Chitosan Pesticides for Control Aphids (*Aphis craccivora*) on High Population in Long Bean (*Vigna sesquipedalis*) Cultivation

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**Abstract.** Pesticides with chitosan as an alternative are still relevant for aphids which are important pesticides in vegetable crops. This research was conducted to see the effect of several types of pesticides with chitosan active ingredients, the concentration of pesticides, and interactions between types of pesticides and concentrations of aphids on long bean plants. The study used factorial methods with randomized block designs. The first factor was the type of pesticide made from chitosan, which consisted of control (JO), pure chitosan (J1), soft guard (J2), super biovit (J3). The second factor was the concentration of pesticides that consisted of 0.1% (K1), 0.3% (K2), and 1% (K3). There were 48 experimental units consisting of 12 treatment combinations and 4 replications. Data were analysed using Analysis of variance (ANOVA), and comparison between averages using Duncan Multiple Range Test (DMRT). The results showed the effect of the treatment was single or there was no interaction between the types of pesticides made from chitosan with an active concentration in all parameters of observation. Furthermore, the effect of the type of pesticide with active chitosan was significantly different only on the average aphid population I and 3 days after the first application. Whereas pesticides made from active chitosan soft guard type tended to control the aphid population higher than other types of pesticides, then the effect of pesticide concentration was not significantly different from all parameters. However, the concentration of 1% indicated to inhibit the population of aphids higher than other concentrations. The high early aphid population, the behaviour of aphid colonies, the application method, and the nature of the active ingredient of chitosan were thought to be factors that reduce the ability of pesticides to control aphids on long bean plants.

**Keywords:** Aphids, Chitosan, Pesticides, Long Bean

1. **Introduction**

Production Indonesian of long beans in 2019 will reach 370,190 tons [1]. The plants have criteria for growing in ecosystems at an altitude of 50-800 under sea level with soil pH values of 5.5 - 6.5, and air temperatures around 200C - 300C [2]. The obstacle of cultivating long bean plants is a disturbance of pest and plant disease.

*Aphids (Aphis craccivora)* are pests belonging to polyphagous and attacking long bean plants [3]. They caused long bean yield loss up to 60% [3]. Efforts used to control aphids were using synthetic
pesticides. However, a reckless use of synthetic pesticides will have an impact on pest resistance, resurgence, and environmental pollution [4].

There is an effort in replacing synthetic pesticide by using more organic pesticides which is easier to dissolve and has little to no effect on environment [5]. Among many potential materials, chitosan is a very good material that can be used as pesticides because it is obtainable from crab, shrimp shells and several other animals. It is also the chemical has biodegradable, biocompatible, non-allergic properties, and low toxicity that are safe for the environment [6]. The metal contents that are bound to chitosan such as Ag, Cu, Hg, Ni, and Zn are not toxic to humans and non-target organisms and is easily biodegradable [7].

Chitosan insecticide also increases the response of plant resistance as it makes plants synthesize callus and lignin faster so that they have antixenosis and antibiotic effects [8]. The use of adjuvants and carriers in chitosan formulations also increases economic effectiveness and efficiency [9]. However, there is no evidence these pesticides can control aphids in the field.

The research examined the effect of the concentration and types of chitosan and their interactions for control of aphids on long bean plants. The results of this study can be used as a reference source in the use of chitosan as an insecticide.

2. Methods
First, a colony of aphids was searched in farmers' cultivation areas. They were reproduced during 48 days in the screen house in which were become adaptive in the field station of research. Second, a media was prepared to grow the colony of aphids by using a mixture of soil and chicken manure on a ratio of 1:0.5. Furthermore, seed Tavi Parade variety was planted in media on polybags. Plants were maintained by weeding out unnecessary things found in the media and periodically watering them twice a day at 08.00 and 16.00 local time.

Aphids were infested on plants 30 days age. Pesticides were carried out three times at 08.00 am. The types of pesticides were pure chitosan (J1), Soft Guard (J2), Super Biovit (J3), and Water (J0) as control. Each type of pesticide concentrated 0.1% (K1), 0.5% (K2) and 1% (K3), so there were 12 treatment. Each treatment was repeated four times that there were 48 experimental units were obtained. Furthermore, the treatment was also applied to plants of 36, 43, and 50 days age.

The number of aphids (imago and nymph) was calculated per plant in each unit of the experiment by hand tool counter. An observation was done one day before application (H-1) and the day after application (HSA) which consisted of one day after the first application (1-I), third HSA (3-I), sixth HSA (6-I), one day after second HSA (1-II), third HSA (3-II), sixth HSA (6-II), and one day after third HSA (1-III), third HSA (3-III), sixth HSA (6-III).

Leaf damage was observed one day after the first application (1 first HSA or 1-I), one day after the second application (second HSA or 1-II), and one-day application after the third application (third HSA or 1-III). Furthermore, the intensity of the symptoms was observed on long bean leaves. Each leaf of the plant is given a score of 0-5, for healthy plants to severe damage with score are; (1) score 0, given the symptoms of healthy leaves (no leaf spot) or 0% damage; (2) score 1, for symptoms of leaf spot, irregular and blemishes with 0 <x ≤ 10% damage; (3) score 2, if there are leaf spots, mild leaf shape deformity occurs with 10% <x ≤ 20% damage; (4) score 3, leaf shape changes with twisting with damage 20% <x ≤ 50%; score 4, if the leaves were twisted, symptoms grow dead spots, side shoots grow 50% <x ≤ 75% score 4 Side shoots and points grow dead, dwarf plants, brown x> 75% score 5 [10].
addition, the observed flowers and pods fall out then given the highest score of 100%. Observations were made one day after the first application (first HSA or 1-I), one day after the second application (second HSA 1-III), and one day the third application (3 third HSA or I-III). In addition, flowers and pods were observed. To analyze the intensity of damage the total number of times each leaf count is divided by the total number of leaves observed times the highest scale value. In this study, the comparison was analyzed between treatments with analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT).

### 3. Results and Discussion

#### 3.1. Effect of pesticides on the number of aphids

The results showed differences only on the effect of pesticides on the number of aphids one day (1 HSA, $F_{\text{sig}} = 0.018$) and three days after the first application (3 HSA, $F_{\text{sig}} = 0.045$), but there was no significant difference in three days (6 HSA, $F_{\text{sig}} > 0.05$). Furthermore, the factor of concentration and interaction between the types of pesticides and concentrations also showed no difference in the effect on all observations. The research showed that the lowest number of aphids on the use of soft guard pesticides, and a concentration of 1% decreased every one day after application (Figure 1). Meanwhile, the interaction that caused the highest population decline was in the combination of J2K1 (Figure 2).

**Figure 1.** Effect of type (a) and pesticide concentration (b) on the average fluctuation of aphids after application.

Aphids was affected by most pesticide especially soft guard pesticide as it is a chitosan that has been formulated with additives to increase its effectiveness. Soft guards are also more soluble, making it easier to apply using a hand straw. However, these effects do not have long-term effect while aphids have very high reproductive and mobility abilities which made it ineffective for long-term use.

Aphid colonies has a very short life cycles (14-18) but they have a very reproductive imago to increase the number of its population which in turn reduced the food source of plants that they have in that field and make them move to another place to find other food sources. This high number of populations was suspected as a major factor that caused ineffective pesticides. In addition, migration (migration) from one plant to another factory while in the field was also considered to be another reason of the ineffectiveness.
The combinations type of pesticides and concentration of treatment showed no significant effects of aphids’ number. However, the J2K1 combination reduced number of aphids more than other combinations in each application. The average number of aphids after the first application ($\bar{x} = 143.8$), the second application ($\bar{x} = 258$), and the third application ($\bar{x} = 185.3$).

The combination of soft guard pesticides with a concentration of 1% showed the best effect on the decline in aphids’ populations. Hence, when the higher concentration was given which means the higher the active ingredient content, it would reduce the population of aphids more effectively. However, high concentrations pesticides will not affect the population of aphids if the active ingredient is ineffective or not compatible.

![Figure 2](image-url)

**Figure 2.** Effect of a combination of species treatment and pesticide concentration on the average number of aphids after application (1 HSA = blue line, 2 HSA = red line, 3 HSA = green line)

### 3.2. Effect of Pesticides on damage to leaves, flowers, and plant pods.

In this study, there were no differences in the effects of pesticides and concentrations on all parameters of damage to leaf, flower, and pod ($F_{sig} > 0.05$). However, pesticide with a concentration of 1% tended to have the lowest damage in the treatment of soft guard pesticide (Figure 3).
Figure 3. Effect of pesticides and concentrations on average damage to leaf (a), flower (b), and pod (c) after application (1 HSA = white bar chart, 2 HSA = grey bar chart, 3 HSA = black bar chart).

For the effect of combination treatment, there were no significant differences on all of the parameter damage to leaves, flowers, dan plant pod ($F_{sig}>0.05$). Meanwhile, a combination among soft guard pesticide and concentration 1% seemed to be more effective in reducing the damage done by aphids (Figure 4).
Leaves, flowers, and pods are plant organs that are places or habitat for aphids to develop. Meaning, they used them as food sources. Damages to the leave caused disruption to the growth of flowers which ultimately has an impact on pod growth and the use of soft guard pesticides proven to reduce more damage to flowers and pods. In addition, chitosan pesticides have antixenosis and antibiotic properties which are a form of ecological resistance even though they are not permanent. Thus, in high aphids’ populations, they would be able to break the resilience, through rapid and abundant population growth and development strategies.

4. Conclusions

After the treatment, it showed that there was no interaction between different types of pesticides with the observed concentration on all parameters. Also, pesticides’ effect only lasted three days after first application which soft guard pesticide tended to inhibit aphid population higher than other types. Meanwhile, the effects of pesticide concentration were insignificant. However, the concentration of 1% was shown to control the population of aphids better than other concentrations. In this study, the high initial population of aphids, the behaviour of aphid’s colonies, the method of application, and the nature of the active ingredient of chitosan were the main factors that reduced the ability to control aphids in long bean plants.

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