EFFECT OF RHIZOBACTERIA ON GROWTH AND PESTICIDE RESIDUE IN CABBAGE *(Brassica oleracea var. capitata)*

Milda Ernita, Fuji Tria Mariska, Zahanis dan Ermawati

Agrotechnology Study Program, Faculty of Agriculture, Univ. Tamansiswa Padang

Correspondence Email : mildaernita28@gmail.com

Abstract

Rhizobacteria are a group of bacteria that can increase plant growth and bioremediation. This experiment aims to determine the interaction of rhizobacteria and NPK Mutiara on growth, yield, and pesticide residues in cabbage. The experiment was carried out on andosol soil with an altitude of ± 1450 mdpl and located in Jorong Padang Laweh, Lembah Gumanti District Solok Regency, West Sumatra. The experiment used a Completely Randomized Design (CRD) with three replications The treatment is type of rhizobacteria as without rhizobacteria, *Bacillus sp., Stenotrophomonas maltophilia,* and *Stenotrophomonas pavanii.* The data were analyzed by analysis of variance *(ANOVA)* based on the F test at 5%. If there is a significant effect, it is continued with Duncan's multiple distance test (DNMRT) at a 5% confidence level. The results showed that the best of *Bacillus* sp increased vegetative growth, while the *Bacillus sp S. maltophilia,* and *S. pavanii* could increase cabbage production, reduce cabbage leaf spot disease and both *Stenotrophomonas* sp were able to reduce the content of pesticide residues in cabbage and in the soil.

Keywords: *Bacillus sp; S.maltophilia; S.pavanii; cabbage, residue pesticides*

1. Introduction

Cabbage (*Brassica oleracea* var. *capitata*). is one type of vegetable commodity that has the potential to be developed. Cabbage contains protein, fat, carbohydrates, fiber, calcium, phosphorus, iron, sodium, potassium and vitamins (A, C, E, thiamine, riboflavin, nocotinamide), calcium and beta carotene compounds, besides that it also contains cyanohydroxybutene (CHB) compounds, sulforaphane and iberine which stimulate the formation of glutathione (Dalimartha, 2000). Cabbage vegetables are generally consumed in fresh form, so it is very important to pay attention to quality, especially free from pesticide residues.

Cabbage production in Indonesia in 2019 was 1,413,060 tons, and in 2020 it was 1,406,985 tons (Central Bureau of Statistics, 2021). West Sumatra is one of the centers of cabbage production with total production in 2020 reaching 211,700.80 tons. Total production has increased from 2019 which was 131,051.60 tons (Department of Food Crops, Horticulture and Plantation of West Sumatra Province, 2020). Despite the increase, cultivation techniques still rely on the intensive use of chemical fertilizers and pesticides in pest and disease control. At this time the price of fertilizers and pesticides are expensive and not environmentally friendly, it is necessary to find other alternatives that can increase production and quality of plants. One of the efforts that can be done to control disease and at the same time increase the production and quality of cabbage is the use of rhizobacterial microorganisms.

Rhizobacteria are bacteria that live in the root environment and have a good effect on plants. Rhizobacteria play a role in increasing growth, yield and able to suppress the development of plant diseases. The use of rhizobacteria to increase crop production has been widely carried out, including; on shallots with the application of several types of rhizobacteria were able to increase growth, yield and

increase onion resistance to bacterial leaf blight disease (Ernita, et al., 2016). and potato tuber quality, (Hipi, et al., 2013) using rhizobacteria and phosphate fertilizers and increasing the growth, yield and quality of hybrid maize seeds.

2. Tinjauan Pustaka

Cabbage belongs to Regnum plantae, super division Spermatophyta, division Magnoliophyta, class Magnoliopsida (dicots), order Papavorales, family Brassicaceae, genus Brassica, species *Brassica oleraceae* L. var. capitata. In Indonesia, cabbage is generally grown in the highlands of 1000 - 2000 meters above sea level. The seedling time requires a weak light intensity, while the growth stage requires a strong light intensity. Cabbage can live at an air temperature of 10 – 24˚C with an optimum temperature of 17˚C. Good air humidity is in the range of 60 – 90%. Humidity above 90% will result in the appearance of watery soft rot disease, seedling fall disease, and other diseases caused by fungi. The amount of rainfall 80% of the normal amount (30 cm) gives an average yield of 12% below the normal average (Fanis, 2013).

The physical condition of the suitable soil is medium textured, i.e. sandy loam, crumb structure (loose), fertile, rich in organic matter, but still tolerant of rather heavy soils. The types of soil that are suitable for cabbage are latosol, regosol and andosol, but cabbage can still live on other types of soil, but the results are not good. High wind rates for a long time can cause the balance of water and air content in the soil to be disturbed, the soil to become dry and hard, the decomposition of organic matter is hampered, nutrients are reduced and cause toxins due to no oxidation of gases (Fanis, 2013)

Rhizobacteria are bacteria that live saprophyteically in the rhizosphere or root areas and act as plant growth promoters to increase agricultural production and act as biocontrol agents against plant diseases. In general, the function of rhizobacteria in increasing growth is divided into three categories, namely as a Bio-fertilizer because of its ability to transform natural sources of nutrients (nutrients) or synthetic fertilizers that are applied to be easily available and absorbed by plant roots through enzymes produced by bacteria. (Widodo, 2016).

Rhizobacteria function as bio-stimulants, because rhizobacteria can produce several growth regulators, namely IAA, cytokinins, gibberellins, and anti-ethylene compounds. One of the hormones produced by PGPR is IAA which can increase root growth. With good root growth, plants will be better at absorbing nutrients and water so that plant growth will be better (Widodo, 2016).

Rhizobacteria function as bio-protectants, because rhizobacteria are able to play a role in protecting plants from attacks by plant pest organisms (OPT). The protective mechanism can be direct by producing anti-microbial compounds (antibiotics) or lytic enzymes that destroy pathogenic cells, or indirectly by activating plants to produce defense compounds (Bhattacharyya*, et.al*, 2012).

Bacillus sp. is a group of PGPR (Plant Growth Promoting Rizobacteria) bacteria that have the ability to produce phytohormones such as indole acetic acid, gibberellin acid, cytokinins, and ethylene, produce siderophores, nitrogen fixers, produce antibacterial, plant antipathogens and can dissolve phosphate. Bacillus sp. is a phosphate solubilizing bacteria that has been widely applied in triggering plant growth (Astuti, 2008).

Rhizobacteria also play an active role in reducing levels of pesticide residues in the soil. According to Bollag (1992) if a pesticide is in contact with microbes there are four possibilities for the pesticide. First, pesticide molecules are degraded by microbes by making them a source of energy or substrate for growth. Second, microorganisms degrade but do not provide energy for growth, this process is called cometabolism. Third, microbes combine pesticide molecules with compounds that exist in nature. Fourth, pesticides accumulate in the microbial cells

Some rhizobacteria are known to be able to degrade pesticide residue compounds, one of which is Bacillus sp. Bacillus sp can degrade DDT by 65%. In addition, Bacillus has also been reported to be able to produce surfactin biosurfactants that can be used to increase the solubility of organic pollutants (Purnomo *et al*., 2017). The results of Khrishna and Philip (2011) also stated that the rhizobacteria Bacillus sp was able to degrade the pesticide compound lindane.

The increase in cabbage production so far is inseparable from the dependence on the use of artificial fertilizers and pesticides. In Nagari Alahan Panjang, NPK Mutiara was applied at 16:16:16 at a dose of 200-400 kg/ha. Compound fertilizers have a balanced composition of nutrients and can dissolve slowly. Pearl NPK contains N, P and K nutrients and is equipped with CaO and MgO nutrients in the form of blue solid granules (granules) with shiny pearl-like granules, hygroscopic and neutral. NPK Mutiara has several advantages, including its slow soluble nature so that it can reduce nutrient loss due to leaching, evaporation, and absorption by soil colloids. In addition, NPK Mutiara has a balanced nutrient content, is more efficient in application, and is not too hygroscopic so that it is resistant to storage and is not easy to clot (Sipayung et al., 2020).

3. Methodology

The research was carried out on Andosol soil with an altitude of ± 1450 mdpl located in Jorong Padang Laweh, Lembah Gumanti District, Solok Regency, West Sumatra, on January to May 2022. Tests for the content of pesticide residues were carried out at the Pesticide Laboratory of the Indonesian Food Crops and Horticulture Protection Agency, West Sumatra.

The materials used in this experiment were cabbage seeds of Green Nova, *Bacillus* sp., *Stenotrophomonas maltophilia, Stenotrophomonas pavanii*, NPK Mutiara, chicken manure and water. The equipment used is a hoe, bucket, machete, tugal tool, sickle, water hose, gembor, manual scale, digital scale, measuring cup, caliper, ruler, tape measure, plastic, stationery, bamboo, raffia rope, nameplate, and label.

The experiment was conducted in a completely randomized design (CRD) with the treatment of rhizobacteria, namely, without rhizobacteria (A0), *Bacillus* sp. (A1), *Stenotrophomonas maltophilia* (A2), and *Stenotrophomonas pavanii* (A3). Each treatment was replicated 4 times, so there were 16 experimental plots. Observational data were analyzed by analysis of variance (ANOVA) based on the F test at 5% level. If there is a significant effect, it is continued with Duncan's multiple distance test (DNMRT) at a 5% confidence level. The data was processed using the SPSS 26.

The land was cleared of plant residues and plots were made with a size of 4.20 m x 1.80 m with 16 plots. Soil that has been processed is given rhizobacteria mixed with chicken manure as much as 10 mL/kg of chicken manure. The

rhizobacteria mixed with chicken manure were applied to the soil at a dose of 10 tons/ha equivalent to 7.56 kg/plot one week before planting and applied evenly over the soil surface in each experimental plot. The application of NPK to plants is carried out in two stages. The first stage was when the plant was 7 day after planting and the second stage was when the plant was 30 dap.

Observations were made on plant height, number of leaves, leaf length, stem diameter, age of shoot emergence, crop diameter, crop weight per plant, yield per plot, yield per ha, rate of leaf spot disease and the percentage reduction in pesticide residue levels in cabbage

4. Result

A. Plant height, number of life, Jumlah Daun, Panjang Daun, dan Diameter Batang

The results of the analysis variance of plant height, the number of leaves treated with rhizobacteria gave a significant effect, while the leaf length and stem diameter parameters had no significant effect. Data on plant height, number of leaves, leaf length and stem diameter of cabbage plants are presented in Table 1.

Table 1. Height, number of leaves, leaf length and stem diameter of cabbage plants influence of various types of rhizobacteria

Treatment	Height (cm)	Number of leaves (leaf)	Leaf length (cm)	Stem diameter (cm)
No. rhizobacteria	24,67b	14,78b	28,22	1,82
Bacillus sp	28,11a	17,11a	30,02	1,83
S. maltophilia	27,00a	18,17 a	31,22	1,89
S.pavanii	27,00a	16,56a	31,48	1,82

Column numbers followed by the same lowercase letters were not significantly different according to DNMRT 5%.

Table 1 shows that the administration of the three types of rhizobacteria was able to increase plant height and number of cabbage leaves compared to no rhizobacteria. The parameters of leaf length and stem diameter showed no significant effect without giving and giving the three types of rhizobacteria. Rhizobacteria can increase the height and number of leaves of cabbage plants because rhizobacteria have ability to provide nutrients and produce growth regulators. According to Guyasa *et al*., (2018), rhizobacteria are able to produce growth hormones, namely Indole Acetic Acid (IAA), gibberellins, and cytokinins. Furthermore, according to Rahni (2012) and Ernita, *et al*., (2016) bacteria from the genus Bacillus were identified as phytohormone-producing PGPR that are able to increase plant growth and yields, especially auxin hormones that play a role in increasing or spurring plant height

B. Umur Muncul Krop, Diameter Krop, Bobot Krop per Tanaman, dan Hasil per Ha

The results of the analysis variance of age of crop emergence, crop diameter, crop weight, production per hectare treated with rhizobacteria gave a significant effect. Data on age of crop emergence, crop diameter, crop weight, production per hectare of cabbage are presented in Table 2.

Table 2. Age of crop emergence, crop diameter, crop weight, production per hectare on rhizobacteria species treatment

Treatment	Age of crop (dap)	Crop diameter (cm)	Crop weight (kg)	Production per hectare (tons)
No. rhizobacteria	44,00c	15,53	1,69b	45,63b
Bacillus sp	34,67a	17,26	2,01a	64.25a
S. maltophilia	37,33b	15,93	1,92a	62,92a
S.pavanii	39,00b	16,77	2,00a	64,59a

Column numbers followed by the same lowercase letters were not significantly different according to DNMRT 5%.

Table 2 shows that introducing rhizobacteria into the soil can provide benefits for plant growth with its ability to increase the absorption of nutrients, especially P (Rondonuwu, 2016). This is supported by the research of Dewi and Nugroho (2014), the role of phosphorus for plants is to encourage the formation and growth of fruit. Deficiency of this element can cause cabbage heads to not form.

The diameter of the crop is closely related to the number of leaves, the more the number of leaves, the wider the diameter of the crop. The size of the crop is influenced by the division, elongation and enlargement of the cells in the cabbage so that the cabbage sprouts appear to be growing bigger. rhizobacteria function to improve soil physical properties so that the texture and structure of the soil becomes loose, improve soil chemical properties because rhizobacteria can stimulate phytohormones and support the process of cation exchange capacity, and improve soil biological properties due to increased soil microorganism activity. This causes an increase in macro and micro nutrients. So that growth is increased to support the process of plant photosynthesis. The photosynthesis process produces high photosynthate which causes the generative development of plants so that the weight and diameter of the crop can increase (Husnihuda *et al.,* 2017). This is supported by the results of Anisa's research (2019), which stated that the administration of rhizobacteria had a significant effect on the diameter of the cauliflower shoots.

Increased plant growth by giving rhizobacteria is because rhizobacteria are able to provide microbes that help break down soil organic matter into nutrients for plants such as N, P, and K. Rhizobacteria can also dissolve stored phosphate with other elements to become available to plants (Marom *et al.,* 2017). This is in line with Vassey's (2003) research which states that rhizobacteria have the ability to provide nutrients due to their ability to dissolve minerals in the form of complex compounds into ionic forms so that they can be absorbed by plant roots.

C. Spots appear, disease percentage, and efficiency

The results of the analysis variance of appears spot, disease percentage treated with rhizobacteria gave a significant effect. Data on appear spot, disease percentage of spot of cabbage are presented in Table 3.

Table 3. Appears spot, disease percentage of spot and efficiency application of rhizobacteria

Treatment	Appears spots (dap)	Disease percentage (%)	Efficiency (%)
No. rhizobacteria	14,00c	35,53c	0
Bacillus sp	26,67b	21,18a	40,3884
S. maltophilia	32,33a	25,93a	27,0194

S. pavanii	31,12a	29,87b	15,9312

The numbers followed by lowercase letters are not significantly different according to DNMRT level 5%

The appearance of spotting symtomps without giving rhizobacteria is faster at 14 days after planting compared to those given rhizobacteria. Treatment with rhizobacteria can be delay the appearance. Rhizobacteria are able to growth promotion and disease control are complec interrelated proceeses that involve direct and indirect mechanisms. The mechanisms include synthesis of same metabolites growth hormone like auxin, cytokinin and gibberellins, production of siderophore, antibiotic and volatile coumpound (Bhattacharyya*, et.al*, 2012).

Bacteria inhabit the rhizosphere the immediate influence of the plant root system and favor the establishment of a large amount of active microbial population. The general mechanisms used for protection of plant antibiotic production, chelation of available Fe in the rhizosphere, synthesis of extracellular enzymes to hydrolyze the fungal cell wall and competition for niche within the rhizosphere (Vessey, 2003)

D. Pesticide residue levels in soil and cabbage yield

Analysis of the pesticide residue content was carried out on soil samples before harvest, when the plants were 6 week after planting (wap), the soil after harvest, when the plants were 12 week after planting. The active ingredient content of the pesticide residue analyzed was acepathe. The pesticide residue content is presented in Table 4.

Table 4. The content of the active ingredient acepathe in the treatment of rhizobacteria

Treatment	In the soil before planting (mg/kg)	In the soil after harvest (mg/kg)	On cabbage (mg/kg)
No rhizobacteria	0,206	0,178	0,161
Bacillus sp	0,204	0,127	0,145
S. maltophilia	0,204	0,128	0,145
S. pavanii	0,205	0,126	0,146

Note:The BMR of acepathe on the cabbage is 2 mg/kg According to the Peraturan Menteri Pertanian Republik Indonesia No.53/PERMENTAN/KR.040/12/2018

The application of insecticides was carried out three times, namely when the plants were 1, 3 and 5 wap. The insecticide applied was Joker 75 SP with acetate active ingredients. Joker insecticide used to control armyworms that attack cabbage. The results of the analysis of pesticide residue levels showed that the levels of acetate residues detected in the cabbage samples were below the Maximum Residue Limit (BMR) regulated in the Regulation of the Peraturan Menteri Pertanian Republik Indonesia No.53/PERMENTAN/KR.040/12/2018 concerning Food Safety and Quality. Fresh from Plants. In the regulation, the BMR of the active ingredient of the acetate for cabbage is 2 mg/kg.

Table 4 shows that soil pesticide residue levels were greater than cabbage pesticide residue levels in the treatment without rhizobacteria. This happens because of the evaporation of pesticide residues that occur in cabbage. Supported by active ingredients acefat which includes organophosphate insecticides and has properties that are easily biodegradable in nature. Unlike

cabbage, the soil will absorb pesticide residues and bind to the soil. The top layer of soil has the most organic content so that pesticides are easily absorbed, tightly bound so that it will inhibit the evaporation of pesticides (Puspitasari *et al*., 2016).

Table 4 also shows that the application of rhizobacteria contained levels of pesticide residues in the soil that were smaller than the levels of pesticide residues in cabbage. This is due to the activity of rhizobacteria in the soil. According to Mulyono (2009), pesticides in the soil always experience dynamic conditions. Every time there is addition and subtraction. The addition of pesticides in the soil occurs because most of the pesticides used will enter the soil. The reduction occurs due to chemical decomposition (chemical degradation) and microbiological decomposition (microbial degradation) carried out by soil microorganisms.

This is supported by research by Siripattanakul *et al*., (2009) which states that rhizobacteria capable of degrading pollutant organic compounds are supported and used as a source of nutrition for their growth. This biodegradation ability can be used to overcome the problem of pesticide contamination with bioremediation techniques.

5. Conclutions

The conclutions of the research is the *Bacillus* sp is the best to increased vegetative growth, while the *Bacillus sp S. maltophilia,* and *S. pavanii* could increase cabbage production, reduce cabbage leaf spot disease and both *Stenotrophomonas* sp were able to reduce the content of pesticide residues in cabbage and in the soil.

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