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The effectiveness of garlic extract against *Spodoptera litura* on chili

Abstract. *Spodoptera litura* is a polyphagous pest and attack many families of cultivated plants, such as chili plants. Application of synthetic pesticides is still the mainstay for controlling this pest in the field. To support eco-friendly plant protection management, it is important to explore potential natural materials such as garlic extract. This research aims to determine the potential of garlic extract in controlling *S. litura* on chili plants, and to see its indirect effect on chili yield. The research was carried out in two sites, in the laboratory and the field. The experiment used a completely randomized design with 6 treatments and 4 replications. The concentrations of garlic extract, i.e., control (0%), 24%, 26%, 28%, 30%, and 32%. The results showed the application of garlic extract had a significant effect on the mortality of *S. litura*, the frequency of attacks, and the intensity of pest attacks in the field, and had an effect on the variable number of fruit and fruit weight of chili plants. The LC_{50} and LC_{90} values reached 19.66% and 29.97% in the laboratory, and 28.30% and 34.3%% in the field, respectively. The LT_{50} and LT_{90} values from the 32% garlic extract in the laboratory were respectively 3.37 and 7.23 days. The application of garlic extraction affected growth and yield, i.e. healthy leaves, number of fruits, and weight of fruits in chili. The garlic extract is potentially used as an organic pesticide to suppress the *S.litura* attacks while keeping the plant's growth and yield.

Keywords: Eco-friendly · Garlic · Organic pesticide · Pest · *Spodoptera litura*

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Introduction

Spodoptera litura, commonly named armyworm, is one of the main pest on several crops in Indonesia. This is a polyphagous insect, which attacks many types of plants from various family. Spodoptera's life cycle ranges from 29-32 days; 5-6 days of imago, the egg hatches on 3-4 days, the growth period of larva from instars 1st to 6th are around 12-15 days, then the pupa stage lasts about 7 days before hatching into an imago. A mated female imago produces thousands of eggs during her life (Fattah & Ilyas, 2016; Lestari et al., 2013). The difference of Spodoptera's life cycle affected by the types of host plants (Xue et al., 2010). Narvekar et al., (2018) reported that imago longevity maximum of 8 days in castor and sweet potato, while the total development period was significantly high in tapioca for 37 days. In chili, the population of Spodoptera (3.67 larvae/plant) appeared after 13 weeks after transplanting seed and the peak reached on 17 weeks after transplanting (Saini et al., 2017). The early and massive attacks of *S. litura* on chili plant affect the chili productivity.

Chili (*Capsicum annum*) has the highest productivity after shallots, potatoes and cabbage in Indonesia. In 2022, the national chili production was recorded at 1.5 million of tons with productivity reaching 8.36 tons per hectare. The consumption of chili reaches 636,560 tons on a household scale, out of food industry and processing (Statistics Indonesia, 2022). However, the low productivity of chili has a much greater effect caused by *S. litura* on chili cultivation because it attacks leaves and obstructs the growth and development of chili (Cahyono et al., 2017). In 2017, Technology Assessment and Application Agency stated that *S. litura* plays the main cause of many chili plants dying and crop failure (Cahyamurti & Purwanto, 2021). *S. litura* larval decrease the productivity of chili up to 35% (de Freitas Bueno et al., 2011) thus, pest management is needed to control the *S. litura* attacks.

S. litura becomes a major pest for chili plant. For controlling this pest, farmers of Jamalpur region are frequently spraying insecticides without any pre-harvest interval causing pest resistance, resurgence and environmental health hazard. Resistance to different insecticides of *S. litura* caused sporadic out breaks of the pest and serious crop damage (Mannan & Rahman, 2020). However, the use of synthetic pesticides is still the main control measure, it is necessary to look for alternative materials for control to better support a better and more sustainable cultivation system by implementing an integrated plant protection pattern as stated in the Republic of Indonesia Law No. 22 of 2019.

Garlic extract has the potential to use as an organic pesticide. The extract prevent the negative effects of abiotic stress on plants, as well as playing a role in controlling biotic stress, both from pest groups and microorganisms cause plant diseases (Rinaldi et al., 2019; Golubkina et al., 2022). Several research proved the potential of garlic extract as an organic pesticide for controlling plant pest organisms include research results from Moniharapon and Nindatu (2015) which show the ability of garlic extract to control the pest *Crocidolomia binoltalis*. The results of other research conducted by Irfan (2010) showed the ability of garlic extract to control plant rot caused by bacterial attacks. Another potential of garlic extract, except being able to control insect pests as well as repellent to birds that attack rice (Hardiansyah et al., 2020). This research aims to find out how effective garlic extract is in controlling the *S. litura* pest, which is one of the pests that often attack chili plants.

Materials and Methods

The research was conducted from June to September 2022 at Plantation Seed Production and Development, Bandung, and Integrated Laboratory, UIN Sunan Gunung Djati, Bandung. The materials used were chili seeds, *S. litura* larva, garlic, planting media (soil and husk charcoal), organic fertilizer, and NPK fertilizer.

The research design used a Randomized Complete Block Design with various garlic extract concentrations as the treatments and 4 replications:

P0 : 0 % garlic extract
P1 : 24% garlic extract
P2 : 26% garlic extract
P3 : 28% garlic extract
P4 : 30% garlic extract
P5 : 32% garlic extract

The observed variables divided into field and laboratory works. Mortality worked for field and laboratory; accelerated death rate, attack frequency and intensity of leaf damage worked in field, and yield parameters (numbers of fruit per plant and weight per fruit).

Jurnal Kultivasi Vol. 22 (3) Desember 2023
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Mortality of *S. litura* observed in 24 hours after application for 7 days in laboratory and for 4 days in the field. The death larva calculated:

$$M = \frac{a}{N} x100\%$$

M = Mortality percentage
a = Numbers of death larva
N = Numbers of observed larva

Accelerate Death Rate

$$V = \frac{T1N1 + T2N2 + T3N3 + \cdots + TnNn}{n}$$

V = Accelerate of death rate
T = Time of observation
N = Numbers of death larva
n = Numbers of observed larva

Attack Frequency in the field observed for 4 days every 24 hours and calculated:

$$FS = \frac{X}{Y}\ x\ 100\%$$

FS : Attack frequency
X : Numbers of affected plant leaves
Y : Numbers of observed plant leaves

Classification of pest attack according to percentage of attack frequency:
<10% : Very low
10-50% : Low
51-75% : Moderate
>75% : High

Intensity of damaged leaves was the level of damage to leaves caused by *S. litura*. The observation worked for 4 days after application. The calculation of intensity of damaged leaves using:

$$IK=\sum \left[\left((ni\times vi)\right)/(z\times n)\times 100\%\right]$$

IK = Intensity of damage
Ni = Number of sample plants –i with certain score
Vi = Score of each sample plant -i
n = Numbers of all sample unit
z = Highest score used

The score of IK leaves:
0 : No attack
1 : Intensity of damage 1-25 %
2 : Intensity of damage >25-50 %
3 : Intensity of damage >50-75 %
4 : Intensity of damage >75 %

Intensity of damage category according to Directorate of Food Crop Protection (2018)
<= 25% = Light
>25<=50% = Moderate
>50<=85% = Heavy
>85% = Puso

Larval Rearing of *S. litura*. Larva used in the research was instar 3 larva from the second stage of rearing in laboratory. The larva-fed chili leaves are pesticide-free during the rearing. The larva fed in boxes, during the pupa stage, the larva provided sterile sawdust to grow as a pupa. The hatched pupa grew into imago, and was fed by honey solution 10% (v/v) and provide fresh leaves as the media to lay the eggs. The egg hatched inside the plastic box until reaching instar III and the larva was ready to be invested.

Garlic Extraction . Garlic extraction was made by grinding the garlic using a blender machine and adding water to reach the concentration of each treatment. The extract was left for 48 hours and got strained. The strain product was the final extraction to be applied.

Application of Garlic Extract. The garlic extract was applied by physical method for laboratory works. The larva was invested in as many as 10, sprayed by the extract, and fed by chili leaves for each treatment and replication in a petri dish (ø 9cm). First, the leaves were weighed to get the initial weight of feed then be replaced every 24 hours, and were weighed for final feeding to get the eating reduction calculation.

Garlic extract application in the field was applied 67 days after planting. Pesticide was applied in each treatment and replication. Each treatment x replication consisted of three plants. As many as 5 larva instar III was invested in the leaves and sprayed by each treatment. The plants were covered using a covering cloth sized 30 x 20 x 60 cm^3).

Data Analysis. The collected data tested homogeneity using DSSTAAT software. The post-hoc test used Duncan Multiple Range Test (DMRT) on 95%. The mortality data calculated on lethal concentration LC_{50} and LC_{90} from each treatment using regression from http://14.139.232.166/Probit/probitanalysis.html.

Results and Discussion

Mortality. Laboratory works for 7 days showed the significant effect of the garlic extraction to the *S. litura* mortality. The garlic extract concentration of 32% produced a mortality response of up to 100%. However, other results show that giving 28% extract can be a more efficient treatment to apply because the results of data analysis and post-hoc tests show that the 28, 30, and 32% treatments provided a mortality response that is not significantly different. Meanwhile, the highest mortality observed in the field was in the 30 and 32% treatments with mortality that was not significantly different between the two (Table 1). The garlic extract has a high mortality of *S. litura* compared to papaya leaves extract for 47-63% (Rahayu et al., 2023) and betel nut extract for 83.30% (Eri et al., 2014).

The differences in mortality rates that occur in the laboratory and the field were affected by other different environmental factors, which also influence the mortality rate after treatment in the laboratory and field.

Based on the mortality data in Table 1, lethal concentration (LC) values were obtained consisting of LC_{50} and LC_{90}. These values indicate the ability or toxic level of garlic extract applied to *S. litura* larva and killed 50% (LC_{50}) and 90% (LC_{90}) of the total larval population tested. Based on the research results, the LC values obtained for both LC_{50} and LC_{90} in the field were higher than the laboratory test results (Figure 1). This proved that garlic extract applied in the laboratory shows higher toxic levels compared to the field. In addition, Jelita et al. (2020) stated the smaller LC value indicates the more toxic of the extract applied to the object being tested. Another cause that affected the difference in toxic levels between research results in the laboratory and in the field is exposure to sunlight, which most likely accelerates the rate of evaporation of extracts applied in the field. Because in this study the extract was made using water as a solvent, which evaporates relatively quickly compared to other solvents.

Table 1. Mortality of *S. litura* larva after applying garlic extract in laboratory and field.

Treatments	*Laboratory*		*Field*	
	Σ Larva	% Mortality*	Σ Larva	%Mortality*
Control	40	20.0 a	20	5.0 a
24% garlic extract	40	82.5 b	20	20.0 ab
26% garlic extract	40	80.0 b	20	35.0 b
28% garlic extract	40	87.5 bc	20	40.0 b
30% garlic extract	40	90.0 bc	20	65.0 c
32% garlic extract	40	100.0 c	20	85.0 c

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Table 2. Effect of garlic extract application to the death rate of *S. litura* larva

Treatments	Σ Larva	Death Acceleration (head/day)	LT_{50}	LT_{90}
Control	40	0.65	19.01	101.2
24% garlic extraction	40	2.75	3.59	8.44
26% garlic extraction	40	2.825	3.93	9.30
28% garlic extraction	40	3.05	3.40	8.09
30% garlic extraction	40	3.725	3.89	7.17
32% garlic extraction	40	3.725	3.37	7.23

Jurnal Kultivasi Vol. 22 (3) Desember 2023
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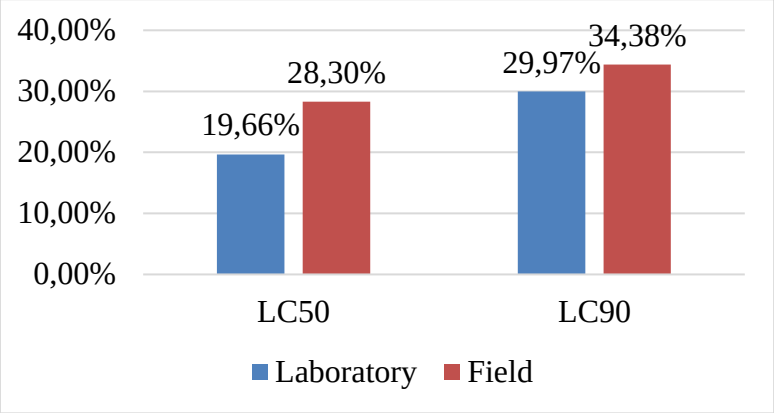

Figure 1. Lethal concentration of garlic extract in *S. litura* larva

Death Rate Acceleration. The results of the rate of death showed that garlic extract had a significant effect on the rate of death of *S. litura* larva in the laboratory. The higher concentration of garlic extract applied, the faster the death rate. The Lethal Time (LT) value consisting of LT_{50} and LT_{90} showed the time required for the treatment to produce a death rate of 50% and 90% of the population. The results of this study showed that treatment in the laboratory with garlic extract with a concentration of 32% resulted in the death of 50% and 90% of the population respectively within 3.37 and 7.23 days (Table 2). the similar toxic level to the fungal culture filtrate, which had the mortality of 96% and 85.33% (LT_{50}) on 7.36 days and 8.09 days, respectively (Gustianingtyas et al., 2020). However, different times of death between treatments given were possible due to the chemical compounds contained in the extract applied. Several compounds in garlic extract were possible to be the active compounds that cause death in the insect larva are allicin and several flavonoid compounds (Sasmilati et al., 2017)

Attack Frequency of *S. litura* in Chili. The application of garlic extract to chili plants significantly had a real effect in reducing the frequency of *S. litura* attacks. The observations made on the fourth day after application of garlic extract to chili plants. Based on the data in Table 3, from the initial observation to the 4th observation after the application of garlic extract, the results showed that increasing the concentration of garlic extract to 32% on chili plants decrease the frequency of attacks by *S. litura* larva. While the highest attack classification in the control was relatively low (< 50%), by a little amount spray of garlic extract could significantly reduce the frequency of attacks to less than 20% for the 30-32% extraction on the fourth day. The results of other research showed similar effect regarding the ability of garlic extract to reduce the frequency of aphid attacks, the higher concentration of the extract decrease the frequency of mealy-bug pests on chili plants (Azizah et al., 2020). Thus, the application of garlic extract is one of the potential organic pesticides to control the *S. litura* larva pest on chili plants.

Table 3. Frequency of *S. litura* attack after application of numerous garlic extract concentration.

Treatments	Percentage of Attacks Frequency*			
	Day 1	Day 2	Day 3	Day 4
Control	46.99 a	44.58 a	43.24 A	40.37 a
24% garlic extract	35.40 b	36.76 b	37.64 B	30.24 b
26% garlic extract	26.59 cd	33.17 bc	31.87 C	27.63 bc
28% garlic extract	28.16 c	29.01 cd	27.30 D	23.97 c
30% garlic extract	22.09 d	23.83 d	21.84 E	14.23 d
32% garlic extract	15.84 e	13.42 e	14.23 E	13.22 d

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Table 4. Intensity of *S. litura* attacks on chili plant after garlic extract application

Treatments	Intensity of Attacks (%)*			
	1 DAA	2 DAA	3 DAA	4 DAA
Control	30.00 c	33.42 d	33.80 e	38.78 e
24% garlic extract	20.16 b	23.93 c	19.47 d	25.88 d
26% garlic extract	12.20 ab	6.32 a	15.01 c	16.72 c
28% garlic extract	11.91 ab	6.32 a	13.10 bc	13.88 bc
30% garlic extract	12.21 ab	9.72 ab	11.37 b	9.13 ab
32% garlic extract	5,.6 a	6.32 a	6.03 a	6.63 a

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Intensity of S. litura attacks in Chili Plants. The intensity of S. litura attacks on chili plants after application of garlic extract with various concentrations showed that the higher the concentration of garlic extract, up to 32%, resulted in decreasing the intensity of S. litura attacks. The application of garlic extract significantly affect the intensity of S. litura attacks on chili plants. In 4 days after application, garlic extraction of 30 and 32% showed the lowest attack intensity compared to other treatments (Table 4). Table 4 qualitatively showed the effect of applying garlic extract significantly reduce the level of attack intensity from the moderate category (38.78%) in control, to the light category (≤ 25%) in the treatment of 24-32% garlic extraction.

The intensity of plant damage can be effected by several things, including the ability of the pest to cause the damage, the availability of host plants for the pest, the age of the plant or the physiological condition of the plant and the effect of pesticide application in the field (Sudewi et al., 2020). The direct effect of organic pesticide application was on larva mortality, while the indirect effect was the intensity of pest attacks or the intensity of damage to cultivated plants. Cahyamurti and Purwanto (2021) stated the bio-control agent againts S. litura should have a significant effect in leaf damage to the control. Thus, the garlic extraction potentially become the organic pesticide to control S. litura attacks.

Growth and Yield of Chili. Despite of direct effect of garlic extract to S. litura insects, the indirect effect observed to the growth and yield of chili plant. In general, the application of garlic extract had no significant effect on chili plant height. Plant height in each treatment, including the control, showed the similar plant height (Figure 2). Plant height was not affected by the application of garlic extract. It is assumed that the invested larva did not attack the growing point of the chili plant, but attacked only the leaves of the plant, so the garlic extract acted as a fertilizer for the growth of the chili plant.

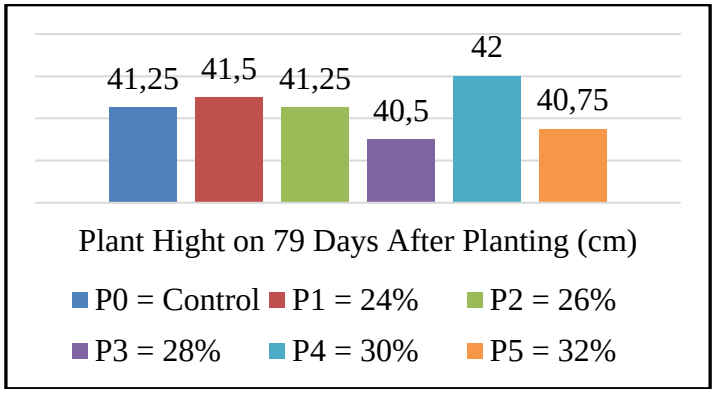

Figure 2. Plant height on 79 days after planting

Jurnal Kultivasi Vol. 22 (3) Desember 2023
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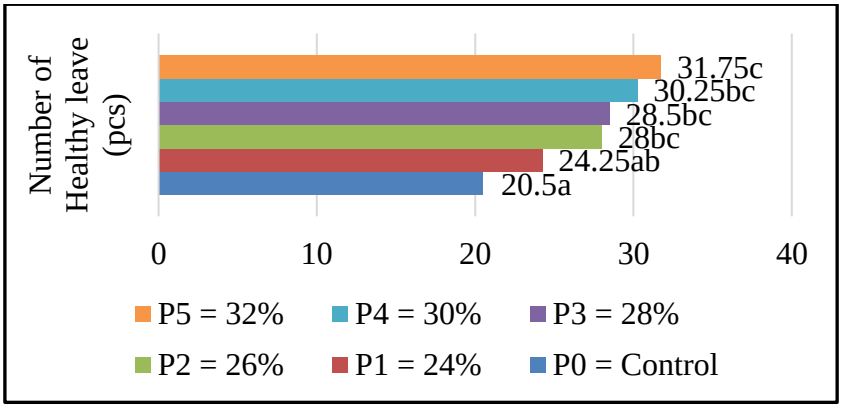

Figure 3. The number of healthy leave (non-attacked) on 79 days after planting

The observation conducted into number of healthy leave (no infection). The application of garlic extract had a significant effect on the number of leave on 79 days after planting. This effect showed in each treatment (26%-32%) while the 24% garlic extract had no significantly different from control (Figure 3). This indirect effect indicates to be related to the intensity of pest attacks on plants. The higher concentration applied, the more decrease intensity of pest attacks, and plant will be able to stand the number of healthy leaves. However, the 36% garlic extract had the number of healthy leaves for 31.75 pcs, while in the control treatment only produced 20.5 pcs.

The results showed that there was a significant effect of garlic extract application to the number of fruit and fruit weight of chili plants. Increasing the concentration of garlic extract had an effect on increasing the number of fruit and average fruit weight. In control treatment, the average number of fruits were only 3.5 pcs, while by 32% garlic extract application produce an average of 16.5 pcs fruits. Nevertheless, the average fruit weight variable, the control only produced 12.96 g, while the 32% of garlic extract application could reach 23.36 g per fruit, twice as high (Figure 4). This might be affected by several observed variables such as mortality, frequency and intensity of pest attacks, which ultimately leads to the growth and development of cultivated plants. Sabaruddin (2021) stated the organic pesticides against *S.litura* attacks and reached the plant height and number of leaves in chili. In addition, the percentage concentration of Neem leaf extract effect on growth of chili plants (Tobing and Mulyaningsih, 2020). It can be concluded that the application of organic pesticides, apart from being able to control pest attacks, can also increase plant growth and yield.

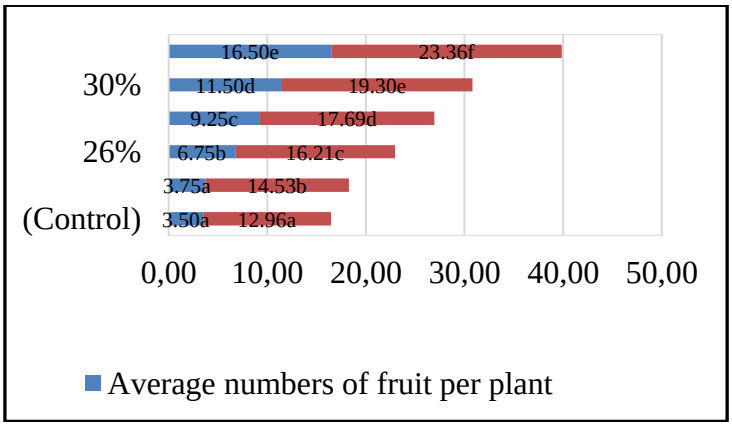

Figure 2. Effect of garlic extract application to the yield of chili.

Conclusion

Garlic extraction controlled *S. litura* in chili cultivation. Increasing the concentration up to 32% increased the mortality and accelerated the rate of death of *S. litura* in both field and laboratory. LC_{50} and LC_{90} reached into 19.66% and 29.97% in laboratory while 28.30 % and 34.3% in the field, respectively. LT_{50} and LT_{90} of 32% garlic extraction in laboratory was 3.37 and 7.23 days. Besides having an effect on *S. litura*, the application of garlic extraction affected growth and yield, such as number of healthy leave, number of fruits and weight of fruits in chili.

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