Effect of soybean leaf trichomes on the preference of various soybean pests on field

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Abstract. Trichomes as morphological characteristics of soybean plants can affect the behaviour of some insect pests. Insect behaviour can be affected positively, negatively, or neutral by trichomes character depending on the insect species. This research is aiming to know the effect of soybean leaf trichome density on various species of soybean pest population dynamics using five local varieties from Indonesia (‘Anjasmoro’, ‘Argomulyo’, ‘Dena-1’, ‘Grobogan’, and ‘Devon-1’). In this research, the pest population on the field was observed by active observation method on the five different soybean varieties every once a week that also treated with corn plant and Crotalaria juncea around plots as barrier plant and refugia plant (with and without barrier plant). The result indicates that a higher number of abaxial leaves trichome density has a negative effect on Empoasca sp. population, which is the opposite of the effect known given to Bemisia tabaci. The leaf trichome density does not have a distinctive impact on aphid, herbivorous orthopteran, and various lepidopteran foliage-feeders founded on the field. This research result may provide information related to additional alternatives for pest management using plant physical traits to enhance plant resistance and encouraging the use of integrated pest management.

1. Introduction
Soybean or Glycine max (L.) Merr. is one of the leguminous plants that have many uses and high economic value in Indonesia. The data of soybean production and consumption in 2017 shown that soybean production in Indonesia has not been able to meet the high demand of soybean from the market [1], then its production cannot suffice the consumption in the country. In 2015, national soybean production can only cover 35% of total demand on the market while the rest covered with imports [2].

Soybean production in Indonesia has been inadequate for several kinds of problems and one of them is the high level of pest attack [2]. There are over 111 species of arthropod described as a pest of soybean in Indonesia [3], and some of them can make a significant loss.

Differences in plant characteristics, even on plant genotype level (different secondary metabolites, nutritional resources, and morphology), may affect plant interaction against various arthropods and this variation in the agricultural sector can be considered as a central to enhance plant resistance and biological control for pest suppression [4]. Trichomes, a hair-like structure on various parts of a plant, is one of the morphological structures that can affect pest behaviour that invading plants such as oviposition and feeding behaviour. Soybean plants also have trichomes on both sides of the leaf surface.
The number and shape varied among each plant depending on its genetic. These trichomes characteristics could affect both pests and their natural enemies positively, negatively, or even neutral on their interaction with the plant [5].

Some research has been done to know the effect of trichome number on leaves against several species of pest and natural enemies on various crops. Silverleaf whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), has shown a positive relationship between its population number and oviposition preference with a higher number of trichomes [6][7]. On the other hand, the negative effect of soybean leaf trichomes density has been reported on various species of phytophagous arthropods such as *Deuterocoris sminthurus yumanensis* (Collombola: Bourletiellidae), *Empoasca fabae* (Hemiptera: Cicadellidae), and *Atrachya menetriesi* (Coleoptera: Chrysomelidae) [8][9]. Pritchard (2017) stated that there is no impact from different trichomes density characteristics against soybean aphid, *Aphis glycines* (Hemiptera: Aphididae), and their natural enemies [10]. Based on these various effects, the uses of trichome characteristics on soybean leaves to potentially enhance plant resistance against pests need to be observed on the field before applied further.

2. Materials and methods

2.1. Experimental design

This research was conducted on July until November 2019 in the soybean field at Jati Village, Bojongpicung Subdistrict, Cianjur District, West Java, Indonesia (lat. 06˚51’01.7” S, long. 107˚15’19.5” E). Soybean varieties used in this research are ‘Anjasmoro’, ‘Argomulyo’, ‘Dena-1’, ‘Grobogan’, and ‘Devon-1’. Each of these five varieties cultivated with two different methods using corn plant (*Zea mays*) and *Crotalaria juncea* as a barrier plant and not using any barrier plants on the other one. A split-plot design with randomized complete block design pattern using four groups for each varieties and treatment is used as an experimental design for this research. The barrier plant treatment was treated as main-plot while soybean varieties was treated as sub-plot. Microclimate data was obtained from Balai Pelatihan Tanaman Pangan dan Hortikultura Bojongpicung, Cianjur District.

2.2. Soybean cultivation

Soybean seeds were planted with 30 cm spacing between them on the 7.5 m x 7.5 m sized field for each sub-plot. Three rows of corn and one row of *C. juncea* was planted on every corner of the sub-plot. The barrier plant was planted one week before soybean. Space given between treatment was 1.5 m between sub-plot and 5 m between main-plot.

2.3. Soybean pest community observation

Soybean pest was observed on the field started from two weeks after soybean was planted until nine weeks after planting. The active observation was used as a method in this observation. Nine plants were determined as a sample plant from each sub-plot using a cross-shaped pattern and then marked. All herbivorous insects were observed from the entire plant directly every once a week.

2.4. Data analysis

Soybean pests population were analyzed using ANOVA (α = 5%) with Tukey pairwise comparison as a post hoc test to compare the means of each treatment. The data analysis conducted using RStudio with “Agricolae” package and Microsoft Excel 2016. The data transformed using $\sqrt{(x+0.05)}$.

3. Results and discussion

3.1. Field condition

Microclimate data obtained from Balai Pelatihan Tanaman Pangan and Hortikultura Bojongpicung, Cianjur has shown that the maximum temperature on the field was 37.23 °C, minimum temperature 15.81 °C with an average of 26.03 °C during the research period. The maximum relative humidity (RH) was 98.2 %, minimum 22.6 % with an average of 73.21 %. The average rainfall amount when the research was conducted is 14.07 mm/month. Based on Schmidt-Ferguson rainfall classification, < 60
mm/month is categorized as drought [11], which means the location happened to be drought when the experiment was conducted. Lutfi et al. (2019) experiment on the screenhouse are using 3 of the same varieties as this experiment (‘Anjasmoro’, ‘Dena-1’, and ‘Devon-1’) and found out that ‘Anjasmoro’ and ‘Dena-1’ abaxial leaf trichomes were significantly lower than ‘Devon-1’ varieties [7]. Warid (2014) was also using 3 of the same varieties on their research as this experiment (‘Anjasmoro’, ‘Argomulyo’, and ‘Grobogan’) and found out that ‘Anjasmoro’ varieties leaf abaxial trichomes were significantly lower than ‘Argomulyo’ and ‘Grobogan’ [12]. In this experiment, we found out the same conclusion for trichomes density (data unpublished).

3.2. Population of soybean pests in the field
Aphid and Empoasca sp. are small hemipteran pests founded on the observation. The result in figure 1 shown that Empoasca sp. population has negatively affected by the higher number of trichome density. ‘Dena-1’ and ‘Anjasmoro’ varieties which have the lowest number of average trichome density observed have a highest Empoasca sp. population. In contrast, ‘Argomulyo’ and ‘Grobogan’ varieties which have a higher amount of leaf trichome density than ‘Dena-1’ and ‘Anjasmoro’ have a lower population of

![Figure 1](image-url)
Empoasca sp. and ‘Devon-1’ which have highest trichome density have the lowest Empoasca sp. population among them all. The negative effect from higher leaf trichome density on Empoasca fabae population has been reported before [8]. Another small hemipteran major pest, Bemisia tabaci, has a positive correlation with leaf trichome density which makes configuration of leaf trichome density as a potential to control B. tabaci population [6][7]. This contradiction that B. tabaci and Empoasca sp. population have needs to be considered if leaf trichome density is used to enhance the resistance of the plant against pest on the field. Empoasca terminalis founded on South Sulawesi can cause a 26 % yield loss on soybean without any pesticide [13] while B. tabaci can be a viral vector of Cowpea mild mottle virus (CPMMV) that also founded in Indonesia and can cause a significant amount of yield loss on soybean [14]. The population of aphid (figure 1) shown no significant reaction against trichome density. There have been several reports implied that there is no significant impact from leaf trichome density to Aphis glycines (soybean aphid) population on soybean plants [10][15].

![Diagram](image_url)

**Figure 2.** Herbivorous orthopteran population, (a) Atractomorpha sp., (b) Oxya sp. different letter on the top of graph marker denote statistically significant difference between varieties, (*) after WAP denote statistically significant difference between treatment with barrier plant and without barrier plant using Tukey pairwise comparison (P-value < 0.05). (WAP = week after planting).

Several species of Orthoptera were also found on this observation with Atractomorpha sp. (Orthoptera: Pyrgomorphidae) and Oxya sp. (Orthoptera: Acrididae) as the most notable species on the field. In figure 2, the population of both Atractomorpha sp. And Oxya sp. are shown inconsistent between varieties. There has been a significant difference on the six weeks after soybean planting on
varieties for *Atractomorpha* sp. and on five and eight weeks after planting for *Oxya* sp. This difference does not have any relation to leaf trichome density or varieties. The effect of soybean leaf trichomes against herbivorous orthopteran is poorly known. Smith and Grodowitz (1983) did an experiment using *Artemisia ludoviciana* (Asteraceae) as a feed to *Melanoplus sanguinipes*, a generalist species of grasshoppers, to examine the effect of non-glandular trichomes on its ingestion and growth under no-choice condition. The result showed that the trichomes are not deterring a generalist from feeding but may affect its growth negatively [16]. The effect of barrier plants was observed significantly different on seven, eight, and nine weeks after planting for both *Atractomorpha* sp. and *Oxya* sp. and two weeks after planting for *Oxya* sp. indicate that this treatment is effective to suppress this pest more than other species. The uses of the corn plant and *C. juncea* as barrier and refugia plant had been reported effective in suppressing populations of several pest insects, including whiteflies, in its relation to the search for host plants by pests that are longer than those planted with one type of plant. The use of these plants is known to be able to suppress the attack of the pest, reduce the time of the virus caused by whiteflies as a vector in spreading the chili crop [17].

Table 1. The average population of *Spodoptera litura* and *Chrysodeixis* sp.

| Treatment and varieties | 2WAP | 3WAP | 4WAP | 5WAP | 6WAP | 7WAP | 8WAP | 9WAP |
|-------------------------|------|------|------|------|------|------|------|------|
| **Tobacco cutworm (Spodoptera litura)** |     |      |      |      |      |      |      |      |
| With border plants (Corn and Crotalaria juncea) |     |      |      |      |      |      |      |      |
| Anjasmoro | 0 | 0 | 1 | 0.5 | 0.5 | 0 | 0.5 | 0.25 |
| Argomulyo | 0 | 0.25 | 0.25 | 0 | 0 | 0 | 0 | 0.25 |
| Dena-1 | 0 | 0 | 0.75 | 0.25 | 0.25 | 0 | 0.25 | 0.25 |
| Grobogan | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 |
| Devon-1 | 0 | 0 | 0 | 0.25 | 0 | 0 | 0 | 0 |
| Without border plants |     |      |      |      |      |      |      |      |
| Anjasmoro | 0 | 0 | 0.25 | 0 | 0.25 | 0 | 0.25 | 0 |
| Argomulyo | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dena-1 | 0 | 0.25 | 0.25 | 0.25 | 0 | 0 | 0 | 0 |
| Grobogan | 0 | 0 | 0.5 | 0 | 1.5 | 0 | 0.25 | 0.25 |
| Devon-1 | 0 | 0 | 0.25 | 0.25 | 0 | 0 | 0 | 0 |
| **Soybean looper (Chrysodeixis sp.)** |     |      |      |      |      |      |      |      |
| With border plants (Corn and Crotalaria juncea) |     |      |      |      |      |      |      |      |
| Anjasmoro | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0 |
| Argomulyo | 0 | 0 | 0 | 1 | 0.25 | 0 | 0 | 0 | 0 |
| Dena-1 | 0 | 0 | 0.25 | 0.25 | 0 | 0 | 0 | 0.25 | 0 |
| Grobogan | 0 | 0 | 0.25 | 0.5 | 0 | 0 | 0.25 | 0 | 0 |
| Devon-1 | 0 | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 |
| Without border plants |     |      |      |      |      |      |      |      |
| Anjasmoro | 0 | 0 | 0.75 | 0 | 0 | 0.25 | 0 | 0 | 0 |
| Argomulyo | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.25 | 0 | 0 |
| Dena-1 | 0 | 0 | 0 | 0 | 0.25 | 1 | 0.25 | 0 | 0.8 |
| Grobogan | 0 | 0 | 0 | 0.25 | 0.5 | 0 | 0 | 0 | 0 |
| Devon-1 | 0 | 0 | 0.25 | 0 | 0 | 0.5 | 0 | 0.5 | 0 |

Some larvae of Lepidoptera Order, or caterpillar, are also classified as the main pest of soybean. Tobacco cutworm *Spodoptera litura*, soybean looper *Chrysodeixis* sp. (Lepidoptera: Noctuidae), and leaf folder *Lamprosema indicata* (Lepidoptera: Pyralidae) were observed during the observation and the result shown on table 1 (for *S. litura* and *Chrysodeixis* sp.) and table 2 (for *L. indicata*). There is no significant difference among the varieties. Styrsky *et al.* (2006) stated that plant trichomes could enhance
tritrophic interaction between host plant, caterpillar, and red fire ant (*Solenopsis invicta*) as generalist predator and make a hypothesis that the predatory by fire ant was enhanced indirectly on the densely and moderately pubescent leaf happened because of the increasing caterpillar population on dense and moderate pubescent leaves. As the caterpillar population increasing, the red ant functional response also increased as density-dependent predation is an attribute of many generalist predators [18]. The average of caterpillar observed per sub-plot relatively low may also indicate that the caterpillar population was controlled by its natural enemies. These three caterpillar species are not reaching its economic threshold value based on another research [19] which means the natural enemies of these pests can suppress the pests population and reduce the losses on the field without any intervention from humans. Some species that can become caterpillar natural enemies was observed, that is *Sycanus* sp. (Hemiptera: Reduviidae), *Odontoponera* sp. (Hymenoptera: Formicidae), various spider, parasitic wasp, and many more. This observed effect may be different in another place with a small number of natural enemies on the field.

### Table 2. The average population of *Lamprosema indicata*

| Treatment and varieties | average individual number in *n* weeks after planting (individual/sub-plot) |
|-------------------------|--------------------------------------------------------------------------------|
|                         | 2WAP | 3 WAP | 4 WAP | 5 WAP | 6 WAP | 7 WAP | 8 WAP | 9 WAP |
| **Leaf folder (Lamprosema indicata)** |                  |                  |                  |                  |                  |                  |                  |                  |
| With border plants (Corn and *Crotalaria juncea*) |                  |                  |                  |                  |                  |                  |                  |                  |
| Anjasmoro              | 0    | 0     | 1     | 0.5   | 0.25  | 0     | 0.25  | 0     |
| Argomulyo              | 0.25 | 0.25  | 1.25  | 0.5   | 1     | 0     | 0     | 0.25  |
| Dena-1                 | 0.5  | 0.5   | 0.5   | 0.5   | 0.25  | 0     | 0     | 0     |
| Grobogan               | 0    | 0.5   | 0.5   | 1.25  | 1.25  | 0.25  | 0     | 0     |
| Devon-1                | 0.5  | 0.25  | 0.25  | 0.75  | 2.25  | 0     | 0.25  | 0     |
| Without border plants  |                  |                  |                  |                  |                  |                  |                  |                  |
| Anjasmoro              | 0.5  | 0.5   | 0.75  | 1.5   | 2     | 2.5   | 1     | 1.25  |
| Argomulyo              | 0    | 0.25  | 1.25  | 1.25  | 2     | 1.5   | 1.75  | 0.5   |
| Dena-1                 | 0.5  | 1.25  | 0.5   | 1.5   | 1     | 2.5   | 1.25  | 0.5   |
| Grobogan               | 0    | 0     | 0.5   | 0.5   | 2     | 1.25  | 0.75  | 0.5   |
| Devon-1                | 0.25 | 0     | 0.5   | 1.75  | 1.75  | 0     | 1.25  | 0.25  |

Soybean generative pest was also observed, namely *Riptortus linearis*, *Nezara viridula*, and *Piezodorus* sp. These pests are observed started on the six weeks after planting. Among the varieties, there is no significant difference to all three generative pests. This kind of pests is more subjected by the pod ripening age, which makes ‘Grobogan’ and ‘Argomulyo’ relatively safe because its ripening age was shorter on the field. Based on the observation, the barrier plant (corn and *Crotalaria juncea*) planting around the corner of the plot may slightly suppress the pest population on soybean plant in general. This means that leaf trichome density can be used alongside another pest control method.

### 4. Conclusion

Soybean leaf trichome density affecting *Empoasca* sp. population negatively and having a neutral effect against aphid, herbivorous orthopteran, and various foliage-feeders caterpillar population. Monitoring the existence of *Bemisia tabaci* and *Empoasca* sp. is needed when implementing the cultural control using leaf trichome density to control the pest population.

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