Efficacy of Extracts of Garlic (*Allium Sativum*) and Neem Leaves (*Azadirachta Indica*) Against Liriomyza Spp.

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Abstract. Lettuce is one of leafy vegetables that has high economic value. Infestation of Liriomyza spp. on lettuce leaves (Lactuca sativa L.) could reduce its quality significantly. This research aimed to study the effectiveness of garlic and neem leaves extract to control Liriomyza spp. Lettuce was cultivated in Nutrient Film Tecnique (NFT) hydroponic system. The experiment was arranged in a Completely Randomized Design (CRD) with 9 various concentration of garlic and neem leaves extract, i.e., 15% garlic extract + 15% neem leaves extract, 15% garlic extract + 30% neem leaves extract, 15% garlic extract + 45% neem leaves extract, 30% garlic extract + 15% neem leaves extract, 30% garlic extract + 30% neem leaves extract, 30% Garlic extract + 45% neem leaves extract, 45% garlic extract + 15% neem leaves extract, 45% garlic extract + 30% neem leaves extract, 45% garlic extract + 45% neem leaves extract, and control (water). The results showed that the concentration of 45% garlic extract + 45% neem leaves extract resulted in 100% mortality of Liriomyza spp. imago, the damage intensity of 26.3%, leaves number of 11, plant height of 28.53 cm, fresh weight of 149.67 g and economic weight of 139.67 g. Application of botanical pesticide with concentration 45% garlic extract + 45% neem leaves extract could control Liriomyza spp. infestation in hydroponic lettuce plants.
Keywords : Lettuce, botanical pesticide, garlic, neem leaves, and Liriomyza spp.

1 Introduction

Lettuce (*Lactuca sativa* L.) is a popular vegetable because it has a color, texture, and aroma that refreshes the presentation of food. It has high economic value and rich with vitamins and minerals. Lettuce can be grown conventionally on the field and cultivated in the greenhouse using hydroponic system. Leafminer (*Liriomyza* spp.) is a major pest in lettuce

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cultivation [1]. It is usually controlled with chemical insecticides. Excessive use of chemical insecticides encourages these insects to become resistant to chemical insecticides [2].

Botanical pesticides are the best choice to replace chemical pesticides because they are more environmentally friendly, as they are not polluting the environment and the source of active ingredients is easy to cultivate [3,4]. Garlic is a plant that is usually grown throughout the year. This plant is part of the onion family that smells the strongest and most spicy [5]. Garlic extract concentration of 60% was effective in controlling the population of *Myzus persicae* (Sulzer) by 77.33%, while a concentration of 45% garlic extract was effective in controlling the population of *M. persicae* by 54.00% [6]. Neem (*Azadirachta indica* A. Juss) is one of the plant sources of botanical insecticides that can be used for pest control. The highest average mortality of the golden snail (*Pomacea canaliculata*) was in the application of a 60% concentration of neem extract [7]. Neem leaf extract treatment with a concentration of 50% tended to provide better control results with the intensity of attacks by *Liriomyza* spp. only 3.04% [8].

The combination use of garlic bulb extract and neem leaves extract is expected to be more effective in controlling *Liriomyza* spp. with lower extract concentrations. This is able to reduce the cost of production of botanical pesticides, so that it is not burdensome for farmers to use them. This study aimed to examine the ability of extracts of garlic bulb and neem leaves to control *Liriomyza* spp. and to determine the best combination between garlic bulb extract and neem leaves to be used as a botanical pesticide.

2 Materials and methods

The lettuce used in this study was the Grand Rapid variety and was cultivated using the Nutrient Film Technique (NFT) hydroponic system. The botanical insecticide solutions were made from garlic bulbs and neem leaves extracts.

The research was carried out using a completely randomized design (CRD) with 1 factor consisting of 9 concentration levels of botanical insecticide namely: 15% garlic extract + 15% neem leaves extract, 15% garlic extract + 30% neem leaves extract, 15% garlic extract + 45% neem leaves extract, 30% garlic extract + 15% neem leaves extract, 30% garlic extract + 30% neem leaves extract, 30% Garlic extract + 45% neem leaves extract, 45% garlic extract + 15% neem leaves extract, 45% garlic extract + 30% neem leaves extract, 45% garlic extract + 45% neem leaves extract, and control (water).

2.1 Lettuce planting

Planting was carried out in three stages, namely the sowing/seedlings stage, the youth production stage and the production stage. The entire planting process lasted for 42 days after the lettuce seeds were sown. The seeds were sown on rockwool media for two weeks. Rockwool media was chosen because it has a water holding capacity of 14 times more than soil and has pores that support good root growth. Rockwool was cut with a size of 12 cm x 8 cm x 2 cm and then given 24 holes per rockwool box.

The next stage after the seedlings was the youth production stage. It is called youth production because the flow of nutrients on the youth production table has followed the production table standard, namely 2 L per minute per 2 hoses with 1,100 ppm and a pH of 6.0. The difference between the production table and the youth production lies in the distance per hole. On the youth production table, the planting distance was 10 cm per hole, while on the production table, the spacing was 20 cm per hole. The plants were on the

youth production table for fourteen days and then transferred to the production table. Transferring plants from youth production tables to production tables was carried out in the morning to prevent wilting of the plants. The production stage is the stage of plant growth until it is ready for harvest. This production stage lasts approximately fourteen days. During the production process several treatments are carried out to support plant growth. Checking the concentration of nutrients and the pH of the nutrient reservoirs is carried out every morning and evening.

2.2 Infestation of liriomyza spp.

Mortality test was conducted in a Petri dish that has been lined with filter paper that has been moistened with distilled water. A healthy lettuce leaf was placed in the Petri dish as a food source for *Liriomyza* sp. Mixture of garlic bulbs extract and neem leaf extract solutions was then sprayed onto the lettuce leaf and left to air dry, then 20-25 *Liriomyza* sp imago was infested into the leaf. Calculation of the number of *Liriomyza* sp. imago that died was performed at 24 hours, 48 hours, and 72 hours after application. To observe *Liriomyza* sp. effect on leaves damage intensity, ten *Liriomyza* spp. imago were infested on each healthy lettuce plant 15 days after replanting in NFT hydroponic system.

2.3 Preparation of garlic bulb extract and neem leaf extract solution

The garlic bulbs solution was prepared by manual extraction [9]. Garlic bulbs that have been cleaned from the skin were blended with water with a ratio of 1:1 (1 kg garlic : 1,000 mL of distilled water) then soaked for 24 hours then squeezed, separated from the pulp and filtered. Extraction results used as a stock solution with a concentration of 100% then made a concentration of 15%, 30% and 45%.

Neem leaf extract solution was prepared according to [10]. 50 grams of fresh neem leaves were blended with 1,000 mL of distilled water and 1 mL of 70% alcohol. The solution was then allowed to stand for 24 hours and filtered. The extraction results were used as a stock solution with a concentration of 100% then concentrations of 15%, 30% and 45% were made

Mixing of garlic bulbs extract and neem leaf extract solutions was conducted just before application. The ratio of mixing of garlic and neem leaves extract solutions was 1:1 each, then mixed with 1% surfactant of the total solution just before application.

2.4 Application of garlic bulb extract and neem leaf extract solution

Mixture of garlic bulbs extract and neem leaf extract solutions were applied at the plant age of 14 to 39 days after sowing. Each plant was sprayed with botanical pesticides until it covered all parts of the plant and stopped at the first drop of botanical pesticides. The application of botanical pesticides was carried out three times a week, namely on Monday, Wednesday and Friday.

2.5 Harvest

The lettuce harvest was carried out when the lettuce was 42 days old. Harvesting was conducted in the morning to maintain the freshness of the plants.

3 Results and discusssion

Application of botanical pesticides solution of 30% garlic bulb extract + 45% neem levesf extract or solution of 45% garlic bulb extract + 45% neem leaf extract was able to cause 100% mortality of *Liriomyza* spp. within 24 hours after application (Tabel 1). The active ingredients in high extract concentrations are able to kill *Liriomyza* spp imago. in a short time. Azadirachtin in neem leaves does not directly cause insect mortality, but by interfering with insect growth and reproduction, as well as a refusal to eat mechanism or as anti-feedant [11]. Flavonoid compounds in garlic bulbs are stomach poisoning in insects. Flavonoids undergo biotransformation into water-soluble compounds. This process requires energy. The more poison that enters, it will hamper the metabolism so that insects die due to lack of energy [12]. The allicin content in garlic causes the growth of *Liriomyza* spp. larvae. hampered. Allicin works to interfere with the synthesis of cell membranes so that the larvae fail to develop into pupae. Allicin will damage the cell membrane of the larvae, causing lysis and leading to the mortality of insect larvae [13].

Table 1. Mortality of *Liriomyza* spp imago (Mean±SEM) (%).

Extract Concentration	Observation		
	24 haa	**48 haa**	**72 haa**
CONTROL (water)	23.7 ± 3.25 f	55.6 ± 11.00 c	100 ± 0 a
A (15% garlic + 15% neem leaves)	30.2 ± 2.71 f	60.7 ± 5.23 c	100 ± 0 a
B (30% garlic + 15% neem leaves)	36.7 ± 5.89 f	70.8 ± 9.61 c	100 ± 0 a
C (45% garlic + 15% neem leaves)	38.3 ± 9.60 ef	74.5 ± 5.84 c	100 ± 0 a
D (15% garlic + 30% neem leaves)	54.6 ± 11.05 de	88.8 ± 12.69 b	100 ± 0 a
E (30% garlic + 30% neem leaves)	61.2 ± 21,47 cd	92.9 ± 8.60 b	100 ± 0 a
F (45% garlic + 30% neem leaves)	77.8 ± 14.90 bc	97.4 ± 2.19 ab	100 ± 0 a
G (15% garlic + 45% neem leaves)	86.3 ± 9.56 b	96.8 ± 5.48 b	100 ± 0 a
H (30% garlic + 45% neem leaves)	100 ± 0 a	100.0 ± 0 a	100 ± 0 a
I (45% garlic + 45% neem leaves)	100 ± 0 a	100.0 ± 0 a	100 ± 0 a

Note: Values followed by the same letter in one column show no significant difference based on Duncan's Multiple Range Test at the 5% level. hat : hours after application

At 72 hours after application of all treatments resulted in 100% mortality of *Liriomyza* spp. This was not only due to the application of extracts of garlic bulb and neem leaves but also due to the life span of *Liriomyza* spp. imago is very short (3 days). Development of *Liriomyza* spp. starting from the egg being laid until it becomes an imago lasts for 18-22 days. The development of pre-adult males is faster than pre-adult females, that is, males last around 19.13 days while females take 19.33 days. The imago of *Liriomyza* spp. could survive for 3-6 days [14]. This led to the observation that 72 hours hours after application all infested imago were died.

Table 2. Leaves damage intensity by *Liriomyza* spp. (Mean± SEM) (%)

Extract Concentration	Observation		
	28 das	**35 das**	**42 das**
CONTROL (water)	52.2 ± 5.1 a	48.6 ± 5.0 a	44.3 ± 4.4 a
A (15% garlic + 15% neem leaves)	47.8 ± 5.1 b	43.7 ± 4.1 ab	38.4 ± 4.4 b
B (30% garlic + 15% neem leaves)	46.9 ± 3.6 b	41.3 ± 3.9 b	40.6 ± 1.6 ab
C (45% garlic + 15% neem leaves)	46.8 ± 5.1 b	39.9 ± 4.9 bc	34.9 ± 4.6 c
D (15% garlic + 30% neem leaves)	44.6 ± 4.4 bc	36.8 ± 3.6 c	35.9 ± 4.8 bc
E (30% garlic + 30% neem leaves)	43.8 ± 2.1 c	36.1 ± 5.3 c	35.5 ± 5.0 c
F (45% garlic + 30% neem leaves)	42.7 ± 2.2 c	33.9 ± 2.0 cd	32.7 ± 2.9 c
G (15% garlic + 45% neem leaves)	40.6 ± 1.0 c	32.0 ± 0.5 d	28.5 ± 3.2 d
H (30% garlic + 45% neem leaves)	40.2 ± 1.2 c	30.4 ± 1.3 d	29.4 ± 1.2 cd
I (45% garlic + 45% neem leaves)	39.6 ± 1.0 c	29.4 ± 0.9 d	26.3 ± 4.3 d

Note: Values followed by the same letter in one column show no significant difference based on Duncan's multiple range test at the 5% level. das: days after sowing.

In treatment E (30% garlic bulb extract + 30% neem leaf extract), F (30% garlic bulb extract + 45% neem leaf extract), G (45% garlic bulb extract + 15% neem leaf extract), H (45% garlic bulb extract + 30% neem leaf extract), and I (45% garlic bulb extract + 45% neem leaf extract) showed the average intensity of damage caused by *Liriomyza* spp. was significantly lower compared to other treatments (Table 2). This is consistent with the observation of mortality in *Liriomyza* spp. imago (Table 1). Treatment E (30% garlic bulb extract + 30% neem leaf extract), F (30% garlic bulb extract + 45% neem leaf extract), G (45% garlic bulb extract + 15% neem leaf extract), H (45% garlic bulb extract + 30% neem leaf extract) and I (45% garlic bulb extract + 45% neem leaf extract) showed mortality in *Liriomyza* spp. imago were more than 60%.

Garlic bulb extract contains essential oil. Photochemical test results on garlic bulb essential oil showed the presence of secondary metabolites, namely alkaloids, terpenoids and tannins. Terpenoid compounds have antifeedant properties. The performance of antifeedant compounds does not kill immediately but inhibits the appetite of the larvae because these compounds have a bitter and sharp taste. This causes the larvae to refuse to eat and eventually die [13]. Azadirachtin in neem leaves can cause many effects on insects, such as decreased feeding activity, developmental disorders, decreased personality, survival and inhibited egg laying [15].

The parameter of the number of leaves when the plants were 35 days old and 42 days after sowing in control treatment (water) showed a significantly lower number of leaves that on treated plants (Table 3). This is consistent with observations on the average intensity of damage caused by *Liriomyza* spp. (Table 2) where the control treatment (water) had higher damage intensity than other treatments. Heavy attack of *Liriomyza* spp. can cause desiccation and premature leaf drop in lettuce, especially in the lower canopy [14]. This

also caused a decrease in the number of leaves in lettuce treatment B (15% garlic extract + 30% neem leaf extract).**ble 3.** Number of lettuce leaves (Mean± SEM) (%)

Extract Concentration	Observation		
	28 das	**35 das**	**42 das**
CONTROL (water)	6 ± 0,6 a	6 ± 1,0 d	7 ± 1,0 d
A (15% garlic + 15% neem leaves)	6 ± 0,6 a	8 ± 0,6 b	8 ± 0,6 c
B (30% garlic + 15% neem leaves)	6 ± 0,6 a	9 ± 0,6 a	8 ± 0,6 c
C (45% garlic + 15% neem leaves)	5 ± 0 a	7 ± 1,2 cd	9 ± 0 c
D (15% garlic + 30% neem leaves)	5 ± 1,2 a	7 ± 1,5 bc	9 ± 1,0 c
E (30% garlic + 30% neem leaves)	6 ± 0,6 a	8 ± 1,0 ab	9 ± 0,6 c
F (45% garlic + 30% neem leaves)	6 ± 0,6 a	9 ± 0,6 a	9 ± 1,0 bc
G (15% garlic + 45% neem leaves)	6 ± 0,6 a	9 ± 0,6 a	10 ± 1,5 b
H (30% garlic + 45% neem leaves)	6 ± 0,6 a	8 ± 1,2 b	10 ± 1,2 ab
I (45% garlic + 45% neem leaves)	6 ± 0 a	9 ± 0,6 a	11 ± 1,2 a

Note: Values followed by the same letter in one column show no significant difference based on Duncan's multiple range test at the 5% level. das: days after sowing.

Observation of the parameters of the average height of lettuce plants on plants aged 35 das showed that treatment I (45% garlic bulb extract + 45% neem leaf extract) showed a significantly higher average height than those of other treatments. At 42 das the control treatment (water) showed an average plant height which was significantly lower than the various botanical insecticides treatments (Table 4). The mean plant height in the control treatment (water) was significantly lower than all treatments due to the absence of active substances that could reduce the activity of eating pests and interfere with pest reproduction so that the imago *Liriomyza* spp. laid their eggs on the leaves of lettuce plants and there are larvae that snore in the palisade tissue of the leaves. The activity of the larvae consuming palisade tissue of leaves can reduce the photosynthetic capacity of plants [16]. A decrease in photosynthetic capacity will result in the growth of lettuce not taking place optimally.

Table 4. Lettuce plant height (Mean± SEM) (cm)

Extract Concentration	Observation		
	28 das	**35 das**	**42 das**
CONTROL (water)	19.4 ± 0.5 a	20.60 ± 0.9 g	21.13 ± 0.3 g
A (15% garlic + 15% neem leaves)	19.4 ± 0.5 a	22.67 ± 0.4 f	23.03 ± 0.4 f
B (30% garlic + 15% neem leaves)	19.6 ± 0.1 a	23.87 ± 0.9 e	23.87 ± 1.0 e
C (45% garlic + 15% neem leaves)	19.6 ± 0.6 a	24.73 ± 0.8 d	24.83 ± 0.5 d
D (15% garlic + 30% neem leaves)	19.7 ± 2.8 a	25.57 ± 1.5 c	25.73 ± 1.5 c
E (30% garlic + 30% neem leaves)	19.7 ± 1.1 a	25.30 ± 1.1 cd	25.53 ± 1.1 c
F (45% garlic + 30% neem leaves)	20.9 ± 0.4 a	27.13 ± 1.1 b	27.20 ± 1.0 b
G (15% garlic + 45% neem leaves)	19.3 ± 0.5 a	27.33 ± 1.4 b	27.60 ± 1.4 b
H (30% garlic + 45% neem leaves)	20.5 ± 0.8 a	27.57 ± 0.2 b	27.77 ± 0.3 ab
I (45% garlic + 45% neem leaves)	19.8 ± 0.4 a	28.33 ± 0.8 a	28.53 ± 0.8 a

Note: Values followed by the same letter in one column show no significant difference based on Duncan's multiple range test at the 5% level. das: days after sowing.

Fresh weight of lettuce on treatment I (45% garlic bulb extract + 45% neem leaf extract) was significantly heavier than those of various other treatments (Table 5). This is consistent

with the results of observations on the mortality of *Liriomyza* spp. imago which was given treatment I (45% garlic bulb extract + 45% neem leaf extract) in Table 1. High concentrations of garlic bulb and neem leaf extract contained more active ingredients capable of acting as pesticides.

Garlic bulb extract contains saponins and neem leaf extract contains salanin. Saponins work by inhibiting the mechanism of digestive enzymes and protein use. Saponins are poisons that can cause hemolysis in the blood. Saponin compounds are one of the compounds that interfere with the ecdysis process. Moulting of the skin (ecdysis) in insects is not only to grow but to reach the adult stage so that they can reproduce. Saponins enter the larvae's body in two ways, namely through the respiratory system and through physical contact and work by inhibiting digestive enzymes so that metabolism will be disrupted and result in death [17]. The active substance salanine acts as an appetite suppressant (antifeedant) which results in greatly reducing the destructive power of pests, even though the insects themselves have not died [18].

Table 5. Lettuce fresh weight (Mean± SEM) (gram)

Extract Concentration	Observation		
	28 das	35 das	42 das
CONTROL (water)	44.33 ± 7.8 a	65.93 ± 7.0 e	116.33 ± 3.5 a
A (15% garlic + 15% neem leaves)	36.67 ± 0.7 a	71.33 ± 2.3 d	115.67 ± 6.7 a
B (30% garlic + 15% neem leaves)	35.43 ± 3.2 a	73.77 ± 1.5 d	123.67 ± 20.5 a
C (45% garlic + 15% neem leaves)	34.87 ± 2.2 a	73.40 ± 7.9 d	126.33 ± 20.6 a
D (15% garlic + 30% neem leaves)	40.07 ± 9.3 a	82.67 ± 3.3 c	135.00 ± 9.9 a
E (30% garlic + 30% neem leaves)	37.97 ± 5.4 a	80.33 ± 3.9 c	138.00 ± 19.2 a
F (45% garlic + 30% neem leaves)	48.53 ± 4.6 a	93.30 ± 3.5 b	142.67 ± 14.0 a
G (15% garlic + 45% neem leaves)	40.77 ± 5.8 a	89.87 ± 3.7 b	142.00 ± 8.7 a
H (30% garlic + 45% neem leaves)	44.97 ± 3.9 a	93.57 ± 5.1 b	148.33 ± 33.6 a
I (45% garlic + 45% neem leaves)	42.53 ± 4.4 a	103.53 ± 5.4 a	149.67 ± 2.1 a

Note: Values followed by the same letter in one column show no significant difference based on Duncan's multiple range test at the 5% level. das: days after sowing.

Attack of *Liriomyza* spp. will affect the economic weight because many parts of the lettuce plant are wasted due to attacks from *Liriomyza* spp. The results of the observed economic weight parameters showed that treatments H (45% garlic bulb extract + 30% neem leaf extract) and I (45% garlic bulb extract + 45% neem leaf extract) had significantly higher economic weight than various other pesticide treatments (Table 6). The presence of active ingredients in the garlic and neem leaf extracts that were applied was able to reduce the damage caused by *Liriomyza* spp. both direct damage in the form of serpentine burrows and indirect damage in the form of ovipositor puncture marks on the leaves.

Table 6. Lettuce economic weight at 42 das (gram)

Extract Concentration	Mean± SEM
CONTROL (water)	95.33 ± 2.08 e
A (15% garlic + 15% neem leaves)	96.67 ± 6.66 e
B (30% garlic + 15% neem leaves)	105.00 ± 20.52 de
C (45% garlic + 15% neem leaves)	107.33 ± 20,60 cd
D (15% garlic + 30% neem leaves)	117.00 ± 9.85 b

E (30% garlic + 30% neem leaves)	120.00 ± 19.16 b
F (45% garlic + 30% neem leaves)	124.67 ± 13.01 ab
G (15% garlic + 45% neem leaves)	123.00 ± 12.17 b
H (30% garlic + 45% neem leaves)	135.33 ± 33.62 a
I (45% garlic + 45% neem leaves)	139.67 ± 5.03 a

Note: Values followed by the same letter in one column show no significant difference based on Duncan's multiple range test at the 5% level. das: days after sowing.

4 Conclusion and recommendation

Based on the results of this study, it can be concluded that a combination of 30% garlic bulb extract + 45% extract neem leaves was as effective as combination of 45% garlic bulb extract + 45% extract neem leaves to control *Liriomyza* spp. in hydroponic lettuce plants. Therefore, combination of garlic bulb extract and neem leaves can be used as a botanical insecticide for hydroponic lettuce plants because it can reduce the intensity of damage caused by *Liriomyza* spp. pest attacks and kept plant weight remained high.

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