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The Effectiveness of Several Repellent Plants to Control Thrips (*Thrips* sp.) in Small Chili (*Capsicum frutescens* L.)

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Abstract. Insect pests such as *Thrips* sp. can result in yield losses in chili up to 23%. To suppress its attacks while reducing pesticide use, repellent plants can be grown at the edges as the barrier of the insects to decrease pest populations. This study aimed to determine the effectiveness of several types of edge plants as repellents to control the population and intensity of *Thrips* attack on small chili (*Capsicum frutescens* L), by conducting a experiment in the field located in the village of Nyiur Lembang, Narmada District, West Lombok Regency. The experimental design used was a randomized block design (RBD) with four treatments, namely chili + basil, chili + marigold, chili + onion and monocropped chili (control), each of which was replicated six times. Data were analyzed with analysis of variance (ANOVA) and Tukey's HSD at 5% significance level. The results showed that the use of basil, marigold and shallots as repellents was effective in reducing the population and intensity of *Thrips* pest attacks on chili plants. The *Thrips* population on chili planted with basil, marigold, and shallots was significantly lower than the control plants. The highest average population of *Thrips* was in control plants (3.52 individuals), while in the plants treated with basil, marigold and shallot were 2.40; 2.60 and 2.79 individuals, respectively. The intensity of attack by *Thrips* sp was significantly higher in the control (3.70%) than in the treated chili plants, i.e. only 2.91% under the treatment with basil, 3.15% with marigold, and 3.32% with shallots.

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1. INTRODUCTION

Cayenne pepper or small chili (*Capsicum frutescens* L.) is a horticultural crop with a high economic value, which is widely used as food ingredients, materials for industry as well as for use as medicinal ingredients. The price of chili as the main food commodity in Indonesia continues to fluctuate from year to year, but has tended to increase in recent years (*Putri & Anggraeni, 2018)*. From the view point of processing industry, chili has currently become one of the main ingredients for production of green chili sauce, red chili sauce, chili powder, and other cooking ingredients because of its spicy nature which comes from essential oils it contains. Meanwhile, in the world of the pharmaceutical industry, chili is a mixed ingredient for the manufacture of balms, inhalers, and candy substitutes for cigarettes (Setiawan & Yetri, 2022).

The fruit yield loss of chili plants can be very significant due to pest attacks. Insect pests that attack red chili plants include *Trips* and aphids, which are the dominant pests. The attacks of these two pests together with mites, armyworms, whitefly, fruit flies, and fruit caterpillars can cause more than 25% damage (Setiawati et al., 2013; Prabaningrum & Moekasan, 2014). One of the most important insect pests for chili plants that can result in yield loss of up to 23% is *Thrips* sp. Attacks that occur at the start of planting can be fatal, allowing for dwarf disease, wilting of plants, and eventually death of the chili plants. Plant damage caused by Thrips sp. will cause changes in color, shape and size of chili plant leaves. Thrips sp. damages buds, leaves, and flowers by piercing plant tissue and sucking plant sap. Dirts from these pests is a growth medium for some fungi so that it can interfere with the photosynthesis process of chili plants. It can also be a vector for plant diseases caused by viruses. Many types of viruses that infect plants are carried by Thrips sp. Tomato Spotted Wilt Virus (TSWV) caused $1.4 billion in tomato yield losses over 10 years in Georgia (Riley et al., 2011). Thrips sp. as a spreader of curly virus disease on chili leaves can cause yield losses of 30.00-50.00%.

In controlling *Thrips* sp., farmers use various types of pesticides. Using the excessive of pesticides will have negative impacts, including insect pests becoming resistant, resurgence, reducing the abundance of natural enemies, polluting the environment and being dangerous to humans. Efforts to reduce these negative impacts require an understanding of agro-ecosystem management based on Integrated Pest Management (IPM) principles. By applying the principle of integrated pest management, environmental pollution by pesticides can be kept to a minimum due to reduced use of chemical pesticides by utilizing several types of plants that are able to resist the presence of pests on cultivated plants as a substitute for chemical pesticides.

One way to suppress thrips pest attacks (*Thrips* sp.) while reducing the use of pesticides is through utilization of several types of plants that have a function as repellent plants, that can repel the presence of Thrips. Control of plant pests by planting several types of repellent plants as edge plants can increase ecosystem stability so that pest populations can be suppressed and are in balanced populations. The certain types of plants that are intercropped can have a function as a repellent or barrier to the entry of pests into the staple food crop by releasing compounds that pests don't like, one of which is by emitting aromas that pests don't like. One of the compounds released by those types of plants is essential oil. Some repellent plants that can be used to control pests biologically, namely shallots, marigolds and basil. Using repellent plants as one of the pest controls will have an impact on reducing the use of chemical pesticides so that it will reduce the negative impact of pesticides on the environment. Intercropping with the aim of suppressing pest attacks can also be done by planting aromatic plants that contain essential oil compounds that are toxic to pests (Pare & Tumlinson 1999; Yi et al. 2006; Azare-Bediako et al., 2013).

The toxicity of broad-spectrum essential oils can act as a fumigant, contact insecticides, repellent, antifeedant or affect the development, reproduction, and behavior of insect pests (Karamaouna et al. 2013). Basil (Ocimum basilicum) is an aromatic plant that can be used as a vegetable and drugs (Khalid et al., 2006; Vina & Chaves, 2006; Shiraga, 2009) can act as repellents for mosquitoes. Basil contains linalool (45.11%) which can kill aphids thereby reducing attacks of potato Y virus on potato plants (Oraby & El-Borollosy, 2013). Schader et al. (2005) reported that intercropping of cotton with basil resulted in a reduction of pest infestation by 50% and an increase in populations of useful fauna by 30%.

Until now, there has not been much research information regarding the types of plants that can play a role in chili plants from the attack of various insect pests. Therefore, to find out several types of plants that can function as repellents for *Thrips* sp. on chili plants, this research was carried out. The purpose of this study was to determine the effectiveness of several types of edge repellent plants on the *Thrips* population and the intensity of their attacks on cayenne pepper (*Capsicum frutescens* L).

2. MATERIALS AND METHOD

The method used in this study is an experimental method by conducting experiments in the experimental field in Narmada Village, West Lombok District, West Nusa Tenggara. The design used was a randomized block design (RBD) with four treatments, each of which was replicated six times so that there were 24 treatment plots. The treatments were as follows: monocropped chili, chili and basil, chili and marigold, chili and shallots. The sample plants observed in each plot were 20% or as many as 6 plants, which were determined by systematic random sampling so that a total of 144 samples were observed. The observed parameters were the population and intensity of Thrips sp attack on chili plants, which was done by directly counting the number of Thrips sp found on those sample plants. The intensity of the attack was determined by observing the damage caused by the *Thrips* sp in sample plants characterized by silvery leaf color, the leaves turn to brown, the leaves turn to yellow and curly. The data were analyzed with analysis of variance (ANOVA), followed by an honest significant difference test (Tukey's HSD) at 5% significance level. Regression analysis was used to determine the relationship between pest population and the intensity of *Thrips* sp attack.

3. RESULTS AND DISCUSSION

3.1. Pest Population

The data showed that the highest Thrips sp population was found in chili plants without repellent plants (the control) with an average of 3.53 individuals, which was significantly different from the treatments of basil, marigold, and shallots.

Table 1. Average Thrips sp population in chili plants

Treatments	Test						Average
	1	2	3	4	5	6	
Control	3,28	3.70	3.71	3.49	3.52	3,42	3.52 a
Basil	2.49	2.38	2.48	2,41	2.34	2,29	2.40 c
Marigolds	2.69	2.48	2.64	2.57	2.60	2.63	2.60 b
Shallot	2.69	2.97	2.73	2.69	2.85	2.81	2.79 b
HSD 5%							0.17

The lowest population of *Thrips* sp was in the basil treatment with an average of 2.40 individuals. This is presumably because the content of compounds consisting of essential oils in the basil plants is more than that of other plants. Basil leaves contain essential oil compounds which are composed of several components, including 48.4% linalool, 12% 1.8-cineol, 6.6% eugenol, 6.2% methyl cinnamate, 5.7% *α-cubebene*, 2.5% caryophyllene, 2.1% *β-ocimene*, 2.0% *α-farnesene* (Ridhwan & Isharyanto, 2016). The compounds such as eugenol, linalool, and geraniol are volatile, and these compounds result in low presence of mosquito (Dinata, 2005) and it is possible that the content of these compounds caused Thrips sp. pest populations in the basil treatment was lower than those in the marigold treatment. In addition, the other active compounds in basil plants that function as repellents are flavonoids, saponins, tannins. Marigold contains essential oil compounds composed of Tagetiin 0.1%, Terthienyl, Helenian 0.74%, Flavoxanthin that can repel and kill Aedes sp mosquitoes. The essential oil in marigold flowers (*Tagetes erecta*) can repell insects, so this plant can be used as a repellent plant (Zen, 2017). Red onion presumably contains the active ingredient allicin which can repel pests (Akmal, 2009). When compared with basil, it seems that allicin and essential oil compounds from shallots cannot effectively repel insects with their aroma, so the pest population level was different from that of basil plants. Essential oils and allicin contained in shallots tend to have anti-microbial properties due to the presence of several active substances they have. Some of the chemical substances contained in the essential oil of shallot (Allium cepa L.) are hexyl sulfide, methyl propyl sulfide, methyl propel disulfide, dipropyl disulfide, dipropyl trisulfide, trilostana, dimethyl thiopen, ethyl isopropyl sulfone, hexyl furanone, methyl furanone, and propane, an antibacterial agent capable of damaging cell walls, damaging cytoplasmic membranes, denaturing cell proteins and inhibiting the action of enzymes in cells (Yuhana, 2008).

3.2. Thrips Population Fluctuations

In the observations on 21 and 28 days after planting (DAP) *Thrips* sp population was low in all treatments, which is presumably due to the use of silvery black plastic mulch, which can suppress the development of *Thrips* sp.

Table 2. The average Thrips sp pest population in each observation between treatments of the chili plants

Treatments	Plant age (DAT)						
	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT
Control	0.71	1.42	3.79	4.89	5.61	4.45	3.78
Basil	0.71	0.97	2.05	3.34	4.33	3.19	2.19
Marigolds	0.71	1.01	2.43	3.61	4.54	3.43	2.44
Shallot	0.71	1.07	2.93	4.22	4.58	3.38	2.64

When exposed to sunlight, plastic mulch will reflect light, causing heat which causes Thrips sp. fly away from the heat source. At the age of 28, 35, 42 DAP the population of Thrips sp. continued to increase in all treatments until the age of 49 DAP. This is because at that age many chili plants form young leaves and begin to enter the flower formation phase as stated by Rante and Manengkey (2017), Thrips sp. often found in certain parts of the chili plant, the part of the chili plant that is commonly found is Thrips sp. namely on the lower surface of the leaves, the young leaves and parts of the flower. In the figure, it can be seen that the increase in Thrips population was very prominent in control plants compared to chili plants with various repellent plant treatments.

At the age of 56 and 63 (DAP) population of *Thrips* sp. decreased in all treatments, however, the highest population was obtained in the control treatment. The decline in the *Thrips* population is due to the fact that at that age the chili plants no longer form young leaves. As stated by the Directorate of Horticultural Plant Protection (2005), *Thrips* sp attack the shoots of plants or young shoots.

The highest population occurred in chilies without Repellent plants (control) while the lowest population was in chilies with Repellent plants (chili with basil). The high population of *Thrips* sp. in chili plants in the control treatment compared to the treatment of chili basil, chili with marigolds, and chili with shallots because there was no barrier so that it attracted the imago pests to lay their eggs. While the lack of population of *Thrips* sp. The intercropping treatment of chilies with basil, merigold, and shallots was due to the diversity of plants in one bed and the chemical compounds released by basil, marigolds, and shallots which are known to have repellent properties for several classes of insects including *Thrips* sp.

3.3. Damage rates

The attack intensity of chilies without repellent plants was the highest, namely 3.74%, significantly different from the treatment with repellent plants either basil, marigold, or shallots. The second highest attack intensity was on chilies with shallots of 3.32%, significantly different from the treatment without repellent plants but not significantly different from the other treatments. Likewise, the damage to chilies with marigolds was 3.15%, significantly different from the treatment without repellent plants but not significantly different from the treatments of basil and marigold and shallots, and mathematically the lowest intensity of nesting occurred in chilies with basil which was 2.93% significantly different from the treatment without repellent plants and shallots but not significantly different from the treatment of marigolds and shallots.

Table 2. Level of Damage to Chili Plants by *Thrips* sp.

Treatments	Test						Average
	1	2	3	4	5	6	
Control	3.59	3.92	3.92	3.75	3.83	3,43	3.74 a
Basil	3,31	2.94	3.04	2.70	2.82	2.68	2.92 b
Marigolds	3.35	3,21	2.87	3,19	3,13	3,16	3.15 b
Shallot	3,32	3,18	3.48	3,23	3.50	3,18	3.32 b
HSD 5%							0.41

The thing that caused the difference in the level of damage to the treatment without repellent plants (control) with all treatments was the presence of secondary metabolite compounds contained in basil, marigold, and shallots which were able to resist the presence of Thrips sp. on chili plants so that the level of plant damage is low compared to the control treatment or without repellent plants. In addition to rejecting the presence of pests, repellent plants are also able to reduce pest appetite.

In basil there are several active compounds such as essential oils (Zahra & Iskandar, 2015), flavonoids, gallic acid, glycosylates, and caffeic acid (Deviyanti & Anggo, 2015). Other essential oil components are geraniol, geranial, metal eugenol, neral, and citral (Sarma & Babu, 2011; Al-Maskri et al., 2011; Bunrathep et al., 2007). Besides that, basil also contains linalool, geraniol, citronellol which are phenolic compounds that have deterrent power against mosquitoes. These compounds are composed of terpenoid compounds that have and give rise to an odor or aroma (Aini et al., 2016; Dardouri et al., 2019).

Apart from basil, marigold and shallot plants also contain essential oils. Active compounds such as flavonoids which are respiratory poisons that enter the mosquito's body through the respiratory system, will then cause disturbances in the nerves and damage to the respiratory system, resulting in mosquitoes being unable to breathe and eventually causing death in mosquitoes (Irfayanti & Jasmiadi, 2022; Setiawati et al.,2008).

Meanwhile, another active compound in basil leaves that is thought to act as an insecticide is tannin which functions as a contact poison which results in the activation of the cell lysis system due to proteolytic enzymes in mosquito body cells. This conjecture is based on the opinion of Harborne (1988) and Kumalasari & Andiarna (2020) that the tannin compounds contained in basil leaf extract are thought to reduce the activity of digestive enzymes such as amylase and protease, so that protein absorption can be disrupted and result in death in mosquitoes due to impaired nutrient absorption and decreased growth rate in mosquitoes. Tannin is a type of polyphenol that will inhibit the entry of food substances needed by insects so that the nutritional needs of insects are not met, eventually there will be metabolic and physiological disorders of cells which will cause cell damage. Other compounds contained in basil leaves which can also act as insecticides are saponins. Saponins work as stomach poisons by inhibiting proteolytic enzymes which will cause a decrease in the activity of digestive enzymes and can also irritate the mucosa of the digestive tract in insects (Wijayani, 2014).

Table 3. Development of damage to chili plants due to *Thrips* sp in various treatments

Treatments	Plant age (DAP = days after planting)						
	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP	56 DAP	63 DAP
Control	0.71	1.92	3.15	4.37	4.93	5.33	5.49
Basil	0.71	0.49	2.02	3.37	4.12	4.15	4.54
Marigold	0.71	1.89	2.68	3.55	4.14	4.33	4.78
Shallot	0.71	1.94	2.95	3.96	4.23	4.59	4.84

Symptoms of Thrips sp attack. it can be seen when the plant is 28 hst, namely the leaves that are attacked are silvery in color which are irregular due to puncture wounds caused by these insects. After some time the silver stains turn yellowish and mottled with brown. The change in leaf color is due to the entry of air into the cell tissue which has been sucked by the liquid by Thrips sp. the. The leaves will curl upwards. Nymph Thrips sp. very mobile and often move to other parts of the plant (Revelation, 2014). The level of crop damage by Thrips sp. the treatment (control) was always higher, this was thought to be due to the easier laying of eggs by imago on the young leaves of the plant because in the control treatment (without Repellent plants) there was nothing that could resist the presence of Thrips sp. compared to the treatment of basil, marigold, and shallots which had the ability to resist the presence of Thrips sp. imago pests. so the damage is less.

The rejection effect occurs through volatile compounds (*volatiles*) from vegetable materials (vapor repellent) or through direct contact with contact repellent compounds. The mechanism of action of repellent compounds is through the chemoreception mechanism of insects. Chemoreception is a physiological process that occurs in certain cells, namely chemoreceptors as a result of contact with certain compounds. Chemoreceptors are generally focused on the antennae, mouth apparatus, and tarsi (Wigglesworth, 1972) in Arifiansyah (2012).

Regression model of the influence of *Thrips* sp. pest populations to the level of damage in chili (Figure 1) shows that the linear line is directly proportional to the pest population. This means that the level of damage will continue to increase along with the increasing population of *Thrips* sp. on plants.

From the results of the regression analysis (Figure 1), it can be seen that there is an influence of *Thrips* sp. pest populations on levels of damage in cayenne pepper plants. The regression equation obtained is Y = 1.418 + 0.6553 X. From this equation it means that the level of plant damage occurs when the population of Thrips sp. increases by 1, then the damage caused by *Thrips* sp. is 0.65 percent. Judging from the value of the coefficient of determination of 0.960, this indicates that the higher the population of *Thrips* sp. the intensity of the damage is increasing. This means that the higher the *Thrips* sp pest population the need for food ingredients also increases for growth and development. The size of the level of pest attack depends on the population level.

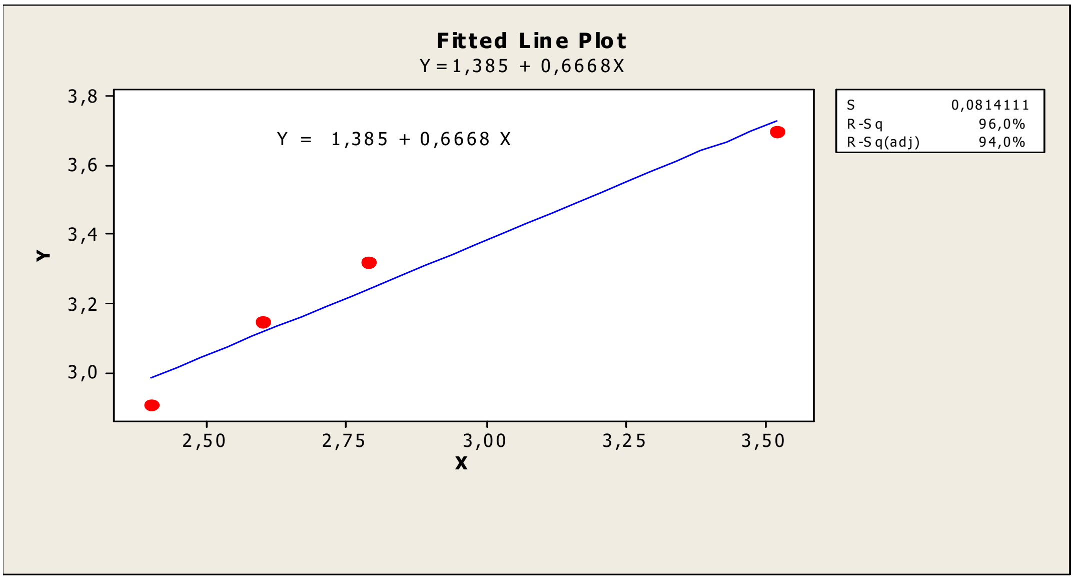

Figure 1. Regression of *Thrips* Pest Population and Damage Level of Chili Plants

4. CONCLUSION

The use of edge plants as repellents is effective in reducing damage to chili plants due to attacks by Thrips sp, in which basil is the most effective plant, but Marigold is another alternative that can be used as a repellent plant to control Thrips sp. pest populations on chili plants. Thus to reduce Thrips sp attacks on chili plants, these two plants can be recommended.

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