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The Effectivity of Arbuscular Mycorrhiza Fungi (AMF) and Nitrogen Fertilizer on The Growth and Yield of Sunflower (Helianthus annus L.)

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Abstract

One of the main products of sunflower is the seed which is a producer of vegetable oil. Sunflower seed oil is needed in the pharmaceutical industry and the health sector. The price of sunflower seed oil is currently very high for the market but sunflower production in Indonesia is quite low. This potential can be used as the basis for the development of sunflower cultivation in Indonesia. One of the efforts to increase the oil content of sunflower seed is to improve and modify appropriate cultivation techniques, one of which is to get the right dose of nitrogen fertilization. The addition of Arbuscular Mycorrhiza Fungi (AMF) is expected to increase the absorption of N nutrients in the soil so that the growth and yield of sunflowers increases. This study aimed to determine the effectiveness of AMF and nitrogen fertilizers with various doses on the growth and yield of sunflower and to obtain the right dose of N fertilizer on sunflower growth and yields. In this study, we used a Split-plot Design with 3 replications. The first factor as the main plot is AMF utilization while the F0 = without AMF, F1 = with AMF 5 g/hole. The second factor as a sub-plot is the dose of urea fertilizer i.e. N1 = 50 kg/Ha, N2 = 100kg/Ha, N3 = 150kg/Ha, N4 = 200kg/Ha, Observations data were evaluated by analysis of variance and followed by a further test of DNMRT at a significant level of 5 %. The results showed that the effectiveness of AMF and nitrogen fertilization could increase the number of leaves, the diameter of flowers, the number of seeds per plant, the weight of 100 seeds, and seed production per plant and also accelerate the initiation of flowering. Economically, the application of nitrogen fertilizer with a dose of 150kg/Ha is more appropriate in increasing the growth and production of sunflowers.

Keywords: doses effectivity, mycorrhiza, nitrogen fertilizer, sunflower

Introduction

Sunflower has been widely cultivated in Indonesia since the early 90s. However, it is only used as an ornamental plant and seed production for consumption. Though sunflower can be developed in the health and cosmetic industries. The cosmetic and medicine industry in Indonesia still has to import sunflower seed and sunflower oil due to serious problems regarding the supply of sunflower seeds from within the country. This is due to inadequate seed quality and unreliable yield continuity due to problems with cultivation techniques.

In West Sumatra, the development of sunflower cultivation techniques has not been maximized and is only used as an ornamental plant. Sunflower products in the form of seed, vegetable oil, and processed seed products have not been able to achieve production quality. This was caused by a decrease in crop production due to less than optimal cultivation management.

Efforts to improve plant growth need to be balanced with the availability of sufficient nutrients to increase plant production. Nitrogen has a role in physiological and biochemical processes in plants especially as the main constituent of amino acids, nucleic acids, and chlorophyll. In addition, many nitrogen enzymes also increase root growth thereby affecting the absorption of water and nutrients (Fageria, 2014). N fertilization can increase the height and diameter of sunflower stems (Ozer *et al.* 2004) and increase the biomass weight and yield of sunflower seeds (Maryati, 2007). The increase in plant growth and development can also be enhanced by the use of Arbuscular Mycorrhiza Fungi (AMF). AMF plays a role in increasing the uptake of various nutrients for plants such as nitrogen nutrients (Xiao *et al.* 2010). In soybeans, AMF utilization can increase plant growth and production, plant height and flower diameter, and leaf chlorophyll content (Handayani, 2012; Abobeker *et al.* 2018). Furthermore, the application of organic fertilizer with AMF on sunflower plants can increase leaf chlorophyll content and flower diameter (Suwarniati, 2014; Abobeker *et al.* 2018).

The study aimed to determine the effectiveness of AMF and nitrogen fertilizer application with various doses on the growth and yield of sunflower and to obtain the right dose of N fertilizer on the growth and yield of sunflower.

Materials and Methods

The research was conducted from October 2020 to March 2021 in the Experimental field of the Faculty of Agriculture, Andalas University, which is located at an altitude of ± 255 m above sea level. Sunflower seeds were obtained from the Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI). The study used a Split-plot Design with 3 replications. The first factor as the main plot is F0 = without AMF, F1 = with AMF 5g/hole. The second factor as a sub-plot is the dose of urea fertilizer with 4 levels i.e. N1 = 50 kg/Ha, N2 = 100kg/Ha, N3 = 150kg/Ha, N4 = 200kg/Ha. AMF was applied during replanting and nitrogen fertilizer is given 2 times, i.e. 1/2 dose was given at 2 weeks after replanting and another 1/2 dose when the plant entered the generative phase. Observations data were evaluated by analysis of variance followed by a further test of DNMRT at the 5% significant level. Observed parameters were the plant height, the number of leaves, the number of branches, the flower initiation, the flower diameter, the total seed per plant, the weight of 100 seeds, and the seed production per plant.

Results and Discussion

Vegetative Growth

The single effect of AMF was significant in increasing plant height and leaf number of sunflower plants but reducing the number of sunflower branches. The reduced number of branches is positively correlated with flower diameter. The fewer the number of sunflower branches, the larger the diameter of the sunflowers formed (Table 1). It is also stated by Santika *et al.* (2018) that the fewer the branches of the plant, the fewer number of flowers produced, the smaller the number of sunflowers will form the maximum sunflower diameter. In its application, AMF does not interact with nitrogen fertilizer application. (AMF) is a type of fungus that lives in symbiotic mutualism with plant roots. AMF is beneficial for plants, especially in increasing the absorption of nutrients. Plants treated with mycorrhizae had more leaves than plants that were not inoculated with AMF (Wachjar *et al.* 1998; Mayerni and Hervani, 2008)

The application of nitrogen fertilizer at a dose of 150-200 kg/Ha can increase the number of leaves of sunflower plants. Sutejo (2002) stated that the application of nitrogen fertilizer can increase plant growth which is characterized by an increase in the size of plant organs and both in terms of number and weight due to division and enlargement of plant cell sizes. However, it does not affect the height of sunflower plants. Nitrogen fertilizer has not significantly affected the average height of sunflower plants, it is suspected that the addition of N fertilizer to the soil is slow to be utilized by the plants. The nature of nitrogen in the soil is easily leached and easily decomposed (denitrification), then the application of nitrogen fertilizer is carried out in stages, namely 3 times so that it can meet the needs of nitrogen elements for plants (Ramadhani *et al.* 2016) According to Purwono and Hartono (2005) and Musyadar *et al.* (2008), nitrogen application in divided doses and gradual time is highly recommended.

Table 1. Average plant height, number of leaves, and number of branches of sunflower with the application of AMF and nitrogen fertilizer

Treatment	Plant height	Number of leaves	Number of branch
Arbuscular Mycorrhiza Fungi (AMF)			
- AMF	109.94 a	23.36 a	5.60 a
+ AMF	134.23 b	37.08 b	2.75 b
Nitrogen Fertilizer			
N1 (50kg/Ha)	119.45	26.61 a	2.50 a
N2 (100 kg/Ha)	125.80	27.00 a	2.89 a
N3 (150 kg/Ha)	130.03	33.55 b	3.55 b
N4 (200 kg/Ha)	136.16	33.73 b	7.15 c

Numbers followed by the same letters on each column are not significantly different at 5% DNMRT

The application of nitrogen can be done 2-3 times with 1/3 of the dose given at planting time, 1/3 at 30 days after transplanting, and another 1/3 given before flowering. The availability of sufficient nutrients, water, and light can encourage plants to increase plant metabolic processes, especially the photosynthesis process so that the formation of photosynthate yields is higher and then used to increase the formation of leaves and other plant parts (Hartoyo *et al*., 2015).

Plant Phenology and Yield

The observations results on plant phenology and yield of sunflower plants showed that there was no interaction between AMF and nitrogen fertilizer. The data about the average flower initiation, flower diameter, total seeds per plant, the weight of 100 seeds, and seeds production per plant is presented in Table 2.

The results showed that the utilization of AMF could accelerate the initiation of flowering, increase flower diameter, total seeds per plant, the weight of 100 seeds, and seed production per plant compared to without AMF utilization. The earliest time for flower initiation to appear was 55.87 days after planting (DAP) compared to without AMF (79.50 DAP). This is estimated because the application of AMF into the soil can develop good root systems and increase the ability of plants to absorb nutrients and water in the soil. Hadiatmi (2008) explained that mycorrhiza hyphae can enter the root cortex layer and form branched and clustered threads (arbuscules) between cortical cells. The arbuscule has a role as an intermediary for the transfer of nutrients between the fungus and the host plant so that it can expand the roots up to 3 times.

Fertilizers containing nitrogen nutrients can indirectly affect the symbiosis between host plants and AMF. Nitrogen fertilization with a dose of 150-200 kg/Ha had the same effect in accelerating the initiation of sunflower flowering, which was in the range of 79-80 days after planting (DAP). Then increasing the diameter of sunflowers from 19 cm to 21 cm, increasing the weight of seeds in the range of 430-440 g per plant, increasing the seed weight of 100 seeds from 10 g to 11 g seeds, and increased seed production per plant with an average of 54-58 g per plant. Therefore, N may be a key nutrient in sunflower growth and development. Nitrogen fertilization serves as the main constituent of protein-containing grains (Maryati, 2007).

AMF Colonization Percentage

The average percentage of AMF colonization which had a moderate category (12-25%) was found in the nitrogen fertilization at a dose of 100 kg/Ha and 150 kg/Ha. Then in the nitrogen fertilization at a dose of 50 kg/Ha and 200 kg/Ha the percentage of AMF colonization was in a low category. According to O'Connot *et al.* (2001), the percentage range of roots colonized by AMF i.e. 0% (not colonized); <10% (low); 10-30% (moderate); >30% (high).

Table 2. Average flower initiation, flower diameter, total seeds per plant, the weight of 100 seeds, and seed production per plant of sunflower with the application of AMF and nitrogen fertilizer

Treatment	Flower initiation DAP*	Flower diameter (cm)	Total seeds per plant (g)	Weight 100 seeds (g)	Seed production per plant (g)
Arbuscular Mycorrhiza Fungi (AMF)					
- AMF	79.50 a	13.97 a	338.86 a	7.94 a	49.99 a
+ AMF	55.87 b	20.12 b	415.59 b	11.30 b	56.05 b
Nitrogen Fertilizer					
N1 (50 kg/Ha)	94.25 a	12.00 a	276.39 a	8.41 a	47.48 a
N2 (100 kg/Ha)	90.15 a	15.00 a	352.70 b	8.62 a	48.19 a
N3 (150kg/Ha)	80.86 b	21.00 b	440.40 bc	11.77 b	58.07 b
N4 (200 kg/Ha)	79.50 b	19.00 b	430.40 bc	10.20 b	54.32 b

Numbers followed by the same letters on each column are not significantly different at 5% DNMRT
*DAP : Day after planting

Table 3. Average percentage of roots colonized by AMF

Nitrogen Fertilizer	FMA colonization (%)	Description
N1 (50 kg/Ha)	7.18	low
N2 (100 kg/Ha)	12.92	moderate
N3 (150 kg/Ha)	25.22	moderate
N4 (200 kg/Ha)	9.70	low

Source: O' Connot *et al.* 2001

This is because the availability of nutrients that are too low and high will inhibit the development of AMF in the soil as stated by Islami and Utomo (1995) and Khalidin *et al.* (2013).

The difference in the effectiveness of AMF is determined by the relationship between the fungus and the host. According to Babu and Reddy (2011), the AMF colonization in plant roots is determined by the compatibility of mycorrhizae with their hosts either in the mechanism of transfer or exchange of nutrients. The percentage of AMF colonization in roots with a high value does not mean that the infection is also large in plants (Novikusianti, 2005).

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Conclusion

The effectiveness of AMF and nitrogen fertilization on sunflowers could increase the number of leaves, the diameter of flowers, the number of seeds per plant, the weight of 100 seeds, and seed production per plant and also accelerate the initiation of flowering. Economically, the application of nitrogen fertilizer with a dose of 150 kg/Ha is more appropriate in increasing the growth and production of sunflowers.

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