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Inventory of Pests and Diseases Intensity on 10 Bambara Groundnut (*Vigna subterranean* L. Verdcourt) in the Dryland of Madura during The Dry Season

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ABSTRACT

Landraces breeding scheme of bambara groundnut from various regions of Indonesia since 2012 provides several potential lines which are uniform, high yielding and drought-tolerant. Evaluation of resistance to pests and diseases is aimed to select potential lines which are resistant to pests and diseases and potential for development in Madura dry land during the dry season. The present study used descriptive method through field observation technique on 10 selected potential lines of Bambara groundnut. The results showed that there were 5 (five) types of pests and 4 types of diseases found in bambara groundnut crops planted during the dry season in Bangkalan Regency of Madura. The pests attacking more than 25% per plot were aphids, ladybugs and grasshoppers. A symptom of pathogen attacking more than 25% per plot were Bean common mosaic virus and soybean common mosaic virus. The GSG 1.1.1 potential line had the lowest pest attack and the BBL 2.1.1 potential line had the lowest disease incidence.

Key words *: bambara groundnuts, diseases, pests, resistance*

PENDAHULUAN

Bambara groundnut (*Vigna subterranean* L. Verdcourt) is a crop of West African origin. The distribution of bambara groundnut covers the continents of America, Asia and Australia. Bambara groundnut has cultivated in Asian regions such as India, Malaysia, the Philippines, Thailand and Indonesia. In Indonesia, Bambara groundnut is been well adapted in Bogor and West Java regions. Bambara groundnut are also cultivated in the areas of Sukabumi, Majalengka, Tasikmalaya, Bandung, Central Java (Pati and Kudus), East Java (Gresik), Lampung, NTB and NTT. A total of 50 Bambara groundnut lines have been collected in Indonesia. The 50 lines were originated from West Java and East Java (Kuswanto et al. 2012).

Bambara groundnut has good potentials for cultivation in Indonesia. It is capable of growing and developing well in sub-optimal, marginal, dryland environments. Bambara groundnut is tolerant to drought stress (Nakano 2002; Berchie et al. 2012; Mabhaudi & Albert 2013; Abejide et al. 2017). In addition, it can also yield well in low-nutrient soils, such as sandy soils. It needs well-drained soil for high production and can be high-yielding in conditions of high temperature and low rainfall. In addition, it also need well-drained soil for high production. Bambara groundnut is also reported to be have good resistance to disease and pests (Muhammad et al. 2020; Ramadhani 2017).

Bambara groundnut is a legume that can be used for food. 100 grams grains of bambara groundnut contains 56.61% carbohydrates, 20.6% protein, 6.6% fat, 6.3% fiber, and 3.25% ash. The fat content of bambara groundnut consists of unsaturated fatty acids, including palmitic, oleic, linoleic, and caprylic. Bambaranuts are recommended as health foods good maintaining for body condition (Mazahib et al. 2013; Mubaiwa et al. 2018; Tan et al. 2020). The demand for bambara nuts in Indonesia continues to increase. Thus, it is necessary to increase its production.

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However, the productivity of bambara groundnut in Indonesia is still low. The average production of bambara groundnut in Indonesia is below 4 tons ha^{-1} (Redjeki 2007). The low productivity of bambara groundnut can be caused by both genetic and environmental factors (Khan et al.2021). Among the environmental factors are pests that cause physical damage, physiological and biochemical disturbances and competition for nutrients with the cultivated plants. Pests and diseases can reduce the productivity and quality of yield (Hillocks et al. 2012).

Pests and diseases during Bambara groundnut cultivation can lead to a decrease in both the quantity and quality of production. According to Hampson et al. (2000), viral diseases are important in Bambara groundnut crops in Burkina Faso. Moreover, according to Ouoba et al. (2019), there are 16 species of fungus found to disrupt the growth of Bambara groundnut crops. Biological control using bacteria *Bacillus* spp. as a natural fungicide in Bambara groundnut has been studied by Pengnoo et al. (2006). In recent times, there have not been many reports on pests and diseases of Bambara groundnut crops grown in Indonesia. Therefore, an inventory of pests and diseases as well as their spread over bambara groundnut crops is needed to design effective control measures.

METHODS

The present study was conducted from September 2020 to January 2021 in the experimental field station of Agroecotechnology and Integrated Laboratory of Trunojoyo University at Village Telang, Sub district Kamal, Bangkalan Regency. The equipment used in the present study consisted of sprayers, labels, hoe, rulers, markers, laminar air flow (LAF), Petri dish and cameras. The materials used in the study included 12 lines of bambara groundnut (Table 1), urea, SP-36 fertilizer, and KCl fertilizers, potato dextrose agar (PDA) and water.

The present study used the descriptive method with an field observation data collection technique on 12 selected potential lines of Bambara groundnut. Ten selected potential lines and two non-selected local land races belongs to bambara groundnut cultivation Centers in Gresik Regency and Bangkalan Regency of Madura were used in the study. All the bambara groundnut genotypes were planted in a randomized complete block design (RCBD). The size of each experimental unit was 200 cm x 150 cm were replicated three times, so that there were 36 experimental units (12 genotypes x 3 replications), the distance between the beds was 50 cm. Each planting hole was planted with one seed with a depth of about 5 cm. Fertilizers i.e., Urea, SP-36 and KCl were used at the rate of 50, 100 and 100 kg ha^{-1} (Redjeki 2003). Fertilization was carried out 3 times: 1/3 dose at the time of planting, 1/3 dose at the second fertilization (plants aged 21 DAP) and the third fertilization was given when the plants aged 40 DAP.

Field observations of pests and diseases in bambara bean crops were focused on each sample plant plot by identifying the types of pests and diseases as well as the symptoms of attack on each sample plant. The observations were performed weekly, starting from germinationto harvesting. Bambara groundnut pests were identified by direct observation and the symptoms were examined according to manual identification. The diseases symptoms that could not be identified directly for the causes, specifically those allegedly caused by fungus, were cultured in vitro prior to being observed under a microscope. The observation parameters included, among others, the damage intensity of pests and diseases on bambara groundnut plants, which was calculated the percentage of damage on 12 lines of bambara groundnut crops. The percentage of pest and disease incidence was calculated using the formula (Rahardjo and Suhandi 2008):

$$DI = a/N \times 100\%$$

where :

DI	=	Pest/Disease Incidence
a	=	Number of plants showing damage/symptom
N	=	Number of plants observed

RESULTS AND DISCUSSION

Pests and Diseases Found on Bambara Groundnut Crops during The Dry Season in Madura

The results showed that there were 5 (five) types of pests and 4 types of diseases found in Bambara groundnut crops planted during the dry season in Bangkalan Regency of Madura (Table 2). Among the five types of pests found, the time of incedences was earlier in the growth of bambara groundnut, including ladybird (*Epilachnaadmirabilis*), grasshopper (*Oxya chinensis*), and aphids (*Aphis craccivora*). Then the leaf borer (*Liriomyzasative*) and the rats (*Rattus argentiventer*) attack at the last

when the pods have hardened. Figure 1 showed the four types of insect pests found in the bambara groundnut plants.

Table 1. List of Bambara groundnut genotypes

Code	Genotype names	Origin of potential lines	Remarks
G1	Local Madura	Local Madura	Short duration
G2	Local Gresik	Local Gresik	Long duration
G3	BBL 6.1.1	Potential line selected from the local Lamongan lines	Short duration
G4	GSG 1.1.1	Potential line selected from the local Gresik lines	Short duration
G5	CKB-1	Potential line selected from the local Bangkalan lines	Short duration
G6	TKB-1	Potential line selected from the local Bangkalan lines	Short duration
G7	GSG 2.4	Potential line selected from the local Gresik lines	Short duration
G8	BBL 2.1.1	Potential line selected from the local Lamongan lines	Short duration
G9	GSG 3.2.1	Potential line selected from the local Gresik lines	Short duration
G10	JLB-1	Potential line selected from the local Bangkalan lines	Short duration
G11	CKB-1	Potential line selected from the local Bangkalan lines	Long duration
G12	TKB-1	Potential line selected from the local Bangkalan lines	Long duration

Table 2. Appearance and duration of pest and disease attacks on bambara groundnut

No.	Pests/Diseases	Time of pest appearance/ disease onset (DAP)	Duration of attack (weeks)	Remarks
	Pest			
1	Grasshoppers (*Oxya chinensis*)	21	10	Vegetative Phase
2	Ladybugs (*Epilachnaadmirabilis)*	15	6	Vegetative Phase
3	Leaf -miner caterpillars (*Liriomyzasative*)	30	6	Vegetative Phase
4	Aphids (*Aphis craccivora*)	21	5	Vegetative Phase
5	Rats (*Rattus argentiventer*)	84	8	Generative Phase
	Diseases			
1	Bean common mosaic virus	21	8	Vegetative Phase
2	Soybean yellow mosaic virus	35	6	Vegetative Phase
3	Peanut rosette virus	37	6	Vegetative Phase
4	Leaf spots	42	8	Vegetative Phase

Four types of diseases dominated in bambara groundnut crops planted on dryland during the dry season in Bangkalan Regency of Madura virus diseases, i.e., bean common mosaic virus (BCMV), soybean common mosaic virus (SCMV), peanut rosette virus and one fungal disease (leaf spot disease). Figure 2 showed the four types of disease symptoms found in the bambara groundnut plants.

Figure 1. Four types of insect pests found (a) grasshoppers (*Oxya chinensis*), (b) ladybugs (*Epilachnaadmirabilis*), (c) Aphids (*Aphis craccivora*)and (d) leaf-miner caterpillar pupa (*Liriomyzasative*)

Figure 2. Disease symptoms found on bambara groundnut crops planted during the dry season in Madura: (a) leaf spot (b) soybean common mosaic virus, (c) peanut rosette virus and (d) bean common mosaic virus

Timing of Bambara Groundnut Pests and Diseases Incidence

The time of appearance of pests and diseases attacking the Bambara groundnut crops was categorised into two growth phases: i.e., vegetative and generative phases). The vegetative phase of Bambara groundnut plants lasts from germination until just prior to flowering around 35 days after planting (DAP). The generative phase was marked by the appearance of flowers out of the nodes at the age of 35-40 days after planting (DAP). Grasshoppers, ladybugs, leaf-miner caterpillars and aphids were found during the vegetative phase. The diseases, bean common mosaic virus, soybean yellow mosaic virus, and peanut rosette virus were found during the vegetative phase. Leaf spot disease symptoms and rat attacks symtoms appeared later, during the generative phase of Bambara groundnut. Timing of pest attack and

disease onset on the bambara groundnut plants are detailed in Table 2.

Table 2 showed that grasshoppers, ladybugs, and aphids were pests that attack at the beginning of vegetative phase, 15 and 21 days after planting (DAP)), while rats began to attack much later when the plants had already formed pods (84 DAP). The pests with the longest duration of attack on the Bambara groundnut plants were ladybugs (11 weeks), while those with the shortest duration of attack were the rats (5 weeks). The earliest attacking disease of the Bambara groundnut was bean common mosaic virus (21 DAP). Leaf spot disease was found at a later stage (42 DAP). Attack by bean common mosaic virus and leaf spot was of longer duration than attack by soybean yellow mosaic virus and peanut rosette virus.

Pest and Disease Attacks on 12 genotypes of Bambara Groundnut

The results showed that aphids were the pests with the highest intensity among the five types of pests found on Bambara groundnut crops in Bangkalan Regency. The incidence rate for aphids was 38%, followed by ladybugs (33.8%), grasshopper (28.6%), and rats (22.0%) .The pests with the lowest level incidence were leaf-miner caterpillars (2.0%).

The results also showed that bean common mosaic virus (BCMV) had the highest percentage disease incidence among the four types of diseases found on Bambara groundnut crops planted in Bangkalan Regency. The bean common mosaic virus (BCMV) had the highest disease incidence (36.4%) per plot, followed by leaf spot disease (26.7%), soybean common mosaic virus(3.5%), and peanut rosette virus had the lowest disease incidence (1.7%) per plot. The data for level of pest and disease incidence are shown in Table 3.

The pest incidence was almost the same level across the twelve Bambara groundnut lines tested, ranging from 22.0% to 26.7%. Among the twelve lines, the selected line from Lamongan Regency (BBL 6.1.1.) was mostly attacked by pests (26.7%), while the selected line from Gresik Regency (GSG 1.1.1) was the least attacked by pests (22.0%). The levels of disease incidence on the twelve Bambara groundnut lines showed lower values relative to those of pest attacks. The levels of disease incidence among the lines ranged from 12.4 % to 20.4%. The selected line from Lamongan Regency (BBL 6.1.1.) was the genotype with the highest level of disease attack (20.4%), while the selected line from Gresik Regency (GSG 2.4.) was the genotype the least incidence (12.4%). The data for the level of pest and disease incidences on the twelve genotypes are shown in Table 4.

Table 3. Level of pest and disease incidence in the experimental plots

No.	Pests/Diseases	Incidence (%)
Pests		
1	Grasshoppers (*Oxya chinensis*)	28.6
2	Ladybugs (*Epilachnaadmirabilis)*	33.8
3	Leaf borer caterpillars (*Liriomyzasative*)	2.0
4	Rats (*Rattus argentiventer*)	22.0
5	Aphids (*Aphis craccivora*)	38.0
Diseases		
1	BMCV	36.4
2	SMCV	3.5
3	Peanut rosette virus	1.7
4	Leaf spots	26.7

The present study found three insect pests that attacked bambara groundnut crops planted during the dry season in Bangkalan Regency of Madura; namely, grasshoppers, ladybugs and aphids. The symptoms of grasshopper attacks observed on bambara groundnut plants consisted of the presence of torn leaves starting from the leaf edge accompanied by grasshoppers observed on the crops. The symptoms of ladybug attack were identified by small round holes on the leaf lamina associated with adult ladybugs observed on the leaves. The symptoms of attack by the aphid Aphis craccivora were wrinkleing of the leaves and abnormal growth of leaves and plants. Pest attacks and pest control efforts on Bambara groundnut crops have also been widely reported. Tlankka et al. (2020) reported the attack of the aphids Aphis craccivora on bambara groundnut crops. Ibrahim et al. (2018) reported that grasshoppers are one of the pests of bambara groundnut. Begna and Dennis (2003) reported that grasshoppers are also one of the insects that destroy soybean leaves. Apriliyanto and Setiawan (2014) reported that grasshoppers and aphids are the main pests of long bean plants, while predator ladybug species are among the natural enemies of aphids.

Table 4. The pest and disease incidence per plot of twelve Bambara bean genotypes during the dry season

Pests and diseases	Bambara groundnut genotypes												Average
	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	
Pests (%)													
Oxya chinensis	29.5	30.5	29.2	29.0	29.8	26.3	29.0	27.7	31.8	27.3	29.8	23.2	28.6
Epilachnaadmirabilis	33.7	33.6	35.5	29.5	35.8	38.0	35.2	35.7	32.0	32.6	33.0	32.0	33.8
Liriomyza s ative	1.8	3.1	3.8	1.3	2.7	2.2	1.8	0.4	2.0	1.3	1.1	2.2	2..0
Rattus argentiventer	23.7	18.7	26.1	20.3	22.7	20.8	20.8	25.6	18.9	19.2	21.1	26.4	22.0
Aphis craccivora	35.1	29.6	39.1	30.0	40.9	38.9	41.8	40.2	40.4	42.4	37.6	40.0	38.0
Disease (%)													
BCMV	33.7	28.2	37.8	28.5	40.0	37.2	40.0	37.5	38.3	40.0	36.7	38.7	36.4
SCMV	2.0	5.1	4.9	5.8	4.4	3.6	4.4	1.1	2.9	0.9	4.2	2.2	3.5
Peanut rosette virus	2.7	-	2.4	-	-	4.0	4.7	-	-	1.8	2.4	1.8	1.7
Leaf spots	20.5	38.2	34.3	28.0	29.0	33.7	32.3	11.2	33.7	20.7	14.0	24.8	26.7

Note: BCMV = *Bean common mosaic virus,* SCMV = *soybean common mosaic virus*

Ghosh (2017) reported aphid is a very important pest attacking tomato crop. Groundnut is a legume crop damaged by various insect pests, of which aphids Aphis craccivora cause heavy damage to tender leaves of the plant and reduces its yield (Ghosh, 2020). The other pests found in this study were leaf-miner caterpillars (Liriomyza sp.) and rats. The initial symptoms of attacks by the leaf borer caterpillar Liriomyza include trace-lines burrowed under the surface layers of the leaves and larvae found between the layers of leaves and palisade tissue. Nonci (2016) suggested that larvae are more commonly found in the lower canopy of plants. The symptoms of rat attacks on bambara groundnut plants are indicated by the peeling of pods and stems around the plant and the presence of rat burrows in the ground around the plant.

There were four types of diseases attacking bambara groundnut crops planted in the dry season in Bangkalan, Madura. They were dominated by the bean common mosaic virus (BCMV), soybean mosaic common virus (SCMV) and peanut rosette virus. The bean common mosaic virus and soybean yellow mosaic virus have almost similar symptoms of attacks, including shriveled and curled leaves and abnormal growth of plants. The differences are that the soybean yellow mosaic virus causes the leaves to become unevenly colored between yellow and green, while the peanut rosette virus leads to the older leaves rolling down and stunting the plant growth. According to Konaté et al. (2017) and Zongo et al. (2019), the viruses CABMV and BCMV-BlCM are also found on bambara groundnut crops in Burkina Faso.

The results of field observations show that the time of appearance of pests and diseases attacking bambara groundnut plants in the dry season can be grouped into two phases, namely the vegetative (up to 35 days after planting) and generative phases (35-40 days). The pests found during the vegetative phase of bambara groundnut plants included grasshoppers, ladybugs, leaf-miner caterpillars Liriomyza sp. and aphids Aphis craccivora. The diseases found during the vegetative phase of bambara groundnut plants were bean common mosaic virus, soybean yellow mosaic virus, peanut rosette virus, and the leaf spot disease. Rats were found to attack during the generative phase of bambara groundnut plants. Grasshoppers and ladybugs attacked =at the beginning of growth, precisely between 15 and 21 days after planting, respectively. The leaf borer caterpillars Liriomyza sp. began to appear when the plants were aged 30 days after planting.

When the plants were aged 21 days after planting, the aphids Aphis craccivora and bean common mosaic virus were also found. These pests and diseases appeared at the same time since the

aphids Aphis craccivora are thought to be the vector of bean common mosaic virus. This is in accordance with the study of Megasari et al. (2014), which found that the aphids Aphis craccivora are vectors (virus carriers) capable of transmitting several important viruses to legumes, including bean common mosaic virus (BCMV), cowpea aphid-borne mosaic virus (CABMV), soybean yellow mosaic virus (SYMV), and peanut rosette virus. The soybean yellow mosaic virus attacked bambara groundnut plants at the age of 35 days after planting while peanut rosette virus attacked the plants at the age of 37 days after planting.

Leaf spots, Fusarium wilt and rats were found to attack bambara groundnut plants in the generative phase in a study by Sumartini (2008). The symptoms of leaf spot disease began to appear at the beginning of flowering, precisely when the plants were aged 42 days after planting. The leaf spot disease began to appear in the generative phase and increased when the pods of bambara groundnut were filled. Symptoms of Fusarium wilt disease began to appear at the age of 45 days after planting. The time of Fusarium wilt attacks was almost simultaneous with the appearance of leaf spots since both are caused by the same soil-borne fungus.

In this study, rats attacked bambara groundnut crops in the generative phase, when the plants were aged 84 days after planting, especially as the pods began to form. Sudarmadji et al. (2017) argued that rats do not actively attack bambara groundnut crops during the vegetative phase, but actively do so when the crop enters the generative phase. It is indicated by the presence of rat burrows around the plants. Rats had a low spreadover bambara groundnut plants sincethey were not found to attack all crop plots. Rats attacked only the plants in the center of the plot and did not attack those onthe edge of the plot. Despite the low spread in each plot, rat attacks reduced pod production since they directly destroyed bambara groundnut pods by eating the seeds and leaving the pod skin around the plants.

The present study found 2 (two) diseases which spread out on all plots of plants, namely the bean common mosaic virusand leaf spot disease. The beancommon mosaic virus spread evenly over all plants in each plot. The spread of this disease was the same as that of the aphids Aphis craccivora since the latter is the vector of bean common mosaic virus. The spread of leaf spot disease in each plot was quite wide, as more than half of the plants in each plot were affected. The wide spread of leaf spot disease with a high attack intensity led to a reduced pod production. The genotypes of bambara groundnutwith a low rate of attack by leaf spotswere the potential lines BBL 2.1.1, CKB-1, TKB-1, JLB-1 and two local lines from Gresik and Madura.

The two diseases with a low rate of attack on bambara groundnut plantswere soybean yellow mosaic virusand peanut rosette virus. The soybean yellow mosaic virusspread over nearly all plant plots. GSG 1.1.1 and GSG 2.4 were the potential lines mostly attacked by soybean yellow mosaic virus. The two potential lines selected from Madura, namely CKB-1 and TKB-1, and the selected potential line from Gresik (GSG 3.2.1) and the Gresik local line were the genotypes moderately attacked by soybean yellow mosaic virus. The Madura local line and the potential line selected from Lamongan BBL 6.1.1 were the genotypes least attacked and only the potential line JLB-1 was not attacked by soybean yellow mosaic virus. The potential lines CKB-1, TKB-1, GSG 2.4 and BBL 6.1.1 were the genotypes moderately attacked by this virus or there were 2 plots of bambara groundnut crops attacked by this virus of the 3 plots. The potential line JLB -1 was only attacked in one plot and this virus did not attack the potential lines GSG 1.1.1, 3.2.1 GSG, BBL 2.1.1 and the local Gresik line.

In general, a conclusion could be drawn that attack with leaf spot disease on bambara groundnut plants has a fairly wide spread and a high intensity of attack capable of reducing pod production. It is different from the attacks by viral diseases. The bean common mosaic virus has a fairly wide spread and a high rate of attack over Bambara groundnut and the soybean yellow mosaic virusand peanut rosette virus spread with a low attack rate. However, attack with the three viruses does not cause a decrease in pod yields, as bambara groundnut plants are thought to be legumes resistant to viral attacks. According to Konate et al. (2019), the viral attack rates on bambara groundnut crops greatly depend on the strain of the attacking virus, age and genotype of bambara groundnut crops. Taiwo et al. (2014) show the negative correlation between the number of nodules and CABMV attacks. The decrease in the number of nodules can be used as the basis for determining the attack of bambara groundnut crops with CABM.

CONCLUSIONS

There were 5 (five) types of pests and 4 types of diseases found in bambara groundnut crops planted during the dry season in Bangkalan Regency of Madura. The pests attacking more than 25% per plot were aphids, ladybugs and grasshoppers. A symptom of pathogen attacking more than 25% per plot were Bean common mosaic virus and soybean common mosaic virus. The GSG 1.1.1 potential line had the lowest pest attack and the BBL 2.1.1 potential line had the lowest disease incidence.

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