Soybean pest control in tidal swamp, South Kalimantan

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Abstract. Pest is one of the problems in soybean development area on tidal swamp. Every year, pest attacks cause 15-20% soybean production lost. The study was conducted within oil palm plants, on tidal swamp, Barito Kuala, Southern Kalimantan, in the dry season of 2016. The research was arranged in a randomized block design each treatment was replicated 6 times nested within treatment. Treatment consists of: 1. Untreated plot, 2. Bioinsecticides (Mixed SBM 50 g/l + S/NPV 2 g/l) based on monitoring (4x), 3. Bioinsecticides (Mixed SBM 50 g/l + S/NPV 2 g/l) weekly (6x), 4. Chemical insecticides based on monitoring (4x). The results showed that the pests found were Spodoptera litura, Plutia calisites, Lamprosema indicata, Riptortus linearis, Nezara viridula and Etella zinckenella. All of them with low population numbers. But at 65 days after planting (DAP), population of S. litura was very high and caused plant damage up to 80%. Monitoring based bioinsecticides and weekly bioinsecticides application effectively suppressed low population and plant damage than chemical treatment based on monitoring. Soybean productivity achieved were 1.623 t/ha; 1.8 t/ha and 1.725 t/ha by monitoring based bioinsecticides, weekly bioinsecticides and chemical control based on monitoring respectively.

Key words: Control, soybean pest, tidal swamp, South Kalimantan

1. Introduction
Soybean (Glycine max L.) is the most important food crop beside rice and corn. It is also a major source of protein and vegetable oil. It is generally used as a raw material for food products such as tofu and tempeh. Soybean consumption by Indonesian people is increasing annually. In 1987-2015 period, the increase in soybean deficit reached an average of 9.20% per year. The increase in national soybean needs is not accompanied by an increase in domestic soybean production, so that, the dependence on imported products increases rapidly [1]. Therefore, it is necessary to increase national production, including through soybean development on tidal swamp.

Tidal swamp type C and D are one type of land with great potential for soybean farming development in Indonesia. The suitable tidal swamp area of approximately 10 million hectares spreading across the islands of Sumatra and Kalimantan are needed for the development of food crops [2]. Soybean cultivation in Indonesia faces major problems, including: an increase in soybean imports by an average of 52.29% per year in last five years, low productivity at farm level (1.506 t/ha), inappropriate management techniques of land, water, and crops, as well as high attack rate of plant pests[1, 3-6]. One obstacle to develop soybeans on tidal swamp is damage caused by insect pests.
In Indonesia, some harmful pests on soybean are leaf eaters, *L. indica* (*F.*); *S. litura* (*F.*) caterpillar, *P. calpites* (*L.*), pod sucker *R. linealis*, *N. viridula*, *P. hybneri*; and pod borer *E. zinckenella* [7-8]. These pests cause significant damage on plant parts including soybean leaves and pods, as well as causing yield decrease up to 25% [9]. According to Rustam [4], 15-20 percent of soybean production is lost directly or indirectly by pest attacks each year.

Norris [10] state that pest attacks have an impact on reducing the quantity and quality of crop yields such as physical damage, chemical poisons, disease vectors, increase of production costs, social and environmental costs, as well as consumer rejection. Therefore, effective and environmentally friendly pest control needs to be investigated.

Indonesian Legumes and Tuber Crops Research Institute (ILETRI) has obtained and used *Spodopterapitula* Nuclear Polyhedrosis Virus (SNPV) bioinsecticide formulation which is effective for controlling armyworm [11]. SNPV is a pathogenic virus that is specific, selective, and effective for controlling armyworms that have been resistant to insecticides and are safe for the environment. SNPV has been developed in vivo in the ILETRI laboratory to control Lepidoptera pests. SNPV engineering with kaolin carriers can maintain the virulence of SNPV, so that it can reduce the intensity of armyworm attack on soybean plants in the field up to 90% [12]. Arifin [3] reports that SNPV produced as bioinsecticides in vivo can be used in the Integrated Pest Management (IPM) program with three strategies, namely: (1) seeking the epizootic SNPV in plantations through vertical transmission from infected female insects to their offspring and transmission horizontally among individual insects of the same generation; (2) investing the armyworm for the purpose of conservation of the SNPV inoculum in plants that had epizootic in the previous season; and (3) repeatedly applying SNPV for short-term purposes because there is no horizontal transmission.

Another effective component of controlling grayak caterpillars is neem seed powder (*Azadirachta indica* A. Juss). The active compound of neem seed powder (SBM) does not kill pests insects quickly, but it affects the feeding capacity of insects, growth, reproductive ability, moulting process, decreasing egg fertility, disrupting insect copulation and sexual communication, and blocking the juvenile hormone (chitin-forming). This compound also acts as a sterile substance [13]. Gupta and Birah [14] report that neem seed powder contains growth inhibitors and feeding deterrent/antifeedant compounds. *H. armigera* feed treated with neem causes high larval mortality, stunted larval growth and development, decreased larval and pupa weight, and prolongs the larval stage [15-16]; Indiati [8] reported that the population of *S. litura* and *B. tabaci* were higher in soybean plants by chemical insecticide treatment than varieties treated with 50 g/1 water.

This study aimed to obtain an environmentally friendly soybean pest control by using a mixture of SBM and SLNPV in the tidal swamp, south Kalimantan.

2. Materials and Methods

The research was conducted among oil palm of tidal swamp, in Sidomulyo Village, Wanaraya Subdistrict, Barito Kuala, South Kalimantan, in the dry season of 2016. The materials used in this study were Anjasmoro variety soybean seeds, Spodopterapitula Nuclear Polyhedrosis Virus (SNPV), alkyl aryl alkoxyate adhesives, chemical insecticide lamdacythotrin and deltamethrin, Urea fertilizer, SP36 and KCl. Anjasmoro soybean seeds were obtained from the ILETRI Source Seed Procurement Unit in Malang. SBM is obtained from the Plant Fiber Institute and Sweetener (BALITAS), SBM is made by mashing or grinding 50 g of neem seeds and then dissolving it in 1 l of water (w/v). The mixture of ingredients is then filtered, added 0.5 ml/l alkyl aryl alkoxyate adhesive, stirred and ready to be applied. SNPV is reproduced in the ILETRI Entomology Laboratory, alkyl aryl alkoxyate adhesives, chemical insecticide sipermetrin, lamdasalotrin and deltamethrin, as well as Urea, SP36 and KCl fertilizers purchased from agricultural kiosks in Malang.

The design used was a randomized block design with four treatments and repeated 6 times nested within treatments. Area of treatment plot was 5 m x 100 m/treatment, with a spacing of 40 cm x 15 cm, 2 plants per hole, variety used was Anjasmoro. Fertilizing: 50 kg/ha Urea + 50 kg/ha SP36 + 50 kg/ha KCl given in of the row during planting, while weeding was performed twice at the age of 21 and 35
days after planting (DAP). Then irrigation was adjusted to the needs of plants. The treatments were: 1. untreated plot, 2. bioinsecticides (mixed SBM 50 g/l + SINPV 2 g/l) based on monitoring (4 times at 21, 35, 49, and 63 DAP), 3. bioinsecticides (mixed SBM 50 g/l + SINPV 2 g/l) weekly (6 times at 21, 28, 35, 42, 49, and 63 DAP), 4. Chemical insecticide based on monitoring (4 times at 21, 35, 49, and 63 DAP). Chemical insecticide spraying treatment for leaf-eating caterpillars was carried out at 21, 35DAP using lambda cyhalothrin 2ml/l. At 49, and 63 DAP sprayed deltamethrin 2ml/l to control pod borer and pod sucker [17].

Observation were conducted on 1) intensity of bean fly attack at 21 DAP, 2) types and population densities of insect at 42 DAP; types and population densities of natural enemies at 42 DAP, 4) population S. litura at 65 DAP, 5), intensity of leaf eating caterpillars at 65 DAP, 6) intensity of pod borer and pod sucker attacks at harvest time,7) grain yields at harvest. The intensity of leaf eating caterpillars was observed in 5 plant samples taken diagonally, using the score method 1-5, and calculated using the formula:

\[ I = \sum \frac{n x v}{N x V} \times 100 \% \]

I = intensity of attacks  
N = total number of leaves  
V = highest score (in this case 5)  
n = number of leaves in each score category  
v = score category

The categories of leaf pest attack scores are [18]:

- 0 = healthy leaves  
- 1 = leaves attacked by 1-20\%  
- 2 = leaves attacked by 21-40\%  
- 3 = leaves attacked 41-60\%  
- 4 = leaves attacked 61-80\%  
- 5 = leaves attacked by 81-100\%

2.1. Data analysis
The data obtained was analyzed using F test at 5% level. Further, to determine the differences among treatments, the smallest significant difference test (LSD) with a significant level of 95% was used.

3. Results
3.1 Population density of pest
During the vegetative phase, many insects were found in soybean plants and they ate leaves and caused damage to soybean plants. These insects included bean fly, grasshoppers, soybean looper, armyworm, leaf rollers caterpillars, and soybean leaf beetles. It’s common for several defoliators to be present at the same time. Bean flies Ophiomyia phaseoli present in soybean plantations since seedling plants in the dry season. The larvae cause damage, mostly on seedlings in the first 1-2 weeks after emergence. The wilting of young plants showed symptoms of attack then become dry and die. Plant death occurred until the plant was around one month old. The observations showed that the intensity of bean fly attack at 3 weeks after planting (WAP) was relatively very low, at less than 4% (Table 1). Damage to plants due to attack between treatments tested was not significantly different.
Table 1. Attack rate of bean fly on soybean aged 3 WAP. Sidomulyo village, Wanaraya Subdistrict, Barito Kuala District, South Kalimantan, 2016

| No. | Treatment                                      | Attack rate (%) |
|-----|------------------------------------------------|-----------------|
| 1.  | Untreated plot                                 | 2.8 a           |
| 2.  | Bioinsecticides based on monitoring            | 2.6 a           |
| 3.  | Weekly bioinsecticides                         | 3.0 a           |
| 4.  | Chemical insecticides based on monitoring      | 3.2 a           |

*Note: Alignments followed by the same letter are not significantly different in the LSD Test with a real level of 95%.

At 45 DAP, we found several pest species in soybean plants including: Soybean looper, Plusia calsites, Helicoverpa armigera, Spodoptera litura, and Lamprosema indicata. All of them with low population numbers. The effect of various treatments on pest population is shown in Figure 1. In all treatments, the population density of soybean looper, H. armigera, S. litura and L. indicata each only reached 3 larvae/5 m², 2 larvae/5 m², 5 larvae /5 m² and 3 larvae/5 m². The population density of soybean looper, H. armigera, S. litura and L. indicata did not show any significant difference between the treatments tested. Besides the pests above, insect nets also successfully captured several pests including Empoasca sp., white fly, grasshopper, leaf beetle, Riptortus linearis, and Nezara viridula. The average pest density was less than 10 insects/5 swings (Figure 2). The population density of Empoasca sp., white fly, grasshopper, leaf beetle, R. linearis, and N. viridula did not show significant differences between the treatments tested.

Figure 1. The population density of soybean looper, H. armigera, S. litura and L. indicata in various control treatments, Sidomulyo village, Wanaraya Subdistrict, Barito Kuala District, South Kalimantan, 2016.

Figure 2. The population density of Empoasca sp., white fly, grasshopper, leaf beetle, R. linearis, and N. viridula in various control treatments. Sidomulyo village, Wanaraya Subdistrict, Barito Kuala District, South Kalimantan, 2016.

The effect of various treatments on S. litura population at 65 DAP were shown in Figure 3. At that time, the population was very high reaching 31 larvae / 35 m² and causing crop damage up to 80% in chemical treatment by monitoring (Figure 4). Population and crop damage on bioinsecticide treatment by monitoring and weekly were lower than chemical treatment by monitoring. Based on statistical analysis, crop damage on bioinsecticide treatment by monitoring and weekly were significantly different from chemical treatments by monitoring.
During the generative phase, pod borer *E. zinckenella* and brown stink bug *R. linearis* had been found in soybean plants. They attacked pods and soybean seeds, and generally the intensity of attacks on pods was higher than on seeds. Pod sucking bugs cause economic damage as a result of a decreased ability for seeds to grow; a decrease in seed quality and yield; a decline in seed vigour because of tissue damage due to puncture of the seed; as well as a delay in the maturing of the plant [19]. Attacks by pod borer ranged from 5-12% and 4-8% respectively in pods and seeds (Table 2). Damaged pods intensity was lowest on bioinsecticides treatment based on monitoring and weekly, and significantly different from untreated plot, but not significantly different from chemical treatment based on monitoring. Pod borer attack on soybean seeds is also low and significantly different from without treatment and chemical treatment based on monitoring. This data shows that SBM and S/NPV bioinsecticides are also effective in suppressing pod borer attacks from the Lepidoptera order better than synthetic insecticides. Besides pod borer, pods and soybean seeds were also attacked by brown stink bug. That pest caused damage to pods and seeds respectively around 11-17% and 5-11%. Among the treatments tested did not show significant differences (Table 2).

### Table 2. Severity of soybean pod borer and pod sucker attack rate before harvest. Sidomulyo village, Wanaraya Subdistrict, Batola, South Kalimantan. Dry Season of 2016

| Treatment                   | Pod borer attack on | Pod sucking bug attack on |
|-----------------------------|---------------------|---------------------------|
|                             | Pod (%)             | Seed (%)                  | Pod (%) | Seed (%) |
| Untreated plot              | 11.2 a              | 7.8 a                     | 17.4 a   | 11.3 a   |
| Monitoring Bioinsec (4x spraying) | 5.9 b              | 4.6 bc                    | 11.8 a   | 6.0 a    |
| Weekly Bioinsec (6x spraying) | 5.6 b              | 4.0 c                     | 11.2 a   | 5.5 a    |
| Monitoring Chemical         | 10.1 ab             | 7.4 ab                    | 12.7 a   | 7.6 a    |
| LSD 5%                      | 4.9                 | 3.2                       | 19.5     | 13.9     |

*Note: Alignments followed by the same letter are not significantly different in the LSD Test with a real level of 95%.*

### 3.2 Population density of Natural Enemies
Natural enemies found in the vegetative soybean phase were predators of the cluster of spider, hymenoptera, Coccinella, and parasites of the Tachinidae family. The natural enemy population in the
field is relatively low (<10 insects/5 swings). Among the predators found, the hymenoptera population is highest and ranges from 3-5/ five net swings. While the population of spiders, Coccinella, and Tachinidae, each less than 4 insects / 5 swings (Figure 5). The population densities of natural enemies found in soybean plantations were not significantly different between untreated plot and the other treatments.

Figure 5. The population density of spider, hymenoptera predator, Coccinella, and Tachinidae in various control treatments. Sidomulyo village, Wanaraya Subdistrict, Barito Kuala District, South Kalimantan, 2016.

Soybean plants produce grain yield ranging from 1.5-1.8 t / ha, the highest yield is obtained from weekly bioinsecticide treatments and it was not significantly different from chemical treatments based on monitoring. The lowest crop yield was achieved by untreated plot/check (Figure 6). Low seed yields in untreated plots may be caused by high crop damage due to armyworm attacks. Crop damage in untreated plots reached > 40%, exceeding the control threshold. According to Arifin, the leaf attack intensity less than 30% in the vegetative phase will not affect soybean yield. But if the intensity of leaf attack is more than 30% in the vegetative phase, it will affect the yield of soybean plants. In reproductive soybeans stage, treatment is recommended if defoliation levels exceed 20% and insects are present. But in vegetative stage, treatment is recommended if defoliation levels exceed 30% [20].

Figure 6. Anjasmoro soybean dry weight in various control treatments. Sidomulyo village, Wanaraya Subdistrict, Barito Kuala District, South Kalimantan, 2016.

4. Discussion
In all treatments the bean fly attack was very low, allegedly because the bean fly population at the location was also low, so it did not cause significant damage to soybean plants. Besides bean fly, some pests include P. celsites, L. indicata, R. linearis, N. viridula and E. zinckenella are found with a low population density, except S. litura which has a high population density. As stated by Verkerk [21], the low population of bean flies was due to the absence of host plants, high natural enemy populations and unfavourable ecosystems to bean flies [22]. Some experts also argue that the composition of pest species in an area is highly dependent on the type of vegetation, the age of the plant, the time at the time of observation, how to control pests, and the history of cropping patterns in the area concerned [23-25]. Matsubayashi [26] reported that the specificity of the host as a food source is one of the most important factors explaining insect diversity. According to Schowalter [27], most pests have several host plant species in one family as a potential food source, but less than 10% of species pests have more than three plant species families as potential hosts. Based on the survey data, the composition of
soybean pests found in South Kalimantan Province was B. tabaci (39.7%), Empoasca sp. (15.1%), O. phaseoli (0.6%), S. litura (7.1%), Attractomorpha sp. (7.7%), Piezodorus. hybneri (9.2%), R. linearis (6.2%), N. viridula (4.8%) and E. zinckenella (0.2%), with a Shannon-Wiener (H) diversity index 1.655 and Simpson dominance index (c) 0.214. The value of H = 1.655 and c = 0.214 shows that species diversity in South Kalimantan is moderately abundant, and no pest species dominate 28. Among these pests, S. litura, pod sucker (P. hybneri, R. linearis, N. viridula) and pod borer E. Zinckenella are pests that have important status in all soybean fields in South Kalimantan [28].

Armyworm, S. litura is one of the most damaging pests in the South Kalimantan Region and causes losses to soybean plants, especially if the intensity of leaf damage reaches more than 30% [28]. The host plant includes 27 plant species consisting of 25 genera and 14 families, which include cultivated plants, vegetables, weeds, fruits and ornamental plants [29]. S. litura is a major soybean pest [30]. Soybean plants are able to compensate for leaf loss, if an attack occurs before flowering. However, pests with high populations will cause severe defoliation and inhibit plant growth. The occurrence of high S. litura attacks on soybean is strongly influenced by the presence of grasses around soybean fields [31]. In addition to damaging the leaves, S. litura larvae can also damage young pods. In endemic areas, this pest causes defoliation of up to 100%, which is one of the obstacles in realizing the potential yield of soybeans [32]. The data shown in Figure 1 reveals that armyworm population and crop damage in both monitoring and weekly bioinsecticide treatments is lower than chemical treatment monitoring. This fact proves that bioinsecticides consisting of SBM and S/NPV are effective in suppressing the population and severity of soybean armyworm attacks in tidal swamp. SBM contains secondary metabolites, namely azadirachtin, salalin, meliantriol, nimbin and nimbidin. These active compounds do not kill pests quickly, but affects growth, development, behaviour, reproduction, and metamorphosis in diverse insect taxa. Azadirachtin acts as a substance that can inhibit the action of the hormone ecdysone. Salalin acts as an antifeedant. Meliantriol acts as a repellent 14. Nimbin and nimbidin act as anti-microorganisms such as anti-virus, anti-bacterial, and anti-fungi. Nimbin and nimbidin are very useful for controlling plant diseases [33]. Furthermore, S/NPV would kill the larvae after the larvae ate part of plants that had been exposed to the S/NPV virus [34]. The data shown in Figure 1 also reveals that armyworm population and crop damage in chemical treatment base on monitoring were height than bioinsecticide based on monitoring and weekly bioinsecticide. This fact shows that in synthetic chemical treatment it is suspected that armyworms have been resistant to synthetic insecticides, or plants that are sprayed with insecticides have better vigour so that they attract armyworms as feed.

5. Conclusions
Based on research data, S. litura is the main pest in soybean plants in South Kalimantan Province, therefore its emergence must be anticipated. Pest monitoring at least once a week during the vegetative phase and early in the reproductive phase needs to be done, to decide on appropriate and accurate control measures. Control of leaf defoliator can be done with bioinsecticides made from S/NPV entomopathogenic virus. Spraying with bioinsecticides (mixed SBM 50 g / l + S/NPV 2 g / l) based on monitoring and bioinsecticides (mixed SBM 50 g / l + S/NPV 2 g / l) weekly, effectively suppressing leaf defoliator populations and crop damage were lower than chemical treatment based on monitoring.

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