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Submission date: 15-Mar-2024 09:05AM (UTC+0700)
Submission ID: 2320788751
File name: Jurnal_Ken_Luar.docx (190.1K)
Word count: 3849
Character count: 21175

The Development of Pests and Diseases in Several Varieties of Sorghum (*Sorghum bicolor*) given Organic Fertilizers

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ABSTRACT

Purpose: *Sorghum are one of the benefical food crops, However there are several pest and diseases that can reduce sorghum crop yields. This research aims to identify the pests and diseases affecting sorghum plants, assess the resistance levels of each variety, and determine the influence of organic fertilizers on pest infestations and disease infections in sorghum plants.*

Research Method: *This study utilizes six varieties of sorghum plants, namely Bioguma 1, Bioguma 3, Plonco, Samurai, Pahat, and Kawali, along with organic fertilizers made from cow and goat manure. Observation of pest infestation and disease infection levels is conducted using pest and disease scoring. The scoring results will then be used to analyze disease intensity, pest damage intensity, and the number of ouccurrences caused by these pest and diseases.*

Findings: *Six disease infecting several varieties of sorghum plants with infection levels ranging from highest to lowest, namely leaf spot disease caused by Alternaria sp., Curvularia sp. fungus, leaf rust disease caused by Puccinia sorghi fungus, Fusarium disease, leaf spot disease caused by Microdochium sp., and Cercospora sorghi fungus. The pests that attacking sorghum plants are Army worms (Spodoptera sp.) and Aphids. Based on Duncan's analysis, the research indicates no influence of organic fertilizers on the level of pest attack and disease infections as well as their occurrences.*

Research Limitations: *This research focuses on the level of pest and disease attacks on sorghum, as well as the resistance of each sorghum variety given organic fertilizers*

Originality/ Value: *This research informs that the resistance of each sorghum variety varies depending on the pest and disease that attack sorghum.*

Keywords: Varieties of sorghum plants, disease intensity, pest damage intensity, number off occurrences, organic fertilizers from cow and goat manure

INTRODUCTION

Sorghum (*Sorghum bicolor*) is one of the staple crops ranking fifth in the world after rice, wheat, corn, and barley. *In Indonesia* sorghum becomes the third cereal food crop after rice and corn. One of the advantages of sorghum is its strong adaptability such as tolerance to drought and waterlogging. Beside its adaptability to environment, the cultivation and maintenance process of sorghum are relatively inecpensive and can be grown in monoculture or intercropping systems. Although sorghum cultivation requires low costs, the production level of sorghum plants is high even on marginal land (Djaenuddin Nursasiah, *et al*., 2020).

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Pramanda *et al*., (2015) cited in Kurniasari Rina, *et al*., (2023) stated that one benefical factor in improving the production yield of one variety of sorghum, namely the Numbu variety is organic materials such as manure The addition of organic materials as nutrients can increase the production yield of Numbu sorghum variety up to 8,6 ton/ha with a dosage of 15 tons/ha. Moreover, organic materials can play a crucial role in improving soil structure and soild properties such as soil biology, soil chemistry, and soil physics.

One of the advantages of cultivating sorghum is do not require specific conditions for cultivation. Sorghum are quite tolerant to drought and waterlogging and can be grown on marginal lands. Some sorghum varieties exhibit resistance to some pest and disease disturbances. Additionally, sorghum do not require special technologies or maintenance like other (Pamekas *et al*., 2023). The use of organic fertilizers for plants serves as nutrient elements, furthermore it also increase the number of decomposer microorganism colonies so that nutrients in the soil can be utilized to maintain plant resilience (Vidyawati and Masnillah, 2022). The application of organic fertilizers can be supportive factor for good soil fertility. In goat manure fertilizers, the levels of N and K elements are twice as high as those in cow manure fertilizers (Roidah, 2013).

This study was conducted with the aim of identifying the types of pests and diseases in several varieties of sorghum plants as well as their levels of attack and infection, and the resistance of each sorghum variety.The study also aimed to determine the effect of cow and goat manure organic fertilizers on the level of pest and disease aattack and infection affecting several varieties of sorghum plants.

MATERIALS AND METHODS

Observation of pest and disease attack levels were conducted using pest and disease scoring tables. Determination of sample plants for pest and disease observation was done by observing the initial symptoms caused by pest diseases. In observing pests and diseases, approximately ±10 sample plants affected by pests and diseases were conducted with a frequency of every 2 weeks and started when the plants were 38 days old until 94 days old. Pest and disease attack observations were conducted at plant ages of 38 days, 52 days, 66 days, 80 days, and 94 days. Disease infection observations were conducted using a scoring table guide with the following modified scoring scale (Hendrayana *et al*., 2020):

Table 01: Sorghum plant disease scoring

Scale	Infection percentage (%)	Description	Resilience categories
0	0	No symptoms	Healthy plants
1	1-25	There are symptoms of the disease	Minor
2	26-50	There are symptoms of the disease	Moderate
3	51-75	There are symptoms of the disease	Heavy
4	76-100	There are symptoms of the disease	Very heavy
5	-	Dead plants	Dead plants

Meanwhile, pest observations are carried out using the scoring table guide with the following modified scoring scale (Girsang *et al*., 2022):

Table 02: Sorghum plant pest scoring

Scale	Damage percentage (%)	Description	Attack categories
0	0	No symptoms	Healthy plants
1	0 < x ≤ 25	Found damage to some leaves of the plant	Very minor
2	25 < x ≤ 50	Found damage to some leaves of the plant	Minor
3	50 < x ≤ 75	Found damage to some leaves of the plant	Moderate
4	75 < x ≤ 100	Found damage to some leaves of the plant	Heavy
5	-	The plant suffers very severe damage to the leaves	Very heavy

In this study, parameters such as the level of pest and disease attack and the number of occurrences caused by these pests and diseases on several varieties of sorghum plants were utilized. Quantitative data in the form of pest and disease scoring on several varieties of sorghum plants were used to determine the level of pest and disease attack. Meanwhile, the number of occurences of pests and diseases was based on the number of pest and disease attack on several varieties of sorghum. Each pest and disease manifest symptoms and damages at different levels, thus requiring calculations of disease intensity and the percentage of occurrences infection several varieties of sorghum. As for the pests, calculations were made for the damage intensity caused by pests and the percentage of pest attacks. Below are the formulas used in observasing pests and diseases:

Asses the intensity of the disease

$$\text{DI} = \frac{\in (ni\ x\ vi)}{N\ x\ V}\ x\ 100\ \%$$

Informations:

DI : Disease intensity

ni : Sample plants

vi : Plant score

N : Number of sample (10)

V : Highest score (5)

Asses the number of occurences of the disease

$$\text{Occurences} = \frac{\in \text{Number of symptomatic plants}}{\in \text{Total crop in treatment plot}}\ x\ 100\ \%$$

Asses the intensity of pest damage

$$\text{PI} = \frac{\in (ni\ x\ vi)}{N\ x\ V}\ x\ 100\ \%$$

Information:

PI : Pest damage intensity

Asses the number of occurence of the pest

$$\text{Occurences} = \frac{\in \text{Pest infested plants}}{\in\ \text{Total crop in treatment plot}}\ x\ 100\%$$

Category of resilience for each variety

The resistance categoriues of each variety to pests and diseases are used as follows(Hendrayana *et al*., 2020):

Table 03: Variety resilience categories

Resilience categories	Percentage of endurance level (%)
Highly resistant	0-5
Resistant	>5-20
Slightly resistant	>20-40
Vulnerable	>40-60
Highly vulnerable	>60

RESULTS AND DISCCUSION

Based on the research findings, several sources of diseases and pests attacking various varieties of sorghum plants have been identified. Diseases infecting several sorghum varieties are caused by fungi, namely *Alternaria* sp., *Curvularia*., *Fusarium* sp., *Microdochium* sp., Cercospora sorghi, and Puccinia sorghi. Meanwhile, the most severe pests attacking several varieties of sorghum are caused by armyworms (*Spodoptera* sp.) and Aphids.

Table 04: The effect of applying organic fertilizers on the intensity of disease and the intensity of pest damage to sorghum varieties

Fertilizer	*Alternaria*	*Cercospora sorghi*	*Curvularia*	*Microdochium*	*Fusarium*	*Puccinia sorghi*	Armyworms	Aphids
Cow	20,4 p	0,8 p	10,53 p	3,93 p	2,6 p	7,8 p	4,4 p	2,06 p
Goat	19,2	0,66 p	10,66 p	4,6 p	3,6 p	6,06 p	4,06 p	1,46 p

Informations: The number followed by the same letter in a row column indicate no significant difference based on the Duncan's Multiple Range Test (DMRT) test at the 5% level
There is no significant interaction

The application of organic fertilizers does not have a significant effect on disease infection and pest infestation at sorghum varieties. Disease infections from highest to lowest in each sorghum plant variety are *Alternaria* leaf spot disease, *Curvularia* leaf spot disease, *P. sorghi* leaf rust, *Fusarium* disease, *Microdochium* leaf spot disease, and *C. sorghi* leaf spot disease. Armyworms attach each sorghum variety more than aphids do.

Table 05: The effect of organic fertilizer application on the number of occurrences of pests and diseases on sorghum plant varieties

Fertilizer	*Alternaria*	*Cercospora sorghi*	*Curvularia*	*Microdochium*	*Fusarium*	*Puccinia sorghi*	Armyworms	Aphids
SP	6,6 p	0,5 p	3,91 p	2,215 p	1,255 p	3,63 p	1,42 p	0,93 p
K	6,47	0,445 p	3,77 p	2,345 p	1,68 p	3,21 p	1,21 p	0,59 p

Informations: The number followed by the same letter in a row column indicate no significant difference based on the Duncan's Multiple Range Test (DMRT) test at the 5% level
There is no significant interaction

The number of occurrences represents the total of disease infections and pest attacks that have affected each sorghum plant variety. Table 05 indicates that the application of organic fertilizers from cow and goats manure does not significantly affect the number of pest and disease occurrences in each sorghum plant variety. In some cases, disease infections and pest attacks occur more frequently in sorghum variety with cow manure organic fertilizer compared to goat manure.

Alternaria sp. leaf spot disease infection

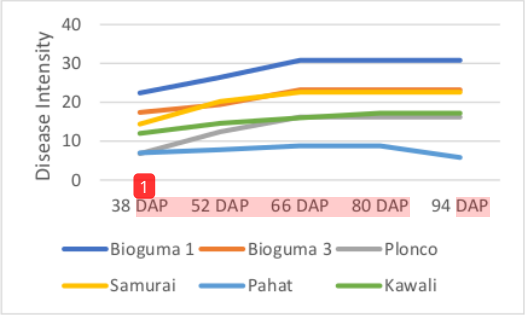

Figure 01: Development of the intensity of Alternaria leaf spot disease

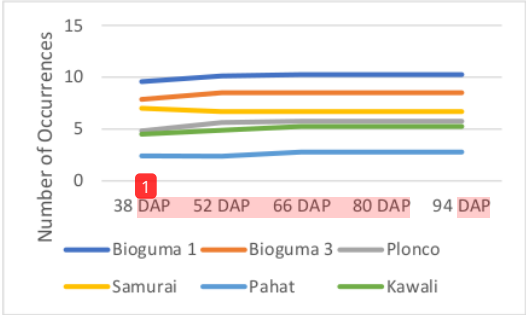

Figure 02: Development of the number of occurrences of Alternaria disease

At the observation of 94 day after planting (DAP) sorghum plants, the highest disease intensity level occurred in Bioguma 1 variety, reaching 30,8%, with an incidence infection rate of 10,25%. Meanwhile, the lowest intensity of *Alternaria* leaf spot disease among other sorghum varieties was observed in the Pahat variety, with a disease intensity value of 8,8% and an incidence rate of 2,78%. *Alternaria* leaf spot disease manifests with brown spot on the leaves turning grayish, then yellowing entirely and shedding. This leaf spot disease can spreads by air and water (Alfiani *et al*., 2021).

C. sorghi leaf spot disease infection

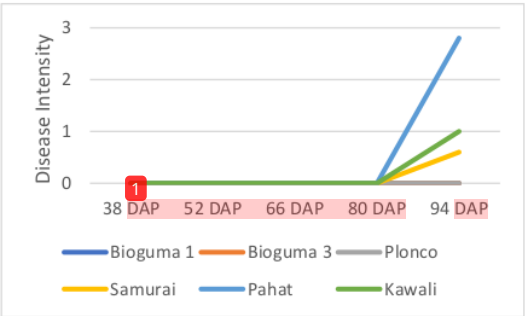

Figure 03: Development of the intensity of C. sorghi leaf spot disease

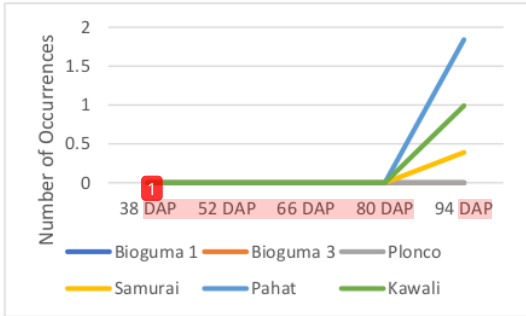

Figure 04: Development of the number of occurrences of C. sorghi disease

Based on the graph above, it shows that the infection of *C. sorghi* leaf spot disease starts to occur in sorghum plants at 80 days after planting (DAP), then increases at 94 DAP. The Infection of *C. sorghi* disease occurs in the Pahat, Samurai, and Kawali varieties. There is a difference in resistance to *C. sorghi* infection, with the highest infection occurring in the Pahat variety with a disease intensity value of 2,8% and an incidence rate of 1,84%.

The initial symptoms of *C. sorghi* leaf spot disease include the appearance of spots on the older leaves of sorghum plants located around the base of the stem, which then spread and extend to the upper leaves, the spots elongated and bordered by leaf veins. These leaf spots are red around the leaf veins and develop well in low temperatures, moist, and warm conditions (Asniwita *et al.*, 2017).

Curvularia sp. leaf spot disease infection

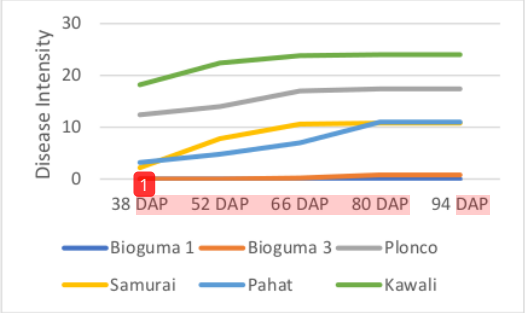

Figure 05: Development of the intensity of Curvularia sp. leaf spot disease

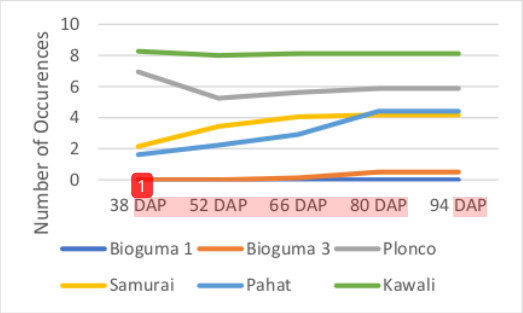

Figure 06: Development of the intensity of Curvularia sp. leaf spot disease

Based on the graph depicting the development of *Curvularia* leaf spot disease infection, the variety with the highest disease intensity occurs in the Kawali variety, while the lowest occurs in the Bioguma 1 variety. *Curvularia* disease starts to attack sorghum plant at 38 days after planting (DAP) with its initial symptomps being the appearance of red to brown spots on the leaves. In the Kawali variety, the intensity level of *Curvularia* disease reaches 24% with an incidence infection rate of 8,125%, whereas symptoms of *Curvularia* disease are not detected in Bioguma 1 variety. One supporting factor for the occurrence of *Curvularia* leaf spot disease is the humid environmental conditions with warm temperatures. The development of *Curvularia* fungi will be optima in humid and less exposed conditions (WinDAPari *et al.*, 2019). From 80 days after planting (DAP) to 94 days after planting, the infection level of *Curvularia* disease does not increase or decrease because the infected leaves undergo aging.

***Fusarium* disease**

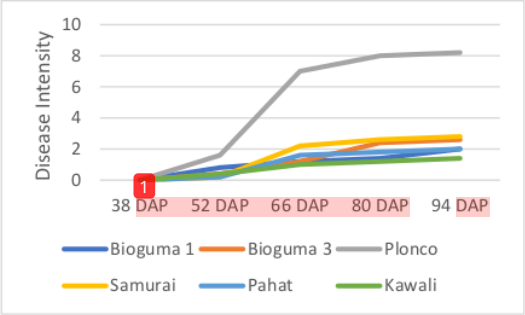

Figure 07: Development of the intensity of Fusarium disease

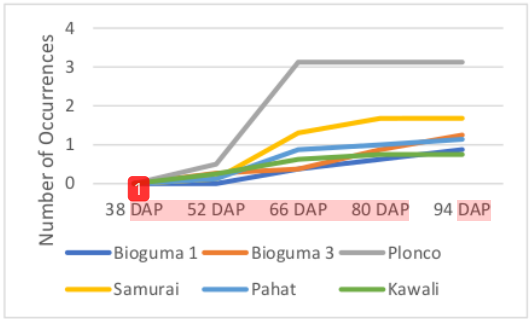

Figure 08: Development of the intensity of Fusarium disease

Analysis results indicate differences in resistance among sorghum varieties against *Fusarium* disease. The highest intensity level of *Fusarium* disease occurs in the Plonco variety, with a value of 8,2% and an incidence rate of 3,125%. Meanwhile, the lowest intensity level of the disease occurs in the Kawali variety, with an intensity rate of 1,4% and an incidence rate of 0,75%.

One of the diseases that can infect sorghum is caused by *Fusarium* fungus. *Fusarium* fungus infects plants by invading the roots, degrading cell walls, and entering the xylem vessels, causing necrosis and blockage, leading to wilting and eventual plant death (Ghufron *et al*., 2017). Based on observations, *Fusarium* disease infecting sorghum plants exhibits symptoms such as wilting and shriveling.

***Microdochium* leaf spot disease infection**

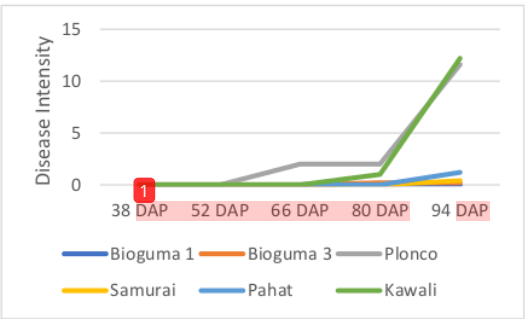

Figure 9: Development of the intensity of Microdochium sp. leaf spot disease

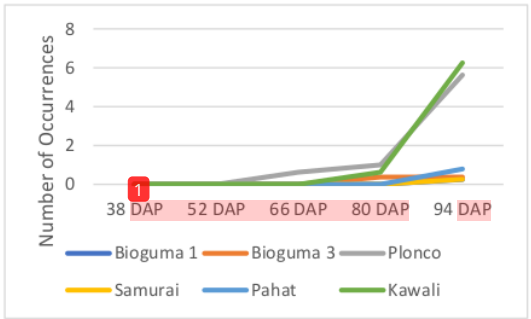

Figure 10: Development of the intensity of Microdochium sp. leaf spot disease

The graph of *Microdochium* leaf spot disease infection shows symptoms appearing on sorghum plants at 66 days after planting (DAP), which then increase until the plants reach 94 days after planting. According to Landschoot's research, (2021), *Microdochium* fungus begins by grass leaf tissues through the *Microdochium* nivale mycelium present in plant residues in the soil. The mycelium and conidia then spread to plants with low resistance and in humid environments. Kawali variety has the highest disease intensity value at 12,2% with an incidence rate of 6,255%, while symptoms of *Microdochium* disease are not detected in the Bioguma 1 variety.

***P. sorghi* leaf rust disease infection**

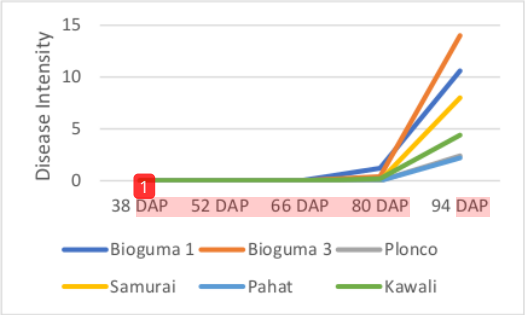

Figure 11: Development of the intensity of *P. sorghi* leaf rust disease

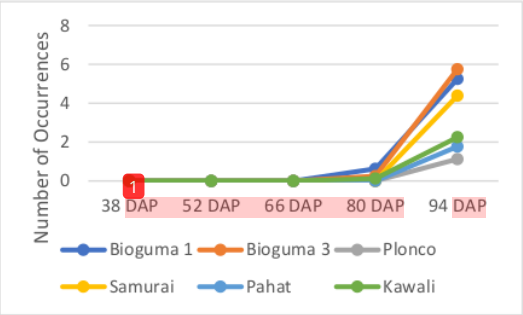

Figure 12: Development of the intensity of *P. sorghi* leaf rust disease

Leaf rust disease caused by *P. sorghi* is first detected in sorghum plants at 80 days after planting (DAP), which then increases as the plants reach 94 days after planting. The initial symptoms caused by *P. sorghi* are the appearance of leaf rust, resembling red to brownish spots on the leaf surface. These leaf rust spots will continue to spread and can be contagious, eventually covering the leaves entirely with rust spots.

photosynthesis in leaves and cause stunted growth in plants (R. Sari *et al*., 2022). The highest infection of leaf rust disease occurs in the Bioguma 3 variety with a disease intensity value of 14% and an incidence infection rate of 5,75%.

Armyworm pest attack (*Spodoptera* sp.)

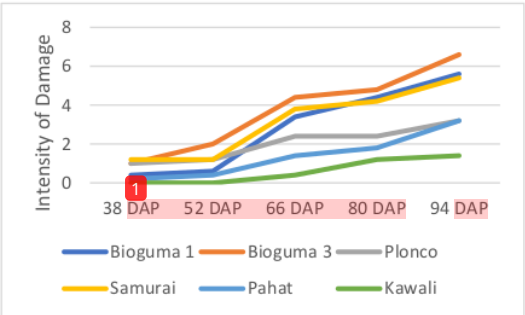

Figure 13: Development of Armyworm pest damage intensity

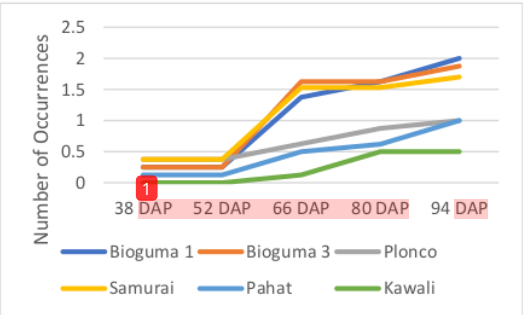

Figure 14: Development of Armyworm pest attack incidence

Armyworms (*Spodoptera* sp.) are one of the pests that can harm sorghum plants due to their attacks. The damage caused by armyworms manifests as holes in the leaves. Armyworms attack plant leaves by consuming leaf tissues and leaving behind a transparent epidermis layer (Prasetya *et al*., 2022).

Armyworms attack every variety of sorghum plants with varying levels of infestation. These pests start to attack sorghum plants at 38 days after planting (DAP). Based on the leaf armyworm infestation graph the least infestation of armyworms occurs in the Kawali variety with a

damage intensity of 1,4% and an incidence rate of 0,5%.

Aphids pest attack

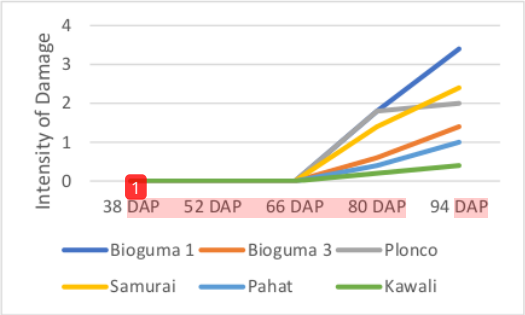

Figure 15: Development of Aphids pest damage intensity

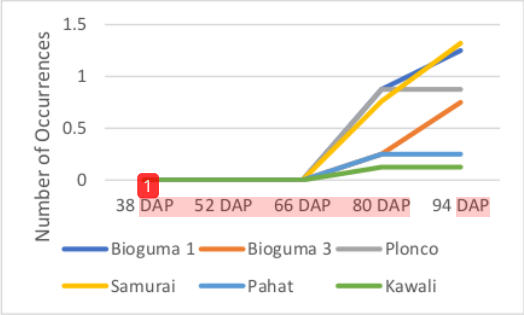

Figure 16: Development of Aphids pest attack incidence

Aphids are one of the pests that attack several crops, including sorghum. Aphids are known to be monophagous, oliophhagous, and some species are polyphagous, serving as important vectors for plant virus diseases. These pests cause damage to affected plants, inhibiting plant development and growth and reducing yield (Sari S. P., *et al*., 2020). Aphids attack sorghum plant leaves that have not fully emerged by sucking cell sap from the leaves, resulting in wilting of the affected leaves. They begin to attack sorghum plants at 80 days after planting (DAP), with their attack intensifying at 94 days after planting. AAphids attack every variety of sorghum plants with varying levels of infestation. The highest intensity of damage and incidence of aphid attacks occur in the Bioguma 1, at 3,4% and 1,25%, respectively

Table 06: Resistance categories of some varieties of infected diseases sorghum plants

Variety	*Alternaria* sp. leaf spot disease	*Curvularia* sp. leaf spot disease	*C. sorghi* leaf spot disease	*Microdochium* sp. leaf spot disease	*P. sorghi* leaf rust disease	*Fusarium* disease
Bioguma 1	Slightly resistant	No symptoms	No symptoms	No symptoms	Resistant	Highly resistant
Bioguma 3	Slightly resistant	Highly resistant	No symptoms	Highly resistant	Resistant	Highly resistant
Plonco	Resistant	Resistant	No symptoms	Resistant	Highly resistant	Resistant
Samurai	Slightly resistant	Resistant	Highly resistant	Highly resistant	Resistant	Highly resistant
Pahat	Resistant	Resistant	Highly resistant	Highly resistant	Highly resistant	Highly resistant
Kawali	Resistant	Slightly resistant	Highly resistant	Resistant	Highly resistant	Highly resistant

Based on the resistance category table against infection diseases, several sorghum varieties demonstrate their level of resistance against diseases that have attacked sorghum variety. The

Bioguma 1 variety could be considered as having good resistance compared to other sorghum varieties because it shows no symptoms of leaf spot diseases caused by *Curvularia*, *C. sorghi*, and *Microdochium* fungi. Some sorghum plant varieties exhibit varying levels of resistance against specific diseases. The resistance level of several sorghum plant varieties to the six disease that have infected sorghum varieties tend to be low or have not yet reached the category of severe disease infection.

Table 07: Categories resistance of sorghum varieties to pest attacks

Varieties	Armyworms pest	Aphids pest
Bioguma 1	Resistant	Highly resistant
Bioguma 3	Resistant	Highly resistant
Plonco	Highly resistant	Highly resistant
Samurai	Resistant	Highly resistant
Pahat	Highly resistant	Highly resistant
Kawali	Highly resistant	Highly resistant

Based on resistance category of sorghum varieties against pest attacks shows that several varieties have good resistance, categorized as resistant and highly resistan, against attack by leaf armyworms and aphids because the level of pests attack cause is not too severe. Armyworms and aphids pest are attack all six sorghum varieties with varying degrees of severity.

Table 08: Nutrient content in soil and organic fertilizers

Sample	Nutrients (%)				
	Potassium	Phosphorus	Nitrogen	Calcium	Magnesium
GOF	0,401	0,361	1,045	0,306	0,166
KRMJ's Soils	0,029	0,026	0,535	0,009	0,007
COF	0,348	0,149	0,941	0,087	0,103

Informations: GOF (Goats organic fertilizers), COF (Cow organic fertilizers), KRMJ's Soils (Karangmojo's soils)

The nutrient conten in soil and organic fertilizers table shows goat organic fertilizer contains higher nutrient contents such as nitrogen, phosphorus, potassium, calcium, and magnesium compared to cow organic fertilizer. Some of these nutrients can enchance resistance to disease infection in sorghum plants. Nitrogen (N) can be a role in protein formation, which functions in plant protection against pests and diseases as well as coordinating organism activities.

Phosphorus (P) is involved in the process of photosynthesis and plant respiration, and it can reduces the occurrence of diseases. Potassium (K) helps mitigate the adverse effects of excessive nitrogen (N) application, making plants less susceptible to pest and disease attacks. Calcium (Ca) enchances harvest productivity by reducing soil acidity, while magnesium (Mg) is a key component in the structure of chlorophyll (Purba, et al., 2021).

CONCLUSIONS

Application of organic fertilizers from cow and goat manure does not affect the level of disease infection and pest attacks but there are diffrences in the resistance of each sorghum variety. Each sorghum variety shows varying levels of resistance to disease infection and pest attack. There are varieties with good growth, namely

Bioguma 1, Bioguma 3, and Kawali. Disease infections from highest to lowest in each sorghum plant variety are *Alternaria* leaf spot disease, *Curvularia* leaf spot disease, *P. sorghi* leaf rust, *Fusarium* disease, *Microdochium* leaf spot disease, and *C. sorghi* leaf spot disease. Armyworms attack each sorghum variety more than aphids do.

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