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Effectiveness of Manganese (Mn) on Growth, Production and Chlorophyll Content of Mustard Greens (*Brasica rapa* L.) With Wick System Hydroponic

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Abstract. This study aims to find out the effectiveness of manganese fertilizer (Mn) on the growth, production and chlorophyll content of mustard pakcoy plants with wicksyhydroponic stem. This study uses a randomized group design (RAK) single factor, namely the dose of Manganese fertilizer with 4 repeats so as to produce 16 units consisting of 4 levels, namely tanpa pupuk Mn; concentration 50 ppm; 100 ppm; and 150 ppm. The observation variable consists of plant height, stem diameter, wet weight, dry weight and chlorophyll content. Dianalis data using variant analysis (ANOVA) then continued with the tukey range test at the level of 5%. The results showed a noticeable response to observations of plant height at ages 14, 28 and 35 hst and stem diameters at ages 21 and 35 hst. The provision of Mn fertilizer is also able to increase the chlorophyll content of pakcoy plants by 29.18%, chlorophyll b by 20.29% and total chlorophyll by 21.68%.

Keywords: Chlorophyll, Manganese Fertilizer (Mn), Pakcoy Mustard

1. Introduction

Vegetables have a very important role as a source of nutrients, vitamins and minerals, one of which is mustard pakcoy. Mustard pakcoy (Brassica rapa L) contains a lot of carbohydrates, fats, proteins, Fe, Ca, P (Syahroni et al., 2013) and contains various vitamins such as vitamins, B, C, E and vitamin K (Rizal, 2017). The many benefits of mustard pakcoy cause the demand for this vegetable commodity to increase. Statistical data shows an increase in the consumption of mustard pakcoy vegetables in 2019 by 13,557 kg / kap to 14,079 kg / kap in 2020 (Ministry of Agriculture, 2020). The transfer of the function of agricultural land into residential areas becomes an obstacle in the process of agricultural production. Therefore, there needs to be efforts in the cultivation of narrow land with high productivity and quality. Plants will grow optimally if their nutrient needs are met. Micro nutrients are no less important than macro nutrients in influencing plant growth and development. The importance of micronutrients is unavoidable because it has a major influence on various plant activities. Although plants only need very little. Nutrient management is one way to increase the efficiency of photosynthesis so that the quality of a plant production is maintained. In addition, in order to maintain the quantity of a plant, each nutrient must be available in sufficient quantities for a plant, as well as the balance and respect for the ratio between nutrients used is also no less important (Mousavi et al., 2011). One of the micro nutrients that are needed in the process of photosynthesis is manganese (Mn). Manganese plays a role in the process of reduction and oxidation in plants such as electron transport (Agustiansyah, 2017). Manganese also plays a waterbreaker in photosystem II (Diedrick, 2010). Not only that, the nutrient element manganese also contributes to the formation of chlorophyll in plants.

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Chlorophyll becomes the most important component in the process of photosynthesis as a light absorber and uses its energy to produce carbohydrates, CO2 and H2O (Singh et al., 2020). Not only that, chlorophyll has potential health benefits including antimutagenic, antigenotoxic and as an effective antioxidant to prevent free radicals (Senge et al., 2014).

Manganese is able to provide green conditions on old leaves so that the plant is still able to carry out photosynthesis so that it will increase plant production. Deficiency manganese can inhibit plant growth and development. Symptoms of manganese deficiency include chlorosis in young leaves and also cause the growth of seeds less optimal (Seran, 2017). Excess Mn can also damage plants such as swelling of the cell walls, which will cause the leaves to wither and brownish yellow spots and result in death. Manganese toxicity begins with the appearance of chlorosis at the ends of old leaves and continues to young leaves. These symptoms occur from the leaf boundary and continue to the area between the leaves and the necrosis of the leaves spreads due to the increased toxicity of manganese. This will lead to uneven distribution of chlorophyll and the accumulation of granule starch in chloroplasts (Bachman & Miller, 1995) in (Mousavi et al., 2011). The increasing number of settlement constructions resulted in the transfer of agricultural land functions. Cultivation using hydroponics is the right solution in Wick System Hydroponic is the simplest narrow land crop cultivation system that uses the axis system to help plants absorb nutrients. In the cultivation of hydroponic systems, plants get nutrients through water. Therefore, supplying the nutritional needs of plant nutrients is the most important component for success in cultivation with hydroponics. All hydroponic systems supply inorganic nutrient needs exclusively through water (Neocleous et al., 2020). From the above explanation, it is necessary to continue with research entitled Effectiveness of Manganese Fertilizer (Mn) On the Growth, Production and Content of Chlorophyll mustard plant Pakcoy (*Brassica rapa* L.) with Wick System Hydroponic.

2. Methodology

This research was conducted in Watesnegoro Village ngoro district of Mojokerto regency with a height of 120mdpl. Further, observations were made at the Laboratory of Plant Physiology Agrotechnology Study Program of Universitas Muhammadiyah Sidoarjo. The main ingredients used in this study are pakcoy seeds, rockwool planting media, AB mix nutrients, water, Mn fertilizer, as well as chlorophyll analysis materials such as dimethyl sulfoxide (DMSO), filter paper, aquadest. The tools used in the study were saws, trays, sterofoams, net pots, digital calipers, ruler, ballpoint, paper, measuring cups, labels, analytical balances, UV-Vis spectrophotometer, scissors, cameras, beaker glasses, TDS, waterbath. This study used a single group randomized design (RAK) dose of Manganese (Mn) fertilizer with 4 repeats resulting in 16 experimental units with each experiment with 9 plants. The Factor of giving Manganese fertilizier consists of 4 levels, namely: Mn0 = Without Fertilizer Mn; Mn1 = 50 ppm; Mn2 = 100 ppm; Mn3 = 150 ppm. Using calculations with formulas (Dewantara, 2017) as follows:

$$Manganese\ weight\ (mg/l) = \frac{ppm \times Mr\ \mathrm{MnSO4.H2O} \times 1\mathrm{L}}{Ar\ Mn} \quad (1)$$

The weight of manganese obtained from the calculation above is as follows Mn0-0ppm = 0mg/l; Mn1-50 ppm = 153.6 mg/l; Mn2-100 ppm = 307.2 mg/l; Mn3-150 ppm = 460.9 mg/l. Manganese fertilizer will be given to plants at the age of 7dap (days after plant), 16 dap and 28 dap. Variables observed among them :

a) Plant height (cm). Observation of plant height is done by measuring the height of the stem of the pakcoy plant ranging from the base of the stem to the top of the plant using a ruler. Measurements of plant height are taken on the 7dap, 14dap, 21dap, 28dap, and 35dap.
b) Diameter of the rod (mm). Observation of the diameter of the stem is done by measuring the diameter of the stem of the pakcoy plant at a distance of 1cm from the base of the stem using the analytical funnel term. Measurements of plant height are taken on the 7dap, 14dap, 21dap, 28dap, and 35dap.
c) Wet Weight (gr). Observation of wet weight is done by weighing the entire part of the pakcoy plant by taking rockwoll that is still attached to the roots. Calculation of crop weight is done at the time of harvest using an analytical balance sheet.

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d) Dry Weight (gr). Dry weight observations are made wrapping all parts of the pakcoy plant with paper and then drying the oven for 48 hours with a temperature of 65^0C. After the plant is purging it weighs the entire part of the pakcoy plant by taking the rockwoll that is still taped to the roots. Weight calculations are carried out at the time of harvest using an analytical balance sheet.
e) Chlorophyll content. The chlorophyll content of pakcoy plant leaves is analyzed at the age of 40dap each analyzed the content of chlorophyll a, b and total using an uV-Vis spectrophotometer.

3. Analysis of Chlorophyll

The sample is taken by weighing the leaves of mustard pakcoy that has been mashed as much as 0.1 grams inserted into erlenmeyer 250mL and adding a solution of DMSO*(Dymethyl Sulfoxide)*as much as 10mL. The solution is incached in the water trimmer for 30 minutes with a temperature of 65^0C at a speed of 10rpm. The next step is filtered using filter paper and measured using a uV-Vis spectrophotometer with wavelengths of 665 and 648. Chlorophyll must be measured first by calibration of its solvent transmitting value. Dmso transmittant value*(Dymethyl Sulfoxide)*is set the absorbance value must show zero value so that the absorbance value produced when measuring is determined only by chlorophyll as its solute. After the known absorbance value of chlorophyll solution at wavelengths 648 nm and 665 nm,then measured by formula (Barnes, et al. 1992):

$$\text{Chlorophyll a (mg/l)} = 14{,}85\ A{\sim}665 - 5.14\ A{\sim}648$$
$$\text{Chlorophyll b (mg/l)} = 25{,}84\ A{\sim}665 - 7.36\ A{\sim}665$$
$$\text{Total chlorophyll (mg/l)} = 7{,}49\ A{\sim}665 - 20{,}34\ A{\sim}665$$

Information:
A~665: Absorbance at wavelength 665 nm
A~648: Absorbance at a wavelength of 648 nm

Data analysis uses variety analysis to determine the effectiveness of Mn fertilizer on the growth and yield of chlorophylm content of mustard pakcoy plants with hydroponic wicksystem. If there is a real difference, it will be continued with a tukey range test 5%.

4. Results and Discussions

4.1. Research Results

4.1.1. Plant Height

From the results of the diversity analysis test showed that there was a noticeable response at plant age 14, 28 and 35 day after plants (dap) and did not give a noticeable response at the age of 7 and 14 dap to the treatment of Mn fertilizer to variable plant height. After the tukey range test 5%, the full data is presented in Table 1. Average Plant Height (cm) of Mustard Pakcoy on Application of Mn Fertilizer at Various Ages of Observation.

Table 1. Average Plant Height (cm) of Mustard Pakcoy on Application of Mn Fertilizer at Various Ages of Observation

Treatment	Plant Height (centimeter) at (DAP) age				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
Mn0	7.625	13.05 b	15.02	17.05 a	18.13 a
Mn1	7.625	11.83 a	15.63	18.23 b	20.48 c
Mn2	7.767	12.21 a	13.36	17.35 a	19.09 b
Mn3	6.675	13.24 b	14.99	17.13 a	19.00 b
BNJ 5%	tn	0.668	tn	0.403	0.673

Description: dap (days after plant), tn (not significantly different), BNJ 5% (Numbers followed by the same letter in the same column show an undeniably different with tukey range test 5%).

Based on Table 1 above it is seen that the average height of plants at the age of 14 hst obtained the highest data of 13.24 cm on the treatment of Mn fertilizer with a concentration of 150 ppm (Mn3) although different is not real from the treatment of Mn fertilizer with a concentration of 0 ppm (Mn0) but different is very real from the treatment of Mn fertilizer 50 ppm (Mn1) and 100 ppm (Mn2). The average height of the highest plant at the age of 28 dap was obtained 18.23 cm (Mn1) and at the end of the observation i.e. 35 hst obtained the highest average of 20.48 cm (Mn1) showed a very real difference from (Mn0), (Mn2) and (Mn3).

4.1.2. Diameter of Rod

From the results of the diversity analysis test showed that there was a noticeable response at plant age 21 and 35 dap and did not give a noticeable response at the ages of 7, 21 and 14 dap to the treatment of Mn fertilizer to variable plant stem diameter. After the tukey range test 5% then the full data is presented in Table 2. Average Plant Stem Diameter (cm) of Mustard Pakcoy on Application of Mn Fertilizer at Various Observation Ages.

Table 2. Average Plant Stem Diameter (cm) of Mustard Pakcoy on Application of Mn Fertilizer at Various Observation Ages

Treatment	Diameter of Rod (millimetres) at (DAP) age				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
Mn0	1.842	5.11	8.47 a	13.62	15.45 a
Mn1	1.850	5.33	9.18 c	13.48	18.98 c
Mn2	1.800	4.53	7.97 a	13.27	18.10 bc
Mn3	1.875	5.17	8.33 a	12.59	16.88 ab
BNJ 5%	tn	tn	0.547	tn	1.569

Description: dap (days after plant), tn (not significantly different), BNJ 5% (Numbers followed by the same letter in the same column show an undeniably different with tukey range test 5%).

Based on Table 2 above it is seen that the average diameter at the age of 21 hst obtained the highest data of 9.18 mm on the treatment of Mn fertilizer with a concentration of 50 ppm (Mn1) shows a very real difference from (Mn0), (Mn2) and (Mn3). The highest average plant at the age of 35 dap is obtained 18.98 mm (Mn1) although it shows a different not real from (Mn2) but shows a very real difference from (Mn0).

4.1.3. Wet Weight per Plant

From the results of the diversity analysis test showed that there was a real influence on the treatment of Mn fertilizer on the wet weight variable per plant. After the tukey range test 5% then the full data is presented in Table 3. Average Wet Weight of Pakcoy Mustard Plants on Application of Mn. Fertilizer.

Table 3. Average Wet Weight of Pakcoy Mustard Plants on Application of Mn. Fertilizer.

Treatment	Wet Weight (grams)
Mn0	86.87 bc
Mn1	70.43 a
Mn2	77.25 ab
Mn3	98.74 c
BNJ 5%	12.61517

Description: BNJ 5% (Numbers followed by the same letter in the same column show an undeniably different with tukey range test 5%.

Based on Table 3 above it is seen that the average wet weight per plant obtained the highest data of 98.74 grams (Mn3) although it shows a different is not real from (Mn0) and (Mn1) but shows a very real difference to (Mn2).

4.1.4. Dry Weight per Plant

From the results of the diversity analysis test showed that there was no real influence on the treatment of Mn fertilizer on the dry weight variable per plant. After the tukey range test 5%, the full

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data is presented in Table 4. Average Dry Weight (gr) of Pakcoy Mustard Plants on Mn Fertilizer Application.

Table 4. Average Dry Weight (gr) of Pakcoy Mustard Plants on Mn Fertilizer Application.

Treatment	Dry Weight (grams)
Mn0	3.62
Mn1	3.01
Mn2	3.66
Mn3	3.08
BNJ 5%	tn

Description: tn (not significantly different)

Based on Table 4 above it is seen that in allthe equipment the provision of fertilizer Mn does not havea real influence on the dry weight of theland.

4.1.5. Chlorophyll Content per Plant

From the results of the colorophile test percentage showed that there was an increase in the treatment of Mn fertilizer on the variable content of chlororfil per plant. The average results of the chlorophyll test can be presented in Table 5. Average Calculation Results of Chlorophyll A, Chlorophyll B and Total Chlorophyll P Values in Pakchoy Mustard Plants.

Table 5. Average Calculation Results of Chlorophyll A, Chlorophyll B and Total Chlorophyll P Values in Pakchoy Mustard Plants

Treatment	Weight (grams)	Chlorophyll Concentrate (mg/l)		
		Average Chlorophyll a	Average Chlorophyll b	Average Total Chlorophyll
Mn0	0,1	7,787	2,774	10.56
Mn1	0,1	10,06	2,486	12.54
Mn2	0,1	7,577	3,337	10.91
Mn3	0,1	9,750	3,097	12.85

From Table.5 it can be known that there is a difference in the content of chlorophyll a and b in each treatment. The highest value of chlorophyll a content is 10.06 mg / l contained in the treatment of Mn1. This means that in one gram sample of pakchoy plant leaves against the provision of Mn fertilizer with a concentration of 50 ppm produces chlorophyll a as much as 10.06 milligrams per liter and this proves that the provision of Mn fertilizer with a concentration of 50 ppm can increase chlorophyll levels a by 29.18%. The highest value of chlorophyll content b is 3,337 mg / l contained in the Mn2 treatment which means that in one gram sample of pakchoy plant leaves against the provision of Mn fertilizer with a concentration of 100 ppm produces chlorophyll b as much as 3,337 milligrams per liter. With the provision of Mn fertilizer with a concentration of 100 ppm can increase the level of chlorophyll a as much as 20.29%. The total chlorophyll content in mustard pakchoy plants in the treatment of manganese fertilizer with different doses can be seen in table 4. That is 12.85 mg / l in the treatment of Mn3. That is in one sample of pakchoy plant leaves against the provision of Mn fertilizer with a concentration of 150 ppm produces a total chlorophyll of 12.85 milligrams per liter. So that it can be estimated that the provision of Mn fertilizer with a concentration of 150 ppm can increase the total chlorophyll level by 21.68%.

4.2. Discussion

This study shows how effective manganese fertilizer (Mn) is with some concentration through the roots on the wick sytem hydroponic uptake as a micronutrient that will be one of the major factors in influencing plant growth. The most important component for success in planting using hydroponic systems is meeting the nutritional needs of plant nutrients. Research (Neocleous et al., 2020) says all hydroponic systems supply inorganic nutrient needs exclusively through water. According to (Shebl et al., 2020), (Das, 2014) manganese (Mn), iron (Fe) and zinc (Zn) are the most essential micronutrients needed for plant growth. The observations showed a noticeable response to plant height variables at observation ages 14, 21 and 35 hst and stem diameters at observation ages of 21 and 35 hst. Manganese (Mn) is able to stimulate the growth and production of biomass (Ciurli et al., 2021). Manganese is an indispensable constitutive element in the Mn cluster structure of the oxygen-evolving complex in photosystem (II) that participates in the separation of water and provides the electrons necessary for photosynthesis (Nickelsen & Rengstl, 2013) which is why it is needed in plant growth and development (Chen et al., 2017). In research (Al Fadlly et al., 2020) proved that the administration of manganese pupun 30mg / l + 60 mg.l zinc fertilizer affects the average height of plants that experience an increase of 26% compared to without the administration of manganese fertilizer at all. But the excess manganese will also be bad for the plant itself, excess Mn will be toxic to the plant. According to (Zhao et al., 2017) manganese toxicity (Mn) is probably the most important growth barrier after aluminum (Al) for sour land plants in some subtropical and tropical regions. Mn toxicity induces oxidative damage and thus interferes with the photosynthetic system in the leaves. This is certainly in line with research (Millaleo et al., 2010) excess manganese (0.5 or 1.5 mM $MnCl_2$)inhibits the efficiency of photosynthesis in long-term hydroponic cultivation. Mn toxicity will damage chloroplasts because excess manganese will interfere with the thylakoid structure and transport chain of photosynthetic electrons. In this case it is possible that the main target is chloroplasts (Chen et al., 2017). (Nazarovna et al., 2020) mentions the provision of manganese fertilizer in low and medium standards is able to increase the height of the plant by 9.6% higher than without the administration of manganese fertilizer. But when manganese is given to a high standard, the height of the plant decreases by 7.4% compared to the height of the plant without the administration of manganese fertilizer.

In plant productivity gives a noticeable response to the variable wet weight of the plant. This is in line with research (Dimkpa & Bindraban, 2016) that the growth and yield of corn, soybeans, wheat, sugarcane cane can increase several times and green beans increase by 58% (Pradhan et al., 2013) on fertilization with Mnin ionic form at the relevant dose. Micronutrients manganese (Mn), copper (Cu) and iron (Fe) are important for the synthesis of proteins, lipids and carbohydrates, this micronutrient deficiency is an inhibitor of root growth and resists the function of the photosynthetic II system this certainly causes a reduction in the size and content of chloroplast proteins causing photosynthesis metabolism is also disrupted and results in a reduction in pollen to decrease crop yields (Lehmann & Rillig, 2015),(Millaleo et al., 2010). In the dry weight observation variable does not give noticeable factor. In the process of plant metabolism, photosynthesis is the main process consisting of four stages of light perception, electron transfer, energy fixation, biosynthesis and photoalylate transfer where photosynthesis is the determinant of plant growth and yield (Blankenship, 2014). Nutrition can increase the rate of photosynthesis (Guo et al., 2019). The provision of manganese fertilizer is one of the efforts in meeting the nutritional needs of a plant. The administration of manganese (mn) can drain the process of photoresiption in plants, so that photosynthesis runs according to its function, so that it can streamline photosynthesis (Bloom &Lancaster, 2018). In his research (Arya & Roy, 2011) mentioned that the total chlorophyll content increased by 22% in the provision of Mn fertilizer. As a result plant growth will be 4-8 times higher when giving Mn levels (40-160 µM) and at concentration (10 µM) buds share only 1-fold. Chlorophyll in photosynthesis converts sunlight into energy. Nutritional deficiencies can result in suffoeency and may lead to decreased quantum photointem (II) efficiency. Manganese (Mn) is an important element in maintaining the normal structure of the chloroplast membrane. In line with research (Chun-xia et al., 2018) that the administration of manganese and giberlin concentrations in wheat leaves showed an increase in total chlorophyll and chlorophyll a, thus improving the parameters of photosynthesis. In this case, of course, it is sustainable and can increase crop yields.

5. Conclusion

Based on the results of research that has been donen can be concludedkan that the provision ofMn fertilizer is quite effective in increasing the growth and production of pakcoy plants. This is evidenced by the real response to plant growth, namely variable observation of plant height at the age of 14, 28 and 35 dap, and variable observation of stem diameter at observation age 21 and 35 dap. In the observation ofplant roduction p also gives a noticeable response to wet weight variables. The provision of Mn fertilizer is also able to increase the chlorophyll content of pakcoy plants by 29.18%, chlorophyll b by 20.29% and total chlorophyll by 21.68%.

Thank you

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