Testing of several types of vegetable insecticides on the mortality of the rice weevil (*Sitophilus oryzae* L.) population and rice quality in Bulog rice during storage in Jayawijaya district

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Abstract. The use of pesticides today by farmers is increasing. This is due to the presence of pest organisms on plants (OPT), one of which is the rice weevil (*Sitophilus oryzae* L). Control of pests must be carried out with due regard to the environment. Vegetable insecticides are active ingredients derived from plants that can be used to control pest organisms. The aims of this study were: 1) to analyze whether vegetable insecticides were able to control the population of rice weevil (*Sitophilus oryzae* L.) and the quality of rice during the storage period of Bulog rice in Jayawijaya Regency; 2) to analyze which botanical insecticide are the best in controlling *S. oryzae* and rice quality during the storage period of Bulog rice in Jayawijaya Regency. The research was conducted at the Agrotechnology Laboratory of the T Petra Baliem Wamena School and the Agricultural Product Technology Laboratory (THP) of the Faculty of Agricultural Products Technology, Gadjah Mada University, Yogyakarta. Observations were carried out for 6 months, from February 2021 to August 2021. The research method used was an experimental method and the design pattern used was RAL (Completely Randomized Design) with 1 factor consisting of 5 kinds of vegetable insecticides. The results of this study were: 1) vegetable insecticides significantly affected the population of *S. oryzae* in May; the mortality of *S. oryzae* in July and August; broken and whole rice amount; water, protein, and carbohydrate content; 2) the best type of insecticide is the one obtained from pandan leaves (P5) in controlling the population of *S. oryzae* L. and producing the best rice quality during the storage period of Bulog rice in Jayawijaya Regency.
Key Words: Bulog rice, flea population, rice content, rice quality, vegetable insecticides.

Introduction. Farmers use of pesticides these days is increasing. The reason is the presence of pest organisms on plants (OPT), one of which is the rice weevil (*Sitophilus oryzae* L). The production of a plant will increase if the growth and development does not experience obstacles. One of these obstacles is from Plant Pest Organisms (OPT). If there are obstacles, it is necessary to control these obstacles. Control of pests must be carried out with due regard to the environment. This is in accordance with the opinion of Muhammad (2015) which stated that control must be carried out wisely, especially in the era of healthy agriculture (back to nature) which is more concerned with quality products and free from contamination, both biological and chemical. Jayawijaya Regency is one of the regencies in Papua Province where the population uses Bulog rice as a staple food. As we all know, Bulog rice is one of the types of rice that is known to contain a lot of dirt and pests, in this case *S. oryzae* when compared to other types of rice. In overcoming this, it is necessary to control the rice weevil. One way to control it is to use natural insecticides. Vegetable insecticides are single, or compound active ingredients derived from plants that can be used to control pest organisms. This plant-based insecticide can function as a repellent, attractor, antifertility compound (sterilizer), killer, and in other forms. In general, botanical insecticides are defined as insecticides whose basic ingredients are plants that are relatively easy to make with limited skills and knowledge. The properties of vegetable insecticides are generally not harmful to humans or the environment and are easily biodegradable compared to synthetic insecticides (Kardinan 1999). *S. oryzae* is one of the types of warehouse pests that damage rice supplies in storage facilities. *S. oryzae* causes the rice grains to become hollow and easy to break and crumble like flour, so the quality is low because it tastes bad and smells musty. One way of controlling it is by using plant material as a vegetable insecticide. This method is safer and cheaper when compared to the use of synthetic insecticides which have a risk with a large residue left in the rice if the use is not appropriate. The purpose of this study was to: 1) analyze whether vegetable insecticides were able to control the population of *S. oryzae* and the quality of rice during the storage period of Bulog rice in Jayawijaya Regency; 2) to analyze which vegetable insecticide is the best in controlling *S. oryzae* and rice quality.

Material and Method. The research was conducted at the Agrotechnology Laboratory of STIPER Petra Baliem Wamena and the Laboratory of Agricultural Products Technology (THP) Faculty of Agricultural Products Technology, Gadjah Mada University, Yogyakarta. Observations were carried out for 6 months, from February 2021 to August 2021. The materials used were Bulog rice and *S. oryzae*, cardboard, plastic, basil leaves, lemongrass, garlic, pandan leaves, and lime (citrus) leaves while the tools used were counters, digital scales, and writing instruments. The research method used is an experimental method with the design pattern used is RAL (Completely Randomized Design). The treatment design used was 1 factor consisting of 5 kinds of vegetable insecticides. Each treatment was repeated with 3 replications (block). The treatment was arranged as a Completely Randomized Design with four replications:

- P1 : basil leaves
- P2 : garlic
- P3 : citrus lime leaves
- P4 : lemongrass
- P5 : pandan leaves

Implementation before the research was carried out and consisted of the rice weevils being propagated first. A total of 60 *S. oryzae* obtained from the rice warehouse were put in a jar containing Bulog rice. For ±30 days, rice weevils were incubated in a jar containing Bulog rice. After ±30 days of infestation, the rice weevils were completely removed from the Bulog rice culture media. From the propagation of rice weevils, 450 rice weevils are needed to be used as research material. We put each rice sample into a plastic bag and weighed it, to where each plastic bag sample amounts to 0.5 kg. *S. oryzae* were added, as many as 5 for each plastic bag. Put each rice sample into a carton according to the treatment. Each carton is filled with 6 Bulog rice plastic bags. The method of making insecticides is insecticide material was prepared and then the type of insecticide, in this case the leaves, were weighed that each weighed 200 g. After being weighed, then the leaves are blended and dried in the sun for ± 1 day. After drying, it is weighed again to a weight of 100 g and put into a plastic bag that has been perforated with the aim that the aroma of the leaves can come out. Inserting vegetable insecticides that have been put in plastic bags into cartons according to each treatment. The rice cartons were arranged according to the experimental plan. The development of the rice aphid pest population after being stored for 4 months was calculated. The observation parameters are: rice weevil population, rice weevil mortality, final weight of rice, whole rice content and broken rice content, chalkiness, water content, ash content, fat content, protein content and carbohydrate content. Broken rice amount was calculated by the following method:

$$\text{Broken rice} = \frac{\text{weight of broken rice}}{\text{weight of early rice}} \times 100\%$$

While whole rice content was calculated in this manner:

$$\text{Whole rice} = \frac{\text{weight of whole rice}}{\text{weight of early rice}} \times 100\%$$

Statistical analysis. Observational data was analyzed by analysis of variance at the 5% confidence level. Then the treatment that shows a significant difference was followed by using the BNT Test (Least Significant Difference Test).

Results and Discussion. Table 1 shows the average population of *S. oryzae* and in Figure 1, for June, July, and August data, it appears that there is no significant effect on the population of *S. oryzae,* while in May the vegetable insecticides had a significant effect on the mortality of *S. oryzae*. In May, some vegetable insecticides significantly affected the population of *S. oryzae*, and in Table 2 it was shown that the lemongrass treatment (P4) resulted in a high population of *S. oryzae* of 5.99, while for the others there is no real difference. Table 1 also shows that the lowest population of *S. oryzae* was found in the treatment of citrus leaves (P3) and fragrant pandan leaves (P5). This shows that citrus leaves (P3) and pandan leaves (P5) have a major influence in controlling *S. oryzae*. Fragrant pandan leaves can repel insects because of the essential oils contained in fragrant pandan. In Ali's research (2016), the administration of fragrant pandan leaf extract at a dose of 30% is more effective because at that dose the content of saponins, alkaloids, flavonoids, tannins, and polyphenols are higher so that it is more toxic and can cause death in house flies compared to giving fragrant pandan leaf extract with a dose of 20% and 10%. In June, July, and August, although not significantly different, we can see that the lowest population of *S. oryzae* was found in the treatment of vegetable insecticides derived from pandan leaves. This shows that the essential oil contained in fragrant pandan leaves can control and repel *S. oryzae*. Essential oil role for plants is to give them smell, for example in flowers to help pollinate, in fruit for seed distribution media, while in leaves and stems essential oils can function as insect repellent (self-defense). This is also in accordance with the research of Wardani et al (2020).

Table 1

Average population of rice weevil pest (*Sitophilus oryzae* L.) during each month

Treatment	*May (I)*	*June (II)*	*July (III)*	*August (IV)*
P1 (basil leaves)	5.33 b	5.22	57.66	68.44
P2 (garlic)	5.33 b	8.00	60.55	78.89
P3 (citrus leaves)	5.00 b	4.55	45.66	66.22
P4 (lemongrass)	5.99 a	4.33	42.99	66.77
P5(pandan leaves)	5.00 b	3.33	32.89	63.11

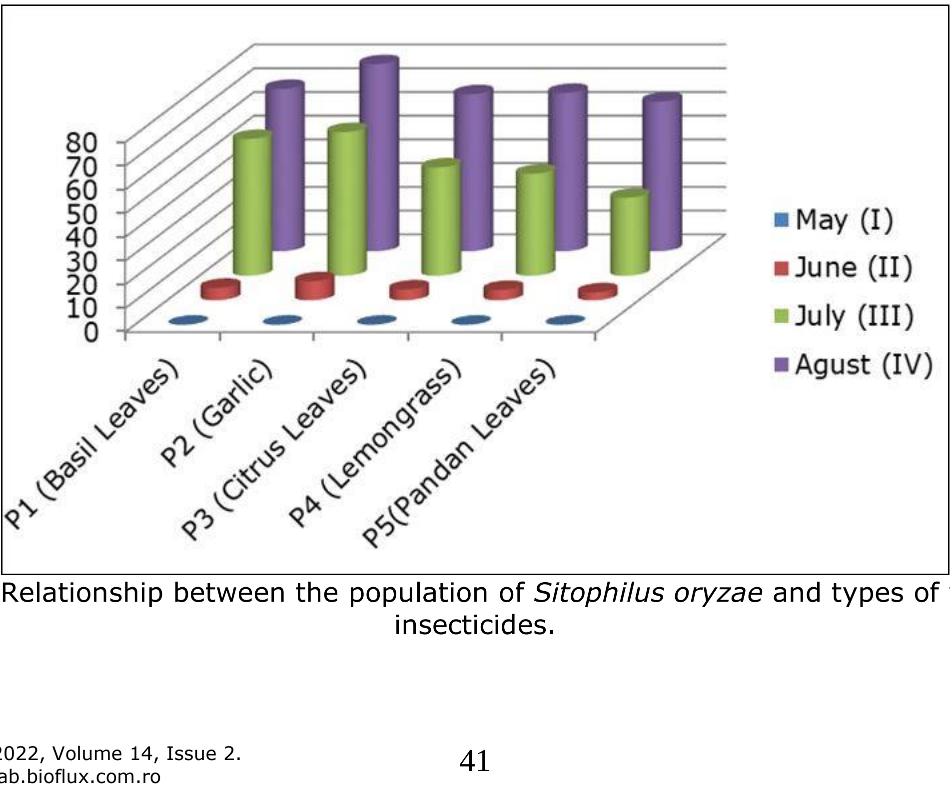

Figure 1. Relationship between the population of *Sitophilus oryzae* and types of vegetable insecticides.

In Table 2, regarding mortality of *S. oryzae*, it can be seen that various types of vegetable insecticides only significantly affect mortality of *S. oryzae* in July and August, while in other months there is no significant difference. In July, the highest mortality of *S. oryzae* was seen in the insecticide treatment of lemongrass (P4) at 2.66 and pandanus (P5) at 3.99. Fragrant pandan leaves had the highest value in killing *S. oryzae* which is 3.99 in July and 6.21 in August. This is because the active ingredients in fragrant pandan leaves can repel and even kill *S. oryzae*. The active ingredient contained in fragrant pandan leaves contains essential oils that give rise to a distinctive aroma, namely an essential oil component called eugenol. From various research results, the eugenol content in this plant can be used as fungicides, bactericides, nematicides and insecticides (PUSTAKA 2021). The high mortality rate was due to the fragrant pandan leaves being able to shed the chitin layer that composes the pest's cuticle. Active ingredients that affect mortality caused by toxic substances present in botanical materials can inhibit respiratory activity, causing death if entered through the digestive tract (Epi 2016). The treatment of vegetable insecticides from lemongrass in Table 2 also shows the effect of high mortality of *S. oryzae* which is 2.66 in July and 4.99 in August and is not significantly different when compared to vegetable insecticides from pandan leaves. Lemongrass is one of the plant-based insecticides that can repel *S. oryzae*. Lemongrass (*Cymbopogon citratus*) contains alkaloids and citronella compounds that can kill rice weevils. This is in accordance with the research of Rahayu and Widyoningsih (2016), which states the ability of lemongrass leaves as a substitute for alternative drugs to kill head lice using citronella compounds and research by Wahyuni et al (2017) which states that the powdered combination of *C. citratus* leaves and Noni leaf (*Morinda citrifolia*) it is known that its use is more effective as a natural insecticide against *Pediculus humanus capitis*. Besides that, lemongrass also contains essential oils that can function as poisons against insects, in this case the *S. oryzae*. Herminanto (2010) also stated that the use of lemongrass leaves and leaf ash increased the mortality of *Callosobruchus analis*. In Table 3, it can also be seen that the type of vegetable insecticide from garlic (P2) produced the lowest mortality of *S. oryzae* in May, June, July, and August. This may be because the content of garlic which acts as a repellent, poison and insect development inhibitor has begun to decrease so that the effect of using these insecticides causes a low mortality of *S. oryzae*.

Table 2

Average mortality of *Sitophilus oryzae* during each month

Treatment	*May (I)*	*June (II)*	*July (III)*	*August (IV)*
P1 (basil leaves)	0.33	1.33	1.55 b	3.11 c
P2 (garlic)	0.33	0.66	1.11 b	2.33 c
P3 (citrus leaves)	1.00	1.66	1.55 b	3.99 b
P4 (lemongrass)	0.66	1.33	2.66 a	4.99 a
P5(pandan leaves)	1.66	2.66	3.99 a	6.21 a

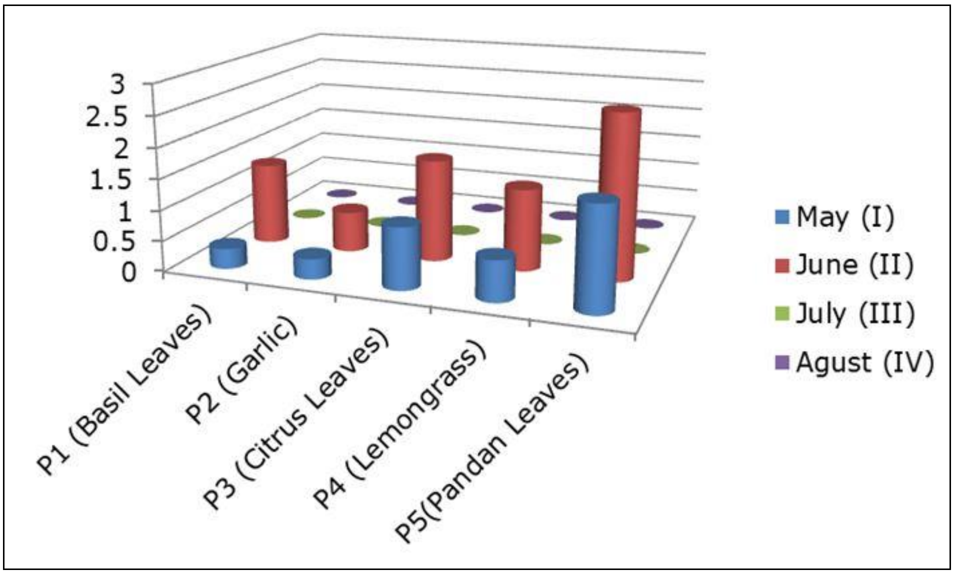

Figure 2. The relationship between mortality of *Sitophilus oryzae* and types of vegetable insecticides.

The final weight parameters of rice are shown in Table 3 and Figure 3 and show the shrinkage of the weight of the rice, which at the beginning was 500 g (0.5 kg). In this study with the final weight parameter of rice, it appears that the types of vegetable insecticides have no significant effect on the final weight of rice. Although the pile of rice did not significantly affect the final weight of rice, the table shows that the vegetable insecticide from pandan leaves (P5) showed a slight reduction in the weight of rice, which was 388.89 grams from the initial weight and the lowest final weight of Bulog rice was 303.50 grams from basil leaf vegetable insecticide (P1). The low final weight of bulog rice indicates that the plant insecticide treatment of basil (P1) has a large population of rice weevil, so that indirectly these pests eat the existing rice so that it will reduce the final weight of rice. Meanwhile, the high final weight of rice, indirectly causes less damage to rice which will reduce the shrinkage of the final weight of rice. This is due to the reduction in damaged rice, so the resulting weight loss will be lower. Damage and weight loss of rice in storage was determined by the density of insects found (Soekarna 1982). The increasing population of rice aphids that appear has resulted in increased damage and shrinkage of the final weight of the rice it causes.

Table 3

Average final weight of rice (grams)

Treatment	*Final weight (grams)*
P1 (Basil leaves)	303.50
P2 (Garlic)	306.40
P3 (Citrus leaves)	341.00
P4 (Lemongrass)	341.93
P5(Pandan leaves)	388.89

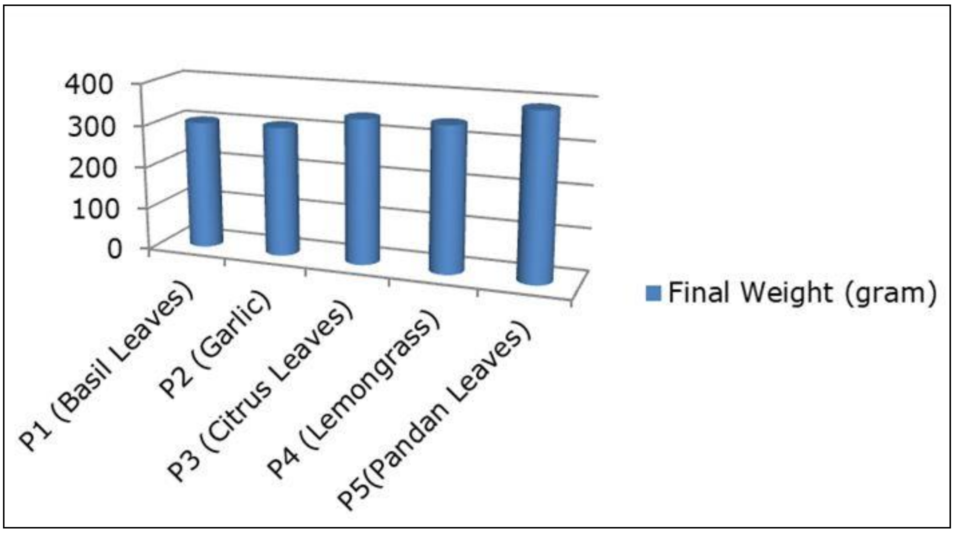

Figure 3. The relationship between total final weight of rice and types of vegetable insecticides.

Parameters of whole rice and broken rice can be seen in Table 4 and Figure 4. In the table we can see that the types of vegetable insecticides significantly affect the percentage of broken rice and whole rice. In the whole rice parameter, it appears that the type of vegetable insecticide from pandan leaves (P5) produces the highest amount of whole rice, which is 91.42% and is significantly different when compared to other types of vegetable insecticides. The high yield was due to the plant-based insecticide from pandan leaves producing the lowest population of *S. oryzae*, so that indirectly the rice was not eaten by *S. oryzae*. According to Anna et al (2017), the quality of rice produced depends on the number of broken grains, if the quality of rice is low it is because it contains many broken grains and the price of rice at the mill will be low.

The percentage of broken rice can be seen in Figure 4, where the vegetable insecticide made of garlic (P2) produced the highest percentage of broken rice which was 57.73% and was not significantly different from the vegetable insecticide made of basil (P1), which was 60.02%. Broken rice also shows that the water content contained in the rice is small in addition to the presence of disturbances from Plant Pest Organisms (OPT), in this case the *S. oryzae*. According to the research of Mahanani (2021), a bigger population of rice weevils will cause increased damage to rice. Syahrullah's research (2019) also stated that the higher the number of *S. oryzae*, the higher the damage.

Table 4

Average of whole and broken rice (%)

Treatment	*Whole rice*	*Broken rice*
P1 (basil leaves)	60.02 c	39.98 a
P2 (garlic)	57.73 c	42.27 a
P3 (citrus leaves)	74.67 b	25.33 b
P4 (lemongrass)	78.67 b	24.67 b
P5(pandan leaves)	91.42 a	8.58 c

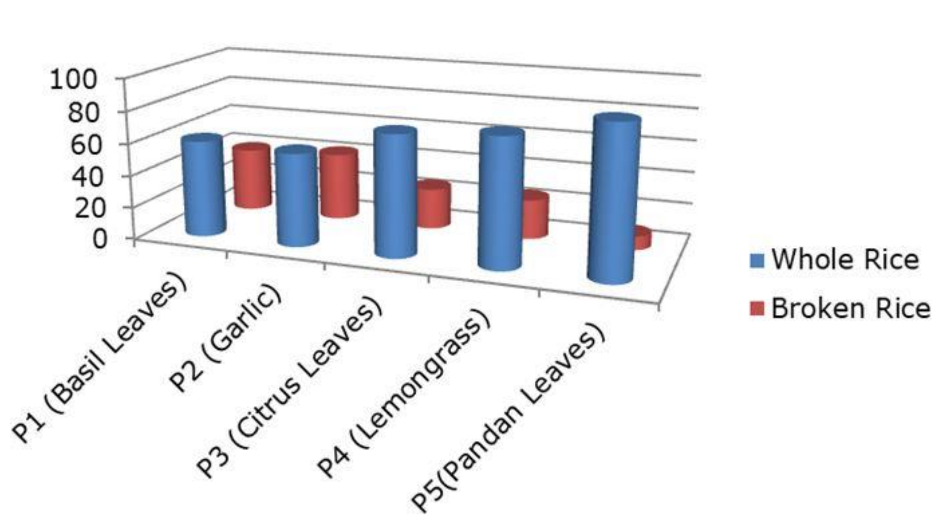

Figure 4. The Relationship of whole rice and broken rice with types of vegetable insecticides.

Chalkiness is one of the determinations of rice quality, which is done by visual observation, especially its turbidity. In Table 5, it appears that for Bulog rice which was given various types of vegetable insecticides, the turbidity of the rice was on a score of 5 which indicates that the liming of the rice is at a moderate level, which is in the range of 10-20%. However, the type of vegetable insecticide from garlic showed the highest turbidity of rice, which was more than 20% with a score of 9.

Table 5

Chalkiness data

Treatment	*Score*
P1 (Basil leaves)	5
P2 (Garlic)	9
P3 (Citrus leaves)	5
P4 (Lemongrass)	5
P5 (Pandan leaves)	5

The types of vegetable insecticides significantly affected the water content but had no effect on the ash and fat content. This can be noticed in Table 6 and Figure 5, where the highest water content is found in the treatment of vegetable insecticides from pandan leaves (P5), which is 39.11%, followed by vegetable insecticides from lemongrass (P4) at 38.48%, citrus leaves (P3) at 36.67%, basil leaves (P1) at 28.14% and the lowest from the types of vegetable insecticides, garlic, was 27.64%. The water content of 14% is the water content where the grain is quite stable, meaning that it is not easy to reabsorb water, so that the increase in water content occurs quite slowly. At a moisture content of 14%, grain is quite safe to store if environmental influences are not damaging, because the heat generated due to respiration of grains and microorganisms is not sufficient to increase the temperature and humidity of the grains (Damardjati & Purwani 1991). If the moisture content of foodstuffs is less than 14-15%, for example in rice and cereals, it can inhibit or slow the growth of most yeasts (Fardiaz 1992). While the water content is more than 15%, the respiration rate of grain increases quite rapidly, so that it can cause damage to the grain (Bailey 1940; Siebenmorgen & Meullenet 2004). Vegetable insecticides from garlic (P2) appear to have low water content. This is because the treatment population of *S. oryzae* is also high. The higher the population of rice weevil, the higher the moisture between the grains of rice. The increase in water content of rice is high due to the respiration process by insects, which breaks down carbohydrates through help by oxygen, carbon dioxide, water, and energy. Ash content is a parameter that shows the mineral content that does not evaporate during the combustion process (Karim 2017). Ash content is an inorganic residue obtained after rice is oxidized due to heat and ash content is a measure of mineral content in rice (Febriana et al 2014; Umar et al 2013). The type of vegetable insecticide from garlic (P2) shows the highest ash content of 0.48% and the lowest is found in the type of vegetable insecticide from pandan leaf (P5), which is 0.27.

Fat content is one of the parameters that shows how much fat is contained in the rice. In Figure 5 the lowest fat content is seen in the type of vegetable insecticide from garlic (P2), which is 0.49%. The higher the population of *S. oryzae* contained in the treatment of garlic insecticide (P2), it will indirectly cause high humidity. The higher the humidity, the greater the fat amount that will be oxidized to free fatty acids.

Table 6

Average percentage of water, ash, and fat content (%)

Treatment	*Water (%)*	*Ash (%)*	*Fat (%)*
P1 (Basil leaves)	28.14 c	0.45	0.59
P2 (Garlic)	27.64 c	048	0.49
P3 (Citrus leaves)	36.67 b	0.38	0.76
P4 (Lemongrass)	38.48 b	0.34	0.86
P5 (Pandan leaves)	39.11 a	0.27	0.89

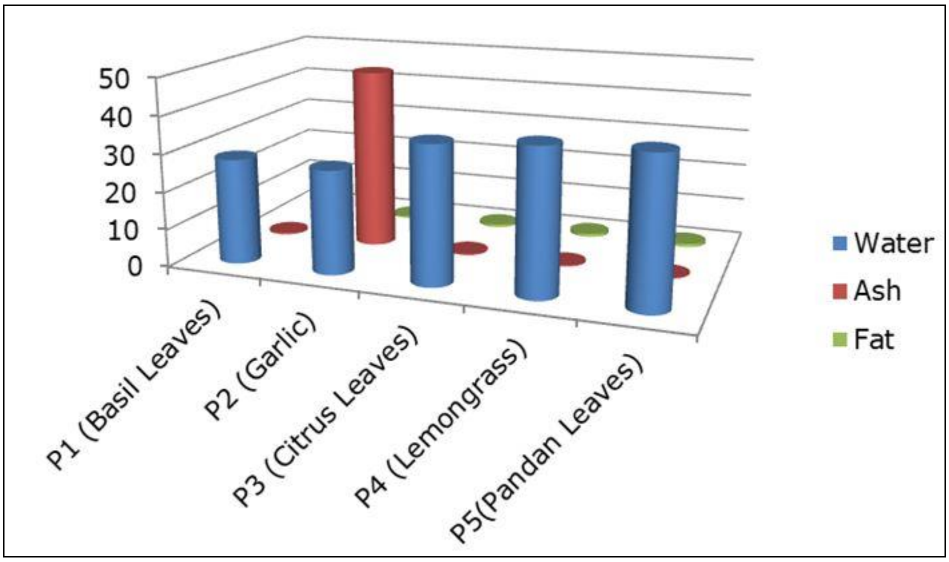

Figure 5. Relationship between water, ash and fat content with types of vegetable insecticides (%).

Types of vegetable insecticides significantly affect the protein content and carbohydrate content of rice. This can be seen in Table 7 and Figure 6. Types of vegetable insecticides from pandan leaves (P5) produced the highest protein content of 14.01% and are significantly different from other treatments. The high protein content indicates that the rice has good quality for consumption. This is in accordance with the opinion of Harini (2013) which states that the protein content in food affects the glycemic index value in food products. Protein influences changes in blood glucose levels.

Rice with a high carbohydrate content means that it can make living things that eat it feel saturation. In Figure 6, it can be seen that the pandan leaf vegetable insecticide treatment (P5) produced a high carbohydrate content of 82.62% when compared to other treatments, but not significantly different when compared to the vegetable insecticide from lemongrass (P4). That is equal to 81.41%. Meanwhile, the lowest carbohydrate content was seen in the insecticide from garlic, which was 59.99%.

Table 7

Average protein and carbohydrate content (%)

Treatment	*Protein (%)*	*Carbohydrates (%)*
P1 (Basil leaves)	8.41 b	69.06 c
P2 (Garlic)	7.03 c	59.99 d
P3 (Citrus leaves)	9.18 c	75.99 b
P4 (Lemongrass)	10.68 b	81.41 a
P5 (Pandan leaves)	14.01 a	82.62 a

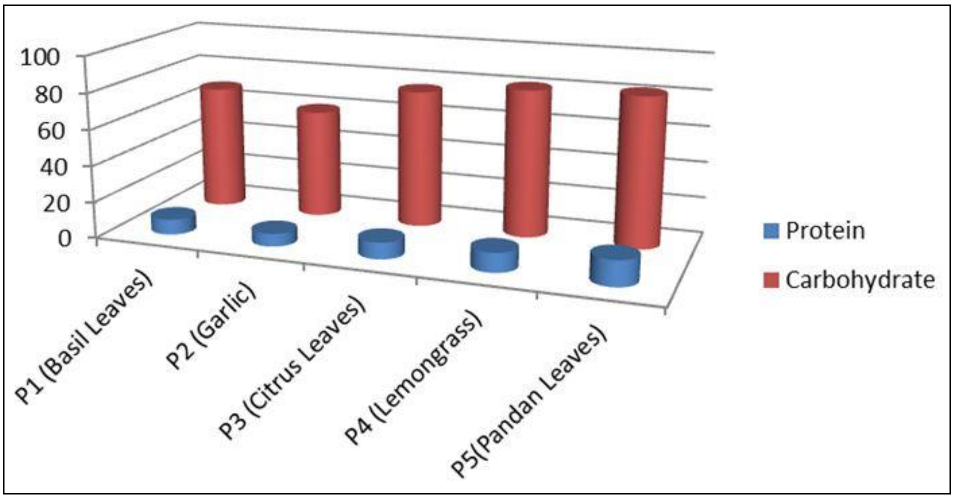

Figure 6. Relationship of protein and carbohydrate content with types of vegetable insecticides.

Conclusions. Types of plant-based insecticides significantly affected the population of *S. oryzae* in May; the mortality of *S. oryzae* in July and August; the average amounts of broken and whole rice, and water, protein, and carbohydrate content. The best type of insecticide was the one obtained from pandan leaves (P5) in controlling the population of *S. oryzae* and producing the best rice quality during the storage period of Bulog rice in Jayawijaya Regency.

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Conflict of interest. The authors declare that there is no conflict of interest.

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