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The Effect of Arbuscular Mycorrhizae and Sp-36 Fertilizer Application on The Growth of Butternut Squash (Cucurbita Moschata Durch) in Swampy Land

Nita Aprillia*, Dewi Erika Adriani, Raihani Wahdah

Study Program of Magister Agronomy, Faculty of Agriculture, Lambung Mangkurat University, Banjarbaru 70714, Indonesia

* Correspondence: nitaaprillia85@gmail.com

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ABSTRACT

This study aimed to: (1) determine the effect of various doses of arbuscular mycorrhizae with SP-36 fertilizer on the growth of butternut squash in the swampy land; (2) determine the best combination of various doses of arbuscular mycorrhizae with SP-36 fertilizer on the growth and butternut squash in the swampy land. The research was carried out in the Green House of SMK PP Negeri Banjarbaru from October 2020 to November 2021. The study used a factorial completely randomized design (CRD) with 2 factors. The first factor was arbuscular mycorrhizae dose (M) which consisted of 4 levels, namely: m0 = Control; m1 = 5 g tan - 1 equivalent to 0.1 ton ha - 1;m2 = 10 g tan - 1 equivalent to 0.2 ton ha - 1; m3 = 15 g tan - 1 equivalent to 0.3 ton ha - 1. The second factor was SP-36 fertilizer dose (S) fertilizer which consists of 4 levels, namely: s0 = Control; s1 = 1,39 g tan - 1 equivalent to 0,125 ton ha - 1; s2 = 2,22 g tan - 1 equivalent to 0,2 ton ha -; s3 = 3.06 g tan - 1 equivalent to 0.275 ton ha- 1, combination repeated 3 (three) times, with 6 polybags of them, so that there were 288 plants in total. The result showed that there was an interaction effect on the volume of roots at 2 and 4 weeks after planting, shoot dry weight, root dry weight, and shoot root ratio. The single factor of application of arbuscular mycorrhizae and SP-36 fertilizer each had a very significant effect on root colonization. Combination of arbuscular mycorrhizae at a dose of 10 g ton - 1 equivalent to 0.2 ton ha- 1 and SP-36 fertilizer at a dose of 3.06 g ton - 1 equivalent to 0.275 ton ha – 1 could increase the growth of butternut squash in the swampy land.

Keywords: Butternut Squash, Bio Fertilizer, Phosphorus, Swampy Land

1. Introduction

The butternut squash is a type of pumpkin that has a promising opportunity because it's price is higher than other types of pumpkin (Imani, 2019). Another potency was also explained by (Zufahmi & Mahajoeno, 2014), who stated that the butternut squash (Cucurbita moschata Durch) is a carbohydrate source plant that has high adaptability, so it can grow in both low and highlands. South Kalimantan has the opportunity to develop butternut squash because it has a swampy land area of 208,893 ha of which 49,749 ha have been utilized and 26,345 ha have not been utilized (Fatah, 2017; Santoso et al., 2007). According to (Subagyo, 2006), swampy land typology is divided into three types, namely: shallow, middle, and deep or very deep. The types of swampy land that have the potential for agricultural development are shallow (bundling) and middle swampy land which are generally used as rice fields with food crops and vegetables in the lower area (sunken beds) in the surjan system.

Plant cultivation in swampy land must fulfill the nutrient requirement to get an optimal yield. SP-36 fertilizer is one of the artificial fertilizers that can meet the needs of plants for P nutrients that are absorbed by plants during vegetative and generative growth. P is a macronutrient that plants need in large quantities, such as N, K, Ca, Mg, and S. The initial soil analysis showed that the swampy land in the study area was classified as acidic (pH 4,78), total N was very high (0,89%), P Bray 1 was low (7,86 ppm P) and P Bray 1 was low (7,86 ppm P). K-dd includes low criteria (0,26 cmol (+) kg -1 (Hairani, 2018). From the initial soil analysis, it is known that element P is included in the low criteria (7,86 ppm P). This is due to soil pH being low, the availability of Al (aluminum) and Fe (iron) in the soil is high and binds P elements so that P in the soil becomes difficult to dissolve and most of it is not available to plants.

In addition, for adding fertilizer as a source of P, one way that can be done to increase the absorption of P to make it available to plants is with arbuscular mycorrhizae which are beneficial for plant growth and production because they have the ability to increase the absorption of P bound in the soil and P from fertilizers (Sastrahidayat, 2011). The response of plants to mycorrhizae infection is strongly influenced by the availability of P fertilizer and the dose given, the effect is more pronounced if the fertilizer used is not easily available to plants (Sastrahidayat, 2011). Butternut squash cultivation in swampy lands needs to be developed by applying technology that can overcome the problem of bound P absorption so it is necessary to study the effect of application of arbuscular mycorrhizae and SP-36 fertilizer on the growth of butternut squash in swampy lands.

2. Materials and Methods

The research was carried out at the Swampy land Agricultural Research Institute (Balittra) and the Green House of SMK PP Negeri Banjarbaru from October 2020 to November 2021. The study used a factorial completely randomized design (CRD) with 2 factors. The first factor was arbuscular mycorrhizae dose (M) which consisted of 4 levels, namely: m0 = Control ; m1 = 5 g tan - 1 equivalent to 0.1 ton ha - 1;m2 = 10 g tan - 1 equivalent to 0.2 ton ha - 1; m3 = 15 g tan - 1 equivalent to 0.3 ton ha - 1. The second factor was SP-36 fertilizer dose (S) fertilizer which consists of 4 levels, namely: s0 = Control; s1 = 1,39 g tan- 1 equivalent to 0,125 ton ha - 1; s2 = 2,22 g tan - 1 equivalent to 0,2 ton ha - ; s3 = 3.06 g tan- 1 equivalent to 0.275 ton ha- 1, combination repeated 3 (three) times, with 6 polybags of them, so that there were 288 plants in total. Testing the homogeneity of variance data was carried out using the Bartlett test. The homogeneous variance was followed by the ANOVA test. The variety of errors that are not homogeneous is transformed showed the data until the variety of errors can be met. If the results of the analysis of variance that the treatment has a significant effect on the treatment, then the analysis is continued with the difference in the mean value using the Duncan's Multiple Range Test (DMRT) at the 5% test level.

3. Results and Discussion

The results of the homogeneity test referred to several observation variables such as plant dry weight, root volume, plant moisture content, relative growth rate, crown dry weight, root dry weight, root crown ratio, number of flowerings, flowering age, root colonization, and plant diseases.

Based on the recapitulation of the homogeneity test and analysis of variance in Table 1, it can be seen that the observation data variables were homogeneous, namely dry weight 8 WAP, root volume 2, 4 WAP, plant water content 4, 6, 8 WAP, shoot dry weight, root dry weight, ratio shoots, flowering time and root colonization. While the observation variables were not homogeneous, the data were transformed into dry weight at 2, 4, 6 WAP, root volume at 6, 8 WAP, moisture content at 2 WAP, relative growth rate at 2-4 WAP, 4-6 WAP, 6 - 8 WAP, and the amount of interest. The interaction of arbuscular mycorrhizae and SP-36 fertilizer had a very significant effect on root volume 2 and 4 WAP, shoot dry weight, root dry weight, root crown ratio and there was a single factor effect of arbuscular mycorrhizae and SP-36 fertilizer, each had a very significant effect on root colonization.

Table 1. Effect of arbuscular mycorrhizae and SP-36 fertilizer root volume (ml) at 2 WAP

SP-36	arbuscular mycorrhizae			
	m_0 (control)	m_1 (5 g tan $^{-1}$)	m_2 (10 g tan $^{-1}$)	m_3 (15 g tan $^{-1}$)
s_0 (control)	1,67 ^{f}	3,00 ^{cde}	2,33 ^{ef}	5,33 ^{a}
s_1 (1,39 g tan $^{-1}$)	3,00 ^{cde}	2,33 ^{ef}	2,00 ^{ef}	3,67 ^{bcd}
s_2 (2,22 g tan $^{-1}$)	2,33 ^{ef}	2,33 ^{ef}	3,67 ^{bcd}	2,67 ^{def}

s_3 (3,06 g tan $^{-1}$)	2,00 ef	3,00 cde	4,33 ab	4,00 bc

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Table 1. The volume of roots aged 2 WAP was better in the treatment of 15 g tan-1 arbuscular mycorrhizae with an average of 5,33 ml and without SP-36 fertilizer. However, it was not better with 10 g tan-1 arbuscular mycorrhizae and 3,06 g tan-1 SP-36 with a mean of 4,33 ml. While the lowest mean was 1,67 ml, that is, without treatment with arbuscular mycorrhizae and SP-36 fertilizer. The interaction effect of arbuscular mycorrhizae and SP-36 fertilizer on root volume at 4 MS T can be seen in Table 4. below:

Table 2. Effect of arbuscular mycorrhizae and SP-36 fertilizer on root volume (ml) at 4 WAP

SP-36	arbuscular mycorrhizae			
	m_0 (control)	m_1 (5 g tan $^{-1}$)	m_2 (10 g tan $^{-1}$)	m_3 (15 g tan $^{-1}$)
s_0 (control)	5,00 def	6,67 abcd	5,33 cdef	6,33 bcde
s_1 (1,39 g tan $^{-1}$)	4,00 f	5,33 cdef	8,67 a	7,67 ab
s_2 (2,22 g tan $^{-1}$)	5,33 cdef	6,00 bcdef	5,33 cdef	6,33 bcde
s_3 (3,06 g tan $^{-1}$)	4,33 ef	7,33 abc	8,67 a	8,00 ab

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Volume at the age of 4 WAP was better when arbuscular mycorrhizae were given 10 g tan - 1 and SP-36 fertilizer was 1,39 g tan - 1 with a mean of 8,67 ml. However, it is not better with the application of arbuscular mycorrhizae 10 g tan - 1 and SP-36 fertilizer 3,06 g tan - 1 with a mean of 8,67 ml, not better with 15 g tan - 1 arbuscular mycorrhizae and SP-36 fertilizer 3,06 g tan - 1 with an average of 8,00 ml, not better with 15 g tan - 1 arbuscular mycorrhizae and SP-36 fertilizer 1,39 g tan - 1 with an average of 7,67 ml, not better than the treatment with arbuscular mycorrhizae 5 g tan - 1 and SP-36 fertilizer 3,06 g tan - 1 with an average of 7,33 ml. The lowest mean in the treatment without arbuscular mycorrhizae and SP-36 fertilizer was 1,39 g tan - 1 with a mean of 4,00 ml.

Table 3. Effect of interaction of arbuscular mycorrhizae and SP-36 fertilizer on canopy dry weight

SP-36	arbuscular mycorrhizae			
	m_0 (control)	m_1 (5 g tan $^{-1}$)	m_2 (10 g tan $^{-1}$)	m_3 (15 g tan $^{-1}$)
s_0 (control)	51,90 gh	58,93 fg	75,23 d	45,77 h
s_1 (1,39 g tan $^{-1}$)	67,60 def	69,20 de	66,87 def	53,20 gh
s_2 (2,22 g tan $^{-1}$)	51,70 gh	59,33 fg	65,70 ef	109,37 b
s_3 (3,06 g tan $^{-1}$)	64,10 ef	58,97 fg	84,27 c	130,60 a

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

The dry weight of the crown was better in the treatment of arbuscular mycorrhizae 15 g tan - 1 and SP-36 fertilizer 3,06 g tan - 1 with an average of 130,60 g, and not better than the treatment with arbuscular mycorrhizae 15 g tan - 1 and without SP-36 fertilizer with the lowest average of 45.77 g.

Table 4. The effect of interaction of arbuscular mycorrhizae and SP-36 fertilizer on root dry weight

SP-36	arbuscular mycorrhizae			
	m_0 (control)	m_1 (5 g tan $^{-1}$)	m_2 (10 g tan $^{-1}$)	m_3 (15 g tan $^{-1}$)
s_0 (control)	9,47 cd	12,47 b	7,90 defg	9,47 cd
s_1 (1,39 g tan $^{-1}$)	9,20 cd	6,23 g	12,30 b	6,60 fg
s_2 (2,22 g tan $^{-1}$)	7,00 efg	9,87 c	9,20 cd	14,93 a
s_3 (3,06 g tan $^{-1}$)	6,20 g	7,20 efg	8,53 cde	8,30 cdef

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Root dry weight density was better in the treatment of arbuscular mycorrhizae 10 g tan^{-1} and SP-36 fertilizer 2,22 g tan $^{-1}$ with an average of 14,93 g, and the lowest was in the treatment without arbuscular mycorrhizae treatment and SP-36 fertilizer 3,06 g tan $^{-1}$ with an average of 6,20 g.

Table 5. The effect of interaction of arbuscular mycorrhizae and SP-36 fertilizer on root crown ratio

SP-36	arbuscular mycorrhizae			
	m_0 (control)	m_1 (5 g tan $^{-1}$)	m_2 (10 g tan $^{-1}$)	m_3 (15 g tan $^{-1}$)
s_0 (control)	5,47 gh	4,73 h	9,63 bcd	4,89 h
s_1 (1,39 g tan $^{-1}$)	7,41 efg	11,20 b	5,43 gh	8,21 def
s_2 (2,22 g tan $^{-1}$)	7,49 efg	6,13 fgh	7,21 efg	7,33 efg
s_3 (3,06 g tan $^{-1}$)	10,44 bc	8,39 cde	9,94 bcd	15,76 a

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Root crown ratio was better in the treatment of arbuscular mycorrhizae 15 g tan $^{-1}$ and SP-36 fertilizer 3,06 g tan $^{-1}$ with an average of 15,76 and the lowest was in the treatment of 5 g tan $^{-1}$ arbuscular mycorrhizae and without SP-36 fertilizer with an average of 4,73.

Table 6. The effect of arbuscular mycorrhizae on root colonization

Arbuscular mycorrhizae	Root Colonization (%)
m_0 (control)	18,33 c
m_1 (5 g tan^{-1})	73,33 b
m_2 (10 g tan^{-1})	80,83 ab
m_3 (15 g tan^{-1})	84,17 a

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Root colonization was better with arbuscular mycorrhizae treatment of 15 g tan- 1 with an average of 84,17%, but not better with arbuscular mycorrhizae administration of 10 g tan - 1 with an average of 80.83%, and the lowest was in the treatment without arbuscular mycorrhizae and SP-36 fertilizer with an average of 18,33%.

Table 7. The effect of SP-36 fertilizer on root colonization

SP-36	Root Colonization (%)
s_0 (control)	55,000 c
s_1 (1,39 g tan^{-1})	71,667 a
s_2 (2,22 g tan^{-1})	61,667 bc
s_3 (3,06 g tan^{-1})	68,333 ab

Note: the numbers followed by the same letter show that they are not significantly different according to the DMRT test at 5% level

Root colonization was better in the treatment of SP-36 fertilizer 2,22 g tan - 1 with an average of 71,67%. But not better with SP-36 3,06 g tan - 1 with an average of 68,33%, and the lowest was in the treatment without SP-36 fertilizer with an average of 55,00%.

Disease observation was carried out by taking samples from the leaves of plants from 5 different points. Leaf samples were examined at the Phytopathology Laboratory, Department of Pests and Diseases, Lambung Mangkurat University, South Kalimantan. Downy Mildew (Pseudoperonospora cubensis) and Anthracnose (Colletotrichum Sp.).

Analysis of soil chemical properties was carried out on the soil used as a planting medium before planting. The soil sampled is swampy landy lebak soil, which is a paddy field that is waterlogged for 3-6 months with a puddle height of 50-100 cm.

Table 8. Analysis of Soil Chemical Properties

Parameter	Value [1]	Criterion [2]
Soil Ph	5,58	a bit sour
N(%)	0,53	Currently
P Tsd (ppm P)	14,79	Low
K (ppm)	2,83	very high

Fe (ppm)	45,88	Tall
Kdd (cmol(+)kg $^{-1}$)	0,30	Low

Source: [1] Balitra Testing Lab, Banjarbaru, South Kalimantan 2020
[1] Soil Research and Development (LPT) 1983

Analysis of the chemical properties of the soil has a slightly acidic pH of 5,58, while N is included in the high criteria (0,53%), P is available in the soil at low criteria, namely 14,79, K content is 2,83 ppm at very high criteria for Fe content in the soil is 45,88 (ppm) in the high criteria, and K-dd including the low criteria 0,30 cmol (+) kg -1.

Discussion

The results of the treatment had an effect on root volume, presumably due to the ability of arbuscular mycorrhizae to produce external hyphae, so that they could absorb nutrients, especially phosphate, to greater. With the addition of SP-36 fertilizer as a source of phosphate, which is one of the essential nutrients needed by plants in large quantities, arbuscular mycorrhizae can produce hyphae intensively, so that plants are able to increase the capacity for absorption of nutrients and water. This is in accordance with the opinion of (Sastrahidayat, 2011), arbuscular mycorrhizae are beneficial for plant growth and production because they can increase the ability of plants to absorb nutrients and water in the soil and have the ability to absorb phosphate bound in the soil and phosphate from fertilizers. Meanwhile, at the age of 6 and 8 WAP, the treatment had no effect on root volume, presumably because a larger biomass distribution was used for crown growth than for roots. So that at the age of 6 and 8 WAP the growth was more towards the plant crown.

The results of this treatment, both single factor and interaction did not affect the relative growth rate, however there was an increase in growth at each age of the plant but was not affected by the treatment. (Sitompul & Guritno, 1995) explained that in the relative growth rate, differences in plant size expressed in biomass can occur between plants of the same age even if they are planted in the same environment and received the same treatment. Furthermore, according to (Sugito, 2013) the relative growth rate is the speed of plant growth in a certain period that applies when the plant is in the vegetative phase where growth takes place quickly until before stepping on the generative phase. (Sallaku et al., 2009) the relative growth rate (RGR) can be used as a comprehensive indicator for the evaluation of different growing conditions that influences seedling growth.

The results showed that the treatment of arbuscular mycorrhizae and SP-36 fertilizer had an effect on the dry weight of the canopy. In line with Agustiyanto's research (2018) that the provision of arbuscular mycorrhizae with one month's storage plays an optimal role in the dry weight of the canopy in corn plants. The research of (Nadeak et al., 2015) stated that the application of arbuscular mycorrhizae fungi had a significant effect on the dry weight of shoots and roots in Sengon plants, and the research of (Wahyuni et al., 2013) stated that the application of phosphate fertilizers had a significant effect on wet weight. canopy of tomato plants and it was also explained that the increase in phosphate content in the plant would increase the rate of photosynthesis and stimulate the formation of new leaves which resulted in an increase in the wet weight of the plant canopy.

Treatment with arbuscular mycorrhizae and SP-36 fertilizer can help plant roots to absorb water optimally. Research by (Kurniasih & Wulandhany, 2009) stated that the dry weight of plant roots indicates the ability to absorb water, because plants with high root dry weight have larger roots and have a higher tolerance for drought than plants with root dry weight. low Plant needs for water can be met by absorption by roots. Furthermore, it was explained in Jadid's research (2007) that the water content in the soil and the ability of the roots to absorb water greatly affect the amount of water absorbed by the roots so the ability of the roots to absorb water greatly affects the wet weight of the roots.

An important factor in plant growth is the root crown ratio, which reflects the ability to absorb nutrients and the metabolic processes that occur in plants. The results of the dry weight of the root canopy showed the absorption of water and nutrients by the roots which were translocated to the plant crown. The results of this study showed an interaction between the treatment of arbuscular mycorrhizae and SP-36 fertilizer which affected the root crown ratio. Plant growth requires nutrients for the survival of the plant and functions for the production of dry weight of a plant. According to (Jumin, 2002), the availability of nutrients will determine the dry weight production of plants which is

the result of three processes, namely the process of assimilate accumulation through photosynthesis, respiration, and accumulation of organic compounds. Dry weight is the accumulation of organic compounds produced by the synthesis of organic compounds, especially water and carbohydrates, which depends on the rate of photosynthesis of the plant, while photosynthesis is influenced by the rate of absorption of nutrients in plants through the roots.

Analysis of variance showed that the interaction of arbuscular mycorrhizae and SP-36 fertilizer had no significant effect on root colonization, while the single factor of each treatment did. In line with (Putra et al., 2016) which stated that arbuscular mycorrhizae had a significant effect on the percentage of root colonization of slow-growing plants (Glodokan and Tanjung), the results of observations on plant roots found an association between roots and arbuscular mycorrhizae that formed root colonization and the presence of AMF infection of the roots indicated with the presence of hyphae and vesicles that was the epidermal cells through the surface of the root or root hairs, so that the infected part is visible. (Husin, 1997) stated that mycorrhizae found in plant roots were able to increase the uptake of nutrients, especially phosphate so as to be able to spur the development of fine roots which were useful for increasing nutrient absorption and higher plant growth so that roots infected with mycorrhizae had the capacity to absorb nutrients. higher nutrients compared to plants that were not infected with mycorrhizae. (Kemas Ali Hanafiah, 2010) explained that the working principle of this mycorrhizae is to infect the root system of the host plant, producing an intensive hyphae so that plants containing mycorrhizae will be able to increase the capacity for nutrient absorption. The application of SP-36 has an effect on root colonization, it is suspected that nutrients in the form of phosphate can be absorbed by plants. In line with the research of (Wahyuni et al., 2013), the application of a single phosphate fertilizer without mycorrhizae can affect tomato plants, because phosphate fertilizers can be directly absorbed by plants which can increase the growth of tomato plants.

The results of the identification of diseases that attack the butternut squash plant are Downy Mildew disease (Pseudoperonospora cubensis) and Anthracnose (Colletotrichum Sp.). The colonies are white, spores are chained, hyphae are swollen and insulated, young colonies are white, colonies are black, hyphae walls are jagged (not straight), spores grow at the tips of the hyphae and the sides of the stem. These observations are in line with the research conducted by (Anggraini et al., 2018) on the host of Downy Mildew (Pseudoperonospora cubensis) and Anthracnose (Colletotrichum Sp.) on Cucurbitaceae plants. Downy Mildew (Pseudoperonospora cubensis) has early symptoms first appear on with small, yellow or reddish-brown, water-soaked spots often on veins, which enlarge rapidly and turn brown, otherwise Anthracnose (Colletotrichum lagenarium) the symptom of the disease first appears on the foliage as small, yellow or reddish-brown, water-soaked spots often on veins, which enlarge rapidly and turn brown. The dead tissue dries and may crack and fall out, (Zhang et al., 2021)

4. Conclusions

The result showed that there was an interaction effect on the volume of roots between 2 and 4 weeks after planting, shoot dry weight, root dry weight and shoot root ratio. The single factor of application of arbuscular mycorrhizae and SP-36 fertilizer each had a very significant effect on root colonization. Combination of arbuscular mycorrhizae at a dose of 10 g ton - 1 equivalent to 0.2 ton ha- 1 and SP-36 fertilizer at a dose of 3.06 g ton - 1 equivalent to 0.275 ton ha – 1 could increase the growth of butternut squash in the swampy land.

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