International Journal of Agricultural Technology 2023 Vol. 19(4):1525-1540
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Insect pests attack sorghum (*Sorghum bicolor* l. moench) in the coastal region of Bengkulu, Indonesia

Ginting, S.[1*], Pujiwati, H.[2] and Susilo, E.[3]

[1]Department of Plant Protection, Faculty of Agriculture, Bengkulu University, St. Raya Kandang Limun, Bengkulu 38371, Indonesia; [2]Department of Agronomy, Faculty of Agriculture, Bengkulu University, St. Raya Kandang Limun, Bengkulu 38371, Indonesia; [3]Department of Agronomy, Faculty of Agriculture, Ratu Samban University, St. Jenderal Sudirman No. 87 Arga Makmur, Northern Bengkulu, Indonesia.

Ginting, S., Pujiwati, H. and Susilo, E. (2023). Insect pests attack sorghum (*Sorghum bicolor* L. Moench) in the coastal region of Bengkulu, Indonesia. International Journal of Agricultural Technology 19(4):1525-1540.

Abstract The results showed that the insect pests attack on cultivated sorghum varieties were *Spodoptera frugiperda, Peregrinus maidis, Rhopalosiphum maidis, Valanga nigricornis, Ostrinia furnacalis, Helicoperva armigera*, and *Sitophilus* sp. Amongst the sorghum varieties cultivated, the Numbu variety was more resistant to *Spodoptera frugiperda* attack, but susceptible to *Ostrinia furnacalis*, Ketan variety was resistant to *Valanga nigricornis*, and Suri was susceptible to *Helicoperva armigera* attack. The highest yield loss by *Sitophilus zeamais* was found in the Numbu variety, and the lowest was in Suri 4 and Ketan.

Keywords: Attack, Insect pests, Sorghum, Varieties

Introduction

Sorghum bicolor L. Moench (Poaceae) is one of the world's most important commodities. Rice is the world's most grown crop and the fifth world's most cultivated cereal after wheat, rice, corn, and barley. According to Zubair (2016), Subagio and Aqil (2013), the leading sorghum producing areas in Indonesia include Lampung, Sumatra, West Java, Central Java, East Java, South Sulawesi, Southeast Sulawesi, West Nusa Tenggara, and East Nusa Tenggara. Sorghum is a highly adaptable plant that can withstand various levels of soil fertility, drought, and temperature and produces high yields (Borrell *et al.,* 2000).

Sorghum is a very important cereal crop providing a livelihood to many people in the world. The grains, leaves, and stems of the sorghum crop are used to serve different purposes for humans and animals in different ways in many countries. In many countries including Indonesia, the sorghum grain is

[*] **Corresponding Author**: Ginting, S.; **Email:** sempurnaginting@unib.ac.id

processed as human food and provides a source for carbohydrates. The stems and leaves are processed into animal feeds (Werle *et al.*, 2016). The sorghum grains are also used in processing food industries as a raw material for the production of beverages like beer, malt. In other countries like the United States, sorghum is used for the production of biofuels like ethanol (Paterson, 2008). Even though sorghum is a very important cereal crop to humans and animals, and the economy of Indonesia, its production is extremely low, for example in Kupang the productivity of sorghum is only between 0.55 - 1.10 tons per ha (Lestari *et al.*, 2019).

One of the leading causing factors of low sorghum production in Indonesia is insect pest attacks at different stages of sorghum plant development from the vegetative to the generative phase. For example, a *Chilo sacchariphagus* attack can cause crop damage ranging from 35 to 65% (Tenrirawe *et al.*, 2013). Pest attacks in storage caused losses of 8.34-13.12% (Suleiman and Rugumamu, 2017). This damage caused by insect pests is a great threat to sorghum productivity.

Based on research reports, the important insect pests of that attack sorghum crops differ between countries and regions (Tenrirawe *et al.*, 2013). For example, in countries like Italy, the main insect pests of sorghum include *Rhopalosiphim maidis, Ostrinia nubilalis,* and *Lygus rugulipennis* that attack sorghum seeds after panicle development (Camerini *et al.*, 2014). In Indonesia, *Locusta migratoria* is one of the main insect pests that attack sorghum in several provinces including East Nusa Tenggara, North Sulawesi, Southeast Sulawesi, Lampung, South Sumatra, Central Kalimantan and West Kalimantan (Nik *et al.*, 2017). The main insect pests of sorghum in Africa include midge, shoot fly, stem borer, and *Helicoverpa* spp. (Sutherland, 2003).

Sitophilus zeamais is one of the important pests in harvesting agricultural commodities such as cereals. The losses caused by the attack of *S. zeamais* are the seeds that are attacked become hollow and produce a lot of powder from the crushing. Pests that attack sorghum seeds can result in significant yield losses. Post-harvest insect pests that mostly attack sorghum seeds include *Rhyzoperta dominica, S. zaemais, Sitotroga cerealella*, and *Ephestia cautella, Corcyra cephalonica, Plodia interpunctella* (Firmansyah *et al.*, 2013; Tenrirawe *et al.*, 2013). The pests that caused the highest yield loss were *R. dominica* and *S. zeamais*. The *S. zeamais* beetle is an important post-harvest pest in various grain commodities in tropical countries (Bhanderi *et al.*, 2015).

Eventhough several studies have been conducted to identify pests that attack sorghum in different parts of Indonesia, information about pests that attack sorghum in the coastal area of Bengkulu has never been reported, and thus a call for this study. Therefore, the research was purposed to evaluate insect pests attack sorghum (*Sorghum bicolor* L. Moench) in the coastal region of Bengkulu, Indonesia.

Materials and methods

Study site

The study was conducted in Kandang Mas, Kampung Melayu, Bengkulu province, Indonesia. The location of the research area was 31.4 m above sea level, with coordinates 3°52'33, 24252"S102°19'8,42988E", from April until October 2021. Kandang mas was located near soybean, spinach and kale, and corn farming areas. Insect pest was carried out at the laboratory of the Department of Plant Protection, Faculty of Agriculture, Bengkulu University, using Olympus microscope. The observed insect pests were identified using the identification book by Borror *et al*. (1996), Sharanabasappa *et al.* (2018), and then photographed.

Experimental design

The experiment was used Randomized Completely Block Design (RCBD) with the treatments of five varieties of sorghum including Numbu, Ketan, Super 1, Super 2, and Suri, and 4 replications. The five varieties of sorghum plants were grown by planting seeds in different plots of land measuring 3m by 2m each. Twelve plant samples for each sorghum variety were used.

The observations of insect pests were carried out directly in all parts of the selected sorghum plant varieties. These observations were conducted routinely once a week for 3 months, from the beginning of planting (vegetative phase) to harvesting (generative phase). The symptomatic plants, symptoms of the attack, and insect pests were identified and recorded. Also, the area is infested by pests (pest attack area) in the planted area for each sorghum variety was calculated using the following formula: $L = \frac{n}{N} \times 100\ \%$

Where;

L = Pest attack area
n = number of affected plants
N = number of plants observed

Plant resistance level based on leaf damage by S. frugiperda

Plant resistance level was assessed by sorghum leaf damage due to *Spodoptera frugiperda* on a scale of 1-9 (Prasanna *et al.,* 2018).

Table 1. Scale for assessment of foliar damage due to *Spodoptera frugiperda* on sorghum

Scoring	Description of damage	Response
1	No visible leaf-feeding damage	Highly resistant
2	Few pinholes on 1-2 older leaves	Resistant
3	Several shot-hole injuries on a few leaves (<5 leaves) and small circular hole damage to leaves	Resistant
4	Several shot-hole injuries on several leaves (6–8 leaves) or small lesions/pinholes, small circular lesions, and a few small elongated (rectangular-shaped) lesions of up to 1.3 cm in length present on whorl and furl leaves	Partially resistant
5	Elongated lesions (>2.5 cm long) on 8-10 leaves, plus a few small to mid-sized uniform to irregular-shaped holes (basement membrane consumed) eaten from the whorl and/or furl leaves	Partially resistant
6	Several large elongated lesions present on several whorl and furl leaves and/or several large uniform to irregular-shaped holes eaten from furl and whorl leaves	Susceptible
7	Many elongated lesions of all sizes present on several whorl and furl leaves plus several large uniform to irregular-shaped holes eaten from the whorl and furl leaves	Susceptible
8	Many elongated lesions of all sizes present on most whorl and furl leaves plus many mid- to large-sized uniform to irregular-shaped holes eaten from the whorl and furl leaves	Highly susceptible
9	Whorl and furl leaves almost totally destroyed and plant dying as a result of extensive foliar damage	Highly susceptible

Leaf greenness level

Leaf greenness level was determined the leaf chlorophyll content using a chlorophyll meter from when the plant began to flower.

Grain damage

Grain damage was calculated the percentage of damaged seeds due to *S. zeamais* in the selected sample plants. The attacking percentage of *S. zeamais* was calculated using the following formula:

$$P = \frac{a}{b} \text{ x } 100 \%$$

Where:

P = Percentage of grain damage, a = number of broken grains and b = total number of grains observed.

Yield loss value

Yield loss value by assessing the weight loss and percentage of perforated seeds. This was carried out by taking a sample of 25 g from each replication, then separating the whole and non-intact seeds after weighing each whole and non-intact seed in each sample. Percentage weight loss of sorghum was calculated using the following formula:

$$L= \frac{U.Nd-D.Nu}{U.N} \text{ x } 100\%$$

Where:

L = Yield loss value, U = Whole seed weight, Nu = Number of whole seeds, D = Weight of perforated seeds, Nd = Number of perforated seeds and N = Number of whole seeds + number of hollow seeds.

Data analysis

The data analysis was carried out using the SPSS software version 16.0 The Analysis of Variance was performed and if there was a difference between treatments, it was continued with the DNMRT (Duncan's Multiple Range Test) tests with a 95% confidence level.

Results

Insect pests' infestation area

The field observation results revealed several types of insect pests in the grown sorghum varieties. The insect pest that attacked the sorghum varieties differed in the vegetative and generative phases (Table 2), and the pest attack area also differed in each variety of sorghum (Figure 1). The insect pests found in the sorghum plants were grouped into two based on the type of mouth apparatus. These groups were the biting-chewing insects consisting of larvae of *S. frugiperda*, larvae of *Ostrinia furnacalis*, larvae of *Potanthus* sp. grasshoppers, larvae of *Helicoperva armigera*, and *Sitophilus* sp., and the sucker-sucking insect pests that included *Rhopalosiphum maidis* and *Peregrinus maidis.*

Table 2. Insect pest species found on sorghum

No	Growth Phase	Order	Family	Species	Varieties				
					Super 1	Super 2	Ketan	Suri	Numbu
1	Vegetative	Lepidoptera	Noctuidae	*Spodoptera frugiperda*	x	x	x	x	
2		Hemiptera	Delphacidae	*Peregrinus maidis*	x	x	x	x	x
3		Hemiptera	Aphididae	*Rhopalosiphum maidis*	x	x	x	x	x
4		Lepidoptera	Hesperiidae	*Potanthus* sp.				x	
5		Orthoptera	Acrididae	*Valanga nigricornis*	x	x		x	x
6	Generative	Coleoptera	Curculionidae	*Sitophilus* sp.	x	x	x	x	x
7		Lepidoptera	Crambidae	*Ostrinia furnacalis*					x
8		Lepidoptera	Noctuidae	*Helicoperva armigera*				x	

Description: X (Infesteded by pests)

The highest attack area by *R. maidis* occurred in the Super 1 and Suri varieties, and the lowest in the Ketan variety. The *R. maidis* attack happened in the vegetative phase, and the part of the plant that attacked was the leaves. The highest attack area by grasshoppers *V. nigricornis* was 66.66% in the Super 1 variety, while in the Ketan variety there was no attack by *V. nigricornis*. The *V. Nigricornis* attacked leaves and they were symptomised with visible damage due to the bite marks on the edges or middle of the leaves. *P. maidis* pest attack was highest on Super 1, 2 and Numbu varieties, and the lowest on Suri. On the other hand, the attack by Lepidoptera larvae *S. frugiperda* was recorded highest in Super 2, while *S. frugiperda* larvae attack occurred evenly in all observation plots except for the Numbu variety in which there were no attack *S. frugiperda* larvae registered. The highest attack area by *H. armigera* occurred in the Suri and Numbu and the lowest in the Super 1, Super 2, and, Ketan (Table 3).

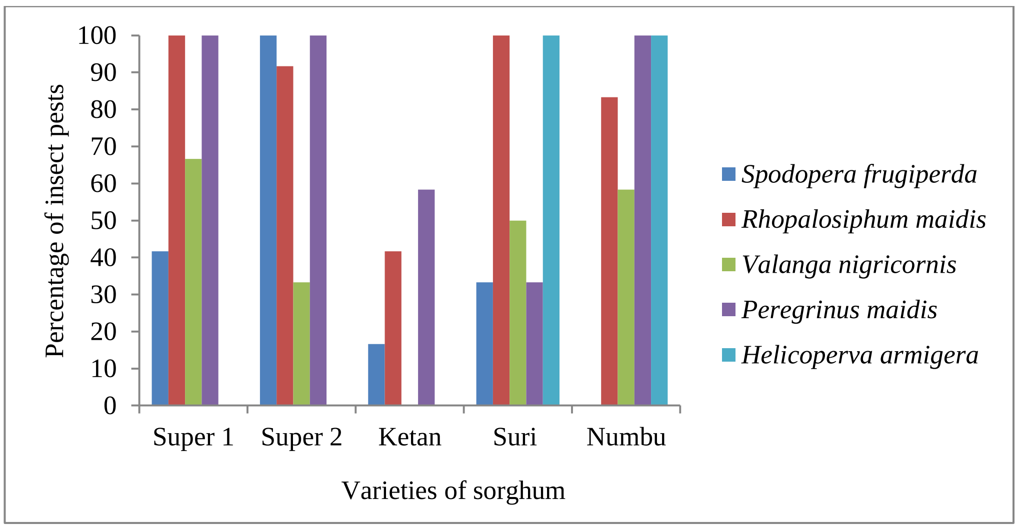

Figure 1. Percentage of insect pests' infestation on five varieties of sorghum

Table 3. The percentage of attack by various pests on five varieties of sorghum in the field

No	Varietas	*S. frugiperda*	*R. maidis*	*V. nigricornis*	*P. maidis*	*H. armigera*
		Insect pest attack (%)				
1	Super 1	41,66±2,51 d	100±0,00d	66,66±2,08e	100±0,00c	0±0,00a
2	Super 2	100±0,00e	91,66±2,52c	33,33±2,52b	100±0,00c	0±0,00a
3	Ketan	16,66±1,52b	41,66±2,52a	0±0,00a	58,33±2,51b	0±0,00a
4	Suri	33,33±2,51c	100±0,00d	50±1,00c	33,33±3,51a	100±0,00b
5	Numbu	0±0,0a	83,33±1,53b	58,33±1,53d	100±0,00c	100±0,00b

The numbers followed by different letters in the same column are not significantly different according to the Duncan test at p > 0.05.

Plant resistance level based on leaf damage by S. frugiperda

The obtained results of scoring plant leaf damage by *S. frugiperda* were different in each sorghum variety that was cultivated. The results showed that the level of leaf damage by *S. frugiperda* was highest in the Suri 4 variety with a score of 8, followed by Super1, Super 2, and Ketan which had the same score of 7 (Table 4). The population of *S. frugiperda* found in sorghum plants contained one cropping larva.

Table 4. Assessment scale of leaf damage due to *S. frugiperda* on sorghum

No	Sorghum varieties	Scoring	Description of damage	Response
1	Numbu	1	• No visible leaf feeding damage	Highly resistant
2	Ketan	7	• Many elongated lesions of all sizes present on several whorls and furl leaves. • Presence of several large uniform to irregular-shaped holes eaten from the whorls and furl leaves	Susceptible
3	Super 1	7	• Many elongated lesions of all sizes present on several whorls and furl leaves • Presence of several large uniform to irregular-shaped holes eaten from the whorls and furl leaves	Susceptible
4	Super 2	7	• Many elongated lesions of all sizes present on several whorls and furl leaves • Occurrence of several large uniform to irregular-shaped holes eaten from the whorls and furl leaves	Susceptible
5	Suri 4	8	• Many elongated lesions of all sizes present on most whorls and furl leaves • Occurence of many mid to large sized uniform to irregular shaped holes eaten from the whorls and furl leaves	Highly susceptible

The Lepidoptera *S. frugiperda* pest caused damage to the leaves while the damage to the grain was caused by *Helicoperva armigera*. The damage to leaves by *S. frugiferda* larvae began to occur at the vegetative phase and the affected leaves showed window panning and had leaf holes. The damage on the grain by *H. armigera* larvae was symptomized by ridges on the grain. Furthermore, the affected grains looked incomplete and hollow. The *H. armigera* larvae attack the grains occurred when the grains were still in the process of filling. The highest grain damage occurred in the Suri and Numbu varieties.

Leaf greenness level

The leaf chlorophyll content was measured using a chlorophyll meter when the plants had begun flower. The results in Table 4 showed that the level of the greenness of the leaves between varieties was not significantly different (chlorophyllmeter SPAD). However, there was a tendency that the Suri 4 variety had the highest level of greenness (49.16) while the lowest level of greenness was achieved by the Super 1 variety (41.92) (Tabel 5).

Table 5. The greenness level of sorghum leaves in five varieties of sorghum

No.	Sorghum Varieties	The greenness of sorghum leaves (SPAD unit)
1	Numbu	43.32a
2	Super 1	41.92a
3	Super 2	42.98a
4	Suri 4	49.16a
5	Ketan	45.34a

The numbers followed by different letters in the same column are not significantly different according to the Duncan test at $p > 0.05$.

Grain damage due to Sitophilus zeamais and yield loss value

The results of the analysis of the percentage of seed damage caused by *Sitophilus* sp. showed that the highest seed damage was found in the Numbu, Super 1 and Super 2 variety, and the lowest was in Suri 4 and Ketan (Table 6). The highest yield loss was found in the Numbu, Super 1 and super 2 variety, and the lowest was in Ketan and Suri 4.

Table 6. Grain damage caused by *Sitophilus* sp. in five varieties of sorghum

No	Cultivars	Percentage (%) of damaged seeds	Percentage (%) of weight loss
1	Numbu	58 ±17.34c	50 ±31.21a
2	Ketan	2 ±1.73a	4 ±4.04b
3	Super 1	54 ±15.13bc	36 ±12.01a
4	Super 2	32 ±10.00b	39 ±2.64a
5	Suri 4	0 ±0.00a	0 ±0.00b

The numbers followed by different letters in the same column are not significantly different according to the Duncan test at $p > 0.05$.

In addition to insect pests found in the sorghum varieties that were cultivated, beneficial insects likes predator and parasitoid (Table 7).

Table 7. Beneficial insects in cultivated sorghum varieties

No	Ordo	Family	Function
1	Orthoptera	Gryllidae	Predator
2	Coleoptera	Coccinellidae	Predator
3	Blattodea	Blattellidae	Predator
4	Hymenoptera	Formicidae	Predator
5	Odonata	Coenagrionidae	Predator
6	Diptera	Sarchophagidae	Parasitoid

Discussion

The results of the insect pests' infestation area obtained in this study revealed that there were differences in the dominant types of pests that attacked each sorghum variety. The *S. frugiperda* was dominant in Super 2 varieties, *Rhopalosiphum maidis* in Super 1 and Suri varieties, *Peregrinus maidis* in Super 1, Super 2 and Numbu varieties, and *Helicoperva armigera* in Suri and Numbu varieties. In terms of overall insect pest infestation area, the Numbu variety was resistant to *S. frugiperda*, Ketan resistant to grasshoppers, and Super 1, while Super 2 and Ketan were resistant to *H. armigera*. *Spodoptera frugiperda* attack on sorghum has been reported for the first time in Indonesia. *Spodoptera frugiperda* J.E Smith or Fall Armyworm (FAW) (Lepidoptera: Noctuidae) was an important pest of corn native from America (Lee *et al.*, 2020). It was an economically significant pest for agricultural commodities and food crops most especially corn plants in Indonesia, and now widely spread in Indonesia, invaded corn production area in West Sumatra, West Java, Lampung (East Lampung), Bengkulu and South Sumatra (Maharani *et al.,* 2019; Trisyono *et al*., 2019; Ginting *et al.,* 2020; Herlinda *et al.,* 2022). *Spodoptera frugiperda* was a polyphagous pest that caused significant economic losses in various agricultural commodities such as corn, rice, wheat, sorghum, beans, potatoes, and cotton (Day *et al*., 2017). According to Suryadi (2013) Lepidoptera that attack cereal plants, includes *Mythimna unipuncta* (Family Noctuidae), *Creatonotos transiens* (Arctiidae), *Cnaphaclorocis medinalis* (Crambidae), *Paralecta* sp. (Xylorictidae), *Parnara bada* (Hesperiidae), *Orthiostola* sp. (Yponomeutidae), *Spodoptera litura* (Noctuidae), and *Potanthus* sp. (Hesperiidae). Murtiyono (2012) reported that larvae from the families Arctidae, Geometridae, and Noctuidae attack wheat plants in the Semarang area.

The results of level of leaf damage showed that the attack by *Spodoptera frugiperda* larvae was different in each variety (Table 3). The results showed that among the varieties of sorghum, Suri 4 was highly susceptible, while the Ketan, Super 1 and Super 2 varieties were susceptible and then Numbu was highly resistant to the attack of *S. frugiperda.* It was influenced by biophysical and biochemical factors, namely morphological and anatomical properties, as well as the content of compounds in these plants. Characteristics of physical organs or plant tissues and toxic secondary metabolites also influence the selection behavior of host plants and are part of the direct defense sequence of plants; for example, trichomes, waxy crystal structure, leaf thickness and toughness, and silica content can cause insect avoidance behavior (Schoonhoven *et al.,* 2007).

Differences in genotype and environment, affected the development of sorghum in the field which results in differences in the content of chemical compounds (phenolic) in sorghum varieties. The phenolic components of sorghum were antibiosis include simple phenols, hydroxybenzoic acids, hydroxycinnamic acids, flavonoids (flavonols, flavones, flavanones, isoflavones, and anthocyanins), chalcones, aurones (hispidol), hydroxycoumarins, lignans, hydroxystilbenes and polyflayanians (Krueger *et al.,* 2003; Awika and Rooney, 2004). The tannins and phenols are classes of secondary metabolites found in all types of cereals, but sorghum contains the highest phenolic content of up to 6% in some varieties (Dicko *et al.,* 2006).

To reduce insect pest damage, the use of resistant varieties is highly recommended, so it is necessary to evaluate their susceptibility to insect pest attacks. Sorghum vulnerability information is needed as a guideline for sorghum breeding programs to support sorghum development. The plant's resistance to damage by pest attacks was usually influenced by the plant's genetics. Mechanisms of plant resistance to FAW attacks have also been developed in maize plants by developing plants that have thicker leaf epidermis (Davis and Williams, 1995; Chuang *et al.*, 2014). Development of transgenic plants or genetically engineered plants is a strategy used to control FAW damage in corn with the expression of genes resistant to Lepidoptera.

The results also showed that the greenness of the leaves was low (41.92-49.16), and there was no significant difference in the greenness level of leaves of the cultivated sorghum varieties (Table 4). The greenness of the leaves was related to the chlorophyll content, which is one of the factors to determine the Nitrogen (N) status of the leaves. Insufficient N fertilizer will cause stunted or yellowish green plants and tend to fall off quickly, excessive N addition can slow fruit ripening because it increases vegetative growth, plants remain green even though the ripening period is over, and can weaken plants against pest attacks (Hanafiah *et al.*, 2005).

The results of the analysis of the percentage of seed damage caused by *S. zeamais* showed that the highest seed damage was found in the Numbu variety, and the lowest was in Suri 4 and Ketan (Table 4). These results are due to the differences in tannin and phenol content in the varieties, i.e low content in the Numbu and high content in the Suri 4 and Ketan. this is physically shown by a brownish red color on the seed coat, while the Numbu, Super 1 and Super 2 varieties have a characteristic color that is a bit duller than the other varieties. Super varieties 1 and 2 have a dull white color. The presence of tannins in seeds is indicated by a reddish or brownish color on the outer skin layer of the seeds (testa).

The phenolic components in sorghum seeds are divided into three main categories including phenolic acids, flavonoids, and tannins. These components occur mostly in the pericarp, testa, and aleurone layers (Dicko *et al.*, 2006). The high polyphenol content in sorghum is characterized by a brown pericarp and colored seed coat. In sorghum grain with a red pericarp and no seed coat, the polyphenol content is quite significant while in colorless sorghum grains the polyphenol content is very low. Previous study by Hendrival *et al.* (2019) stated that the sorghum grains from Suri 3, Suri 4, Kawali, and Numbu varieties were classified as moderate, while the Samurai 1 variety was classified as moderate to susceptible, and Super 1, Super 2, Samurai 2, and Pahat varieties were classified as susceptible to *S. oryzae* during sorghum storage.

The tannins in sorghum are usually associated with low protein content. Tannins in sorghum were usually associated with low protein content. In addition to physical factors such as seed coat hardness, chemical factors such as the presence of secondary metabolites of phenols and tannins, high levels of tannins can give sorghum a bitter taste. Both tannins and phenols act as antinutrients by means of antibiosis, a resistance mechanism that occurs between sorghum and *S. zeamais*. According to Teetes (2009), the antibiosis mechanism causes a decrease in the abundance of insect pests, with increasing mortality rates, decreasing longevity, and decreasing reproductive rates.

The predator and parasitoid found in the field were Coccinellidae, Blattellidae, Formicidae, Coenagrionidae, Gryllidae and Sarchophagidae (Table 7). Biological control using natural enemies using predators and parasitoids to control pest populations that are more environmentally friendly than chemical insecticides. The status of insect functions as predators and parasitoids on sorghum plants include the order Hymenoptera (Formicidae), Coleoptera (Coccinellidae), Blattodea (Blattellidae), Odonata (Coenagrionidae), Orthoptera (Gryllidae), Diptera (Sarchophagidae) (Tarihoran *et al.*, 2020). To increase the effectiveness of natural enemies in the field, environmental sustainability must be maintained so that natural enemies can develop properly.

The Sorghum varieties Numbu, Super 1, Super 2, suri, and Ketan that were cultivated were found to be infested by several insect pests including *Spodopera frugiperda, Peregrinus maidis, Rhopalosiphum maidis, Valanga nigricornis, Ostrinia furnacalis, Helicoperva armigera*, and *Sitophilus* sp. The insect pest found in the sorghum were different in the five varieties. The Numbu variety was more resistant to *Spodoptera frugiperda* but susceptible to *Ostrinia furnacalis*, Ketan variety was resistant to *Valanga nigricornis*, and Suri was susceptible to *Helicoperva armigera*. The highest yield loss by *Sitophilus zeamais* was found in the Numbu variety, and the lowest was in Suri and Ketan.

Acknowledgements

The author would like to extend sincere acknowledgment to Fundamental PNBP UNIB for the research grant offered under Contract Number 1815/UN30.15/PG/2020 in 2021. Other appreciation is also extended to the Department of Plant Protection, Faculty of Agriculture, Bengkulu University for providing all the necessary facilities for this research.

References

Awika, J. M. and Rooney, L. W. (2004). Sorghum phytochemicals and their potential aspects on human health. Phytochemistry, 65:1199-1221.

Bhanderi, G. R., Radadia, G. G. and Patel, D. R. (2015). Ecofriendly management of rice weevil *Sitophilus oryzae* (Linnaeus) in sorghum. Indian Journal of Entomology, 77: 210-213.

Borrell, A. K., Hammer, G. L. and Henzell, R. G. (2000). Does maintaining green leaf area in sorghum improve yield under drought? Dry matter production and yield. Crop Science, 40:1037-1048.

Borror, D. J., Triplehorn, C. A. and Johnson, N. F. (1992). Introduction to insect studies. Gadjah Mada University Press. Yogyakarta.

Camerini, G., Groppali, R., Limonta, L. and Maini, S. (2014). A survey on pest insects of fiber and grain sorghum in northern Italy. Maydica electronic publication, 59:243-249.

Chuang, W. P., Ray, S., Acevedo, F. E., Peiffer, M., Felton, G. W. and Luthe, D. S. (2014). Herbivore cues from the fall armyworm (*Spodoptera frugiperda*) larvae trigger direct defenses in maize. Molecular Plant-Microbe Interactions, 27:461-470.

Davis, F. M. and Williams, W. P. (1995). Anatomical characteristics of maize resistant to leaf feeding by southwestern corn borer (Lepidoptera: Pyralidae) and fall armyworm (Lepidoptera: Noctuidae). Journal of Agricultural Entomology, 12:55-65.

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R. and Godwin, J. (2017). Fall armyworm: Impacts and implications for Africa. Outlooks on pest management. Outlooks Pest Manag, 28:196-201.

Dicko, M. H., Gruppen, H., Traore, H., Voragen, G. J. A. and Berkel, J. W. H. (2006). Phenolic Compounds and Related Enzymes as Determinants of Sorghum for Food Use. Biotechnology and Molecular Biology Review, 1:21-38.

Firmansyah, I. U., Aqil, M. and Suarni (2013). Postharvest Handling of Sorghum. In: Sumarno, Damardjati, D.S, Syam, M., and Hermanto (Editor), Sorghum: Technological Innovation and Development. IAARD Press, Jakarta, pp.242-259.

Ginting, S., Nadrawati, Zarkani, A. and Sumarni, T. (2020). Natural incidence of entomopathogenic fungus Nomuraea rileyi on *Spodoptera frugiperda* infesting corn in Bengkulu. Jurnal Hama dan Penyakit Tumbuhan Tropika, 20:85-91.

Hanafiah, A., Anas, I., Napoleon, A. and Ghofar, A. (2005). Soil Biology. Jakarta, Raja Grafindo Persada.

Hendrival, Putra, R. L. and Aryani, D. S. (2019). Susceptibility of Sorghum Cultivars to *Sitophilus oryzae* L. (Coleoptera: Curculionidae) During Storage. The Journal of Agricultural Science, 7:111-116.

Herlinda, S., Suharjo, R., Sinaga, M. E., Fawwazi, F. and Suwandi, S. (2022). First report of occurrence of corn and rice strains of fall armyworm, *Spodoptera frugiperda* in South Sumatra, Indonesia and its damage in maize. Journal of the Saudi Society of Agricultural Sciences, 21:412-419.

Lee, G., Seo, B. Y., Lee, J., Kim, H., Song, J. H. and Lee, W. (2020). First report of the fall armyworm, Spodoptera frugiperda (Smith, 1797) (Lepidoptera, Noctuidae), a new migratory pest in Korea. Korean Journal of Applied Entomology, 59:73-78.

Lestari, L., Rachmadiyanto, A. N. and Magandhi, M. (2019). Sorghum Cultivation, Production and Utilization at Kupang District of Nusa Tenggara Timur, Indonesia. Proceedings The 3rd SATREPS Conference, 2:146-153.

Krueger, C. G., Vestling, M. A. and Reed, J. D. (2003). Matrix-assisted laser desorption/ionization time-of-flight mass spectrometry of heteropolyflavan3-ols and glucosylated heteropolyflavans in sorghum (*Sorghum bicolor* (L.)) Moench. Journal of Agricultural and Food Chemistry, 51:538-543.

Maharani, Y., Dewi, V. K., Puspasari, L. T., Rizkie, L., Hidayat, Y. and Danar, D. (2019). Cases of fall army worm *Spodoptera frugiperda* J.E Smith (Lepidoptera: Noctuidae) attack on maize in Bandung, Garut, and Sumedang District, West Java. Cropsaver, 2: 38-46.

Murtiyono, E. (2012). Pests and diseases at the growth stage of 13 lines and two varieties of wheat (*Triticum aestivum* L.) in Wates Village, Getasan District, Semarang Regency. (Thesis). Universitas Kristen Satya Wacana Salatiga. Semarang.

Nik, N., Rusae, A. and Atin, B. (2017). Pest Identification and Application of Bioinsecticides to *Locust migratoria* as an Integrated Pest Control Model for Sorghum. Savana Cendana, 2:46-47.

Paterson, A. H. (2008). Genomics of sorghum. Int. J. Plant Genomics, 2008:1-6.

Prasanna, B. M., Huesing, J. E., Eddy, R. and Peschke, V. M. (2018). Fall Armyworm in Africa: A Guide for Integrated Pest Management. 1st Edition. Mexico: CIMMYT.

Schoonhoven, L. M., van Loon, J. J. A. and Dicke, M. (2007). Insect-Plant Biology, 2nd ed.; Oxford University Press: New York, NY, USA, pp.421.

Sharanabasappa, Kalleshwaraswamy, C. M., Maruthi, M. S. and Pavithra. H. B. (2018). Biology of invasive fall army worm *Spodoptera frugiperda* (Smith, J. E.) (Lepidoptera: Noctuidae) on maize. Indian Journal of Entomology, 80:540-543.

Subagio, H. and Aqil, M. (2013). Development of sorghum production in Indonesia. Proceeding of National Seminar on Agriculture Innovation. BPTP Kalimantan Selatan, pp.199-214.

Suleiman, M. and Rugumamu, C. P. (2017). Management of insect pests of stored sorghum using botanicals in Nigerian traditional. Journal of Stored Products and Postharvest, 8:93-102.

Suryadi (2013). Identification of caterpillars and aphids on wheat (*Triticum aestium* L.) plantations in Bogor and Kuningan, West Java. (Thesis). Bogor Agricultural University. Bogor

Sutherland, A. J. (2003). Pests of African sorghum. Final Technical Report.

Tarihoran, P., Siregar, A. Z. and Marheni. (2020). Diversity Index of Insect Species on Sorghum Plantations in Kolam Village, Percut Sei Tuan District, Deli Serdang. Indonesian Journal of Agricultural Research, 3:89-10.

Teetes, G. L. and Pendleton, B. B. (2009). Insect pests of sorghum In: Sorgum: origin, history, technology and production Smith CW, Frederiksen RA, eds. J Wiley and Sons, New York.

Tenrirawe, A., Tandiabang, J., Adnan, A. M., Pabbage, M. S., Soenartiningsih. and Haris, A. (2013). Pest management in sorghum. In: Sumarno, Damardjati, D.S., Syam, M., and Hermanto (Editor), Sorghum: Technological innovation and development. IAARD Press. Jakarta. pp. 222-241.

Trisyono, Y. A., Suputa, Aryuwandari, V. E. B., Hartaman, M. and Jumari (2019). Occurrence of heavy infestation by the fall armyworm *Spodoptera frugiperda*, a new alien invasive pest, in corn in Lampung Indonesia. Jurnal Perlindungan Tanaman Indonesia, 23:156-160.

Werle, R., Jhala, A. J., Yerka, M. K., Anita, D. J. and Lindquist, J. L. (2016). Distribution of herbicide-resistant shattercane and Johnsongrass populations in sorghum production areas of Nebraska and northern Kansas. Agronomy Journal, 108:321-328.

Zubair, A. (2016). Sorgum: Multi Benefit Plants. Unpad Press. Bandung, pp.78.

(Received: 15 September 2022, accepted: 3 July 2023)