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Pest control technology for *Plutella xylostella* L. on green mustard (*Brassica juncea* L.) using Bacillus thuringiensis in tukungan soil

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ABSTRACT

Green mustard (*Brassica juncea* L.) is a popular vegetable among the people. Green mustard leaves are commonly used as complementary ingredients such as chicken noodle, meatballs, etc. These vegetables are easily accessible to traditional markets, supermarket, and mall. The main obstacle in cultivating green mustard is *Plutella xylostella* attack. *P. xylostella* pests can attack both vegetative and generative, striking at the shoots and leaves of plants from breeding to harvesting. One of the effective and safe controls is the bioinsecticide *Bacillus thuringiensis*. Tukungan soil is a swamp land management technology that aims to diversify commodities that can be planted. This technology is very helpful in utilizing and maximizing existing agricultural land, especially in South Kalimantan. The bioinsecticide material used is a strain of *B. thuringiensis* which is the Turex WP. This research aims to determine the best dose of bioinsecticide *B. thuringiensis* (Turex WP) in controlling *P. xylostella* pests, increasing growth and yield of green mustard in tukungan soils. The research used a one-factor randomized block design, namely the dose of bioinsecticide (Turex WP) consisting of five treatments: p_0 = 0 g/L, p_1 = 0.5 g/L, p_2 = 1 g/L, p_3 = 1.5 g/L, and p_4 = 2g/L. The results showed that the bioinsecticide *B. thuringiensis* (Turex WP) with a dose of 2 g/L was effective in controlling *P. xylostella* pests, increasing growth and yield of green mustard in tukungan soils.

Keywords: Bioinsecticide, *Plutella xylostella* L., Sub-optimal land, Swamp land, Tukungan soil

1. Introduction

Green mustard (*Brassica juncea* L.) is a vegetable that is popular with the community. Green mustard leaves are consumed as additional ingredients in several dishes, such as chicken noodles, meatballs noodles, cap cay, and so on. This vegetables is easily found in traditional markets or supermarkets (Drost & Johnson, 2010).

The main obstacle in cultivating mustard crops is the attack of *Plutella xylostella* pests. *P. xylostella* can attack in vegetative or generative stages, by attacking the shoots and leaves of plants from seedling to harvesting. One effective and safe control is by using bioinsecticide *Bacillus thuringiensis* (Sastrosiswojo, Uhan, & Sutarya, 2005). *B. thuringiensis* is a microbial material used as a bioinsecticide, gram-positive, rod-shaped bacteria, and has the ability to produce protein crystals during its sporulation period. As biological control, these protein spores and crystals can be toxic to the digestive system of insects (Pujiastuti, 2004).

One of the popular brands containing *B. thuringiensis* which is commonly found in agricultural shops is Turex WP. It is used to prevent caterpillar attacks, especially *P. xylostella*, because it is safe to use and does not cause environmental residues. Turex WP is a bioinsecticide that works as a stomach

poison, with a powdery form and light brown color, containing the active ingredient $^{\delta}$-endotoxin produced from *B. thuringiensis* var. Aizawai strain GC-91: 3.8% (Källqvist et al., 2016).

South Kalimantan is an area with extensive wetlands reaching 382,272 ha (Tavinayati, Effendy, Zakiyah, & Hidayat, 2016). According to the Direktorat Jenderal Prasarana dan Sarana Pertanian (2011), the tidal land area in South Kalimantan is 86,000 ha. This data shows that tidal land is potential to be used as agricultural land, especially green mustard. Land arrangement is very necessary to manage tidal land. One way of arranging tidal land for green mustard is the tukungan system. Tukungan has long been used by farmers in tidal land, especially by people in South Kalimantan. Farmers organize their land into two parts, namely the raised part (*guludan*) and the excavated part (*tabukan*), so that a paddy field system and a dry field system are formed in one stretch. In this system, farmers can optimize farming in various ways commodities and cropping patterns (Maftuah et al., 2021). Land management with the tukungan system makes it easier for farmers to diversify their food. Apart from planting rice, other crops such as green mustard and other vegetables were also carried out (Ismail, 1993). This research aims to determine the best dose of bioinsecticide *B. thuringiensis* (Turex WP) in controlling *P. xylostella* pests, increasing growth and yield of green mustard in tukungan soils.

2. Materials and Methods

Materials

The materials used in this study included Turex WP, urea, dolomite, chicken manure, Green Pakchoy mustard seeds, while the tools used were measuring cylinder, hoes, analytical balance, ruler, camera, millimeter block, and handsprayer.

Methods

The experiment was conducted at Land Saka Batur Village, District Kapuas, Central Kalimantan from June - August 2019. This study used a one-factor randomized block design (RBD) with five treatments and five replications so that 25 unit experiments were obtained. The treatments given are as follows: p_0 = 0.0 g/L Turex WP (control), p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, and p_4 = 2 g/L Turex WP.

The research stages include:

a. Land preparation. The land used in this research is tukungan soil in the tidal land type B in Saka Batur Village, Kapuas Regency, as many as 25 plots of tukungan soil measuring 0.5 m x 0.5 m x 0.2 m. Tukungan soil age about two years.
b. Fertilizer application. The first application of fertilizer is carried out one week before planting, using chicken manure at a dose of 10 t/ha (Saputra & Sari, 2021) and dolomite at a dose of 1.5 t/ha. Urea is given at the time of planting at a dose of 150 kg/ha.
c. Planting. Green mustard was planted into the land at the age of two weeks after seeding with a spacing of 0.15 x 0.15 m.
d. Turex WP application. The Turex WP application is given when the plants are five weeks old after planting, by dissolving Turex WP into clean water, with doses according to treatment, namely 0.5 (p_1) g/L, 1 g/L (p_2), 1.5 g/L(p_3), and 2 g/L (p_4).
e. Maintenance. Maintenance activities include replacing the abnormal or dead plants, watering, and weeding. Watering was done every day (morning and evening), and the weeding was done once the weeds appear around the plants.

Observations in this study include:

a. Attack intensity. Measuring the intensity of *P. xylostella* pests on green mustard at 6 and 8 week after planting (WAP) using millimeter blocks and the formula as follows: I= $\frac{\sum niVi}{ZV}$ x 100%.

   Note: I= intensity of leaf damage; ni= the number of leaves on each plant observed; Vi= the scale value of the highest attack category (1-4); Z= the scale value f the highest attack category; V= the number of leaves observed. The intensity of the attack obtained from the calculation formula is then interpreted using the criteria for the intensity of leaf damage (Table 1).

Table 1. Leaf damage intensity criteria

Leaf damage criteria	Symptoms	scale
0%	No attack	0
1-25%	Leaf attacked slightly, perforated with a very small attack size	1
26-50%	The affected leaves are quite large, the number of attacks is quite large and the blood falls out	2
51-75%	All the leaves are attacked, the number of attacks is large, and the leaves fall	3
76-100%	Dead plants	4

Source: (Mokodompit, et al., 2019)

b. Attack frequency (FS). Measurement of the frequency pest attacks carried out at ages 6 and 8 WAP with the formula: FS = $\frac{x}{y}$ x 100%. Note: x= the number of leaves affected; y= the number of leaves observed. The attack frequency obtained from the calculation formula is then interpreted using the criteria for the percentage of pest attack (Table 2).

Table 2. The percentage value of pest attack

Persentage	Pest attack rate
<10%	Very low
10-50%	Low
51-75%	Moderate
>75%	High

Source: Supartha et al. (2021)

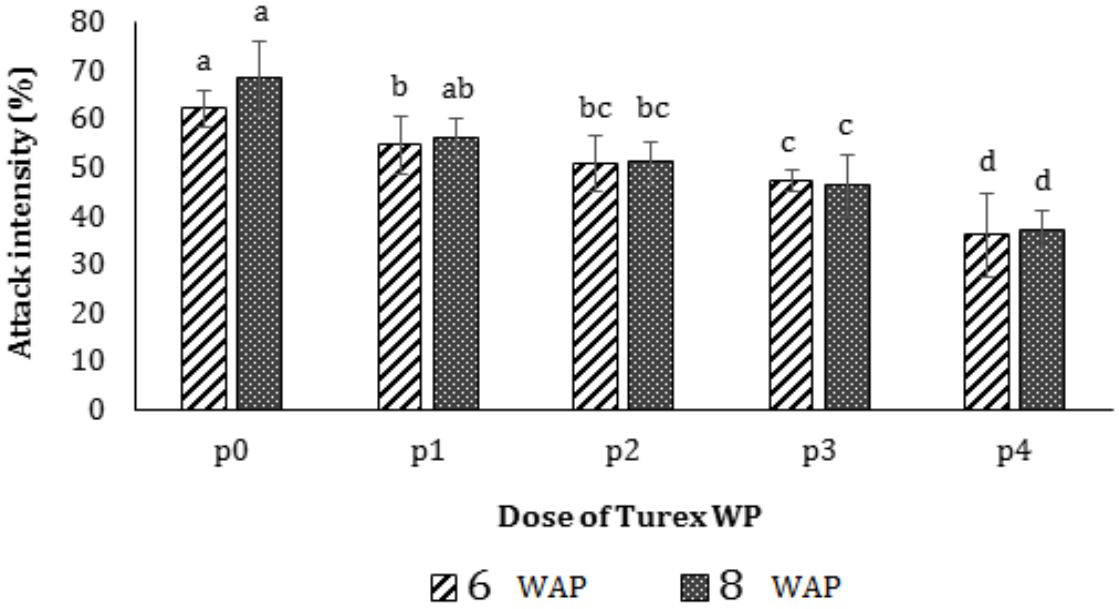
c. Plant height. Measurement at 5 to 8 WAP using a ruler from the soil surface to the tip of the leaf. The unit used is centimeter (cm).
d. Number of leaves. Observations at 5 to 8 WAP by counting the number of completely open leaves. The units used are strands.
e. Fresh weight. Observations were made at harvest by weighing all plants (leaves, stems, and roots). Weighing using analytical balance. The unit used is grams per plot (g/plot).

To see the effect of the application of Bioinsecticide (Turex WP) on *P. xylostella* pests on mustard greens, a variance analysis was carried out using the GenStat 12ed. The results of the analysis of variance showed the effect (P≤0.05), followed by the Least Significance Difference (LSD) test at 5% level.

3. Results and Discussion

Attack intensity

The intensity of *P. xylostella* attacks carried out at the age of plants 6 WAP and 8 WAP presented in Figure 1. Based on Figure 1 below, observing the intensity of mustard attack at ages 1-4 WAP has not yet seen the symptoms of *P. xylostella* attack. The attack calculation is done after the pest attacks for one week at the age of 6 WAP and 8 WAP, with the highest intensity of attacks respectively in the control treatment (62.04% and 68.16%), the use of bioinsecticides with active ingredients *B. thuringiensis* (Turex WP), giving a significantly different effect from control treatment, with the best treatment that is the treatment of p_4 (2 g/L Turex WP) on plant age of 6 WAP and 8 WAP with attack intensity of 36.05% and 36.94%, respectively. In accordance with the statement of (Sianipar, 2004)that the higher the concentration of insecticide applied, the higher the pest mortality, so that its effectiveness in dealing with pest attacks also increases.



Note: p_0 = 0 g/L Turex WP, p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, p_4 = 2 g/L Turex WP. The line above the bar is the Standard error of treatment (n=5). The same letter in the same week of observation shows that the treatment gives no different effect based on the Least Significance Difference Test (LSD) at the 5% level of the control treatment.

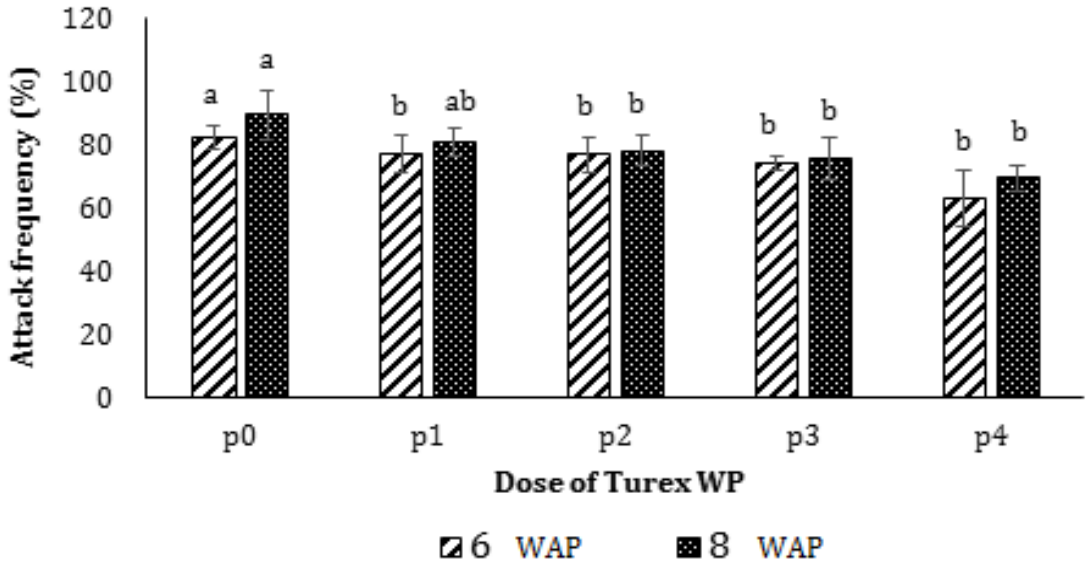
Figure 1. Intensity of *P. xylostella* attack on the age of green mustard plants 6 WAP and 8 WAP

The intensity of *P. xylostella* pest in this study included in attacks that entered the age of plants that are relatively classified as adults, *P. xylostella* at the beginning of planting has not appeared to attack. This is allegedly due to the condition of the environment where mustard greens grow in good condition, where weeds that grow around the crop are always cleaned, so pests are difficult to breed. According to (Palit, Pinaria, & Meray, 2016), insect in the dry season to humidify the air of 70% and a temperature of about 28-33˚C, these conditions favor *P. xylostella* to proliferate and lead to more eggs that hatch, so the pest population will increase.

Attack frequency

The frequency of attacks *of P. xylostella* was done at the age 6 WAP and 8 WAP are presented in Figure 2. Based on Figure 2 below, observations of the frequency of mustard attack at the age of 1-4 WAP have not yet seen the symptoms of *P. xylostella* attack. The attack calculation is done after the pest attacks for one week at the age of 6 WAP and 8 WAP, with the highest frequency of attacks respectively in the control treatment (82.47% and 89.88%), the use of bioinsecticides with active ingredients *B. thuringeinsis* (Turex WP), gave a significant effect of control treatment with the best treatment, namely p_4 (2 g/L Turex WP) at the age of 6 WAP and 8 WAP with attack frequency of 63.21% and 69.86% respectively.

The number of leaves that were attacked in each unit of the experiment was classified as many, exceeding half of the total number of leaves. This is presumably because the application of bioinsecticides made from active *B. thuringiensis* (Turex WP), does not directly kill *P. xylostella* larva, but *B. thuringiensis* works as a stomach poison that attaches to the surface of plants (leaf epidermis), does not enter the inner tissue plants so that the larva eat many parts of the leaves of the plant will then experience interference in the digestive tract and eventually die.



Note: p_0 = 0 g/L Turex WP, p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, p_4 = 2 g/L Turex WP. The line above the bar is the Standard error of treatment (n=5). The same letter in the same week of observation shows that the treatment gives no different effect based on the Least Significance Difference Test (LSD) at the 5% level of the control treatment.

Figure 2. Frequency of *P. xylostella* attack on the age of green mustard plants 6 WAP and 8 WAP

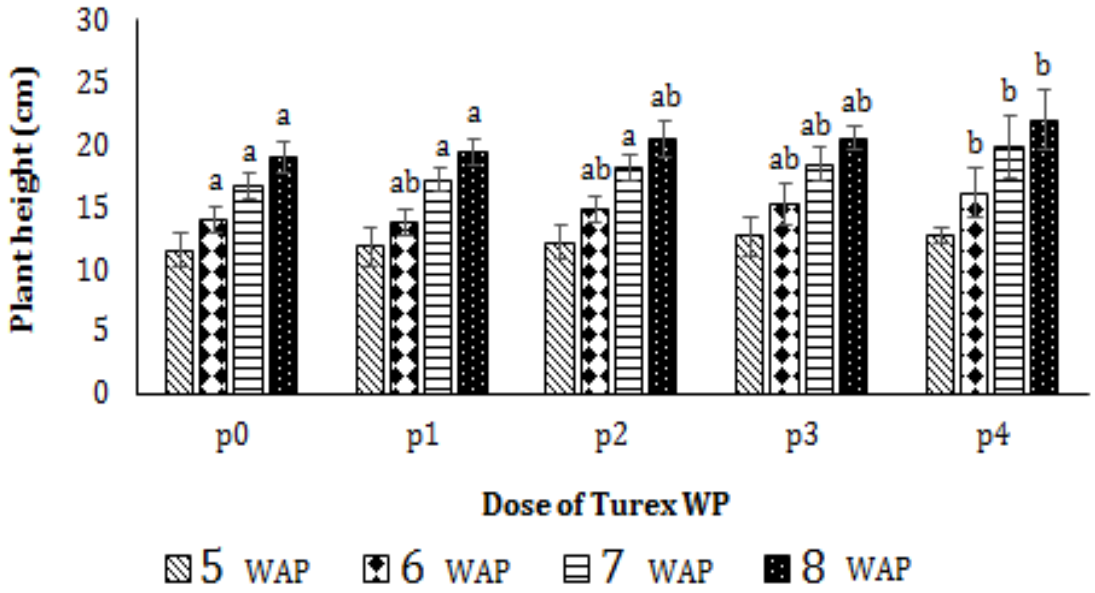
Bacillus thuringiensis is a protein-producing bacterial that is killing insects. These protein crystals have an insecticide property called end-endotoxin. Crystals a soluble pro-toxin in the gut of insects turn into a more pen polypeptide deck (27-149 kd) and insecticidal properties (Höfte & Whiteley, 1989).

In the opinion of (Health Organization, 2009), *B. thuringiensis* is a stomach poison so that in order to kill *P. xylostella,* it must eat parts of the plant that have been given *B. thuringiensis*. Alkaline atmosphere in the larval digestive tract will activate the toxins carried by these bacteria, so that the disruption of the process of absorption and osmotic balance is disrupted. The toxin will collect bacteria, then spread throughout the body and enter the himolymph fluid which causes symptoms of swelling and death.

Plant height

The height of green mustard that were attacked by *P. xylostella* at the age of 5 WAP to 8 WAP are presented in Figure 3. Based on Figure 3 below, the application of bioinsecticides with active ingredients of *B. thuringiensis* (Turex WP) shows the effect in reducing the intensity of *P. xylostella* pest attack, along with the increased concentration of Turex WP, so that plants can grow well compared to height of control plants (0 g/L Turex WP). The best treatment is p_4 treatment (2 g/L Turex WP) which can be seen in the observation of the average plant height at the age of plants 6 WAP, 7 WAP, and 8 WAP respectively as high as 16.11 cm, 19.84 cm, and 22.04 cm.

The high intensity of *P. xylostella* pests that attack can affect the growth of plant height, the higher the intensity of *P. xylostella* attacks received by plants, it will inhibit the process of plant growth. Treatment plant at p_0 (0 g/L Turex WP) tend to have an average plant height lower than the average height of the plants on treatment (p_1, p_2, p_3, and p_4). In accordance with the opinion of (Karowa,et al., 2015) plant growth and development will be disrupted if it suffers damage to plant parts, especially leaves.

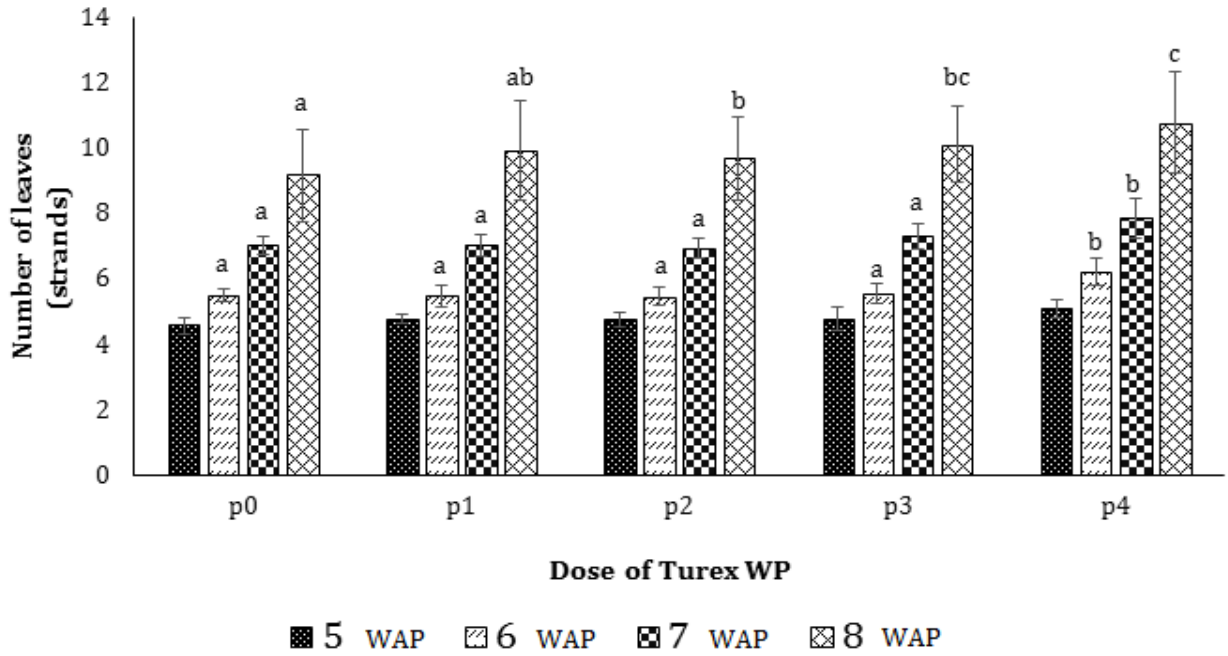


Note: p_0 = 0 g/L Turex WP, p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, p_4 = 2 g/L Turex WP. The line above the bar is the Standard error of treatment (n=5). The same letter in the same week of observation shows that the treatment gives no different effect based on the Least Significance Difference Test (LSD) at the 5% level of the control treatment.

Figure 3. Plant height at the age of green mustard 6 WAP to 8 WAP

Number of leaves

The number of leaves of green mustard attacked by *P. xylostella a*t the age 5 WAP to 8 WAP are presented in Figure 4 below.



Note: p_0 = 0 g/L Turex WP, p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, p_4 = 2 g/L Turex WP. The line above the bar is the Standard error of treatment (n=5). The same letter in the same week of observation shows that the treatment gives no different effect based on the Least Significance Difference Test (LSD) at the 5% level of the control treatment.

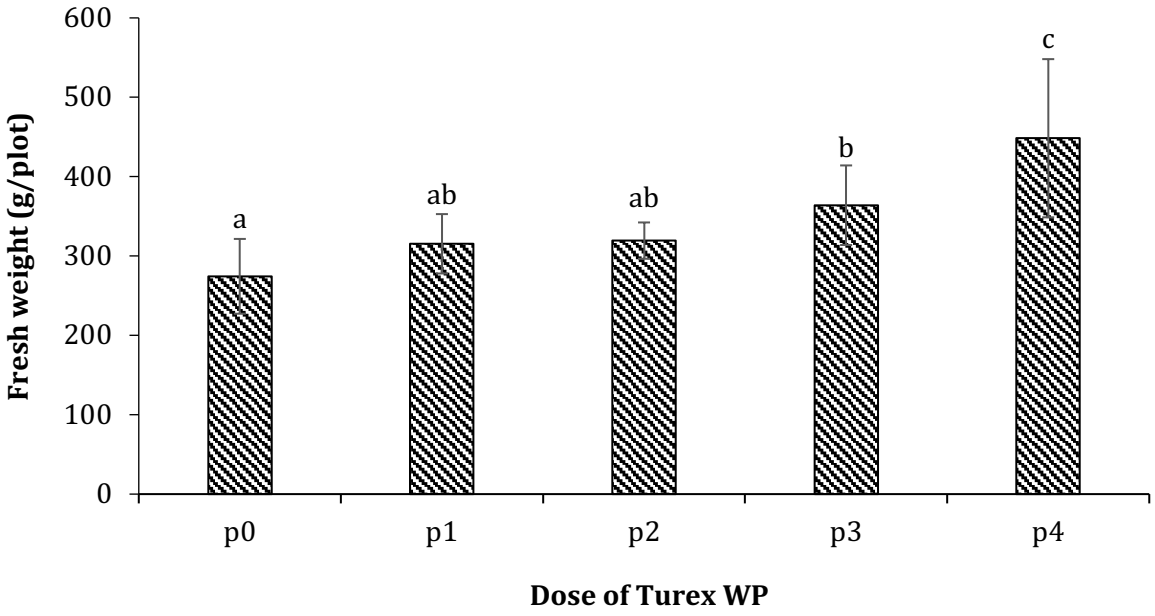
Figure 4. Number of leaves at the age of green mustard 5 WAP up to 8 WAP

Based on Figure 4 above, the application of bioinsecticides with active ingredients of *B. thuringiensis* (Turex WP) shows the effect in reducing the intensity of *P. xylostella* pests, along with the increased concentration of Turex WP, so that plants can grow well especially in increasing the number of plant leaves from plants with control treatment (0 g/L Turex WP). The best treatment is the treatment of p_4 (2 g/L Turex WP) at the age of plants 6 WAP, 7 WAP, and 8 WAP with an average number of leaves each namely 6.22 strands, 7.87 strands, and 10.78 strands.

Pests *P. xylostella* affects the growth of leaves, where treatment p_0 (0 g/L Turex WP) tend to have on average the lowest leaf number compared to any given trial bioinsecticide *B. thuringiensis* (Turex WP), the high intensity of *P. xylsotella* pest influences plant growth especially the photosynthesis process. This is in accordance with the opinion of (Karowa et al., 2015), excessive or severe leaf damage will disrupt the process of photosynthesis, because the more chlorophyll is lost, the growth in the number of leaves becomes disrupted. (Syam, et al., 2017) reports that an increase in the amount of chlorophyll and the number of leaves formed will make the photosynthesis process better and the resulting photosynthesis will be higher, so that growth becomes better, so the number of plant leaves will also increase.

Fresh weight

The fresh weight of green mustard at the age 8 WAP are presented in Figure 5. Based on Figure 5 below, the application of bioinsecticides with active ingredients of *B. thuringiensis* (Turex WP) shows the effect in reducing the intensity of *P. xylostella* pests, along with the increased concentration of Turex WP, so that plants can grow well and plant yields also increase. The best treatment is the treatment of p_4 (2 g/L Turex WP) at the age of the plant 8 WAP with the total fresh weight of the plant per treatment that is equal to 448.4 g/plot.



Note: p_0 = 0 g/L Turex WP, p_1 = 0.5 g/L Turex WP, p_2 = 1 g/L Turex WP, p_3 = 1.5 g/L Turex WP, p_4 = 2 g/L Turex WP. The line above the bar is the Standard error of treatment (n=5). The same letter in the same week of observation shows that the treatment gives no different effect based on the Least Significance Difference Test (LSD) at the 5% level of the control treatment.

Figure 5. Fresh weight at the age of green mustard 8 WAP

Pests of *P. xylostella* caterpillars on the growth of mustard plants in this study can affect the yield of green mustard, especially the fresh weight of these plants. High intensity of pest attacks on treatment p_0 (0 g/L Turex WP) resulted in an average fresh weight which tends to be lower compared with the treatment given bioinsecticide *B. thuringiensis*. In accordance with the opinion of (Julaily & Rima Setyawati, 2013), that the high and low fresh weight of plants is affected by pest attacks. The higher

the attack, the lower the fresh weight. In addition, in the opinion of (Karowa et al., 2015), pest attacks on plants generally can reduce crop yield because it can eliminate plant body parts, resulting in the process of photosynthesis for the distribution of nutrients to be reduced.

The ratio of fresh weight of green mustard in this study using support soil media which produced the best weight of mustard plants was 484.4 g/plot, with research conducted by (Setiawan, et al., 2013), mustard cultivation was carried out using hydroponic media which produced the best fresh weight of the plant i.e. 509.92 g/12 hydroponic pipe holes, whereas in research conducted by (Wahid, et al., 2015), mustard cultivation in optimal soil media and treatment in the form of urea, bokashi, cow manure, liquid organic fertilizer, and cow urine produced the best fresh weight of the plant which was 943 g/plot with 12 plants.

4. Conclusions

Application of bioinsecticide contains active *B. thuringiensis* (Turex WP) at a dose 2 g/L can reduce the intensity and frequency of *P. xylostella* attack, increase plant height, leaf number, and fresh weight of green mustard on tukungan soils.

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