutrients production.

Keywords: *mycorrhizal fungi, watering frequency, nutrient production, sorghum*

1 INTRODUCTION

Forage is the main source of ruminants feed. The forage availability, both in quantity and quality, is needed to increase the ruminants productivity. Forage planting management is needed to get high productivity. There are several activities to increase productivity, such as manage the fertilizer from several sources, i.e. urine [1], N Fertilizer [2] [3], NPK level of fertilizer [4] [5] [6]. Another activity to increase forage productivity is to arrange the harvesting age [7] [8] and manage the regrowth phase [9] [10] [11] and manage the plant density also planting material [12] [5] [13]. Farmers face a problem of lack of forage in the dry season. It is necessary to develop forage plants that can survive and in the dry season. One of the plants that can survive the dry season is sorghum *(Sorghum bicolor* (L.) Moench) and can be harvest more than once [11].

Sorghum (*Sorghum bicolor* (L.) Moench) is a cereal plant that can be developed as animal feed, especially in high drought levels areas. The watering frequency can see sorghum resistance to drought stress. The water requirement of sorghum plants is 400-450 mm [14]. If the soil water content is less than the water requirement of the sorghum plant, then the sorghum plant will experience drought stress. The impact of drought stress is that the leaf stomata are closed and inhibit the entry of CO_2 so that photosynthetic activity decreases and can reduce sorghum production. Efforts to overcome drought stress sorghum are to provide mycorrhizae to the plants. This is because mycorrhizal hyphae can absorb water and nutrients [15][16].

Mycorrhizae are soil fungi and perform symbiotic mutualism with plant roots. The advantages of mycorrhizae are to help plant roots absorb nutrients, increase plant resistance to drought stress, and increase plant root resistance to root pathogen attacks [17][18]. Giving arbuscular mycorrhizal fungi as much as 10 g/plant can increase the number of leaves and the degree of root infection in sweet sorghum and increase the sorghum production [19][20]. Research on the application of mycorrhizae at different levels and watering frequency needs to be done to determine the effect of mycorrhizae in increasing sorghum nutrients production.

2 MATERIAL AND METHODS

2.1 Research Design

The materials used were commercial mycorrhizal fungi and polybag measuring 40 x 20 x 40 cm (length x width x height) with a thickness of 0.10 mm. The seeds used were local Nagekeo sorghum seeds. The tools used were: hoe, machete, shovel, Camry electric scales with 5 kg capacity and the minor scale of 1 gram and thermometer (DEA). In addition to the tools mentioned above, other tools used in this study were scissors, loose wood, and 50 meters.

Media preparation included disassembling the soil and sifting with a diameter of 1 mm. Then, the media were mixed with cow manure in a ratio of 9:1. Then it is put into polybags as much as 10 kg/polybag. There were 45 polybags. After preparing the planting media, the sorghum seeds were planted. Planting holes were made with a depth of ±3 cm. After that, as many as 3 to 5 plants were given in each planting hole. The thinning of the sorghum plants was carried out 6 days after planting, leaving one best plant. Mycozia provision was done 7 days after planting. Plant watering was done according to the research treatment. Harvesting was done when the plants were 70 days after planting and cut at a distance of 5 cm from the soil surface. The forage obtained was then prepared by grinding and sieved through a 1 mm diameter sieve and then ready for proximate analysis. The result of the proximate analysis and then were converted become tons/ha with a planting space of 70x40 cm for the produces sorghum plant with the best productivity [21].

2.2 Sample Analysis

Sample analysis included dry matter, organic matter, crude protein, crude fiber, and crude lipid. The results of the proximate analysis were converted to ton/ha to determine the sorghum nutrients production.

2.3 Data Analysis

This research used a completely randomized design with a 3x3 factorial pattern with repeated each treatment 3 times. The research factors were the mycorrhizal level (M0: without mycorrhizae, M10: mycorrhizal 10 grams/polybag, and M20: mycorrhizal 20 grams/polybag) and different watering frequencies (A1: watering in every day, A4: watering in every four days, and A8: watering in every eight days). The study results will be analyzed quantitatively using the Analysis of Variance (ANOVA) based on the factorial pattern. The result with differences between the treatments was further tested with Duncan's test.

3 DISCUSSION

The results of the analysis of variance showed that the use of mycorrhizal fungi with different levels had a significant effect ($P < 0.05$) on the sorghum nutrient production (dry matter, organic matter, crude protein, crude fiber, and crude lipid), but the different watering frequency did not affect the sorghum nutrients production ($P > 0.05$) (Tabel 1). The interaction of giving mycorrhizal fungi at different levels and different watering frequencies did not affect the sorghum nutrient production ($P > 0.05$).

Table 1. Average nutrient production of sorghum.

Variable (ton/ha)	Mycorrhizal levels	Watering frequency			Average
		A1	A4	A8	
Dry matter	M0	5.93±0.16	5.77±0.32	5.79±0.43	5.83±0.29^{a}
	M10	6.25±0.15	6.11±0.18	5.89±0.05	6.08±0.20^{b}
	M20	5.90±0.31	5.81±0.10	6.03±0.12	5.91±0.20^{ab}
	Average	6.03±0.25	5.90±0.25	5.90±0.25	5.94±0.25
Organic matter	M0	23.10±0.23	23.18±0.26	23.34±0.27	23.20±0.20^{a}
	M10	23.95±0.39	24,19±0.50	23.96±0.86	24.03±0.54^{b}
	M20	24.26±0.50	23.38±0.10	24,19±0.76	23.94±0.62^{b}
	Average	23.77±0.62	23.58±0.53	23.83±0.70	23.73±0.60
Crude protein	M0	2.80±0.12	2.87±0.16	2.76±0.27	2.81±0.17^{a}
	M10	3.27±0.15	3.50±0.12	3.33±0.17	3.37±0.16^{b}
	M20	3.19±0.26	2.78±0.11	2.82±0.25	2.93±0.27^{a}
	Average	3.09±0.27	3.05±0.36	2.97±0.34	3.04±0.31
Crude fiber	M0	9.76±0.07	9.89±0.41	9.61±0.37	9.76±0.30^{b}
	M10	9.02±0.04	9.21±0.19	9.39±0.41	9.21±0.28^{a}
	M20	9.68±0.58	9.46±0.33	9.53±0.75	9.563±0.51^{ab}
	Average	9.49±0.43	9.52±0.41	9.51±0.48	9.51±0.43
Crude lipid	M0	1.41±0.06	1.43±0.09	1.43±0.05	1.42±0.06^{a}
	M10	1.88±0.06	1.90±0.09	1.87±0.11	1.88±0.08^{b}
	M20	2.02±0.16	1.78±0.10	1.82±0.13	1.87±0.16^{b}
	Average	1.77±0.29	1.70±0.23	1.71±0.22	1.73±0.24

^{ab} different superscripts on the same line indicate significant differences ($P < 0.05$)

The highest average dry matter production was in the M10 treatment, followed by M20 and M0. The dry matter production of sorghum forage on sorghum plants treated with mycorrhizae was higher than that of those without mycorrhizae. This was due to mycorrhizae's ability to absorb soil nutrients such as phosphorus. The external hyphae of mycorrhizae absorb phosphate elements from the soil and are immediately converted into polyphosphate compounds [22]. Mycorrhizae Polyphosphate compounds are converted to organic phosphate by the internal hyphae of mycorrhizae and are absorbed by plants. Nutrients such as phosphorus can increase the dry matter production in sorghum.

Phosphorus plays a role in various processes such as photosynthesis, assimilation, and respiration so that the dry matter production of plants increases [23][24]. The highest average dry matter production was in the M10 treatment, followed by M20 and M0. The organic matter production from sorghum treated with mycorrhizal fungi was higher than the sorghum without mycorrhizae. The increased production of organic matter in sorghum was caused by the ability of mycorrhizae to absorb soil organic matter so that it affected the organic matter. Mycorrhizae can interact positively with organic matter in the soil to help increase forage organic matter levels [22].

The high production of organic matter in sorghum was linear with the production of dry matter. High organic matter production was supported by plant dry matter production [25]. The highest average crude protein production was in the M10 treatment, followed by M20 and M0. The best crude protein production of sorghum was found in plants treated with mycorrhizal fungi. Mycorrhizae can absorb nitrogen (N) nutrients [26]. Mycorrhizae also can convert nitrogen into ammonium and nitrate through a decomposer process so that the crude protein content of forage increases. Nitrogen is needed for grass growth and is an essential component of plant proteins [27].

The highest average crude fiber production was in the M0 treatment, followed by M20 and M10. Plants with mycorrhizae have low crude fiber production due to the ability of mycorrhizae to decompose carbohydrates and lignin so that the crude fiber of plants is reduced. High crude fiber production will reduce the production of other nutrients such as crude protein and crude fat. The application of the mycorrhizal M20 reduced the production of crude fiber sorghum forage to 2,35%. In addition, the ability of mycorrhizae to absorb nutrients and water causes the crude fiber production of plants treated with mycorrhizae to be lower but the production of other nutrients such as dry matter, organic matter, and crude protein increases. The highest average crude protein production was the M10 treatment, followed by M20 and M0.

The crude lipid in sorghum treated with mycorrhizae was higher than others because mycorrhizae can decompose bound mineral compounds into available minerals. The formation of these compounds is from the transformation process of organic matter [28]. Crude lipid production is also formed from humin compounds due to the humification process and form humus which still contains fat and wax [29].

Different watering frequencies did not affect sorghum nutrient production. This was due to the ability of sorghum plants to survive in drought stress so that the nutrient production of the forage was still stable. In addition to the water, sunlight is essential for plants for photosynthesis. The rate of photosynthesis and respiration in plants is also influenced by light [23]. The harvest age of the plant also affects the nutrient production of the plant. The harvest age of sorghum in this study was 70 days after planting. Sorghum nutrient production was quite maximal at harvest age 70 days after planting [25].

4 CONCLUSION

Based on the study results, it can be concluded that the administration of different levels of mycorrhizal fungi increased sorghum nutrient production and reduced sorghum crude fiber production. The best treatment was giving mycorrhizae 10 grams/polybag (M10). Different watering frequencies did not perform a significant effect on sorghum nutrient production.

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