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Research Article

Impact of armyworm *Spodoptera litura* (Lepidoptera: Noctuidae) attack: Damage and loss of yield of three soybean varieties in South Sulawesi, Indonesia

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Abstract: This study aims to elucidate the relationship between the larval armyworm *Spodoptera litura* F. population density (0, 2, 4, and 6 per plant) with leaf damage level and yield loss in three soybean varieties, Anjasmoro, Argomulyo, and Grobogan. *S. litura* larvae were introduced both in the plant's vegetative phase (20 and 30 days after planting) and its generative phase. This research used a split-plot design with the varieties as the main plots and the larval population as the subplot, with five replications. The results showed that the highest leafdamage was in the Anjasmoro, 6.5% to 8.87% in the vegetative phase and 6.95-7.81% in the generative phase. Meanwhile, Argomulyo had 5.96% to 6.68% and 5.78% to 6.39% of damage in both phases, and Grobogan was less susceptible, with 5.90% to 5.98% and 5.28% to 6.17% at the vegetative phase and generative phase, respectively. The highest decline in seed yield was in Argomulyo (0.81% and 0.79% in the vegetative and generative phase) and the lowest was Anjasmoro (0.66% and 0.64% in the vegetative and generative phase). For the population density, the highest level of soybean varieties seed yield loss in South Sulawesi was with 6 larvae per plant, which was at 23.44% in the vegetative phase and 23.48% in the generative phase. Among the varieties, the highest of seed yield loss was with Argomulyo (14.93%) and the lowest at Anjasmoro (11.30%). It can be concluded that the relationship between the *S. litura* larvae population density and the decrease of seed yield is quite strong (90.2% to 96.4% for vegetative phase and 94.8% to 96.4% for generative phase).

Keywords: soybean, varieties, armyworm, population density, damage intensity, seed yields

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Introduction

Armyworm *Spodoptera litura* F. (Lepidoptera: Noctuidae) is a polyphagous insect pest that can cause high damage and yield loss in some types of plants. There are about 60 insect species that cause significant damage to soybeans in the tropics (Panizzi and Corrêa-Ferreira, 1997). Whereas in India, about 150 species of insects cause serious damage to soybeans from the plantation to harvest time (Ahirwar*et al.*, 2013). Armyworm is one of the most important pests in soybeans in India (Choudhary and Shivastava, 2007). *S. litura* is also a common pest in other crops, resulting in yield loss of about 10% to 30% (Jeyanthiand Kombairaju,

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2005). In Bangladesh, about 15-20% of total soybean production is reduced due to caterpillar pests, including *S. litura* (Biswas, 2013). In Brazil, *S. litura* can cause damage to soybean leaves of approximately 35% of the total leaf count (Bueno*et al.*, 2011). In Indonesia, armyworm is a dominant pest on soybean, with a leaf damage rate of about 80% (Bayu and Krisnawati, 2016). While in South Sulawesi, the damage to soybean leaves ranged from 12.11% to 45.26% (Fattah and Hamka, 2012). Several approaches have been tried to overcomethe intensity of armyworm attacks, such as testing theresistanceof different soybean varieties. The results showed that two varieties were resistant to armyworm attacks, namely GepakIjo (9.10%) and Gepak Kuning (9.20%) (Rahman and Fattah, 2014). However, these two varieties were less favored by farmers in South Sulawesi because the seeds were small, ranging from 6.82 to 8.25g per 100 seeds (RCPTC, 2013).The preferred varieties in South Sulawesi had larger seeds, 15.0-18.0g per 100 seeds. Besides, the effectiveness of vegetable insecticides against armyworms was investigated and the extracts of neem seeds, cashew, and clove flowers were found to significantly reduce the intensity of army caterpillar attacks by 11.39% (Fattah *et al.*, 2013). However, the results of the study were not continued to the actual farm because the raw materials were not available and the farmers used the chemical insecticides. Sadly, the chemical insecticides are excessively used because they were applied 2-3 times per week,higher than the recommended threshold by the government,at one instar-3 larva per clump (Marwoto and Suharsono, 2008).

In this context, we developed a study to 1) determine which location-specific soybean varieties in South Sulawesi with large seed, tolerant to armyworm attack, and produce high return value; and 2) produce a regression model of the relationship between larva population and seed yields loss. This study focused on three large-seeded soybean varieties, Anjasmoro, Argomulyo, and Grobogan, which are dominantly planted by farmers in South Sulawesi. and have large seed weight (14.8-15.3 g, 16.0 g, and 18.0 g per 100 seeds, respectively) (RCPTC, 2013). Meanwhile, the research focused on testing the effect of different levels of the population of *S. litura* larvae, namely 0, 2, 4, and 6 larvae per plant to create the regression model.

Materials and Methods

Experimental design

This research was conducted at the Tanah Maros Experimental Garden, South Sulawesi, from August to December 2016. The study was divided into two blocks, the first block was in the vegetative phase of the plant and the second block was in the generative phase. Each research block used a separated plot design with three soybean varieties (Anjasmoro, Argomulyo, and Grobogan) as the main plot and the level of larval population density (0, 2, 4, and 6 larvae per plant) as the subplots with 5 replication. The main plot was 3 m × 5 m and the subplot was 1 m × 5 m. Each variety was planted in a 1 m × 5 m subplot with a 40 cm × 50 cm spacing, so there were 20 individual plants in one plot. From the 20 individual plants, 6 clumps were randomly selected to be covered and selected as treatment plants, which were infested with larvae in different density: 0, 2, 4, and 6 per plant. In each research block, the infested plants were given a 100 cm × 100 cm × 50 cm gauze cloth with wooden frame covers to protect the treatedplants from other pests. To optimize the growth of soybean plants, 10 g NPK fertilizer was applied per clump.

S. litura infestation

The *S. litura* larvae were maintained in the laboratory of Assessment Institute for Agricultural Technology (AIAT), South Sulawesi, Indonesia. When the larvae reached the instar-3 stage, they were introduced to the plants, 20 days after planting forthe vegetative phase and 35 days after for the generative

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phase. The number of larvae per plant was adjusted according to the treatment. The plants were infested in the afternoon at16.00-17.30, to avoid stressing the armyworm larvae due to the sun.

Data collection

The observations on the attack intensity were carried out at 3, 6, and 9 days after infestation. Also, we observed the seed yield per plant. Leaf damage intensity was determined based on the following formula:

$$I = \frac{\sum_{i=0}^{x}(n_1 x v_1)}{ZXN} \times 100\% \quad (1)$$

Where I is the intensity of attack; n_1 is the number of plant leaves observed with scale v_1; v_1 is the value of the leaf damage scale to i; N is the observed plant leaves, and Z is the highest leaf value.

The scale value was 0 = no damage to leaves; 1 = Leaf damage > 0 - 20%; 3 = Leaf damage > 20 - 40%; 5 = Leaf damage > 40 - 60%; 7 = Leaf damage > 60 - 80%; and 9 = Leaf damage > 80 - 100%

The determination of yield loss (KH) was calculated by the following formula:

$$KHi = \frac{Hp - Hi}{Hp} \times 100\% \quad (2)$$

Where KHi is the percentage of loss for treatment i; Hp is the potential harvest obtained from the control; and Hi is the harvest from treatment i.

The calculation of regression values (r) was done using the formula from Gomez and Gomez (2010) as the following.

$$r = \frac{\sum xy}{\sqrt{\left(\sum x^2\right) \times \left(\sum y^2\right)}} \quad (3)$$

Statistical analysis

All observed data were analyzed using variance analysis (ANOVA). The average ratio of leaf damage intensity caused by *S. litura* and the other parameters were tested using the LSD test at a probability level of 5%.

Results

***S. litura* attack intensity on leaves and its effect on seed yields**

Table 1 shows themost intense attack in the vegetative phase was on the Anjasmoro and significantly different from Argomulyo and Grobogan at everyobservation period. In contrast, Argomulyo and Grobogan varieties were significantly different at 6 and 9 days after infestation. Regarding the intensity of attack inthe generative phase, Anjasmoro variety was still the most damaged (27.23-31.25%) compared to the other varieties and the least affected was Grobogan (22.91-24.81%) at every observation period. The similar intensity in both phases indicating that armyworms did not distinguish between the vegetative or generative phase; the plant will be attacked if the conditions are favorable (Table 1).

The intensity of attack and seed yield loss indifferent population

The highest intensity of armyworm attack in both vegetative and generative phases was at 6 larvae per plant and significantly different from the rest of population density levels at all levels of observation. This result demonstrated that the higher the larval population on the plant, the moreintensee the attack on soybean leaves will be (Table 2). Table 3 showed that the average seed yield and yield loss percentage following the *S. litura* attack on both phases of soybean in South Sulawesi. The rate of seed yield loss was influenced by the leaf damage level due to the larva attack.The highest rate of seed yield loss is at the population density of 6 larvae per plant (23.44% for the vegetative phase and 23.48% for the generative phase). The high loss of seed yields at the population density of 6 larvae per plant was caused by the high leaves damage due to *S. litura* attacks around 38.35% to 43.52% (Table 2).

Table 1 Average damage intensity of *Spodoptera litura* on leaves and seed yield in both phases.

Varieties	Damage intensity on leaves (%)[1]						Seed yields (g.plant^{-1})	
	3 DAI		6 DAI		9 DAI			
	VP	GP	VP	GP	VP	GP	VP	GP
Anjasmoro	26.68 a	27.23 a	32.69 a	31.25 a	30.67 a	28.90 a	18.60 b	18.00 a
Argomulyo	23.70 b	21.05 b	26.34 b	25.16 b	26.17 b	24.35 b	19.17 a	18.37 a
Grobogan	23.04 b	24.81a	23.69 c	23.90b	23.95 c	22.91b	17.30 c	17.07 b

1 Means followed by the same letters in each column showed no significant difference at 5%, LSD Test. VP: Vegetative phase, GP: Generative Phase, DAI = Days after infestation

Table 2 The average intensity of damage by *Spodoptera litura* on leaves of soybean in both phases.

Population density (larvae plant^{-1})	Damage intensity on leaves (%)[1]					
	3 DAI		6 DAI		9 DAI	
	Vegetative phase	Generative phase	Vegetative phase	Generative phase	Vegetative phase	Generative phase
0	0.00 d	0.00^{d}	0.00 d	0.00^{d}	0.00 d	0.00^{d}
2	25.82 c	24.39^{c}	30.96 c	27.59^{c}	27.88 c	29.10^{c}
4	33.43 b	32.96^{b}	35.71 b	37.51^{b}	36.33 b	34.10^{b}
6	38.64 a	39.96^{a}	43.63 a	41.98^{a}	43.52 a	38.35^{a}

[1] Meansfollowed by the same letters in each column showed no significant difference at 5%, LSD Test.
DAI = Days after infestation.

Table 3 Average seed yield and yield loss percentage following *Spodoptera litura* attack on vegetative and generative phases of soybean in South Sulawesi.

Population density (larvae.plant^{-1})	Seed yields (g.plant^{-1})		Yield loss (%)	
	Vegetative phase	Generative phase	Vegetative phase	Generative phase
0	20.47^{a}	20.94^{a}	0.00^{c}	0.00^{c}
2	17.81^{b}	18.97^{b}	12.85^{b}	13.93^{b}
4	17.55^{b}	17.48^{c}	14.12^{b}	14.67^{b}
6	15.68^{c}	16.02^{d}	23.44^{a}	23.48^{a}

Superscipt same letters in each column showed no significant difference at 5%, LSD Test.
Kalau dibutuhkan (Ada tambahan Tabel).

Table 4 Averageyield loss percentage following *Spodoptera litura* attack on soybean varieties in South Sulawesi.

Varietas	Yield loss (%)[1]	
	Vegetative phase	Generative phase
Anjasmoro	10.72 b	11.30 b
Argomulyo	13.57 a	14.93 a
Grobogan	12.67 a	12.84 b

[1] Means followed by the same lettersin each column showed no significant difference at 5%, LSD Test.

Regression analysis

Three days after infestation in the vegetative phase, the regression equation for Anjasmoro varieties was Y = 6.502x, while forArgomulyo was Y = 5.9649x, and for Grobogan was Y = 5.9097x with the regression (r) values of 0.92309, 0.9291, and 0.9378, respectively. The equation indicatedthat each addition of 1 larvaper plant would cause damage of around 6.50% to Anjasmoro, 5.96% to Argomulyo, and 5.91% to Grobogan leaves. In the generative

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phase, the regression equation for Anjasmoro was Y = 7.66x, while for Argomulyo was Y = 5.834x, and for Grobogan was Y = 5.6995x, with the regression (r) values of 0.9808, 0.8009, and 0.9590, respectively. Based on this equation, it could be assumed that each addition of 1 larvaper plant would cause damage of 7.66% to Anjasmoro, 5.83% to Argomulyo, and 5.69% to Grobogan leaves (Fig. 1).

The r values for all varieties ranged from 0.92309 to 0.9378 in the vegetative phase and 0.8009 to 0.9808 in the generative phase. The r values confirm that 80-98%, damage to soybean leaves was influenced by *S. litura* attack on all varieties and phases. After six days of infestation, the population density and attack intensity showed a positive correlation, in both phases. However, there was a tendency for higher *Y* values in the generative phase than the vegetative phase within the same variety (Fig. 2). It can be seen that the Anjasmoro variety had a value of Y = 7.6851x in the vegetative phase and Y = 7.8125x in the generative phase. Using this equation, it could be assumed that each addition of 1 instar-3 larva could cause 7.69% leaf damage in the vegetative phase and 7.81% in the generative phase. In Argomulyo varieties, the value of Y = 6.6843x in the vegetative phase, was higher than in the generative phase (Y = 6.3948x). Which indicated that each addition of one larva would cause 6.68% leaf damage in the vegetative phase, higher than the damage in the generative phase (6.39%) (Fig. 2).

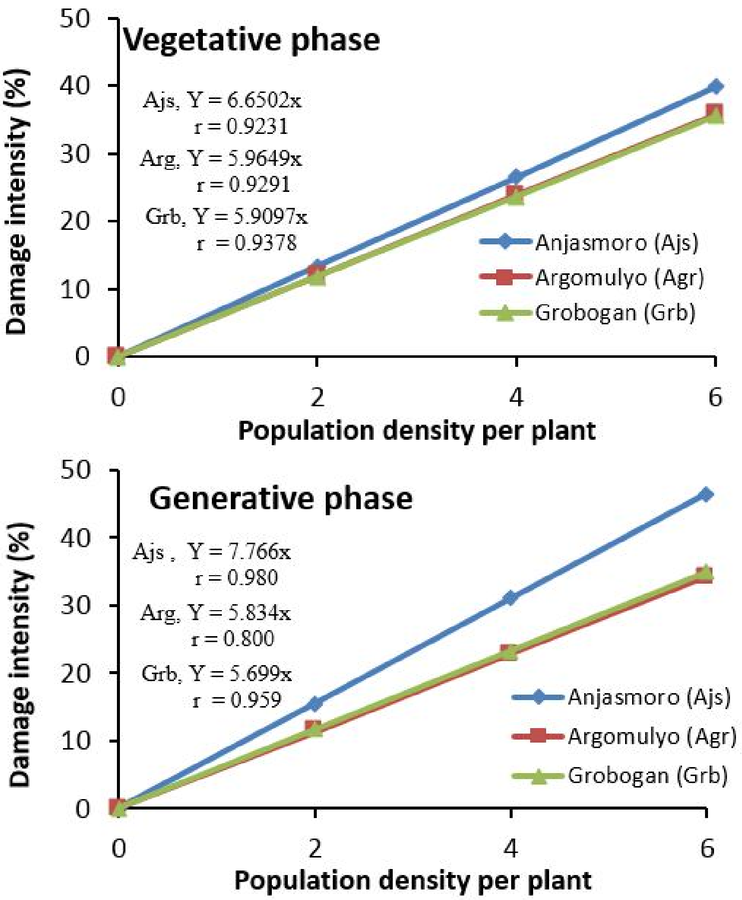

Figure 1 The relationship between *Spodoptera litura* larvae population and leaf damage in vegetaive and generative pahses of soybean three days after investation of larvae.

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Nine days after infestation, the equation for leaf damage in Anjasmoro variety was Y = 8.869x in the vegetative phase andY = 6.9523x in the generative phase. For Argomulyo, the value of Y = 6.6392x in the vegetative phase was higher than the value of Y = 5.7788x in the generative phase. Similarly, for the Grobogan varieties had Y = 5.9237x in the vegetative phase and Y = 5.2763x in the generative phase. This equation showed that an addition of one instar-3 larva per plant would cause around 8.7% in Anjasmoro, 6.64% in Argomulyo, and 5.92% leaf damage in the vegetative phases of Grobogan varieties and this damage was higher than in the generative phase (Fig. 3). Fig. 4 shows the relationship between the population density of larvae of *S. litura* and seed yields and showed a negative correlation for each variety. This meant that each addition of 1 instar-3 larva in the vegetative phase would result in the decrease in seed yield per plant of 0.663 g for Anjasmoro, 0.808 g for Argomulyo, and 0.766 g for Grobogan. The decrease of seed yield per plantif attacked in the generative phase would be 0.640 g in Anjasmoro, 0.793 g in Argomulyo, and 0.765 g in Grobogan. From the obtained equation, the highest decrease in seed yield due to *S. litura* attack was in the Argomulyo variety, with the loss of 0.808 gin the vegetative phase and 0.793 g in the generative phase.

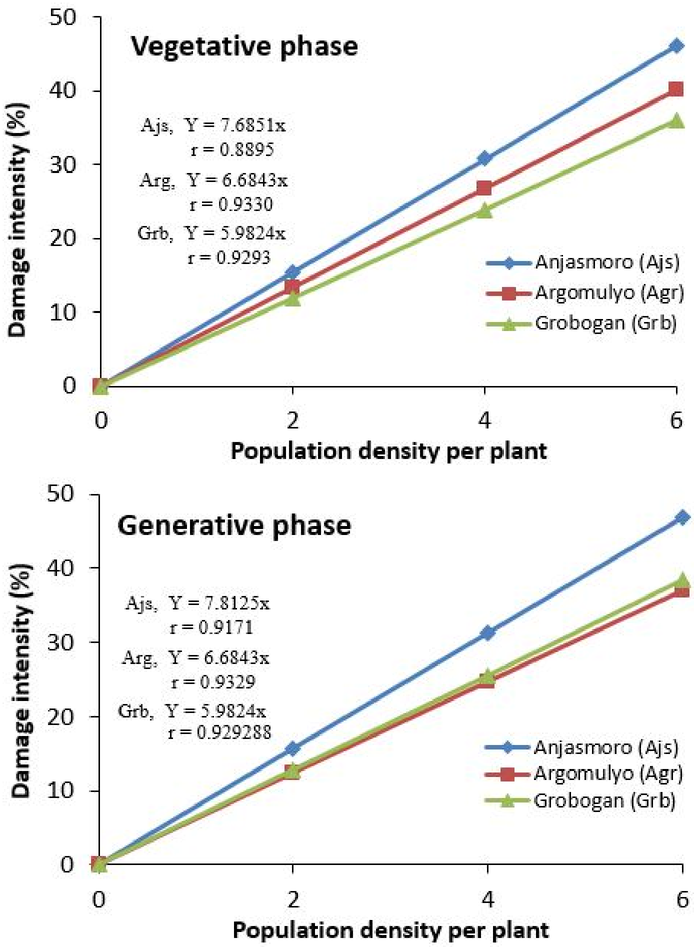

Figure 2 The relationship between *Spodoptera litura* larvae population and leaf damage in vegetaive and generative pahses of soybean six days after investation of larvae.

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The decrease of seed yields due to *S. litura* attack on soybean leaves in the Argomulyo and Grobogan varieties was higher in the vegetative phase than in the generative phase, different from the Anjasmoro variety, which was the opposite. The relationship between larval population density and the decrease in seed yield was quite strong, the r-value was 0.933-0.964 in the vegetative phase and 0.948 to 0.964 in the generative phase. It meansthat more than 90% decrease in seed yield was caused by *S. litura* attack on the leaves on both phases.

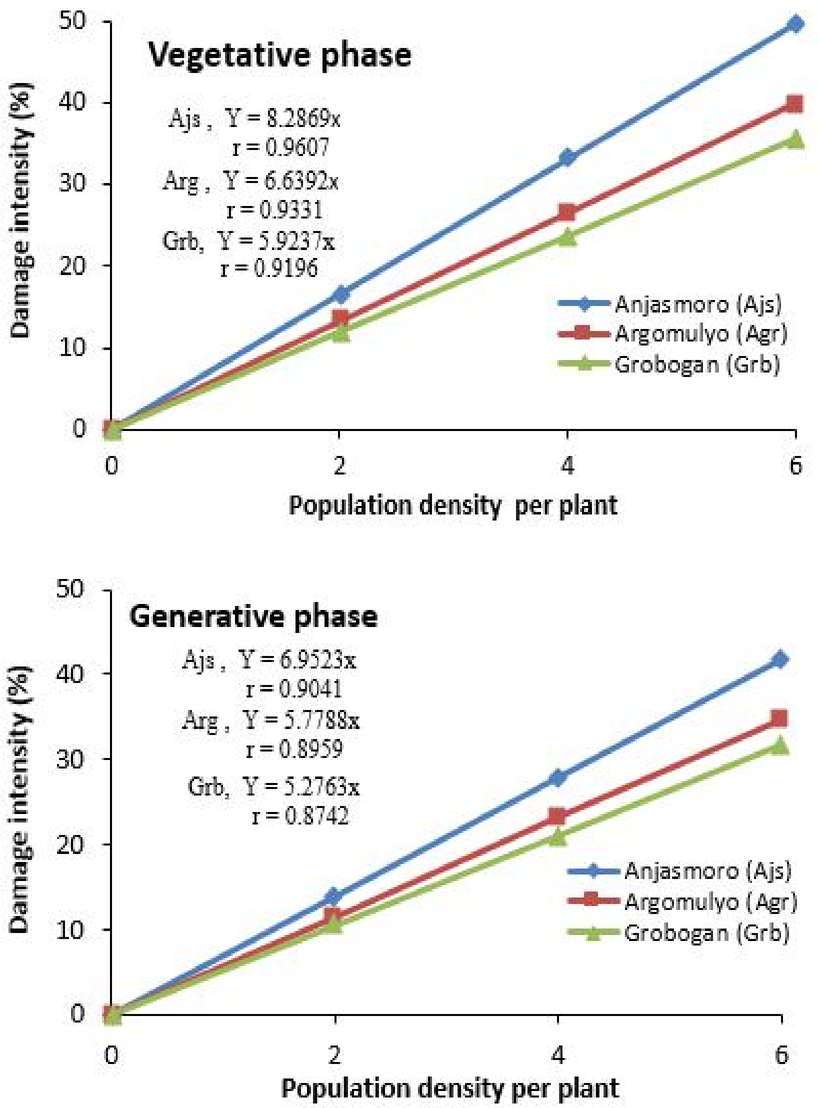

Figure 3 The relationship between *Spodoptera litura* larvae population and leaf damage in vegetative and generative pahses of soybean six days after investation of larvae.

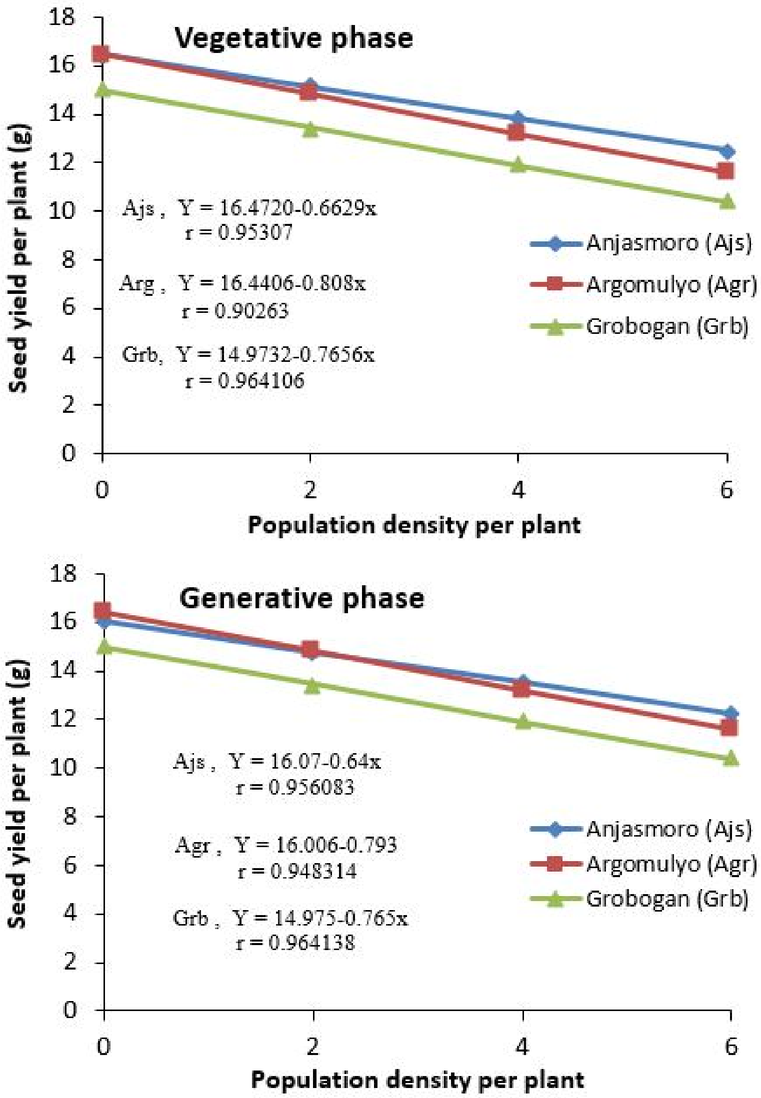

Figure 4 Relationship between *Spodoptera litura* larval population density and seed yield for the vegetative and generative phases of soybeans.

Discussion

The *S. litura* attack rate in the planted soybean varieties in South Sulawesi was variousand the Anjasmorovariety was more sensitive to *S. litura* attack than the Argomulyo and Grobogan varieties. This is because Anjasmoro has fewer leaf feathers or trichomes (28.95 per cm) than Argomulyo (37.80 per cm) and Grobogan (56.80 per cm) (Fattah, 2018). According to Mitchell *et al.* (2016), trichomes in leaves inhibit larval leaf consumption, while according to Krisnawati *et al.* (2017), the trichomes are part of the mechanism of antixenosis resistance which inhibits larval feeding and egg-laying by mature insects. A similar finding was reported by Adie *et al.* (2012) that trichomes inhibit larvae from feeding, discourage imago insects from laying eggs, and poison larvae from glands produced by the trichomes.

Argomulyohad the highest seed yield of the three varieties, while the Anjasmoro had a higher seed yield than Grobogan. Interestingly, the intensity of *S. litura* attacks on the first two varieties was higher than Grobogan. The high yield in the Anjasmoro was due to several factors, such as higher plant height, number of branches, and a higher number of podsper plant in Anjasmoro compared to Grobogan. According to Fattah *et al.* (2018), Anjasmoro varieties have 73.35 cm plants with 6.2 branches and 81.8 pods, whileGrobogan only 43.1 cm tall with 55 branches and 70.9 pods.

The seed yield achieved in the vegetative phase was higher than in the generative phase in each variety. This was due to differences in the capacity for damage compensation. The vegetative phase had a higher capacity to recover from the caterpillar attack than the generative phase, including the formation of new shoots and branches. Plant growth and development havepeakedin the generative phase,thus restricts the formation of new shoots. Similarly, Minarno and Khoiriyah (2011) found that plants, that have been attacked by armyworms during the vegetative phase, have a higher capacity to form new tissues such as leaves, stems, and new branches than those in the generative phase, so the chance to produce seeds in the vegetative phase is higher than in the generative phase.

The intensity of attack in the vegetative phase was higher than in the generative phaseas the leaves are softer in the vegetative phase, so they are more palatable and favored by the *S. litura* larvae. This is in agreement with Fattah (2018) who found that hard soybean leaves are less desirable to armyworm larvae and can increase larva mortality.

The rate of seed yield loss was influenced by the level of leaf damage by the larval attack. The higher the population of larvae, the higher the level of leaf damage. Likewise, the higher the population of larvae, the higher the rate of seed yield loss. This finding was in linewith Tengkano and Harsono (2005) whoreported that if the leaf damage reaches 50% in the vegetative phase, it will result in a 3-9% loss of yield, and an18% yield loss if it occurs in the generative phase. Furthermore, Marwoto and Suharsono (2008) stated that leaf defoliation due to armyworm attacks occurring in the flowering and pod formation phase will result in greater yield loss than in the pod-filling phase. Bapatla *et al.* (2017) explained that damage to soybean leaves due to S. *litura* attack has a significant effect on seed yield. According to Hendrival *et al*. (2013), seed yield loss due to *S. litura* pests can reach 80%, depending on the level of leaf damage, its variety, and the time of attack. Furthermore, Zestyadi *et al*. (2018) stated that the leaves damage caused by *S. litura* attacks can reach 100% if the area has become endemic and result in loss of soybean to 100%. Fitriani *et al*. (2011) also have shown that yield losses due to *S. litura* attacks on leaves and pods in peanuts can reach 71%.

Sundari *et al.* (2017) reported that if 2-4 *S. litura* larvae were present in the plant, it would result in a 23.0-24.20% decrease in seed yield and if 8 larvae per plant, then the decrease would be 50.40%.Armyworm attack in the generative phase causesthe high level of leaf defoliation and inhibits the photosynthesis and metabolism. This will directly affect the formation of flowers, pods, and pod filling, resulting in reduced seed yield (Nugrahaeni *et al*, 2013).

Bayu*et al*. (2012) stated that the relationship between 1-2 larvae population per plant with damage level in leaves had an r-value of 0.6037. Meanwhile, the relationship between a population of 3-4 larvae per plant with the level of leaf damage had the r-value = 0.6163.These result shows that the relationship between the number of larvae per plant with the level of damage to soybean leaves is quite high. Damage to the leaves of soybean plants, 60.37% (1-2 larvae per plant) and 61.63% (3-4 larvae per plant) is affected by *S. litura* armyworm larvae attacks.

According to Bier *et al.* (2010), the lowest seed yield was in Anjasmoro (0.6629 g per plant) for the vegetative phase after 3 larvae of *S. litura*per plant investation. The attack can lead to high levels of leaf damage in the growth phase of soybean. Lee *et al.* (2006) reported the

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yield loss rate follows the equation Y = 1.655x – 0.475 or Y = 0.475 – 1.655x with r = 0.952 on the flowering phase of soybeans. Meanwhile, the yield loss rate follows the equation 0.725x – 0.475 or Y = 0.475 – 0.725x with r = 0.986 in the pod-forming stage, and the rate of decline follows the equation Y = 0.635x – 1.325 or Y = 1.325 – 0.635x with r = 0.986in the seed-forming stage.

S. litura is one of the important pests in soybean which could cause leaf damage as much as 70% of the total plant (Santi and Krisnawati, 2016). According to Marwoto and Suharsono (2008), every 1 instar III larva addition could cause 12,5% leaf damage to soybean. *S. litura* could cause 35% leaf damage in Brazil (Bueno *et al*., 2011). The higher the leaf damage to Anjasmoro and Kipas variety soybean, the lower the bean and seed yield per plant and per hectare will be (Hedrival *et al*., 2013).

Fattah and Ilyas (2016) reported the negative correlation of the leaf damage by *s. litura* infestation with seed yield; Grobogan variety had 8.61% leaf damage and 1.64 t ha^{-1}, while Sinabung and Wilis had 12.16% damage with 0.77 t ha^{-1} yield and 14,41% damage with 0,94 t ha^{-1} yield, respectively. Ahmad and Mehmood (2015) stated that every 2 addition of *S. litura* larvae per plant could decrease the yield by 13% yet Santi *et al* (2013) reported the damage tothe leaf could be as much as 60% for 1-2 larvae addition. Arifin and Rizal (1989) stated that every 2 until 4 addition of *S. litura* larvae to soybean could decrease the harvest yield by 9.68 g in the vegetative phase and 10.02 g in the generative phase.

Conclusion

The highest level of soybean leaf damage after the*S. litura* attack was in Anjasmoro varieties, in both vegetative and generative phases.The highest rate of seed yield loss was at thepopulationof 6 larvae per plant in both phases, and The highest seed yield loss per plant was in Argomulyo variety. Each addition of 1 larva would increase the leaf damage and decrease the yield results of all varieties in vegetative and generative phases.

Conflict of Interest

The Authors state that there is no conflict of interest

Author's Contributions

All author contributes equally to this research.

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تأثیر لارو برگخوار مصری *Spodoptera litura* (Lepidoptera: Noctuidae) بر خسارت و عملکرد سه گونه سویا در سولواوسی جنوبی، اندونزی

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چکیده: این مطالعه با هدف بررسی رابطه بین تراکم لارو برگخوار مصری پنبه (۰، ۲، ۴ و ۶ در بوته) *Spodoptera litura* F. با سطح آسیب برگ و کاهش عملکرد در سه رقم سویا، آنژاسورو، آرگومولیو و گرووبوگان انجام شد. لاروهای *S. litura* در مرحله رویشی (۲۰ و ۳۰ روز پس از کاشت) و هم‌چنین در مرحله زایشی به گیاهان مورد آزمایش اضافه شدند. در این پژوهش از طرح کرت‌های خرد شده با انواع مختلف کرت‌های اصلی و جمعیت لارو به‌عنوان کرت‌های خرد شده استفاده شده است که دارای پنج تکرار است. نتایج نشان داد که بیش‌ترین میزان خسارت برگ در آنژاسورو ، ۵/۵ درصد تا ۸/۸۷ درصد در مرحله رویشی و ۶/۵ تا ۸/۸۷ درصد در مرحله زایشی بوده است. این درحالی است که آرگومولیو دارای ۵/۹۶ تا ۶/۶۸ درصد و ۵/۷۸ تا ۷/۸۱ درصد خسارت به‌ترتیب در مرحله رویشی و زایشی بوده است. گروبوگان کم‌تر حساسیت داشته و در فاز رویشی و فاز زایشی به‌ترتیب ۵/۹۰ تا ۵/۹۸ درصد و ۵/۲۸ تا ۶/۱۷ درصد خسارت به‌ترتیب در مرحله رویشی و زایشی بوده است. بیش‌ترین کاهش عملکرد بذر در آرگومولیو (۰/۸۱ و ۰/۷۹ درصد در مرحله رویشی و زایشی) و کم‌ترین آن مربوط به آنژاسورو (۰/۶۶ و ۰/۶۴ درصد در مرحله رویشی و زایشی) بود. از نظر تراکم جمعیت، بیش‌ترین میزان کاهش عملکرد بذر سویا در سولواوسی جنوبی با شش لارو در هر بوته بود که در فاز رویشی ۲۳/۴۴ درصد و در فاز زایشی ۲۳/۴۸ درصد بود. در بین ارقام، بیش‌ترین میزان کاهش عملکرد بذر در رقم آرگومولیو (۱۴.۹۳ درصد) و کم‌ترین در آنژاسورو (۱۱/۳۰ درصد) بود. می‌توان نتیجه گرفت که رابطه بین جمعیت لارو *S. litura* و کاهش عملکرد بذر کاملاً بالاست (برای فاز رویشی ۹۰/۲ تا ۹۶/۴ درصد و برای مرحله زایشی ۹۴/۸ تا ۹۶/۴ درصد بود.

واژگان کلیدی: سویا، ارقام، کرم ارتش، تراکم جمعیت، شدت خسارت، عملکرد بذر

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