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Potential pest of high amylopectin and rich anthocyanin corn varieties

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Abstract. As part of plant breeding activities, the resistance of cultivated plants to pest attacks is one of the characteristics that must be prioritized. This research was conducted to study the type of pest and their damage intensity as the first step in the breeding program of waxy corn and black corn. The study was carried out through field survey activity on a weekly observation starting from plants aged 1 to 12 weeks old after planting. The type of pest found was identified and the damage intensity was calculated. The type of pests found consisted of grasshoppers, thrips, stem borer, earworm, and rat as well. There was no difference in population size and damage intensity of all pests in two corn varieties. The population size and damage intensity of all pests were affected by the age of corn plant because each pest was attacked at different times either when the plants were in the vegetative or generative phase or both. Generally, the damage intensity of pest is still in the mild to moderate category. A monitoring activity needs to be conducted in the subsequent activity to obtain information on the development of these potential pest species and their populations size.

1. Introduction

Corn is a very important food commodity in the world after rice and wheat. Due to its distribution in almost all over the world, a collection of local or introduced corn germplasm is needed to increase genetic diversity. Local varieties with good characteristics suitable with the environment of an area can be utilized because they have gone through the process of natural selection or selection by farmers during the cultivation process. Meanwhile, the introduction is done as an effort to collect varieties that can adapt to and be cultivated in environments that are different from their original environment. One of the Indonesian corn germplasm that has the potential to be developed is waxy corn (Jagung Pulut Sulawesi) and black corn as introduced varieties.

Waxy corn is one of the corn varieties that is colorfully attractive, contains large amylopectin, has fluffy taste, and has a distinctive aroma. However, waxy corn is less popular among people. Furthermore, this variety has low productivity so that the level of promotion and attention in breeding program development for this variety are still low [1]. Meanwhile, black corn is a corn variety that has deep black-purplish kernels color. This variety originates from the United States so it is sometimes referred to as Mexican corn. Black corn contains fat, fiber, calcium, zinc, selenium, potassium, folic acid, niacin and other elements. Black-purplish color on this variety is caused by the content of



anthocyanin compounds [2] that function as antioxidants, anticancer, and antidiabetic [3]. Based on the nutritional content of waxy corn and black corn, breeding programs to produce high-yielding varieties with high amylopectin and anthocyanins content as well need to be done as an effort in producing an alternative food.

One of limiting factors in corn production is the threat of pest attacks. Pests can be a threat because their attacks can reduce the quality and quantity of production. Baco and Tandiang [4] explain that there are around 50 types of insects that attack corn but only a few often cause economic losses in Indonesia. Loss of corn yields due to pest attacks ranges from 25-30% each year caused by several main pests such as stem borer (*Ostrinia furnacalis*), corn borer (*Helicoverpa armigera*), leaf eater such as army worm (*Myimna separata*, *Spodoptera litura*) and grasshopper (*Valanga nigricornis*) and cutworm (*Agrothis ipsilon*) [5].

Desirable characteristics of waxy corn and black corn can only be obtained if information including properties of morphology, agronomy, and resistance to pests and diseases is available [6]. Since pests are organisms that have high adaptability, are planting waxy corn and black corn in other places still possible to be attacked by corn pests as usual? are there other pests that might be associated with waxy corn and black corn if planted elsewhere? Therefore, because of the unavailability of information regarding the potential pest and their damage intensity to waxy corn and black corn in Indonesia, this research has been conducted to obtain these data as a first step in the breeding program of waxy corn and black corn.

2. Materials and Methods

2.1. Corn Planting and Determination of Sampling Plots

Corn planting was carried out on the experimental field of the Department of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta. Each corn variety was planted in a plot area (6 x 4 m) with 75 x 25 cm planting space. Each plot within varieties was separated 100 cm apart, and the plot between varieties was separated by 300 m to avoid unwanted cross pollination. Each variety was planted in three different plots, so there were six research plots in total.

Fertilization was done three times by the side dressing method. The first fertilization was basic fertilization during land preparation using compost with 12 kg/plot dose and SP-36 with 0.48 kg/plot dose. The second and the third fertilization were done when corn plants reached 10 and 30 days old using ZA and KCl with 0.7986 kg/plot and 0.12 kg/plot dosage respectively. These doses were similar to the method applied by Sirappa and Razak (2010) in their study. Replanting was carried out when the plant was 7 days old only. Irrigation was provided during the growth period through irrigation systems. Pesticides was not given during planting.

2.2. Insect Observation

Observations of potential pests were carried out on sample plants in systematic random sampling. Observation of pests began when plants were 1 week old and continued periodically during 12 weeks. Observations were conducted by direct observation to record the type of pest, the pest population size, and the damage intensity caused. Each pest found was collected and was taken to the laboratory for identification. Pest populations were calculated using this following formula [5]:

$$x = \frac{(x_1 + x_2 + x_3 + \dots + x_n)}{N}$$

Remarks:

x : Average number of pest/plant populations

x_n : Pest population in the nth sample plant

N : Number of plant samples observed

Damage intensity is categorized into a scale following the method of Natawigena [7] :

Table 1. Value of plant damage intensity scale

Scale	Percentage of Attack	Category
0	0	Normal
1	$1 < x \leq 25$	Mild
2	$25 < x \leq 50$	Moderate
3	$50 < x \leq 75$	Severe
4	$x > 75$	Very Severe

Damage intensity on leaves is calculated using the following formula:

$$DI = \left(\frac{\sum n.v}{Z \cdot N} \right) \times 100\%$$

Remarks:

DI : Damage intensity (%)

N : Number of plants attacked by each attack category

V : Scale value of each attack category

Z : Highest scale value (4)

N : Number of plants observed

Meanwhile, the damage intensity to corn (stem and cob) is calculated using the following formula:

$$DI = \left(\frac{A}{B} \right) \times 100\%$$

Remarks:

DI : Damage intensity (%)

A : Number of damaged stem or cob

B : Number of stem or cob observed

In addition, insect natural enemies found are also collected and identified.

2.3. Pest Identification

Insect identification was conducted at the Plant Protection Laboratory, Department of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta. Identification was done by observing morphological characters of pests found using Borror, Triplehorn [8] identification keys .

2.4. Data Analysis

Pest population and pest damage intensity were grouped according to type of pest. The data were then analyzed descriptively. Differences in population size and damage intensity of each pest on both corn varieties were analyzed by Analysis of Variance (One-way ANOVA). This analysis was used based on research conducted on 6 different plots in 12-time weekly observations. Statistical analysis was performed using R Statistics ver. 3.5.2.

3. Results and Discussion

Based on the observations, there were 9 potential pests found in the two corn varieties. These potential pests consisted of insects and mammals. Potential pests from insect group were belong to three orders, 5 families, and 8 species i.e., 5 species of grasshoppers, 1 species of thrips, 1 species of stem borer and 1 species of earworm. The potential pest of the mammal group was only from one species of rat. Those potential groups pest group of insects were found in both waxy corn and black corn at different times either in vegetative or generative phases. Meanwhile, the potential pest of mammalian groups was only found in waxy corn during the generative phase (Figure 1).

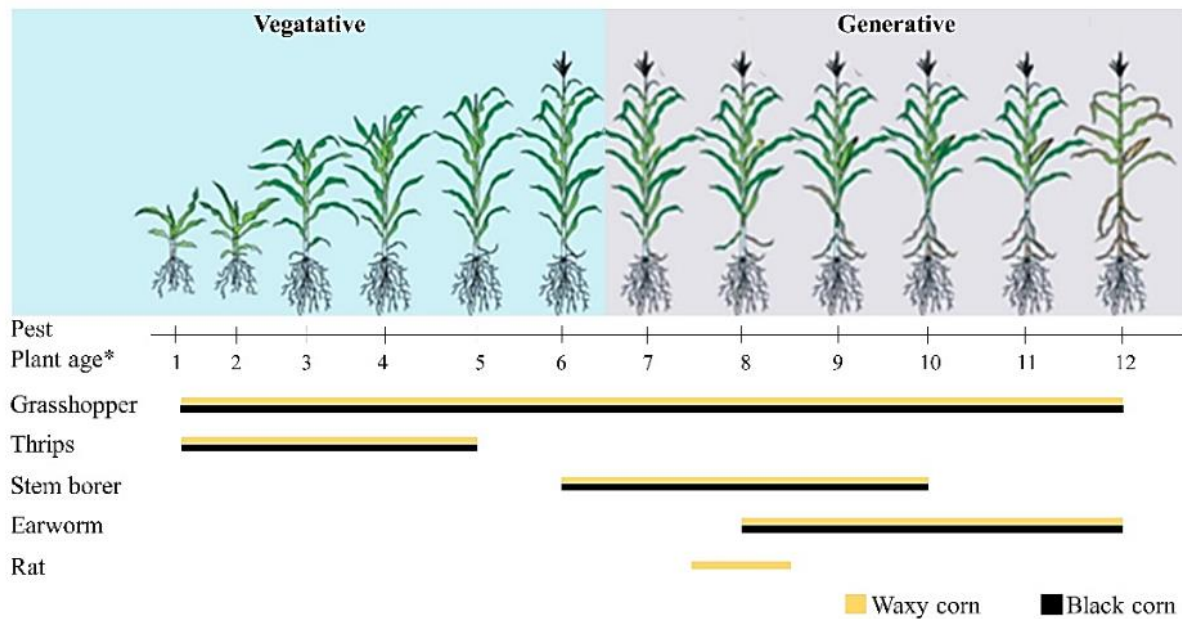


Figure 1. Potential pest found on waxy corn and black corn based on phenology of corn plant. *Plant age displayed as weekly after planting.

Grasshopper is a leaf-eating pest that is always found during the corn growth phase. Grasshoppers found were from two families and 5 species i.e., *Oxya chinensis*, *Acrididae01*, *Patanga* sp. (Orthoptera: Acrididae) and *Atractomorpha crenulata*, *Pyrgomorpha conica* (Orthoptera: Pyrgomorphidae). There was no difference in terms of the population size of grasshoppers in two varieties. ($F=0.169$, $df=1$, $P>0.05$). However, it is evident that such phenomenon was mainly affected by the age of corn plants ($F=50.170$, $df=1$, $P<0.001$). Each species of grasshopper found has a fluctuating population development and tends to decrease as the plant growing older (Figure 2). This is directly proportional to its damage intensity caused.

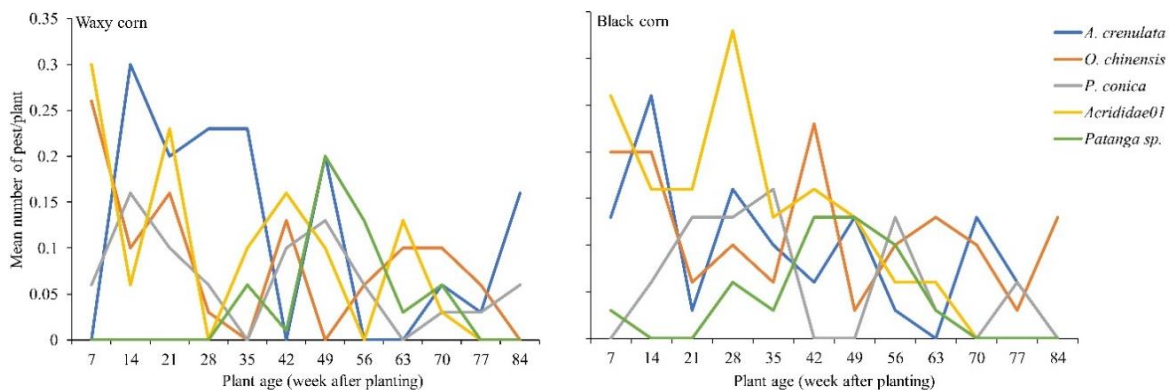


Figure 2. Population development of grasshopper on waxy corn (left) and black corn (right).

Plant damage caused by grasshopper was observed since the plants were one week old and continued to increase until the plants were six weeks old. As the population of grasshopper began to decline from that week, the damage intensity caused did not increase as well (Figure 3). Morrill [9] said that grasshoppers have the ability to spread irregularly (at an uncertain time). This pest is polyphagous so

that its damage intensity is spread evenly. As the plants grow older, the hardness of the plant tissue gets increasingly hard so that the plants are no longer preferred by grasshoppers. Based on the analysis of variance, plant damage intensity by grasshopper was affected by the age of the corn plant ($F=13.916$, $df=1$, $P<0.001$). Meanwhile, there was no difference in plant damage intensity caused by grasshopper on the two varieties of corn ($F=0.004$, $df=1$, $P>0.05$). In general, plant damage intensity by grasshopper is still relatively mild (see Table 1).

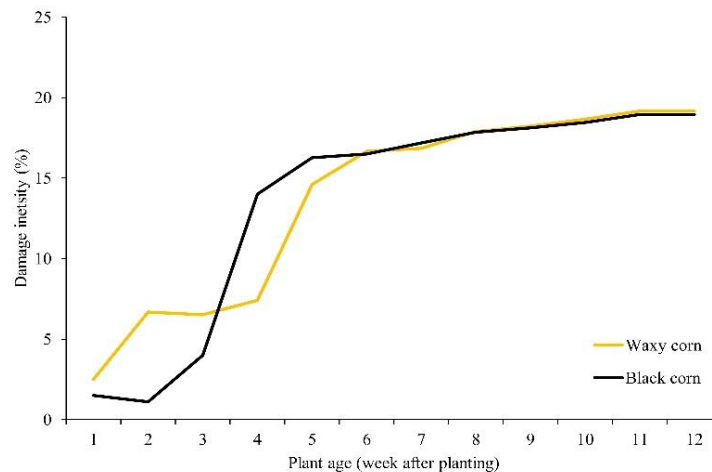


Figure 3. Damage intensity of grasshopper on waxy corn and black corn.

Caliothrips striatoptera (Thysanoptera: Thripidae) is a leaf-sucking pest found during the vegetative phase. In waxy corn, thrips were found when plants were 1-5 weeks old. Meanwhile, thrips were found in black corn when plants were 1-4 weeks old. There was no difference in terms of the thrips population in two corn varieties ($F=0.120$, $df=1$, $P>0.05$). However, the thrips population was affected by the age of corn plants ($F=37.172$, $df=1$, $P<0.0001$) (Figure 4A). In black corn, the highest average population of *C. striatoptera* was 24.76 thrips/plants found when plants were 2 weeks old. On the other hand, the highest average population of *C. striatoptera* was 18.3 thrips/plants found when plants were 3 weeks old in waxy corn. The high population of thrips was affected by environmental conditions at the time of observation which was at 23.6 °C temperature and 79.3% of relative humidity. Such conditions are reported to be quite suitable for thrips development [10]. Another thing which is worth noting is that the thrips population declined. This might be related to the life cycle of thrips themselves. Thrips complete their life cycle for 2-3 weeks [11], and adult thrips can live for 20 days [12]. In addition, the decline in thrips population was also affected by the presence of natural enemies such as the ladybug, *Harmonia octomaculata* (Coleoptera: Coccinellidae) which began to be discovered when the thrips population started to decline. *H. octomaculata* is a predator of scale insects such as aphids, whiteflies, leafhoppers, thrips, mites, *Helicoverpa* eggs and small larvae [13].

Thrips population development was directly proportional to its damage intensity caused. Damage intensity was increasing since the plants were 1 to 4 weeks or 5 weeks old. Damage intensity caused by thrips did not increase anymore as their population decreased (Figure 4B). Similar to thrips population size, damage intensity caused by thrips was also affected by the age of plant ($F=34.991$, $df=1$, $P<0.0001$). At the same time, there was no difference in damage intensity caused by thrips in those two corn varieties ($F=0.977$, $df=1$, $P>0.05$). Damage intensity to leaves by thrips was still relatively mild - moderate (see Table 1).

Damage to the stem is caused by Asian stem borers *Ostrinia furnacalis* (Lepidoptera: Crambidae). This pest starts to attack in the generative phase at the beginning of the formation of male flowers. *O.*

furnacalis is a pest that attacks the stem, male flowers, as well as the cob [14]. Based on the observations, *O. furnacalis* attacked male flowers and the stem of waxy corn. However, *O. furnacalis* only attacked the stem of black corn. Interestingly, the position of the bore on waxy corn was different from that of black corn.

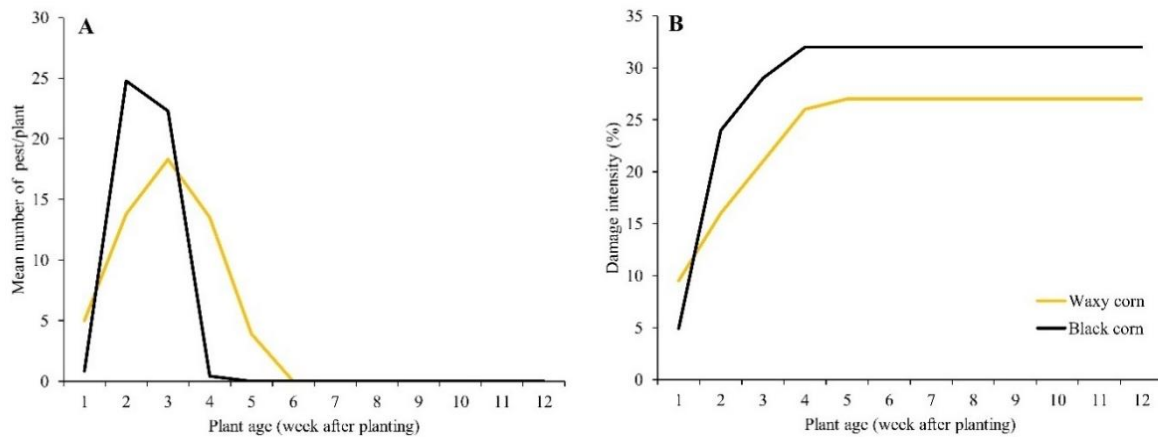


Figure 4. Population development (A) and damage intensity (B) of *Caliothrips striatoptera* on waxy corn and black corn.

The position of the bore on waxy corn was in the upper internode, while that of the black corn was near the cob with the number of holes was 1 hole per plant. Another study reported that *O. furnacalis* can make 5-8 holes per plant [15]. The population of *O. furnacalis* in waxy corn was higher than of black corn ($F=1.855$, $df=1$, $P=0.1$) (Figure 5A). *O. furnacalis* was found to attack waxy corn when the plants were 6 weeks old with the average number of larvae found was 0.13 larvae/plants, and it was found to attack black corn when the plants were 9 weeks old with the average number of larvae found was 0.06 larvae/plants. Litsinger, Dela Cruz [16] and Subiadi [17] reported that *O. furnacalis* begin to lay eggs when the plants are 3-5 weeks old. *O. furnacalis* eggs will hatch after 3-5 days oviposited [18]. The 1-2 instar larva was actively moved and ate young leaves or panicles. The 3 instar larva was the most destructive stage because they can make a hole in the stem [14]. *O. furnacalis* was not found at the early stage of growth because at that time the plants contained fairly high dimboia enzymes. This enzyme is a repellent compound for *O. furnacalis* [19]. *O. furnacalis* were also not found at the late stage of corn because at that time the nutrients in the leaves and stems had decreased so that the adult of *O. furnacalis* did not preferred to lay eggs anymore [16].

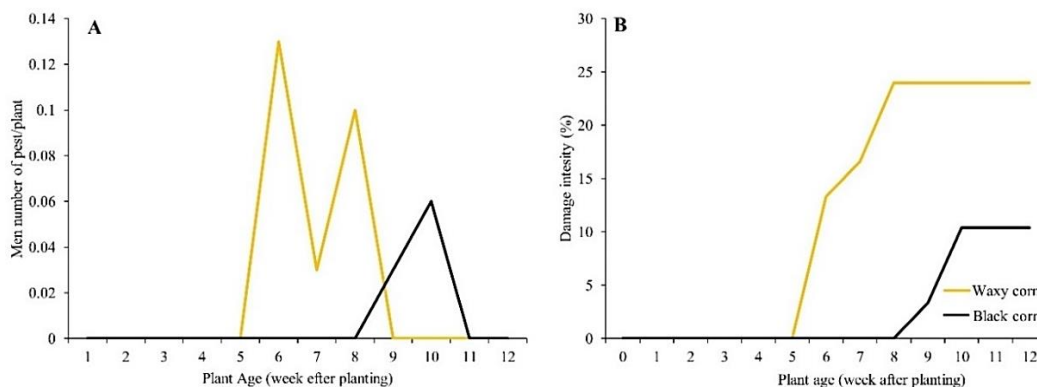


Figure 5. Population development (A) and damage intensity (B) of *Ostrinia furnacalis* on waxy corn and black corn

O. furnacalis was found in various stages such as eggs, larvae and pupae. No adult was found because they are active at night [20]. Generally, *O. furnacalis* population was found in 1-2 larvae/plants. This number was still relatively low. Therefore, plant age did not affect the population size of *O. furnacalis* ($F=0.973$, $df=1$, $P>0.05$). However, damage intensity by *O. furnacalis* was significantly affected by the age of corn plant ($F=121.014$, $df=1$, $P<0.0001$). Damage intensity by *O. furnacalis* was higher in waxy corn than of black corn. The population of *O. furnacalis* is considered to be dangerous if there are 5-6 larvae/plants [21] or 1 eggs cluster per 30 plants [22].

Similar to other pests, the population of *O. furnacalis* was also directly proportional to damage intensity caused (Figure 5B). Damage only occurred at the beginning of the generative period, and there was no increase in damage intensity as the population of *O. furnacalis* decreased. Damage intensity on waxy corn was also higher than black corn ($F=60.497$, $df=1$, $P<0.0001$). However, the attack rate of *O. furnacalis* in those two corn varieties was still relatively mild (see Table 1).

The other corn borer found was earworm *Helicoverpa armigera* (Lepidoptera: Noctuidae), a polyphagous pest that also attacks cotton, tomatoes, soybeans and sorghum [23]. *H. armigera* was only found during the generative phase in the two varieties. *H. armigera* was discovered when the plant was 8 weeks old. *H. armigera* was also reported to attack corn during the generative phase (8 weeks old) in hybrid P27 corn variety [24]. There was no difference in the population size of *H. armigera* in both corn varieties ($F=0.696$, $df=1$, $P>0.05$). The population of *H. armigera* was affected by the age of corn plants ($F=14.962$, $df=1$, $P<0.0001$). The population of *H. armigera* decreased until the plants were 10 weeks old and did not change until the plants reached 12 weeks old (Figure 6A). It indicates that as the plant grows older, the corn hair became dry and it was not suitable for oviposition so their population did not increase anymore. Adult of *H. armigera* lays egg singly at the beginning of female flower formation when the hair is about to emerge from the cob [24]. The highest average population of *H. armigera* was found 0.4 larvae/plants on black corn when the plant is 8 weeks old. Meanwhile, the highest population of *H. armigera* was found 0.33 larvae/plant on waxy corn. In general, one cob was attacked by one larva with a mark of one hole covered with *H. armigera* frass.

The damage caused by *H. armigera* was also directly proportional to the population size. The results of the analysis showed that the damage to waxy corn was not different from black corn ($F=0.221$, $df=1$, $P>0.05$). However, the damage intensity of *H. armigera* was strongly affected by the age of corn plants ($F=9.176$, $df=1$, $P<0.0001$) (Figure 5B). Nevertheless, damage intensity of *H. armigera* in those two corn varieties was still relatively mild in general (see Table 1).

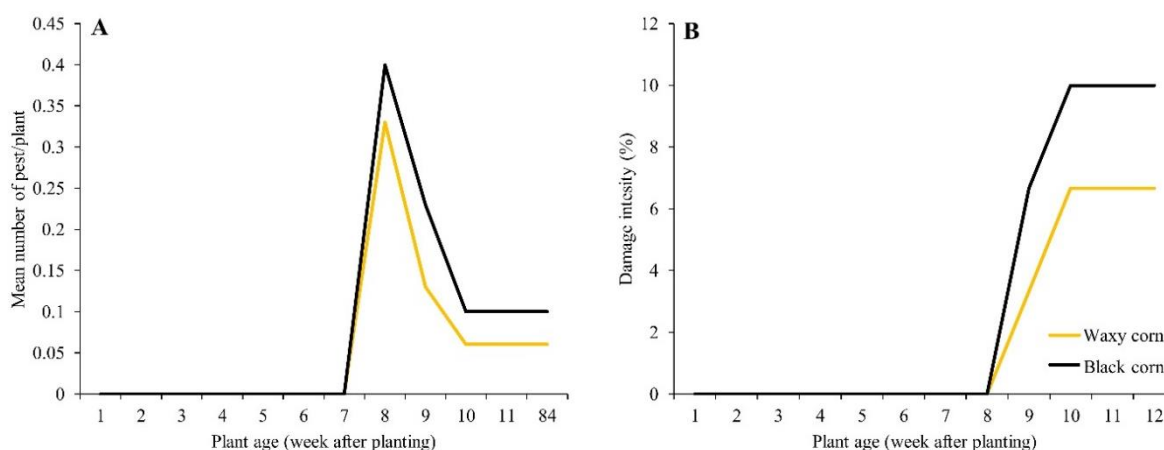


Figure 6. Population development (A) and damage intensity (B) of *Helicoverpa armigera* on waxy corn and black corn.

Damage to corn cobs was also caused by rat with very low damage intensity. Rat was only found to attack the waxy corn cobs when the plants were 8 weeks old. Meanwhile, there was no attack of rat on

black corn. We could not identify the rat species because we did not see the present of rat in the field during observation. We only found its symptom.

The insect natural enemy found in the two corn varieties was spiders *Oxyopes javanus* (Aranae: Oxopidae). Abdullah [25] said that the presence of spiders in corn plants is closely related to the population of lepidopteran pests. Another natural enemy found was *Mantis* sp. (Mantodea: Mantidae), *Orthetrum sabina* (Odonata: Libellulidae), as well as ants (Formicidae01) and (Formicidae02). The interaction between pests and natural enemies was not known in a more detail way because this research focused on the types of insects found.

4. Conclusion

Pests found in waxy corn and black corn were pests commonly found in corn. There were no new pests found. These pests included grasshoppers, thrips, stem borer, earworm and rat. In general, the attack rate occurred was still in the mild - moderate category.

Monitoring needs to be carried out in the cultivation of waxy corn and black corn to monitor the development of pest species and its population that have the potential to attack both waxy corn and black corn in the future. In addition, research on the diversity of natural enemies as well as interactions between pests and natural enemies in corn plants also needs to be conducted.

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