Use of Light Trap for Controlling Cabbage Pests

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Abstract. Cabbage leaf caterpillars (Plutella xylostella L.) and cabbage head caterpillars (Crocidolomia binotalis Zell.) are key pests of cabbage in Indonesia. Crop loss due to both pests can reach as high as 50-100%. In general, the pests control done by the farmers is still based on the use of insecticides. Therefore, it is necessary to identify another method that is environmentally friendly. This study aimed at determining the effectiveness of the light trap in controlling P. xylostella and C. binotalis. The experiment was conducted at the Margahayu Experimental Garden, the Indonesian Vegetable Research Institute in Lembang (1,250 m asl.), from March to July 2018. The experiment was designed using the paired comparison with two treatments. The treatments tested were: (A) using light traps + control threshold and (B) without light traps + sprayed with insecticide twice a week. Each treatment consisted of six replications. The results showed that the use of light traps was able to suppress the population of P. xylostella and S. litura larvae and egg masses of C. binotalis. It also reduced the frequency of insecticide spray by 81.82% and insecticide costs by 77.61%. Cabbage cultivation using a light trap could maintain cabbage yield equivalent to yield on the treatment used insecticides twice a week and gave more profitable than insecticide spray twice a week. Therefore, the use of a light trap for controlling lepidopteran pests in cabbage cultivation was properly adopted.

Keywords: Cabbage (Brassica oleracea var. capitata), main pest, light traps, environmentally friendly control

1. Introduction

Cabbage (Brassica oleracea var. capitata) is one of the vegetable commodities which has a high economic value and is widely cultivated in various countries including Indonesia. One of the problems in cabbage cultivation is the occurrence of pest attacks, especially cabbage leaf caterpillars (Plutella xylostella L.) and cabbage head caterpillars (Crocidolomia binotalis Zell.) Crop loss due to the pests can be reached as high as 50-100% [1, 2]. In general, farmers rely on insecticides to control these pests. The cost of pesticides used in cabbage cultivation reached 20 - 40% [3-5].

Training of implementation of integrated pest management (IPM) on cabbage has been carried out in Indonesia since the early 1990s and an evaluation of the results of IPM training in East Java Province showed that there has been a reduction in insecticide use of 61-81% [6]. Unfortunately, a survey conducted in 2011 reported that the use of insecticides by cabbage farmers who had attended IPM training was not significantly different from farmers who had not been trained [7]. The failure of IPM training on cabbage was also reported from West Java Province. The farmers did not adopt the control threshold of cabbage pests because it was difficult and impractical. This was indicated by the data that although 25% of farmers in this province have been trained, only 5-10% still implement the control threshold [8]. Therefore, efforts are needed to reduce the use of insecticides by utilizing other control methods such as a light trap.

The light trap has been used as a monitoring tool for flying insects [9, 10]. Nocturnal insects are usually attracted to light sources that emit Ultraviolet radiation. This behavior is used to develop a light trap, which is intended as moth monitoring tools and pest control tools [11-15]. Light traps with...
Ultraviolet A rays (wavelength 315-400 nm) have been introduced in agriculture since 75 years ago [16]. The use of a light trap was effective for controlling cotton pests [17]. Other researchers reported that the light trap was able to capture more *Lasioderma serricorne* female moths than pheromone trap, with a ratio of 60 females and 15 males, so that the light trap was more effective in controlling the pest [18]. The light trap is also used to trap pests from the order Coleoptera and Lepidoptera [19]. Light trap has been used as a component of controlling caterpillar larvae on cabbage in Florida [20]. In North Carolina, the application of insecticides to control the tobacco pest, *Manduca sexta* could be reduced by 90% by using light traps [21].

Basic research was carried out to develop the use of a light trap to control *P. xylostella* and *C. binotalis*. A study of the flight activity of *P. xylostella* moths showed that the moth began flying one hour after sunset to one hour before sunrise, with the flight peaks in 2-4 hours after sunset [22]. *P. xylostella* moths were more attracted to green light (98.3%) than to Ultraviolet light (90%) [23], while the other researcher reported that light traps with Ultraviolet light were most effective at attracting *P. xylostella* moths [24].

The use of a light trap to control pests in Indonesia is still very limited. The use of a light trap was reported to control lepidopteran pests in rice and shallot [25-27]. Its use for controlling cabbage pests has never been reported. Therefore, it is necessary to conduct research to determine the effectiveness of light trap to control pests in cabbage. The hypothesis was that the population of cabbage leaf caterpillars and cabbage head caterpillars decreased and insecticide application was reduced by using the light trap.

### 2. Materials and Methods

The study was conducted at the Margahayu Experimental Garden (1,250 m asl.), the Indonesian Vegetable Research Institute at Lembang, West Java, Indonesia from March to July 2018. The study was designed using the Paired Comparison with two treatments [28], based on the IPM concept and based on local farmers’ practice. The treatments tested were: (A) using light traps + control threshold of *P. xylostella* and *C. binotalis*, and (B) without light traps + sprayed with insecticide twice a week. Each treatment consisted of six replications. We used a control threshold in this study to assess how far the use of light trap can reduce the pest population.

#### 2.1. Land preparation

The treatment plot was 6 m long and 17 m wide = 102 m² (220 plants/plot). Between treatment plots A and B were separated by 6 m wide corn plants (12 rows of corn plants). The basic fertilizer used consisted of chicken manure 15 tons/ha; ZA 120 kg/ha; Urea 55 kg/ha; SP 36 250 kg/ha and KCl 200 kg/ha that applied at 7 days before transplanting. The cabbage was top dressed using Urea 55 kg/ha and ZA 120 kg/ha at 30 days after transplanting.

#### 2.2. Light trap preparation and installation

A light trap equipped with a water container was installed in each treatment plot. Water was used to collect the trapped targeted insects. The distance between light traps equipment was 30 m [29]. This was done because the light traps were only able to attract moths which were a maximum distance of 15 m [30]. Traps used solar-powered LED lights with ultraviolet light which had a wavelength of 365-385 nm [31, 32]. The light traps were installed at transplanting time and the first observation was carried out at 4 days after transplanting interval of 3-4 days.

#### 2.3. Control decision

The control threshold applied in treatment A was the *P. xylostella* control threshold of 0.5 larvae/sample plant and the control threshold of *C. binotalis* of 0.3 egg masses/sample plant [6]. When the control threshold reached, cabbage plants were sprayed using the emamectin benzoate insecticide (1 g/l). Cabbage plants in treatment B were routinely sprayed 2 x/week starting from 7 days after
transplanting using the insecticide emamectin benzoate (1 g/l), chlorpyrifos (3 ml/l), chlorphenapyr (1.5 ml/l), beta cyfluthrin (1 ml/l), abamectin (1.5 ml/l), and chlorphenapyr + cypermethrin (0.75 ml/l) in rotation.

2.4. Observation
Observations were done on 10 sample plants which were randomly assigned systematically from 14 days after transplanting with 7 days interval. Observational parameters included: larvae population, egg masses population, crop damage, insect population caught in a light trap, the number of insecticide spraying, the amount of insecticide used and the yield.

2.5. Data analysis
Crop damage was calculated using the following formula [33]:

\[
P = \frac{\sum (n \times v)}{N \times Z} \times 100\%
\]

- \(P\): Plant damage intensity (%)
- \(n\): Number of plants that have the same crop damage (v)
- \(v\): Score of crop damage based on leaf area attacked in each plant, namely:
  - 0 = There is no damage at all
  - 1 = Plant damage area > 0 - ≤ 20%
  - 3 = Plant damage area > 20 - ≤ 40%
  - 5 = Plant damage area > 40 - ≤ 60%
  - 7 = Plant damage area > 60 - ≤ 80%
  - 9 = Plant damage area > 80%
- \(N\): Number of plants observed.
- \(Z\): Highest score (v = 9).

Figure 1. A light trap equipped with a water container.
The economic feasibility of technology can be determined by analyzing a partial budget [34]. In this experiment the data collected for partial budget analysis were: (1) Sale price of cabbage yield, (2) pesticide spraying costs, and (3) pesticide purchase costs. These data were analyzed using the Partial Budget Analysis technique and the formula was as follows [34]:

\[
\Delta NI = \Delta TR - \Delta VC
\]

\[
R = \frac{\Delta NI}{\Delta VC}
\]

**TR**: total yield price per treatment (Rp/ha) = yield (kg/ha) x yield price (Rp/kg)

**VC**: the variable cost per treatment (Rp/ha), i.e. the quantity of inputs used (units/ha) x the price of the input (Rp/ha)

**NI**: revenue, i.e. total income - total variable costs

**Δ**: differences, differences or changes

**Δ NI**: difference in net income from the use of light trap (A) with net income without light trap (B)

**Δ TR**: difference in yield between the use of lights trap (A) with yield without light trap (B)

**Δ VC**: difference in the variable cost of using light trap (A) with variable cost without lights trap (B)

**R**: rate of return

Decision-making criterias:
1. If the NI value remains the same or lower, the light trap will be rejected,
2. If the NI value rises and the VC remains the same or lower, the light trap will be accepted and have the opportunity to be adopted,
3. If the value of NI and VC rises, calculated R. If the value of R ≥ 1.0, the light trap has the opportunity to be adopted,
4. If it has a higher NI and R-value, the light trap is economically attractive to be adopted

If the results of observations indicated differences between treatments, then further test will be done using a t-test at the 5% level. Therefore, in this experiment if there were differences between treatments a t-test was performed at the 5% level [28].
3. Results and Discussion

In the field, three species of pests were found that attack cabbage plants, namely *P. xylostella*, *C. binotalis*, and *S. litura*. These three species were also reported as the main pests of cabbage in India [35].

3.1. *P. xylostella* larvae population

*P. xylostella* larvae began to be found when cabbage plants were 14 days after transplanting, then the population declined because the larvae had entered the pupae stage. The population rose again and at 35 days or 7 weeks after planting reached a peak, then fell and rose again and reached a peak at 77 days or 11 weeks after transplanting. The pattern occurred both in the treatment using light trap and without light trap. In Indonesia, the larvae population generally reached the peak at 5 to 8 weeks after transplanting and then declined because it was replaced by the cabbage head caterpillars *C. binotalis* [36-38]. However, if the population of *C. binotalis* cabbage head caterpillar was low, the population of cabbage leaf caterpillars increased until harvest time [33, 39]. In this study, there were no caterpillars that were parasitized by *Diadegma semiclausum*. Farmers’ practice in the application of non-selective insecticides with high frequency was responsible for this condition.

Figure 3 showed that in the treatment using a light trap, the control threshold was reached by three times, whereas in the treatment without a light trap and sprayed with insecticides twice a week, the larvae population still reached the threshold by six times. It was reported that *P. xylostella* was difficult to be controlled [40]. However, it turned out that the use of a light trap was able to control this pest until below the control threshold.

![Figure 3. Development of population of *P. xylostella* larvae](image)

3.2. Population of *C. binotalis* egg masses

Starting at 49 days after transplanting, the egg masses of *C. binotalis* was found with populations that exceeded the control threshold in both treatments (Fig. 4). Furthermore, *C. binotalis* was pushed by *P. xylostella* whose population increased again so that the population of *C. binotalis* egg masses decreased. In the treatment using a light trap, the control threshold was reached once, while in the treatment without light trap was reached four times. It meant that the use of a light trap was also able to suppress the population of egg masses below the control threshold. The control of laying eggs was very important because if the pest attacked in the head formation period, the caterpillars would enter the cabbage head and was difficult to be controlled.
Figure 4. Development of population of *C. binotalis* egg masses

3.3. Population of *S. litura* larvae

Armyworm (*S. litura*) was also found and attacked the cabbage plants. This pest was polyphagous, but the most preferred hosts were plants from the Brassica family. The loss of yield due to the pest reached 25.8 – 100% [41, 42]. The population of *S. litura* in the treatment using a light trap was lower than the population in the treatment without light trap. It showed that the use of a light trap could suppress the pest population (Fig. 5).

Figure 5. Development of population of *S. litura* larvae

3.4. Plant damage due to caterpillar

Among the three types of pests found that attacked the cabbage plants, the cabbage leaf caterpillar *P. xylostella* was most dominant. Thus, the damage to plants that occur was largely due to this pest. The use of light trap had proven to be able to reduce the plant damage below 10%, while spraying insecticides twice a week still showed plant damage above 10% (Fig. 6).

3.5. Development of the moths caught

The moths caught were observed twice a week. For four days after transplanting, the moths of *P. xylostella, C. binotalis* and *S. litura* were found in the light traps. Since the beginning of transplanting,
The population of *P. xylostella* moths had been above 25 individuals/trap and at 46-50 days after transplanting its population reached above 50 individuals/trap. This indicated that the moth population in the field was also high and caused caterpillar population increased in the following weeks (Figure 7).

Since the beginning of transplanting, *C. binotalis* moths had been found in traps, but because of the low population, it was suspected that the moths could not find a partner so they did not produce eggs on the cabbage plants. At 49 days after transplanting, that was, two weeks after the moths were caught by 10 individuals/trap, the egg masses were found on the plants. The peak of the moth caught occurred at 60 days after transplanting i.e. as many as 15 individuals/trap, and followed by the increase of egg masses population on the cabbage plants (Fig. 4).

*S. litura* moths had also been caught since the beginning of transplanting, but the armyworm was found on cabbage plants at 49 days after transplanting. Furthermore, the caterpillar population decreased.

![Figure 6. Plant damage due to caterpillar](image)

![Figure 7. Development of moths of *P. xylostella*, *C. binotalis*, *S. litura* caught in the light trap according to the plant age.](image)
3.6. Yield, number of insecticide spray, and insecticide costs

The cabbage yield data were presented in Table 1. The data showed that the number of plants forming the head in the treatment with a light trap was higher than it in treatment without a light trap, but the yield weight in the two treatments were not significantly different. It showed that the use of a light trap could keep the cabbage yield still high.

The frequency of insecticide spray in the treatment with a light trap was only four times, while in the treatment without a light trap was 22 times. Thus, the use of a light trap could save 81.82% of insecticide applications. The cost of insecticides was presented in Table 2 and the data showed that the use of a light trap could save insecticide costs by 77.61%.

| Treatments                                | Number of head / plot | Cabbage weight (kg/102 m$^2$) | Number of insecticide spraying/planting period |
|-------------------------------------------|-----------------------|--------------------------------|-----------------------------------------------|
| With light trap + control threshold       | 218.0 a               | 513.7a                         | 4                                             |
| Without light trap + sprayed 2x/week     | 205.2 b               | 501.6 a                        | 22                                            |
| CV                                        | 0.7                   | 3.63                           |                                               |
| Efficiency of insecticides spray (%)     |                       | 81.82                          |                                               |

3.7. Financial analysis

The cost of cabbage cultivation using a light trap is presented in Table 3. The results showed that in the treatment with a light trap, the net income (NI) was higher, and the variable cost (VC) was lower than those of the treatment without a light trap. It indicated that pest control technology using the light trap in cabbage cultivation had a chance to be adopted. The rate of return (R) was 1.22. It meant that...
the technology was attractively to be adopted because it was more economically advantageous than using insecticides routinely twice a week. Another advantage gained was the pest control using a light trap more save to the environment.

Table 3. Revenues and variable cost in two pest control treatments

| Description | With light trap + control threshold | Without light trap + sprayed 2x/week | Difference |
|-------------|--------------------------------------|--------------------------------------|------------|
| I. Yield    |                                      |                                      |            |
| • Weight (kg/ha) | 50,359.80                           | 49,172.55                           | + 1,187.25 |
| • Price (IDR/kg) | 2,000                               | 2,000                               | -          |
| Total revenues (TR)/(IDR/ha) | 100,719,607.84                     | 98,345,098.04                      | + 2,374,509.80 |
| II. Variable cost (VR) (IDR/ha) |                                    |                                      |            |
| • cost of insecticides | 1,701,502.94                      | 7,600,620.59                        | - 5,899,117.65 |
| • cost for spraying | 1,200,000.00                     | 6,600,000.00                        | - 5,400,000.00 |
| • observation cost | 200,000.00                        | 0                                   | + 200,000.00 |
| • light trap depreciation cost per planting period | 1,250,000.00                 | 0                                   | + 1,250,000.00 |
| • capital interest (1.67%/ month for 4 months) | 363,350.50                      | 1,185,751.82                        | - 822,401.32 |
| Total of variable cost (VC) (IDR/ha) | 4,714,853.44                     | 15,386,372.41                       | - 10,671,518.97 |
| Net income (NI) (IDR/ha) | 96,004,754.41                   | 82,958,725.63                       | + 13,046,518.97 |
| Rate of return (R) | 1.22                               | -                                   |            |

Notes:
- costs for spraying insecticides: Cost of insecticides spray every application was IDR 300,000 (6 persons @ IDR 50,000)
- light trap depreciation cost per planting period: Light trap of 30 pieces per hectare @ IDR 250,000 could be used for 6 planting periods

4. Conclusions

From the results of this study, it can be concluded that the use of light trap on the cabbage cultivation was able to suppress the population of *P. xylostella* and *S. litura* larvae and egg masses of *C. binotalis*. It also reduced the frequency of insecticide spray by 81.82% and insecticide costs by 77.61%. Cabbage cultivation using a light trap could maintain cabbage yield equivalent to yield on the treatment used insecticides twice a week and gave more profitable than insecticide spray twice a week. Therefore, the use of a light trap for controlling lepidopteran pests in cabbage cultivation was properly adopted.

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