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Response of Growth and Production of Butternut Squash (*Cucurbita moschata*) to Application of Mycorrhizae and Quail Manure

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ABSTRACT
The demand for butternut squash, which continues to increase yearly, makes farmers try to increase their production by applying biological and organic fertilizers. This study aims to determine the response of growth and production of butternut squash to the application of mycorrhiza and quail manure. This study used a randomized block design (RBD) with 2 factors and 3 replications. The first factor was the application of mycorrhiza which consisted of 3 levels, namely: 0, 2.5, and 5 g per plant, while the second factor was quail manure which consisted of 4 levels, namely: 0, 1, 2, and 3 kg per plot. The results showed that the application of mycorrhizae had a significant effect on fruit length and fruit weight. The application of quail manure had a significant effect on increasing fruit weight. The interaction of mycorrhizae and quail manure did not significantly affect all observed parameters. Although it had no significant effect, the application of mycorrhiza and quail fertilizer was proven to increase the growth and production of butternut squash compared to the control (without the application of mycorrhiza and quail manure). Combining mycorrhizal 2.5 g per plant and quail manure 1 kg per plot could increase butternut squash production.

Keywords: Butternut squash; Growth; *Mycorrhizae*; Production; Quail manure

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INTRODUCTION

Butternut squash (*Cucurbita moschata*) is native to North America and can grow well with sufficient yearly rainfall. Butternut squash is also rich in carbohydrates, vitamins A, C, E, and minerals that help boost immunity and fight free radicals. The orange color of pumpkin is high in carotene, an antioxidant that converts vitamin A and helps reduce cancer risk. Increasing the productivity of honey gourd is a challenge to increase the production of horticultural commodities in general, national income, and reduce imported commodities. Efforts to increase crop yields are carried out by using various ways of using fertilizers containing Nitrogen (N), Phosphorus (P), Potassium (K), and the use of organic fertilizers and manure (Kurniati et al. 2018).

The application of organic fertilizer has advantages that can improve the state of physics, chemistry, and biology in the soil. The use of organic fertilizers, apart from being applied independently, can also be applied with mycorrhizae. The addition of mycorrhizae in plant cultivation provides high benefits because mycorrhizae play a role in improving environmental conditions. Mycorrhizae can adapt to environmental conditions that are not suitable for their growth (Wicaksono et al. 2014). Mycorrhizal biofertilizers function as biofertilizers and bioprotectors for the growth and production of various types of plants. According to Nurmasyitah et al. (2013), each type of mycorrhizal has different abilities in its activities with plants. *Glomus mosseae* mycorrhizae is a type of mycorrhizal that is more active in soils dominated by the clay fraction, while other mycorrhizae such as *Gigaspora* sp. more active on sandy soils, 10 g of mycorrhizal application in plants can increase P nutrient uptake in drought-stressed plants. The results showed that the use of types and doses of mycorrhizae can affect the increase in growth and production of various plants and plant quality without reducing the quality and productivity of soil ecosystems (Matondang et al. 2020).

If in previous studies only used organic fertilizers, in this study organic fertilizers were combined with manure, with the hope that increased production could be more optimal. The manure used in this study was quail manure. Quail manure is one type of manure. Quail manure includes hot fertilizer and decomposes quickly so that it is directly absorbed by plants. Besides being easy to obtain, quail manure is also a good type of manure to be used as fertilizer, because it contains macro-nutrients (Ca, P, N, K, and Cl) and micro-nutrients

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(Fe, Cu, Zn, Mn, and Mo) which are needed by plants. The selection of quail manure is because it contains high levels of N, P, and K and can be used as a supplier of organic matter. Quail manure has a protein content of 21%, a nitrogen content of 0.061%, a P_2O_5 content of 0.209%, and a K_2O content of 3.133% (Kusuma 2012).

Based on the description above, this study aims to identify the response of growth and production of butternut squash to the application of mycorrhizae and quail manure to increase butternut squash production.

MATERIALS AND METHODS

This research was conducted at the Experimental Field, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, at Tuar Street, Medan Amplas District (3°33'25.8'N 98°37'54.5'E), in May-August 2021. The materials used were honey pumpkin seeds of the F1 variety, mycorrhizae *gigaspora,* quail manure fertilizer, bamboo/wood, mulch, raffia, wire, and other materials that support this research. The tools used in this study were hoes, saws, *gembor*, tape measure, machetes, knives, planks, scissors, buckets/barrels, plastic, scales, cameras, stationery, and other materials that support this research.

This study used a Randomized Block Design (RBD) with two factors, the first factor was the provision of mycorrhizae (M) which consisted of 3 levels, namely: M0: 0 (control), M1: 2.5 g per plant, M2: 5 g per plant and factor the second was quail manure (P) which consisted of 4 levels, namely: P0: (control), P1: 1 kg per plant, P2: 2 kg per plant and P3: 3 kg per plot, where there were 12 treatment combinations repeated 3 times.

Installation of mulch and planting

Installation of silver-black plastic mulch was done on sunny days so that the mulch could expand it close the beds tightly. Before the mulch is installed, bamboo pegs are prepared about 20 cm. The mulch is placed with the black facing down and the silver facing up. Then it is pulled at each end of the mulch section, after that it is staked with bamboo and then the edges of the mulch are covered with soil. After the mulch has been installed, make planting holes by punching holes in the mulch using a can filled with hot coals at 50 cm x 50 cm. Furthermore, the honey pumpkin seeds are planted by first soaking the seeds in warm water for 3 hours. After that, the seeds are planted as much as one seed per hole with a depth of 2-3 cm. After the seeds are planted, they are sprinkled with water evenly.

Installation of Ajir

Ajir pumpkin plants are made using bamboo with a height of 150 cm. The stakes are stuck near the planting hole in an upright position, then bamboo partitions are placed on top for the pumpkin vines to be planted.

Application of mycorrhizae

Mycorrhizae applications were applied 2 weeks after planting by sprinkling around the plants according to a predetermined concentration. The mycorrhizae application interval is once a week until the plants enter the generative phase.

Application of quail manure

Quail manure was applied by spreading it with a predetermined dose in each study plot, and then leveling it until it was mixed with the soil. Quail manure application is done a week before planting with the aim that it can be properly decomposed.

Parameter observed

Tendril length (cm). Observation of the length of the vines was carried out by measuring the stem of the plant from the standard stake to the tip of the growing point of the plant. Measurements were made using a measuring tape. Observation of plant length begins after the plants are 3 weeks old after planting with an interval of 1 week and is observed until the plants start to flower.

Number of leaves (blade). Observation of the number of leaves is done by counting the leaves of plants that have opened perfectly. Observation of the number of leaves began after the plants were 3 weeks after planting with an interval of a week and observed until the plants began to flower.

Leaf area (cm²). Observation of leaf area was carried out by measuring the leaf area of the widest leaf of the plant. Observation of leaf area was started after the plants were three weeks old after planting with an interval of a week and observed until the plants started to flower. Observation of leaf area using the weeds Buana method with the formula, according to Sitompul and Guritno (1995) as follows:

$$Y = -58{,}1404 + 5{,}4328x_1 + 0{,}9628x_2$$

Note: Y= Leaf area (cm²), x_1= Leaf length (cm), and x_2= Leaf width (cm).

Flowering age (days). Observation of flowering age was carried out when the plants had produced more than 60% flowers from each research plot.

Fruit length (cm). The length of the fruit is measured at the time of harvest. The length of the fruit is measured by measuring from the base of the fruit to the top of the fruit.

Fruit weight (kg). Fruit weight per plot is obtained by weighing the fruit that has been harvested from each plant in one plot.

Number of fruit (fruit). Observations were made by counting the number of fruit plants in one plot that already had criteria for harvest maturity.

Data analysis

Data analysis was carried out by ANOVA test and continued with Duncan's Mean Difference Test (DMRT) at a 5% level.

RESULTS AND DISCUSSION

Tendril length

The results of statistical analysis showed that the application of mycorrhizae and quail manure and their interactions had no significant effect on the tendril length of the butternut squash. the application of mycorrhizae at a dose of 2.5 g per plant and the lowest was found at a dose of 5 g plant^{-1}. The application of quail manure at a dose of 1 kg per plot resulted in the highest tendril and the lowest was found at a dose of 3 kg plot^{-1}. The best interaction that produced the highest tendril length was the application of mycorrhizae 2.5 g plant^{-1} with quail manure 1 kg per plot (Table 1).

The application of mycorrhizae and quail manure showed no significant effect on the tendril length of butternut squash. This is caused by the number of nutrients needed by plants has not been fulfilled, so the growth rate of plants is slow. The length of the tendril on the plant is influenced by the rate of plant growth, if the growth rate of the plant does not increase significantly it will affect the growth of the tendril (Dwidjoseputro 1999). This is presumably because the butternut squash's vegetative growth is more influenced by the availability of N in plants. The N element in the soil media functions to form amino acids and proteins which are used to stimulate the growth of the vegetative phase (Leghari et al. 2016). In addition, environmental factors, especially light, are also suspected to be the cause. The light intensity in this study was relatively the same so the growth of plant height had no significant effect, as stated by Fitter and Hay (2016) that plant growth was strongly influenced by environmental factors such as light and temperature, where these two factors played an important role in the production and transportation of foodstuffs. With the same light intensity, the resulting plant growth is also relatively the same.

Number of leaves

The results of statistical analysis showed that the application of mycorrhizae and quail manure and their interactions had no significant effect on the number of leaves of butternut squash. The application of mycorrhizae and quail manure with the appropriate dose can increase the number of leaves of butternut squash, where the highest number of leaves was found in the application of mycorrhizae at a dose of 2.5 g per plant and the lowest was found at a dose of 5 g per plant. The application of quail manure at a dose of 2 kg per plot resulted in the highest number of leaves and the lowest was found at a dose of 3 kg per plot. The best interaction that produced the highest number of leaves was the application of mycorrhizae 5 g per plot with quail manure 2 kg per plot (Table 2).

The number of leaves of butternut squash plants was not significantly affected by the application of mycorrhizae and quail manure, this caused the amount of nutrients available in the growing media. Leaf growth in plants is influenced by N elements. In line with this Alridiwirsah et al. (2020), the presence of nitrogen elements will increase the growth of vegetative parts such as leaves. N elements function in the process of leaf growth, if the N element in the growing media is not sufficient then vegetative growth in plants will not take place properly. This is also because the dose of quail manure given is still too low to stimulate the growth of the butternut squash plant, so it has no significant effect on the number of leaves. Visually, the higher the dose of quail manure given, indicates that there is a tendency to increase the number of leaves, but statistically, the increase is not significantly different. Barłóg et al. (2022) explain that improper fertilization, in terms of the dose, can affect the process of plant growth and development. According to Danial et al. (2020), the nitrogen content in quail manure is only 1.35%, in other words, it is still relatively low so it needs high doses of application.

Table 1. Mean of tendril length with the application of mycorrhizae and quail manure

Mycorrhizae (kg per plant)	Quail manure (kg per plot)				Mean
	0	1	2	3	
	cm				
0.0	164.67±24.3	183.22±16.1	144.78±98.8	169.56±13.0	165.56±15.9
2.5	189.44±36.3	212.22±33.4	161.78±64.6	174.00±26.0	184.36±21.7
5.0	178.11±11.7	149.89±41.5	188.33±25.2	123.22±76.1	159.89±29.4
Mean	177.41±12.4	181.78±31.2	164.96±21.9	155.59±28.1	

Table 2. Mean number of leaves with the application of mycorrhizae and quail manure

Mycorrhizae (kg per plant)	Quail manure (kg per plot)				Mean
	0	1	2	3	
	blade				
0.0	19.33±4.9	19.44±4.4	18.33±9.2	20.56±5.9	19.42±0.9
2.5	19.33±4.6	20.67±2.5	21.00±3.8	19.89±5.5	20.22±0.8
5.0	19.22±4.5	17.78±6.2	21.56±5.1	16.89±6.9	18.86±2.0
Mean	19.30±0.1	19.30±1.5	20.30±1.7	19.11±1.9	

Leaf area

The results of statistical analysis showed that the application of mycorrhizae and quail manure and their interactions had no significant effect on the leaf area of butternut squash. The application of mycorrhizae and quail manure increased the leaf area of butternut squash, where the highest leaf area was found in the mycorrhizae application at a dose of 2.5 g plant^{-1}, and the lowest was found in the control treatment (without mycorrhizae application). The application of quail manure at a dose of 2 kg plot^{-1} resulted in the highest and lowest leaf area in the control treatment. The best interaction that produced the highest leaf area was the application of mycorrhizae 2.5 g per plant with quail manure 2 kg per plot (Table 3).

The application of mycorrhizae and quail manure showed no significant effect on the leaf area of butternut squash. Several factors cause the growth of the butternut squash plant to be less than optimal, in addition to the insufficient dose of nutrients given to the plant for plant growth, the most important thing is that the soil conditions are not ideal, and the presence of rain after fertilization which causes nutrients in the quail manure to be given the plants was leaching and not completely absorbed. The research results of Dermawan et al. (2020) reported that butternut squash plants require soil with high organic matter content. High levels of organic matter will improve soil structure, soil biology, nutrient absorption ability, and soil moisture retention. In addition, plants will grow well if the required nutrients are sufficiently available in a form that can be absorbed by plants and supported by loose soil structure conditions (Nasution et al. 2013).

Flowering age

The results of statistical analysis showed that the application of mycorrhizae and quail manure and their interactions had no significant effect on the flowering age of butternut squash. The application of mycorrhizae and quail manure can accelerate the flowering period, where the fastest flowering age was found in the mycorrhizae application of 2.5 g per plant, and the longest was found in the control treatment (without mycorrhizae application). The application of quail manure with control treatments that were not significantly different from the application of 1 kg per plot resulted in the fastest and longest flowering age at a dose of 3 kg per plot. The best interaction that resulted in the fastest flowering age was the application of mycorrhizae 2.5 g per plant with quail manure 1 kg per plot (Table 4).

The application of mycorrhizae and quail manure had a significant effect on flowering age, this was presumably because the dose was still relatively low, so the application of quail organic fertilizer and mycorrhizae biological fertilizer could not meet the nutrient needs for plant growth. Plant growth is strongly influenced by the availability of nutrients in the soil. Nutrient deficiency can cause plant growth to be disrupted both vegetatively and generatively. In addition, environmental factors are also very influential on plant growth, if the temperature and biological ecosystems in the environment are not adequate, there will be a delay in generative growth (flowering). However, the application of mycorrhizae can accelerate the flowering age compared to the control treatment. According to Weaver (1972), mycorrhizae can inhibit vegetative growth and will indirectly divert assimilate to fruit development and pass through one phase of plant growth.

Table 3. Mean of leaf area with the application of Mycorrhizae and quail manure

Mycorrhizae (kg per plant)	Quail manure (kg per plot				Mean
	1	2	3	4	
	cm^2				
0.0	129.58±62.1	176.95±36.7	143.96±76.0	198.55±56.4	162.26±31.3
2.5	151.11±20.0	181.32±8.7	230.22±85.2	210.65±91.4	193.33±34.6
5.0	196.27±4.6	164.03±91.4	219.58±52.1	118.31±50.7	174.55±43.9
Mean	158.99±34.0	174.10±8.9	197.92±47.0	175.83±50.2	

Table 4. Mean of flowering age with the application of Mycorrhizae and quail manure

Mycorrhizae (kg per plant)	Quail manure (kg per plot)				Mean
	0	1	2	3	
	days				
0.0	42.44±0.2	42.33±0.0	42.33±0.0	42.44±0.2	42.39±0.1
2.5	42.22±0.2	42.11±0.2	42.33±0.3	42.44±0.2	42.28±0.1
5.0	42.11±0.2	42.33±0.3	42.44±0.2	42.44±0.2	42.33±0.2
Mean	42.26±0.2	42.26±0.1	42.37±0.1	42.44±0.0	

Fruit length

The results of statistical analysis showed that the application of mycorrhizae had a significant effect on fruit length, while the application of quail manure and their interactions had no significant effect on fruit length. Table 5 shows that mycorrhizae application had a significant effect on the length of the fruit of butternut squash with the highest mean being at a dose of 2.5 g plant^{-1}, which was 21.09 cm and the lowest mean was at 5 g plant^{-1}, which was 21.01 cm (Table 5). The relationship of mycorrhizae to the length of the fruit of butternut squash can be seen in Figure 1.

Based on Figure 1, the fruit length with mycorrhizae application forms a linear relationship with the regression equation = 21.056-0.005x with a value of r = 0.09. This is because mycorrhizae can assist plants in exploring the soil, a very important characteristic for phosphorus and nitrogen which do not move in soil solution. There is some evidence that fungi can help plants in tolerance drought. So, mycorrhizae become a symbiotic association between the roots of most plant and fungal species. This symbiosis is characterized by a bidirectional movement of nutrients in which carbon flows into the fungus and inorganic nutrients move into the plant, thus providing an important link between plant roots and the soil. In fertile soil, the nutrients taken by mycorrhizae fungi can lead to better plant growth and reproduction. Mycorrhizae are also associations between fungi and plant roots that can benefit both plants and fungi. Fungi connect plants with the soil by acting as nutrient exchange agents. Meanwhile, the fungus receives carbohydrates or sugars as energy from the roots of the host plant, while nutrients such as phosphorus and zinc are passed back to the plant roots from the soil (Safriyani et al. 2021). It is assumed that the plants have been infected with mycorrhizae which can absorb nitrogen in the soil which can be absorbed and utilized by plant roots to stimulate vegetative growth in plants. Setiadi and Setiawan (2011) explained that mycorrhizae can increase the absorption of water or nutrients, especially N by plants, which will increase the metabolism of carbohydrates, proteins growth regulators, and vitamins in their hosts which can stimulate plant growth (Tarigan et al. 2018).

Fruit weight

The results of statistical analysis showed that the application of mycorrhizae and quail manure had a significant effect on fruit weight, but the interaction of mycorrhizae and quail manure had no significant effect on fruit weight. Table 6 shows that mycorrhizae application had a significant effect on the fruit weight of butternut squash with the highest mean being at a dose of 5 g per plant, which was 6.64 kg and the lowest mean was at a dose of 2.5 g per plant, which was 5.28 kg. In addition, the application of quail manures also significantly affected the fruit weight of butternut squash with the highest mean being at a dose of 3 kg per plot, which was 6.51 kg, and the lowest was found in the control treatment, which was 5.00 kg. The relationship of mycorrhizae to the fruit weight of butternut squash can be seen in Figure 2.

Based on Figure 2, the fruit weight of butternut squash with mycorrhizae application forms a linear relationship with the regression equation = 5.2607 + 0.2212x with *r*= 0.58. This is presumably because the mycorrhizae given can have a symbiosis with the roots of the butternut squash plant and the growing media, so the mycorrhizae application given has a significant effect on the growth and production of the butternut squash. The symbiosis between plant roots and mycorrhizae hyphae occurs when the fungus enters the plant roots and causes infection. The infection process begins with the germination of spores in the soil and forms hyphae, growing hyphae penetrate the roots and develop in the cortex. In infected roots, arbuscular will form, from these arbuscular mycorrhizae can help absorb nutrients (Ortaş and Rafique 2017). In line with the opinion of (Diagne et al. 2020), each combination of mycorrhizae fungi and host plants has different functions and responses in terms of nutrient uptake for plant growth and production.

Based on Figure 3, the fruit weight of butternut squash with quail manure forms a linear relationship with the regression equation = 5.0878 +0.4839x with *r* = 0.97. This is caused by using a dose of 100 g per polybag is sufficient for plant needs. The increase of growth in fruit weight is influenced by the role of nutrients such as N, P, and K which can improve physiological processes increasing the product produced in plants that are expressed in the generative part, namely fruit, both in the number of fruits that can be formed and their size. Xu et al. (2020) state that the availability of sufficient nutrients allows the photosynthesis process to run optimally and produce more food reserves in the tissue of the plant, which will allow the formation of many flowers or fruit.

Number of fruits

The results of statistical analysis showed that the application of mycorrhizae and quail manure and their interactions had no significant effect on the number of fruits of butternut squash. Table 7 shows that the application of mycorrhizae and quail manure can increase the number of fruits, where the highest number of fruits was found in the mycorrhizae application of 5 g per plant and the lowest is in the control treatment (without mycorrhizae). The application of quail manure 3 kg plot^{-1} produced the highest number of fruits and the lowest was found in the control treatment (without quail manure). The best interaction that produced the highest number of fruits was the application of mycorrhizae 2.5 g per plant and quail manure 1 kg per plot, which were not significantly different from the application of mycorrhizae 2.5 and 5 g per plant and quail manure 3 kg per plot.

The application of mycorrhizae and quail manure could increase the number of fruits of butternut squash, but the increase was not significantly different from the control treatment. This is caused by the amount of nutrients contained in the planting medium has not been sufficient so plant production has not been maximized. A lack of nutrients in the soil can result in low plant productivity. Lack of one or more nutrients will result in improper plant growth; there are abnormalities or deviations and many plants die young. The production of a plant is influenced by the K element, if the K element is too little then the number of fruits will not be maximized. Apart from K nutrients, N and P elements also support fruit formation (Waluyo 2019).

Table 5. Mean of fruit length with the application of mycorrhizae and quail manure

Mycorrhizae (g per plant)	Quail manure (kg per lot)				Mean
	0	1	2	3	
	cm				
0.0	20.65±0.4	21.58±0.4	21.35±0.8	20.55±0.1	21.03±0.5b
2.5	21.12±0.4	21.28±0.6	20.88±0.6	21.07±0.6	21.09±0.2a
5.0	21.58±0.4	20.78±0.4	20.87±0.6	20.80±0.3	21.01±0.4c
Mean	21.12±0.5	21.22±0.4	21.03±0.3	20.81±0.3	

Note: Means followed by different letters in the same column or row are significantly different according to DMRT at 5%

Table 6. Mean of fruit weight with the application of mycorrhizae and quail manure

Mycorrhizae (g per plant)	Quail manure (kg per plot)				Mean
	0	1	2	3	
	kg				
0.0	4.10±0.3	7.53±0.5	4.97±1.5	5.52±1.0	5.53±1.5b
2.5	5.70±1.0	3.33±1.0	6.13±1.5	5.93±0.9	5.28±1.3c
5.0	5.20±0.3	6.28±1.5	7.00±0.7	8.07±0.7	6.64±1.2a
Mean	5.00±0.8c	5.71±2.2bc	6.03±1.0b	6.51±1.4a	

Note: Means followed by different letters in the same column or row are significantly different according to DMRT at 5%

Table 7. Mean number of fruits with the application of mycorrhizae and quail manure

Mycorrhizae (g per plant)	Quail manure (kg per plot)				Mean
	0	1	2	3	
	fruit				
0.0	3.00±0.0	3.33±0.6	3.67±1.2	3.67±0.6	3.42±0.3
2.5	3.00±1.0	3.67±1.2	3.33±1.6	4.00±1.0	3.50±0.4
5.0	3.00±1.0	4.00±1.0	3.67±0.6	4.00±1.0	3.67±0.5
Mean	3.00±0.0	3.67±0.3	3.56±0.2	3.89±0.2	

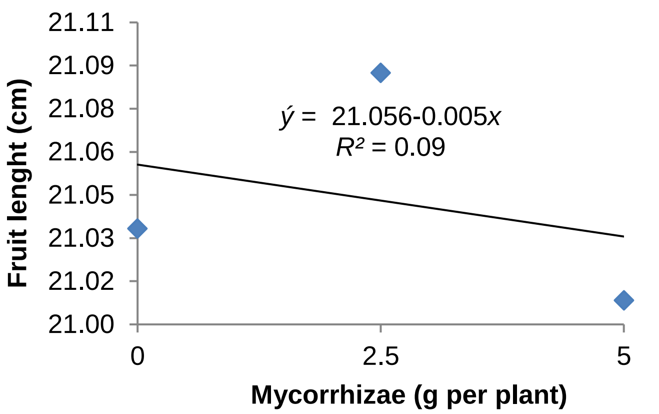

Figure 1. The relationship between mycorrhizae to fruit length of butternut squash

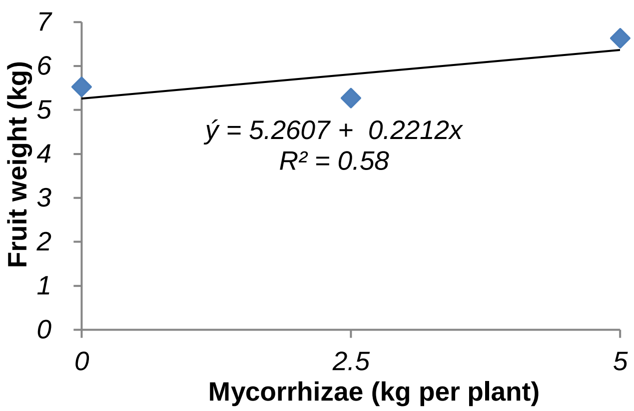

Figure 2. The relationship between mycorrhizae to fruit weight of butternut squash

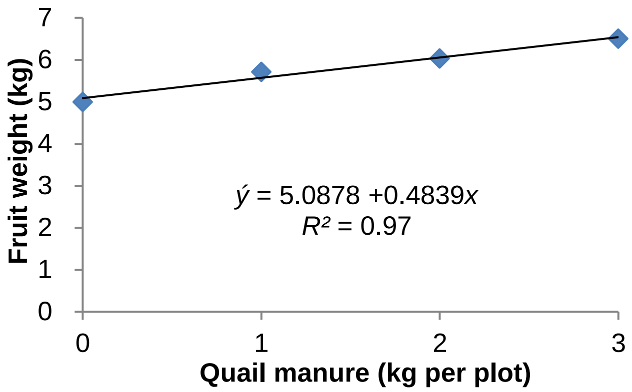

Figure 3. The relationship between quail manure to fruit weight of butternut squash

CONCLUSIONS AND SUGGESTIONS

The application of mycorrhizae had a significant effect on fruit length and fruit weight. The application of quail manure had a significant effect on fruit weight. The interaction of mycorrhizae and quail manure did not significantly affect all observed parameters. Although there was no significant effect, the application of mycorrhizae and quail manure was shown to increase the growth and production of butternut squash compared to the control (without application). The combination of mycorrhizal 2.5 g per plant and quail manure 1 kg per plot could increase butternut squash production.

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