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VALIDATION OF TECHNOLOGY COMPONENTS FOR PEANUT POD BORER (*Etiella zinckenella* Triet.) CONTROL

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ABSTRACT

Validation of technology components for peanut pod borer* (Etiella zinckenella *Triet.*) *control. Peanut pod borer caused by *Etiella zinckenella* is one of the important pests of peanut in Indonesia. The symptoms of *E. zinckenella* attack are blackened pods and rotten seeds, causing yield loss up to 90%. The research aim was to validate the efficacy of various control technology components of peanut pod borer pests. The research was arranged using a randomized complete block design (RCBD), the treatment consisted of six control technology components and treatment was repeated four times. The results showed that the more larvae found in the pods, the greater the damage of the pods are crushed by larvae. Application of lambda cyhalothrin insecticide (P6) starting at 35–70 days after planting (DAP) was not able to suppress larval populations of *E. zinckenella* so that damaged pods were also larger and not significantly different from control (P0). Lambda cyhalothrin insecticide application also harms the survival of natural enemies (predators and parasitoids). Lambda-cyhalothrin insecticides can be combined with other control components such as soybean trap plants, thiamethoxam and carbofuran and parasitoid *Trichogramma bactrae-bactrae)* to control of peanut pod borer. Application of *Lecanicillium lecanii* biopesticide that combined with chemical insecticides thiamethoxam or carbofuran can suppress *E. zinckenella* larvae and yield loses, beside it can safety against the survival of predators (Araneida and Coleoptera) and parasitoid (Hymenoptera and Diptera). Biopesticides of *L. lecanii* were combined with thiamethoxam or carbofuran insecticides can be recommended for controlling *E. zinckenella* the peanut pod borer.

Key words: chemical insecticides, *E. zinckenella,* natural enemy, peanut, pod borer

INTRODUCTION

Pod borer, *Etiella zinckenella* Treit. (Lepidoptera: Pyralidae) is an important pest in soybean. These pests are distributed in almost all soybeans production centers in Indonesia (Van den Berg *et al.*, 2000; Tengkano *et al.,* 2006; Tengkano, 2007; Permana *et al.,* 2012; Ganeshi, 2013) and have been reported to attack peanut in Bengkulu with damage rates ranging from 31–48% (Apriyanto *et al.,* 2008; Apriyanto *et al.*, 2010). Pod borer has also been reported to attack in several peanut production centers in Lampung province and Central Java with endemic criteria (Baliadi, 2006).

The peanut pods which are attacked by pod borer are characterized by boreholes on the pod surface which black and hollow, the damaged seeds then rot and the larvae droppings were found in the pods (Baliadi & Rahmiana, 2010). Besides, the larvae or pupae of pod borer are often found in damaged pods (Baliadi, 2006; Apriyanto *et al*., 2009). The losses caused by these pests are quite high with yield losses in peanuts were up to 90% (Baliadi & Rahmiana, 2010). In addition, pods that have been brooded by *E. zinckenella* larvae can trigger the infection of the fungus *Aspergillus flavus*, which causes peanuts to become highly toxic due to the aflatoxin produced by *A. flavus* (Hedayati *et al*., 2007; Reddy *et al.,* 2010).

Pod borer control techniques generally carried out by farmers using chemical insecticides (Abdou & Abdalla, 2006). However, yield losses due to pod borer attacks in the fields have not been fully overcome yet instead, they are likely to increase. The increase in pod borer attack on peanuts was probably caused by the excessive use of chemical insecticides that kill all pod borer's natural enemies (Rodrigues-Saona *et al.,* 2013). Moreover, the increase in the population of pod borer in the field is also caused by the availability of host plants throughout the season. Several types of plants have been reported as hosts for pod borer, such as soybeans, green beans, snails (*Crotalaria juncea*), and other types of legume crops (Van den Berg *et al.,* 1998).

Control of these pests is quite difficult because the imago stages develop on plant surfaces, while the larvae develop inside pods that are in the soil. Various methods of control have been developed, such as the use of trap crops, the release of *Trichogramma bactrae-bactrae* parasites, and the use of resistant varieties (Sutrisno *et al.,* 2002; Damayanti *et al.,* 2001), apparently they were not able to significantly suppress the development of pod borer populations in the field. The results of the efficacy test of the combination of several technological components for peanut pod borer control showed positive results at two experimental fields, Kebun Percobaan (KP) Natar (Lampung) and KP Muneng (Probolinggo) (Prayogo *et al*., 2012). This study aimed to evaluate the efficacy of the technology components for controlling peanut pod borer (*E. zinckenella*).

MATERIALS AND METHODS

Research Site. The research was conducted in the KP Natar Experimental field of Assessment Institute for Agricultural Technology (BPTP) Lampung, which is one of the endemic areas of peanut pod borer. The study was conducted from April to August 2014.

Experimental Design. The experiment was arranged using a randomized complete block design (RCBD), with four replications. The treatments used were six control technology components that were assembled based on the results of testing in 2012 (Table 1). The pest control technology components are as follows; P0 (no pest control), P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* parasitoid + soybean trap plant + lambda-cyhalothrin), P2 (carbofuran + *T. bactrae-bactrae* + soybean traps + lambda-cyhalothrin), P3 (*T bactrae-bactrae* + soybean trap plant + lambda-cyhalothrin), P4 (thiamethoxam + carbofuran + *L. lecanii*), P5 (thiamethoxam + *L. lecanii*), and P6 (lambda-cyhalothrin).

Land Preparation. The land was processed by twice plowing, then it was softened and added manure as much as 2.5 tons/ha. Each treatment used a 400 x 500 cm plot, the distance between plots was 50 cm. Peanuts used in this study were Bison variety, the planting distance was 40 x 10 cm, with one seed on each planting hole.

The basic fertilizer applied was 50 kg Urea + 100 kg SP36 + 50 kg KCl/ha that ditch along the row of plants at the age of 10 days after planting (DAP). Weeding was done manually at the age of 21 and 45 DAP, while irrigation was done according to the land conditions.

Preparation of Trap Crops. The Wilis variety of soybean was used as a trap for *E. zinckenella* imago. Trap crops were planted around each treatment plot 14 days before planting the peanuts expecting that, when the peanut was flowering, the soybean had formed pods. Thus, *E. zinckenella* imago can collect on the legumes of soybeans because soybeans are the main host of pod borer.

Preparation of Experimental Plants. Peanut seeds for P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + soybean trap crop + lambda-cyhalothrin + *L. lecanii*) and P4 (thiamethoxam + carbofuran + *L. lecanii*) treatments were treated with chemical insecticide contain thiamethoxam before planting. The peanut seeds for P1, P2 (carbofuran + *T. bactrae-bactrae* + soybean trap crop + lambda-cyhalothrin), and P4 treatments at planting time were sprayed by

Table 1. Peanut pod borer (*E. zinckenella*) pest control technology components

Treatment	Thiamethoxam	Carbofuran	*T. bactrae-bactrae*	Trap crops	Labmda-cyhalothrin	*L. lecanii*
P0	-	-	-	-	-	-
P1	+	+	+	+	+	-
P2	-	+	+	+	+	-
P3	-	-	+	+	+	-
P4	+	+	-	-	-	+
P5	+	-	-	-	-	+
P6	-	-	-	-	+	-
Application time	Seed treatment	Planting (planting hole)	35 DAP	14 days before planting	35–70 DAP (weekly)	35–70 DAP (weekly)

(+) application of each component of pest control technology; (-) no pest control.

insecticides containing carbofuran on the planting holes at a dose of 20 kg/ha. Thiamethoxam insecticide with a dose of 2 mL/L of water mixed with seeds before planting.

Preparation and Infestation of *T. bactrae-bactrae*. The imago of *T. bactrae-bactrae* was obtained from the Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI) and then propagated on *Corcyra cephalonica* eggs which were attached to paper sheets. *C. cephalonica* eggs that had been parasitized by *T. bactrae-bactrae* for the next six days were invested in each treatment plot at the age of 35 DAP with a population of 15,000 head/ha. Biopesticide containing active conidia of entomopathogen fungi, *L. lecanii* with conidia density of 10^7conidia/mL were applied weekly from the age of 35–70 DAP by spraying it into the flower's formation as a candidate for gynophore. Application dose of *L. lecanii* biopesticide was 2 mL/plant, spray volume 500 L/ha with a population of 250,000 plants/ha. Lambda-cyhalothrin insecticide application was applied every week seven times from the age of 35–70 DAP with the same spray volume as *L. lecanii* biopesticide.

Observed Variables and Data Analysis. Observed variables were: (1) intensity of pod damage due to *E. zinckenella* larvae in 10 clumps of plants were taken randomly at harvest, (2) pest types and populations were observed in 10 clumps starting 42, 49, 56, and 63 DAP, in addition, it was also caught by using sweepnets which were swung five times at each treatment plot, the captured insects then observed in the laboratory and identified based on the determination key (Norton *et al.,* 2000), (3) species and populations of natural enemies were visually observed in 10 clumps of plants and captured using insect nets in each plot from the age of 42, 49, 56, and 63 DAP then identified in the laboratory using determination key (Norton *et al*., 2000; Schell & Latchininsky, 2007), (4) the total number of pods/10 clumps of plants, (5) the number of *E. zinckenella* pods/ 10 clumps of plants, (6) dry pod weight/plot measuring 10 m^2. The attack rate of *E. zinckenella* on peanut was calculated using the following formula:

$$\mathrm{DI} = \frac{\sum \mathrm{Pd}}{\sum \mathrm{Pt}} \times 100\%$$

DI = damage intensity
Pd = damaged pods caused by *E. zinckenella*
Pt = total of observed pods

All data obtained were analyzed using the MINITAB program version 14. Then, if there were differences between treatments, the Duncan's Multiple Range Test was calculated at the significant level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The Number of *E. zinckenella* Larvae. The results showed that the number of larvae found ranged between 3–20/five clumps of plants at each plot. The highest number of *E. zinckenella* larvae was found in the P6 treatment (lambda-thiamethoxam chemical insecticide

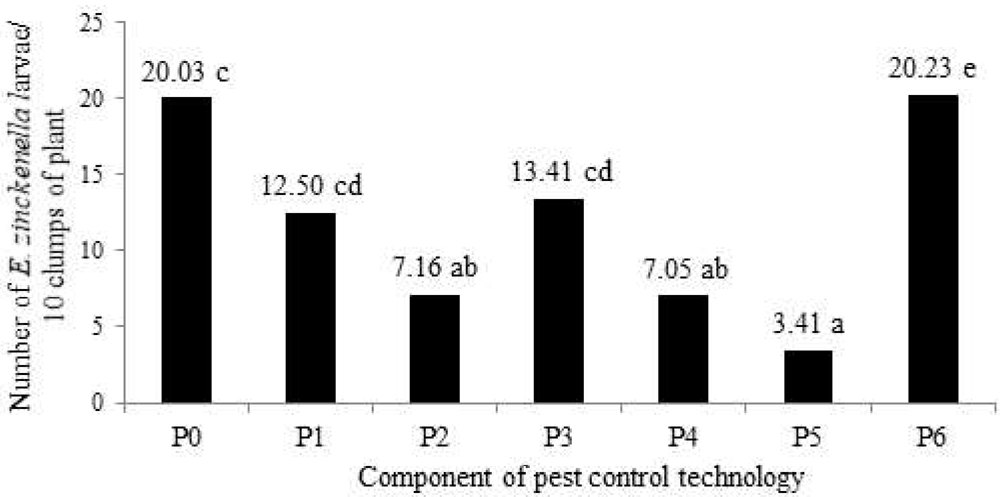

Figure 1. Number of *E. zinckenella* larvae on the peanut pod/10 clumps of plant at each plot. P0 (no pest control); P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P2 (carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P3 (*T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P4 (thiamethoxam + carbofuran + *L. lecanii*); P5 (thiamethoxam + *L. lecanii*); and P6 (lambda-cyhalothrin).

application) and control (P0), however, the two treatments were not significantly different (Figure 1). The high number of larvae found in the P0 treatment was due to the research site as an endemic area for pod borer, thus insects naturally develop in every season. The pod borer larvae population observed at P6 was up to 20, it was suspected that the chemical insecticide compound, lambda-cyhalothrin, which was applied could only kill the imago on the surface of the plant. Meanwhile, the larval stage in the pod remained alive because the chemical insecticide compound was unable to reach in the soil where the pods are formed. In addition, the chemical insecticide compound which is applied is not ovicidal (kills eggs) so that the eggs continue to develop normally into larvae and imago.

The pod borer larvae population in the P1 and P3 treatments was also quite high, ranging from 12–13/10 clumps of plants. At P2 treatment, seven pod borer larvae were observed and not significantly different from P4. The lowest population of *E. zinckenella* larvae was three for every 10 clumps of plants observed in the P5 treatment (thiamethoxam + *L. lecanii*). Based on the number of observed pod borer larvae, the P5 treatment was able to suppress the development rate of pod borer populations compared to other treatments. The low number of larvae population in the P5 treatment caused by the thiamethoxam insecticide applied at the time of planting which able to induce plant systemic resistance. Meanwhile, *L. lecanii* which was applied during flowering was assumed to be able to infect a group of pod borer eggs placed by the imago on the flower petals. Furthermore, eggs that have been infected with *L. lecanii* eventually can not hatch to larvae so that the flower that develops into a gynophore and enters the soil is free from *E. zinckenella* larvae attacks. This condition occurs because the *L. lecanii* was ovicidal, which able to thwart the hatching of insect eggs or kill the egg. The ovicidal nature of *L. lecanii* against whitefly eggs (*Aleurodicus disperses*) was reported by Thangavel *et al*. (2013). Prayogo (2009) also reported that *L. lecanii* was ovicidal against soybean pod sucking eggs (*Riptortus linearis*) so that the infected eggs did not hatch until they reached 90%. The ovicidal ability of the *L. lecanii* fungus was characterized by producing several types of enzymes and toxins, including; chitinase, protease, lipase, and amylase (Isaka *et al.,* 2005). In addition, this fungus also produces several types of toxins namely dipicolinic acid, hydroxycarboxylic acid, and cyclosporine to kill its host (Murakoshi *et al*., 2005).

The Pod Borer (*E. zinckenella*) Larvae. The level of damage to peanuts due to *E. zinckenella* attacks can be calculated from the percentage of pods picked up by larvae. The more larvae found in pods, the greater the chance of pod damage. The results showed that damaged pods by *E. zinckenella* were ranged from 13.51–30.33% (Figure 2). The P6 treatment showed the highest pod damage (30.33%), and the treatment was not significantly different from P0. The results of this study indicated that the application of chemical

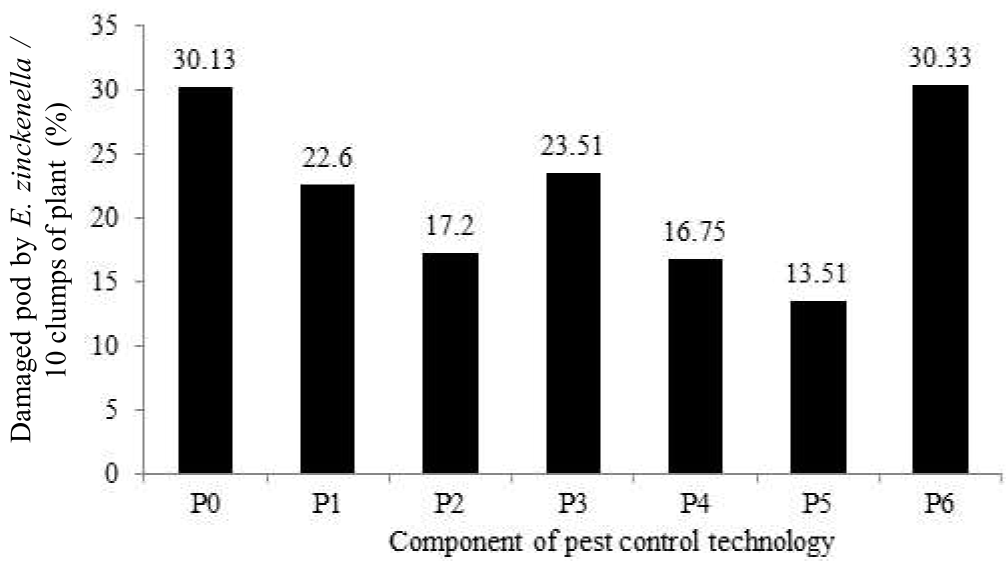

Figure 2. The average number of damaged pod by *E. zinckenella*/10 clumps of plant. P0 (no pest control); P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P2 (carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P3 (*T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P4 (thiamethoxam + carbofuran + *L. lecanii*); P5 (thiamethoxam + *L. lecanii*); and P6 (lambda-cyhalothrin).

insecticides sprayed seven times from the age of 35–70 DAP was not significantly different from control. Control of peanut pod borer pests is more difficult than the control of other pests because larval stages that damage the pod are inside soil. The results of research conducted by Badii *et al.* (2013) also indicated that the application of lambda-cyhalothrin insecticide for the control of pod borer (*Maruca vitrata*) attacking pigeon pea was also not significantly different from control treatments resulting in the high number of pod damage.

The pod damage in the P4 and P2 treatments was ranged from 16–17% and not significantly different from the P5 treatment. The efficacy of P4 treatment in suppressing the development of pod borer larvae is thought to be due to the thiamethoxam insecticide compatible with *L. lecanii* fungi. According to Alizadeh *et al.* (2007), several types of chemical insecticides, except imidacloprid and amitraz insecticides, are compatible with entomopathogenic *L. lecanii* fungi so that they can increase the efficacy of these biological agents in controlling pests. Meanwhile, destructive observations on P2 found that *E. zinckenella* was more interested in laying eggs on soybean plants that were used as trap crops, rather than the peanut plants in treatment plots. With the small number of eggs in peanuts in the plot, the number of larvae formed was also smaller. This condition was observed on the P2 treatment plot which was not significantly different from P5.

P3 treatment showed higher pod damage reaching 23.51% compared to P2. This condition was considered to be the role of *T. bactrae-bactrae* was not significant in parasitizing *E. zinckenella* eggs as a result of the application of chemical insecticides. The results of this study were supported by Takada *et al.* (2001), Mason *et al*. (2002), Consoli *et al.* (2009) and Araya *et al.* (2010), that some types of chemical insecticide active ingredients can negatively affect the longevity and the morphology of parasitoids. Furthermore, Sattar *et al*. (2011) and Blibech *et al.* (2015) also explained that chemical insecticide compounds such as deltamethrin, spinosad, indoxacarb, and lufenuron can inhibit the process of oviposition and the emergence of parasitoid *T. chilonis*. Nevertheless, there are several types of chemical insecticides such as phenvalerate and phenoxycarb that are safe against the development and survival of *T. evanescens* parasitoid (Carrillo *et al.,* 2009; Abulhay & Bathi, 2014). According to Hermandez *et al.* (2011) and Costa *et al.* (2014), lambda-cyhalothrin and triflumuron insecticides are also safe against the survival of the parasitoid *Ganaspidium nigrimanus* and *T. galloi*. Furthermore, emamectin benzoate and clothianidin insecticides were also safe against the behavior and survival of the *Cotesia vestalis* parasite in citing the caterpillar cabbage *Plutella xylostella* (Kawazu *et al.,* 2010).

Pod damage in treatments P1, P2 and P3 was still quite high, respectively 22, 17 and 23%. This condition was due to the chemical insecticide compound which was applied negatively to the other control components so that the control becomes less optimal. According to Zhao *et al.* (2012) and Hussain *et al.* (2012) that the application of chemical insecticide thiamethoxam and carbofuran that is not timely can interfere with the performance of the parasitoid *T. chilonis* and *T. japonicum*.

Pod Dry Weight. The yields obtained from each treatment ranged from 4.6–8.2 kg/plot (Figure 3). The lowest yield occurred in the P6 treatment which was only 4.6 kg/plot. Yields in P6 were not significantly different from P3 and P0 treatments with an average dry pod yield was 4.7 kg/plot. The low yields in the P6 treatment were due to the large number of larvae found inside the pods reaching 20 larvae/10 clumps of plants so that pod damage was also quite large. The results of this study indicate that the chemical insecticide from lambda-cyhalothrin which was applied seven times was considered not able to suppress the development of *E. zinckenella* population because the pod damage was high and not statistically different from the control (P0). This result was in contrast to the research conducted by Gehan & Abdalla (2006) and Dhaka *et al.* (2011) which stated that the lambda-cyhalothrin was quite effective for controlling *E. zinckenella* in cowpea. The difference in the efficacy of this study was probably due to the differences in the host plants of *E. zinckenella*. Peanut pods are in the soil while cowpea pods are on the surface of the soil, thus affecting the bioecology and behavior of the insects. The application of chemical insecticides on plant surfaces will kill the entire structure of pest populations that exist on the plant surface. Conversely, the application of insecticides on plant surfaces is unable or difficult to reach larvae that attack pods under the soil surface.

Dry pod weight in P1 and P2 ranges from 7.1 to 7.4 kg/plot, higher than P3 and P6. The highest dry pod weight observed in the treatments of P4 and P5 reaching 8.2 kg/plot. The high weight of dry pods in both treatments was related to the limited number of damaged pods due to the low number of pod borer larvae populations, especially for P5, which was only 3 larvae, while the number of larvae in P4 was 7/10 clumps of plants. Based on the number of larvae, percentage of damaged pods, and the weight of dried pods, we can conclude that *L. lecanii* technology components combined with thiamethoxam or carbofuran insecticides were effective as control technologies for controlling *E. zinckenella* pod borer.

The effectiveness of *L. lecanii* application caused by the conidia of the entomopathogenic fungus was able to infect variety of insect stages, starting from the egg, larvae and imago (Wang *et al*., 2007; Shinde *et al.,* 2010; Park & Kim, 2010). The effication of *L. lecanii* also due to a wide range of hosts including the order; Homoptera, Hemiptera, Coleoptera, Lepidoptera; Orthoptera, nematodes and plant diseases (Gan *et al.,* 2007; Goettel *et al.,* 2008; Shinya *et al*., 2008). The advantages of *L. lecanii* was their ability to produce chitinase enzymes with high concentrations, these enzymes function as a degenerator of layers cuticle and toxic in killing host insects (Liu *et al*., 2003; Lu *et al*., 2005).

Survival of Natural Enemies. Peanut pod borer control using a combination of various pest control components appears to be safer for the survival of useful insects, especially general predators, *Coccinella* sp. (Coccinellidae) and *Oxyopes* sp. (Oxyopidae) and parasitoids order Hymenoptera and Diptera compared to single control component such as application of chemical insecticides only (Figure 4). The highest predator and parasitoids population occurred in treatment P0, while the lowest population occurred in treatment P3 and P6. The high number of predators population, *Coccinella* sp. and *Oxyopes* sp. in P0 was due to the presence of prey populations (*B. tabaci* and *A. glycines*) in the crop (Figure 5). Fotukkiaii & Sahragard (2013) stated that, the population of predators in habitat was determined by the number and types of prey available. Tian *et al*. (2017) also reported that the abundance of the predator *Serangium japonicum* (Coleoptera: Coccinellidae) is related to the types of prey populations that exist in the field.

In the P0 treatment, there was a development on the prey population, especially the whiteflies (*B. tabaci*) and aphid (*A. glycines*), 216 and 78 each in 10 clumps of plants respectively (Figure 5). The population of both types of prey consists of eggs, nymphs, and imago stages which are a source of food for predators *Oxyopes* sp. and *Coccinella* sp. to maintain the survival of both types of predators. Freier *et al*. (2007) reported that the abundance of predator populations was strongly influenced by the presence of prey populations. The more abundant the prey population in the field, the predator population of the Coccinellidae order were also rapidly increased (Zhao *et al*., 2013a; Zhao *et al*., 2013b; Kindlmann *et al*., 2015).

The lowest number of natural enemy populations was observed at the P6 treatment, especially for the generalist *Oxyopes* sp., in contrast, the predator population at P1, P2, P3, and P4 was high. Population abundance of *Oxyopes* sp. at the four treatments was allegedly due to the presence of more prey populations, especially the egg and imago stages of pod borers and other types of pests. This condition was followed the Huseynov's (2006) report that mentioned the

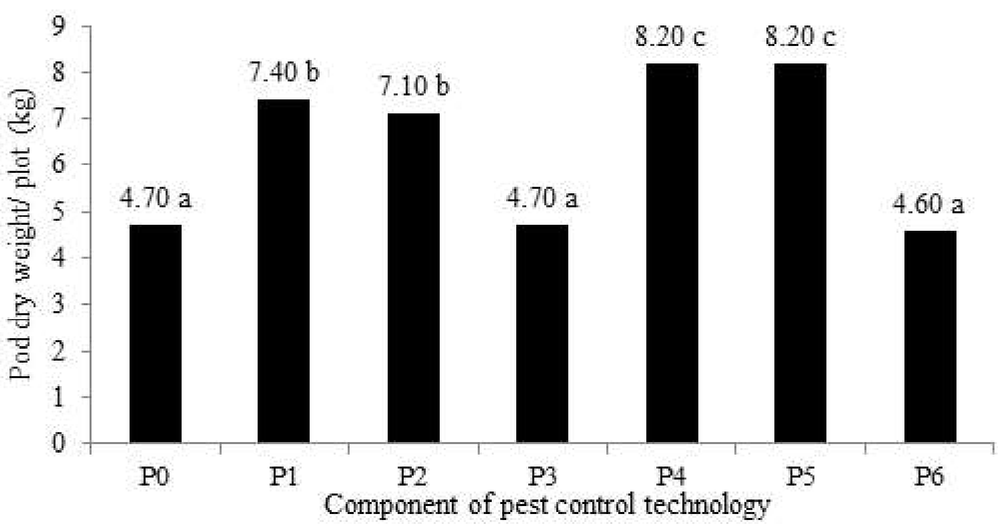

Figure 3. Pod dry weight on each treatment. P0 (no pest control); P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P2 (carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P3 (*T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P4 (thiamethoxam + carbofuran + *L. lecanii*); P5 (thiamethoxam + *L. lecanii*); and P6 (lambda-cyhalothrin).

Oxyopes sp. was a generalist predator that can inhabit the soil surface and plant canopy so that it has a fairly high preying ability and a broad range of prey from several types of insects. Generalist predators have a wider chance to survive because they are able to eat various types of prey compared to specialist predators (Huseynov, 2007; Inayat *et al*., 2011; Rana *et al*., 2012).

The parasitoid population order Hymenoptera and Diptera at P0 treatment was the highest, while the lowest parasitoid population was observed at P6 treatment (Figure 4). The parasitoid population in P1, P2 and P3 were relatively high although not as abundant as in the P0 treatment, this condition was due to the application of chemical insecticide on the three treatments in the seed and planting time (P1), and scheduled applications

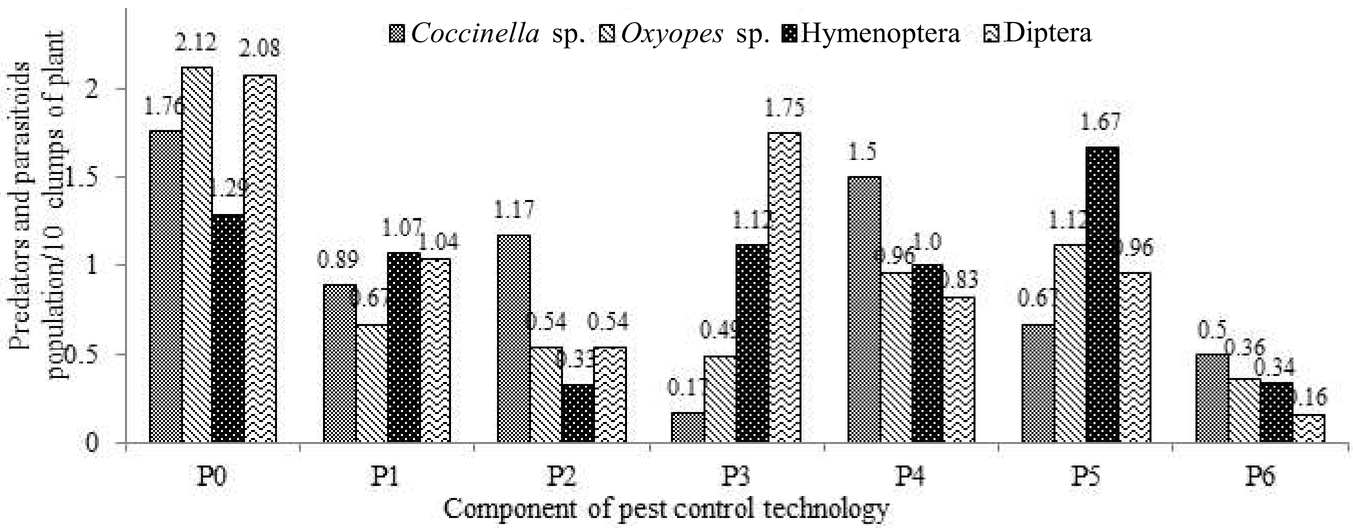

Figure 4. Predators and parasitoids population at each treatment plot. P0 (no pest control); P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P2 (carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P3 (*T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P4 (thiamethoxam + carbofuran + *L. lecanii*); P5 (thiamethoxam + *L. lecanii*); and P6 (lambda-cyhalothrin).

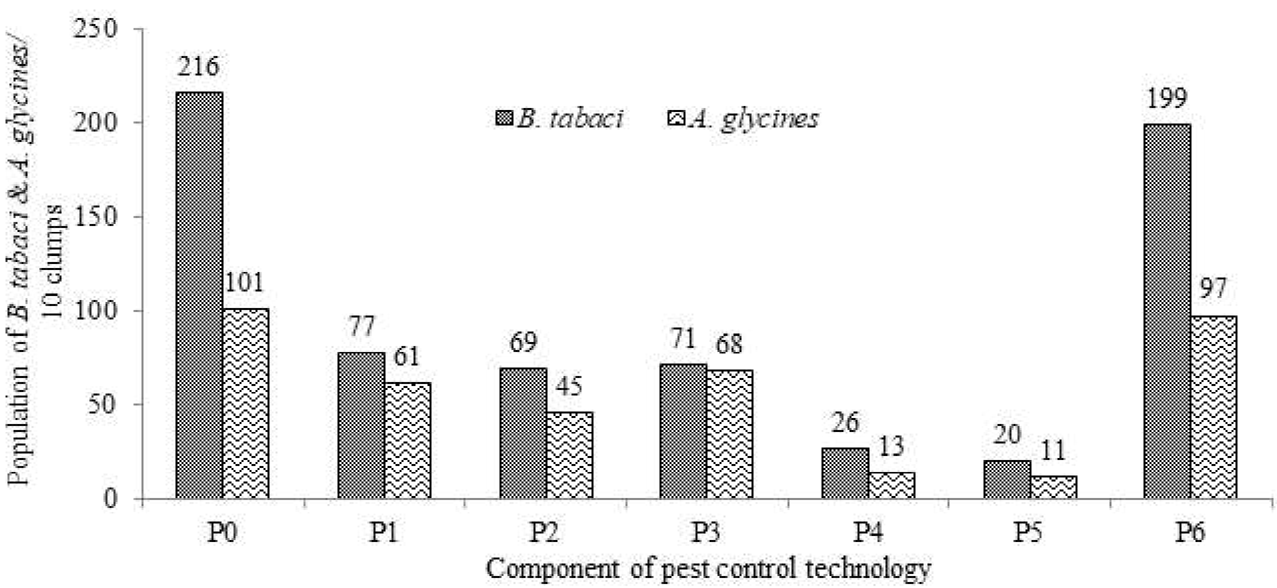

Figure 5. Population of *B. tabaci* and *A. glycines*/10 clumps of plant at each treatment plot. P0 (no pest control); P1 (thiamethoxam + carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P2 (carbofuran + *T. bactrae-bactrae* + trap crops + lambda-cyhalotrin); P3 (*T. bactrae-bactrae* + trap crops + lambda-cyhalothrin); P4 (thiamethoxam + carbofuran + *L. lecanii*); P5 (thiamethoxam + *L. lecanii*); and P6 (lambda-cyhalothrin).

every week starting from 35–70 DAP (P2 and P3). According to Sugiyama *et al.* (2011) and Shimoda *et al.* (2011), parasitoid groups are more susceptible to chemical insecticide applications than pest insects. Meanwhile, the high parasitoid population in P1, P2, and P3 was probably due to the presence of soybean trap crops around the plot so that the crops can function as a shelter (reservoir) for parasitoids. According to Noma *et al.* (2010) that the abundance of parasitoid populations was related to the presence of hosts and crops as a shelter or to maintain their survival.

The observed parasitoids were identified as a member of Hymenoptera, meanwhile, parasitoids from the Hymenoptera had the ability to parasitize several types of hosts, thus the high diversity of the host population would directly influence the number of the observed parasitoid population. Some of the results from previous studies also shown that parasitoids from the order Hymenoptera have the ability to parasitize the broad range of hosts, on various types and stages of pests (Herz & Hassan, 2006; Kalyebi *et al.,* 2014).

In P4 and P5 treatments the parasitoid Hymenoptera and Diptera populations were higher than P1, P2, P3 and P0 although both treatments also used chemical insecticide and *L. lecanii* biopesticides. This condition was caused by the application of chemical insecticides only for seed treatment and planting so it was suspected that exposure to chemical insecticide residues in the fields was low and has little impact on the parasitoid abundance. Besides, the parasitoids are highly mobile so that the *L. lecanii* conidia that applied did not inoculate the two types of parasitoids. According to Al-Deghairi (2009) the application of entomopathogenic fungus *Beauveria bassiana* for the control of whitefly (*B. tabaci*) appears to be more compatible with natural enemies such as parasitoids from the order Hymenoptera. Furthermore, Velez (2008) reports that entomopathogenic fungus *L. longisporum* can be combined with predators of the order Diptera. Ren *et al*. (2010) and Cuthbertson *et al.* (2010) explained that the application of *L. muscarium* entomopathogenic fungus were safe for the survival of parasitoids and predators, especially in adult stages.

CONCLUSION

The application of biopesticides containing conidia of *L. lecanii* fungus combined with carbofuran or thiamethoxam insecticides was effective in controlling pod borer (*E. zinckenella*) and maintain the survival of natural enemies (predators and parasitoids). The thiamethoxam, carbofuran, lambda-cyhalothrin, parasitoid *T. bactrae-bactrae*, and trap crops could be applied in an integrated way to control *E. zinckenella*. The application of lambda-cyhalothrin insecticide has not been able to suppress the development of population *E. zinckenella* and kill the presence of natural enemies. *L. lecanii* biopesticides combined with thiamethoxam or carbofuran insecticides was recommended as a technology for controlling peanut pod borer.

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