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Research Paper

# Effect of several types of insecticide on predator population and damage intensity due to soybean pest attack in South Sulawesi, Indonesia

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***Abstract.*** *Spodoptera litura* was one of the pests that caused soybean seed yield decrease in South Sulawesi. In order to challenge the pests, farmers still largely choose chemical insecticides. This research aimed to establish effectiveness level of several insecticide types that were frequently used by farmers. The design used was Randomized Block Design with 7 treatments (6 insecticide types and 1 control) with 3 replications. The insecticide types examined were: 1) acephate 75%, 2) thiamethoxam 200 g/L + chlorantraniliprole 100 g/L, 3) permethrin 200 g/L, 4) chlorpyrifos 550 g/L + cypermethrin 60 g/L, 5) deltamethrin 50 g/L, 6) profenofos 500 g/L, and 7) polyculture, soybean + corn (control). The result showed that insecticide type of thiamethoxam 200 g/L + chlorantraniliprole 100 g/L was the most effective insecticide to control *S. litura* with soybean leaves damage intensity (15.19%) and population of *Bemisia tabaci* whitefly (5.07 tails plant$^{-1}$). However, thiamethoxam 200 g/L + chlorantraniliprole 100 g/L mostly killed *Lycosa* sp. predator (0.63 tails plant$^{-1}$) and *Crocothemis servillia* (3.26 tails plant$^{-1}$). The highest predator population was found in multiple cropping of soybean and corn, *C. servillia* (3.94 tails plant$^{-1}$), and *Lycosa* sp. (3.26 tails plant$^{-1}$). The insecticide of chlorpyrifos 550 g/L + cypermethrin 60 g/L were effective to control soybean pod borer pest *Etiella zinckenella* (2.40%). Furthermore, insecticide of deltamethrin 50 g/L was effective to control *Aphis glycine*s pest (2.05 tails plant$^{-1}$). Several types of insecticides are effective in controlling *S. litura, N. viridula*, and *B. tabasi* pests, but these insecticides are also effective in killing predators. The highest predator population is soybean-corn intercropping.

**Keywords:** Soybean, insecticides, pests, intensity of damage, predators, seed yields.

## INTRODUCTION

Soybean is one of the most cultivated crops by farmers in South Sulawesi. Biotic and abiotic factors are one of the issues in increasing soybean productivity (Hartman *et al.,* 2011) Biotic factor is in form of pests and diseases with damage intensity around 15-35% (Food Plant Protection and Horticulture Center, 2019). In order to overcome damage due to pests attack and diseases, farmers are mostly (95.29%) to choose chemical insecticides (Agricultural Research and Development Agency, 2019). The reason is they assume that chemical insecticides are more effective, easy to use and to be found. Indonesian farmers' dependency in using chemical insecticides to control pests and plant diseases could be seen in the increasing use of chemical pesticides in 1998 in which 11,587.2 t became 17,977.2 t. Moreover, this pesticide was used since the initial plant growth until harvest time (Hasibuan, 2015). Similar things also occur in the region of Tempe Lake, Wajo District, South Sulawesi, where farmers use insecticide around 8-24 l ha$^{-1}$ per growing season to control soybean pests (Fattah *et al.*, 2018).

Each kind of insecticide has different killing power or toxicity. According to Sreelakshmi *et al*. (2017), toxicity of each insecticide to control pest armyworm (*S. litura*) depends on the formulation; lambda cyhalothrin 3.05 ppm, cypermetrin 1.98 ppm, and quinalphos 3.93 ppm. Incorrect use of pesticides can increase risks on food product, environment, and human health (Sumiati *et al*., 2019). According to Adriyani (2006) that excessive use of pesticides will have a negative impact on human health, the environment, water, soil, and air pollutions, damage to ecosystem balance, pests resistant, secondary pests and resurgence. The negative impacts of insecticide applications on human health when the insecticides used by farmers generate residues in plants or bioaccumulation and biomagnification through the food chain. More pest problems, secondary outbreaks, destruction of natural enemies such as parasitoids or predators and useful insects, residency and poisoning as a result of excessive and inadvertent use of pesticides (Siregar, 2015). Hendrival and Khalid (2017) stated that the higher value of species diversity in a habitat, then the balance of the community will also be higher. According to Gazzoni *et al.* (1999) stated that lambda cyhalothrin at 4.5 or 9 g a.i.ha$^{-1}$ reduces the number of predators (spiders) of soybean pests, while other tested insecticides only affect the predators number at the highest dose. Indoxacarb and spinosad results in close to 30% mortality to the predators, and are classified as slightly harmful, while the fungicides copper hydroxide causes 58% mortality and is rated as moderately harmful (Martinou *et al.,* 2013). According to Purwanta and Rauf (2000), all types of insecticides from the BPMC, prefenofos, and deltamethrin groups can kill and decrease the predator populations of the Atropods (spiders), especially the Linyphiidae, Salticidae, and Oxyopidae families.

Therefore, this research aims to establish effectiveness level on several insecticide types that are used by soybean farmers to control armyworm pests (*S. litura*) and its effect on predators in the farming region around Tempe Lake, Wajo District, South Sulawesi.

## MATERIALS AND METHODS

Research of effectiveness level of several insecticide types in controlling soybean *(Glycine max* (L.) Merril) pests and diseases was conducted in Tancung Village, Tanasitolo Sub-district, Wajo District since July until December 2019. This research used Randomized Block Design with 7 treatments (6 insecticides and 1 control) and 3 replications. The insecticide types examined were: 1) acephate 75%, 2) thiamethoxam 200 g/L + chlorantraniliprole 100 g/L, 3) permethrin 200 g/L, 4) chlorpyrifos 550 g/L + cypermethrin 60 g/L, 5) deltamethrin 50 g/L, 6) profenofos 500 g/L, and 7) polyculture, soybean+corn (control). This research was performed in farmers's monoculture and intercropping (soybean-corn) vegetated land by involving 7 farmers and each farmer did one type of treatments (insecticides). The data were collected in 2 m × 3 m plot (6 m$^2$) diagonallywith 15 samples per plot.

The parameters examined were; damage intensity of pests and diseases (%), predator populations, and soybean seeds yield (tha$^{-1}$).

Leaf damage intensity is calculated based on the following formula (Rahardjo and Suhardi (2008):

$$\mathrm{I} = \frac{\sum_{i=0}^{x}(n_1\, x\, v_1)}{\mathrm{Z\,X\,N}} \times 100\%$$

$\mathrm{I}$ = Attack intensity
$\mathrm{n_1}$ = Number of leaves of soybean observed at $\mathrm{v_1}$
$\mathrm{v_1}$ = The value of leaf damage at the i leaf
$\mathrm{N}$ = Number of leaves observed
Z = The highest scale value to leaf damage

### Statistical analysis

All observed data were analyzed using Statistical Analysis System (SAS Software). The comparison of mean leaf damage intensity caused by *S. litura* and other parameters was made using the Duncan test at a 5% probability level.

## RESULTS AND DISCUSSION

The lowest attack intensity of armyworm S.litura on soybean after chemical insecticides applied was found in insecticide type of thiamethoxam 200 g/L + chlorantraniliprole 100 g/L, and then followed by insecticide type of deltamethrin 50 g/L, until the highest attack intensity was in the usage of profenofos (26.11%). The low *S. litura* attack intensity which had been sprayed by thiamethoxam 200 g/L + chlorantraniliprole 100 g/L was influenced by high effectiveness of this insecticide's active ingredient and synergism level of those two active ingredients. According to Sahputra (2013) that mixing the two active ingredients of the insecticide emamectin benzoate and beta-cypermethrin can result in 94% of Setothosea asigna caterpillar death with a low concentration of 0.099 ppm, while without mixing only emamectin benzoate insecticide with a high concentration of 1.26 ppm pest death only 92%. Moreover, insecticide of deltamethrin 50 g/L gave the second lowest intensity of damage to soybean leaves due to *S. litura* (17.26%). The low leaves damage intensity after such insecticide applications presumably because the toxicity level of the insecticides. Besides that, other factors also take place such as concentration of active ingredients and its designation or usage of each insecticide types. Based on the data from Directorate Fertilizer and Pesticide about name of formulation, active ingredient, pesticide types, and usage, deltamethrin is indeed for controlling *S. litura* (Directorate General of Fertilizer and Pesticide, 2012). Meanwhile, permethrin

**Table 1.** Leaves damage intensity due to *S. litura* and the population of *A. glycines.*

| Type of chemical insecticide | The intensity of leaf damage of *S. litura* (%) | The population of *A. glycines* (tails plant$^{-1}$) |
|---|---|---|
| Acephate 75% | 23.40$^{d}$ | 3.72$^{b}$ |
| Thiamethoxam 200 g/L + chlorantraniliprole 100 g/L | 15.19$^{a}$ | 2.09$^{a}$ |
| Permethrin 200 g/L | 23.20$^{d}$ | 4.25$^{b}$ |
| Chlorpyrifos 550g/L + cypermethrin 60 g/L | 20.37$^{c}$ | 4.07$^{bc}$ |
| Deltamethrin 50 g/L | 17.26$^{b}$ | 2.05$^{a}$ |
| Profenofos 500 g/L | 26.11$^{e}$ | 4.89$^{c}$ |
| Polyculture, soybean+ corn (control) | 18.23$^{b}$ | 4.05$^{b}$ |

The column number (followed by the similar letter) has no significant difference at 5% Duncan Test.

200 g/L was for controlling leaves pest *Myzuz persicae*, *Aphis gossypii* and thrips pest (*Thrips* sp). Nonetheless, farmers use such insecticide to control *S. litura*, permethrin 200 g/L usage to control *S. litura* on soybean still causes high leaves damage intensity, 23.20%, even after insecticide application. The highest *S. litura* attack symptom was observed on profenofos 500 g/L (26.10%) and the second lowest was on deltamethrin. According to Tong *et al*. (2013) that *S. litura* is resistant to chlorpyrifos and profenofos but vulnerable to deltamethrin. (Table 1)

The interesting thing in this research is *S. litura* attack level on soybean + corn polyculture included as the lowest attack of 18.23% after insecticide thiamethoxam 200 g/l + chlorantraniliprole 100 g/L. However, without chemical insecticide on soybean + corn polyculture, leaves damage intensity due to *S. liture* attack still lower than application of insecticide chlorpyrifos 550 g/l + cypermethrin 60 g/L (20.37%), profenofos 500 g/L (26.11%), and deltamethrin 50 g/L (23.20%). This low leaves damage intensity of *S. litura* attack on soybean + corn polyculture is caused by the role of natural enemy that can suppress pest populations. According Hanum *et al*. (2013) that type of predator found in such polyculture is dragonfly. Dragonfly eats larva and *S. litura* egg family. Dragonfly types found mostly are *Crocothemis servillia* which has red or yellow color. Then, followed by dragonfly type of *Orthetrum sabina* which has black leg and wings. According to Rizal and Mochamad, (2015) that dragonfly as predator is capable to prey on various pests in various phases including egg and larva phases of *S. litura*. (Table 2)

The lowest pod damage intensity (2.71%) due to *N. viridula* attack is found in the use of insecticide thiamethoxam 200 g/L + chlorantraniliprole 100 g/L and the highest found in the use of insecticide profenofos (5.36%) as well as chlorpyrifos 550 g/L + cypermethrin 60 g/L (5.80%). The high attack intensity of *N. viridula* on soybean pod is caused by resistant symptom of *S. litura* towards the insecticides that too frequently used by farmers. According to Baeki *et al.* (2016), resistance of a pest towards a type of insecticide is through three ways. The first one is metabolic resistance where insect detoxifies or break toxin faster than vulnerable insect or such insect can avoid toxic molecule. The second way is through penetration resistance where resistant insect performance in absorbing toxin is slower than vulnerable insect. Penetration resistance occurs when outside cuticule of insect develops barrier which capable to slowdown chemical absorption to insect body. Furthermore, the third way is through behavior resistance where insect is able to detect and recognize danger then avoid insecticide toxin. Such insect can move from sprayed place or it stops eating if spraying conducted in the occupied plant.

The lowest pod borer pest attack intensity was found in treatment with the insecticide chlorpyrifos 550 g/L + cypermethrin 60 g/L (2.40%), whereas the highest was found in acephate 75% (4.67%) treatment. These results are in line with Siburian *et al.* (2013), in which the lowest pod borer pest attack intensity (6.95%) is due to the chlorpyrifos insecticide usage. Pod borer pest attack intensity on the application of insecticide permethrin (4.33%) and deltamethrin (3.92%) is not significantly different with none insecticide application (soybean+corn polyculture) (3.84%). This result is in accordance with Indiati (2007) that deltamethrin application to control pod borer pest has higher attack intensity (14.58%) than by using lambda cyhalothrin insecticide (6.04%). (Table 3)

The highest population of *Lycosa* sp*.* predator on soybean plant is found in soybean + corn polyculture

**Table 2.** The population of *C. servillia* and the intensity of pod damage of *Nezara viridula.*

| Type of chemical insecticide | The population of *C. servillia* (tails per 6 $m^2$) | Intensity of pod damage of *Nezara viridula* (%) |
|---|---|---|
| Acephate 75% | $2.06^{b}$ | $3.53^{b}$ |
| Thiamethoxam 200 g/L + chlorantraniliprole 100 g/L | $1.52^{a}$ | $2.71^{a}$ |
| Permethrin 200 g/L | $1.95^{b}$ | $3.95^{bc}$ |
| Chlorpyrifos 550 g/L + cypermethrin 60 g/L | $2.79^{c}$ | $5.80^{e}$ |
| Deltamethrin 50 g/L | $1.84^{b}$ | $4.62^{d}$ |
| Profenofos 500 g/L | $2.01^{b}$ | $5.36^{e}$ |
| Polyculture, soybean+ corn (control) | $3.94^{c}$ | $4.34^{cd}$ |

The column number (followed by the similar letter) has no significant difference at 5% Duncan Test

**Table 3.** Attack intensity of pod borer, pod sucker, and natural enemy population.

| Type of chemical insecticide | Intensity of pod damage of *Etiella zinckenella* (%) | The population of *Lycosa* sp. (tails per 6 $m^2$) |
|---|---|---|
| Acephate 75% | $4.67^{d}$ | $1.41^{bc}$ |
| Thiamethoxam 200 g/L + chlorantraniliprole 100 g/L | $3.55^{b}$ | 0.63a |
| Permethrin 200 g/L | $4.33^{cd}$ | $1.55^{c}$ |
| Chlorpyrifos 550 g/l + cypermethrin 60 g/L | $2.40^{a}$ | $1.53^{c}$ |
| Deltamethrin 50 g/L | $3.92^{bc}$ | $1.08^{b}$ |
| Profenofos 500 g/L | $4.77^{d}$ | $1.43^{bc}$ |
| Polyculture, soybean + corn (control) | $3.84^{bc}$ | $3.26^{d}$ |

The column number (followed by the similar letter) has no significant difference at 5% Duncan Test.

(3.26 tails per 6 $m^{-2}$) and significantly different with the population of predators on soybean monoculture after it is sprayed by chemical insecticide (Table 3). According to Koswanudin and Zulchi (2015), the population of *Lycosa* sp. on soybean plant is around 4.30 to 10.80 tails per 12 $m^{-2}$ without insecticide application. The population of *Lycosa* sp. *was* 3.26 tails per 6 $m^{-2}$ or 6.52 tails per 12 $m^{-2}$ is capable to decrease pest population so that damage due to such pest can be decreased. Spiders can play a role as natural enemy of pest in almost all agriculture ecosystems, although they cannot counterbalance the increase in prey density (Koswanudin and Zulchi, 2015). However, the spider has several strengths, such as spreading very well, being able to colonize the seasonal agriculture ecosystem earlier, eating prey both on the land surface and at the head of the plant, and eating prey both at noon and at night (Maesyaroh, 2012).

The lowest population of *B. tabasi* whitefly after insecticide application found in thiamethoxam 200 g/L + chlorantraniliprole 100 g/L (5.07 tails $plant^{-1}$), then followed by acephate 75% (6.12 tails $plant^{-1}$), and the highest found in chlorpyrifos 550 g/L + cypermethrin 60 g/L (8.43 tails $plant^{-1}$). According Inayati and Marwoto (2011) that the lowest population of whitefly after sprayed

**Table 4.** Intensity of whitefly attack and soybean seed yield.

| Type of chemical insecticide | The population of *Bemisia tabasi* (tails plant$^{-1}$) | The intensity of leaf damage of soybean mosaic virus (%) | Seed yield (t ha$^{-1}$) |
|---|---|---|---|
| Acephate 75% | 6.12b | 2.48b | 2.46b |
| Thiamethoxam 200 g/L + chlorantraniliprole 100 g/L | 5.07a | 1.75a | 3.19a |
| Permethrin 200 g/L | 7.81 cd | 3.53e | 2.69b |
| Chlorpyrifos 550 g/L + cypermethrin 60 g/L | 8.43 d | 3.62e | 2.59b |
| Deltamethrin 50 g/L | 7.65 c | 2.85bc | 2.76b |
| Profenofos 500 g/L | 7.77 cd | 3.38 de | 2.34b |
| Polyculture, soybean+ corn (control) | 7.09 c | 2.96 cd | 2.44b |

The column number (followed by the similar letter) has no significant difference at 5% Duncan Test.

with insecticide was in the application of thiamethoxam 25%, 1 g/L (128 tails plant$^{-1}$), thiamethoxam + lambda cyhalothrin 106 g/L (133.7 tails plant$^{-1}$), and acephate 75% (133.0 tails plant$^{-1}$). Meanwhile the highest population is in the use of neem powder (170.00 tails plant$^{-1}$) and without insecticide (174.83 tails plant$^{-1}$).

The most interesting thing is population of whitefly on multi cropping of soybean and corn which is lower (7.09 tails plant$^{-1}$) than the use of insecticide chlorpyrifos 550 g/L, cypermethrin 60 g/L (8.43 tails plant$^{-1}$) and profenofos 500 g/L (7.77 tails plant $^{-1}$). The low population of whitefly *B. tabasi* on multi cropping of soybean+corn is caused by the corn plant as a barrier for *B. tabasi* movement (Inayati and Marwoto, 2011). Furthermore, corn plant can be where predator lives such as for family Anthocoridae, Coccinelidae, Chrysopidae, Hemerobidae, Macrolopus, and Dicyphus to control *B. tabasi* (Inayati and Marwoto, 2011). Meanwhile Wijayanto *et al*. (2017) that suggests that predator *Coccinella* sp is more found (30 tails) on plants that are attacked by *B. tabasi* than attacked by *Tetragnatha* sp (17 tails) and *Oxyopes* sp (21 tails). (Table 4)

Mosaic virus symptoms on soybean is transmitted by the vector *A. glycines*. Besides infected virus, soybean aphis also absorbs plant liquid so that the plant becomes dry. In order to control the aphis, farmers largely choose insecticides (Indiati and Marwoto, 2017). The most effective insecticide to control aphis as virus vector is thiamethoxam 200 g/L + chlorantraniliprole 100 g/L so that mosaic virus symptoms on soybean becomes low (1.75%) rather than the use of insecticide deltamethrin (3.53%) and chlorpyrifos 550 g/L + cypermethrin 60 g/L (3.62%). The symptoms of transmitted virus by aphis on soybean+corn polyculture (without insecticide) (2.96%) almost as the same as those with insecticide deltamethrin 50 g/L (2.85%) also lower than permethrin 200 g/L (3.53%) and chlorpyrifos 550 g/L + cypermethrin 60 g/L (3.62%). It is assumed to happen because of predator *Coccinella* sp. on policulture soybean+corn multi cropping to decrease *A. glycines* population, so that the attack symptom is lower. According to Timon *et al.* (2011) that *Coccinella* sp. is the dominant predator and has very important role in decreasing *A. glycines* population in North America.

The highest seed yield by farmers generated by using insecticide thiamethoxam 200 g/L+ chlorantraniliprole 100 g/L (3.19 t ha$^{-1}$). Meanwhile, other insecticides usages are not significantly different with control (soybean+corn polyculture). It is indicated that polyculture cultivation model is effective in controlling pests and plant diseases. The polyculture cultivation model is more sustainable than monoculture since it gives predators chance to stabilize ecosystem.

## CONCLUSION

The type of insecticide of thiamethoxam 200 g/L + chlorantraniliprole 100 g/L is effective in controlling *S. litura, N. viridula, and B. tabasi* on soybean. However, this type of insecticide is also effective in killing *Lycosa* sp and *C. servillia* predators. Meanwhile, insecticide Chlorpyrifos 550 g/l+cypermethrin 60 g/L is effective in controlling pod barrier pest *E. zinckenella* on soybean. Furthermore, insecticide deltamethrin 50 g/L is effective in controlling *A. glycines* pest. The highest population of predator *Lycosa* sp. and *C. servillia* is found in polyculture system of soybean + corn.

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