Open Access & Available Online

Agrovigor: Jurnal Agroekoteknologi

ISSN: 1979-5777 (*Print*), 2477-0353 (*Online*)

Journal homepage: https://journal.trunojoyo.ac.id/agrovigor

Article

Diseases in Tobacco with Monoculture and Polyculture Farming Systems

Vera Januarsih[1], Hagia Sophia Khairani[1*], Tri Asmira Damayanti[1]

[1] Department of Plant Protection, Faculty of Agriculture, Institut Pertanian Bogor, Jl. Kamper, Kampus IPB Darmaga, Wing 7 Level 5, Bogor, 16680, Indonesia

*Corresponding author: **Hagia Sophia Khairani** (hskhairani@apps.ipb.ac.id)

ARTICLE INFO

Article history
Received: March 2nd, 2025
Revised: April 29th, 2025
Accepted: May 8th, 2025
Published: June 3rd, 2025

Keywords
Leaf curl;
Leaf spot;
Mosaic;
Nicotiana tabacum;
Plant disease

DOI:
https://doi.org/10.21107/agrovigor.v18i1.29407

ABSTRACT

Tobacco (*Nicotiana tabacum* L.) is an important agricultural product in Indonesia. Disease information on tobacco is required to develop effective control methods for supporting a proper tobacco farming system. This study investigates the disease type and intensity of tobacco in monoculture and polyculture cropping systems in Patebon District, Kendal Regency, Central Java. Disease evaluation factors such as types of symptoms, disease incidence and severity, and crop productivity under both crop systems were measured on tobacco every week for four weeks from 14 to 17 weeks after planting, as well as during harvest. Microscopic observation was used to identify the causative infections. The findings revealed that the disease makeup differed amongst crop systems. The leaf curl (*Tobacco leaf curl virus*) and mosaic (*Tobacco mosaic virus*) diseases were discovered in both cropping systems. However, anthracnose (*Colletotrichum* sp.) and leaf spot (*Cladosporium* sp.) were only observed in monoculture farming systems, whereas wildfire (*Pseudomonas syringae* pv. *tabaci*) was only identified in polyculture farming systems at a low incidence. In general, disease incidence and severity were higher in monoculture agriculture systems than in polyculture crops. Furthermore, the policulture crop system had a slightly higher yield, indicating that tobacco would be better planted in polyculture than monoculture crop systems.

INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is a highly valued commodity in various nations, including Indonesia. Tobacco is a source of foreign currency, government revenue and taxes, income for farmers, and community employment (growing and cigarette processing) (Rachmat & Nuryanti 2009). Indonesian tobacco production in 2020 was 198.739 tons, representing a 7,92% rise over 2016. However, this level of production has not been sufficient to meet domestic tobacco demand, which averages 335.000 tons per year. As a result, tobacco is imported from other countries, such as China, Turkey, and the United States, to make up the difference (Triono 2017).

Pests and diseases are a major issue for tobacco farmers, resulting in significant production losses. Tobacco plant pests include thrips (*Thrips parvispinus*), armyworms (*Spodoptera litura*), earthworms (*Agrotis ipsilon*), tobacco shootworms (*Helicoverpa armigera*), shoot borers (*Heliothis* sp.), peach aphids (*Myzus persicae*), aphids (*Aphis* sp.), and whiteflies (*Bemisia tabaci*). Tobacco diseases include black shank (*Phytophthora nicotianae*), frog-eye leaf spot (*Cercospora nicotianae*), stem rot (*Sclerotium rolfsii*), bacterial wilt (*Ralstonia solanacearum*), root knots (*Meloidogyne* sp.), leaf curl (*Tobacco leaf curl virus*), mottle (*Tobacco etch virus*), and mosaic (*Tobacco mosaic virus*) (Siregar 2016).

The monoculture and polyculture farming systems used by tobacco producers in Kendal Regency, Central Java, are hypothesized to influence disease dynamics. As a result, this field study was undertaken to assess the impact of planting patterns on disease progression. Farmers can utilize the information gained to determine the appropriate planting patterns and targeted disease management strategies.

MATERIALS AND METHODS

Observation site and farmers interview

Disease observation was carried out on two tobacco fields with distinct farming systems (monoculture and polyculture) in Patebon District, Kendal Regency, Central Java. Both observation fields covered 5000 m2. To learn about the cultivation of tobacco plants, farmers were interviewed using a systematic questionnaire. The observed plants were 11 to 17 weeks after planting (WAP). Plant samples were picked using a stratified sampling across rows, up to 50 per field. Tobacco plants were observed for disease symptoms in both fields beginning at the age of 11 WAP in the monoculture field and 14 WAP in the polyculture field. The disease's symptoms were confirmed in the published reports, and the pathogen's identity was confirmed through microscopic observation in the Department of Plant Protection, Faculty of Agriculture, IPB University.

Disease incidence, disease severity, and yield estimation

A total of 50 samples from each field were analyzed for disease incidence, severity, and harvest results at 17 WAP. Disease incidence (DI) and disease severity are calculated using the following formula (Cooke 2006):

$$DI = \frac{n}{N} \times 100\ \%$$

with DI = disease incidence (%); n = number of symptomatic plants; N = total plants observed.

$$DS = \frac{\sum_{i=1}^{5}(ni.vi)}{N \times Z} \times 100\%$$

with DS = disease severity (%); ni = number of symptomatic plants in a scale; vi = disease severity scale; N = total plants observed; Z = maximum disease severity scale.

Disease severity is used to describe disease progress in both fields. The severity score of leaf curl disease is as follows: 0 for asymptomatic plants, 1 for yellow leaves on the edges beginning on young leaves, 2 for slightly curly leaves, s3 for curly leaves, curved, and plants still growing, and score 4 for curly leaves, stunted plants, and undeveloped growth (Trisno *et al.* 2009). The severity score of mosaic disease is 0 for asymptomatic plants, 1 for mild mosaic, 2 for moderate mosaic, 3 for severe mosaic without leaf shape changes, 4 for severe mosaic with leaf shape changes, and 5 for severe mosaic with severe leaf shape changes and stunted plants (Suhara & Yulianti 2017).

The area under disease progress curve (AUDPC) based on the results of observations of disease severity is determined using the formula (Cooke 2006) as follows:

$$AUDPC = \frac{(Xt+Xo)}{2}.(t2 - t1)$$

with Xt = disease severity at present observation; Xo = disease severity at the previous observation; t_2-t_1 = observation time interval.

Data analysis

The data collected from weekly observations were processed using the MS Excel 2007 application. Data on incidence, disease severity, harvest results, and AUDPC were analyzed using IBM SPSS 26 software with the Mann-Whitney non-parametric test at α 0.05.

RESULTS AND DISCUSSION

General conditions of the tobacco plantations

The tobacco plantation in Patebon District, Kendal Regency, Central Java has an average air temperature of 26-28 ºC and relative humidity of 75%-85%, with an average rainfall of 53-206 m^3 from August to November (Central Bureau of Statistics 2021). Based on farmer interviews, the local tobacco plant varieties used are Serumpung and Semboja. Farmers chose the two local types because they are readily available and ideal for planting in Kendal's lowland areas.

Tobacco plants can be harvested from 90 to 100 days after planting (DAP). Harvesting occurs six times, with a 5-7-day interval. Harvesting is accomplished by selecting the oldest leaves at the very bottom. Yellowish green leaves indicate that they are ready for harvest. To acquire dry tobacco leaves, thinly slice the leaves and then dry them. Tobacco leaf picking is critical in influencing the quality of both the outcomes and the tobacco itself (Herminingsih 2014). Table 1 summarizes the general state of the observation land.

Diseases in tobacco plantations

The same diseases were discovered in tobacco fields with monoculture and polyculture cropping systems, specifically leaf curl disease caused by the *Tobacco leaf curl virus* and mosaic disease caused by the *Tobacco mosaic virus*. Other diseases found only in monoculture fields included anthracnose stem rot disease caused by the fungus *Colletotrichum* sp. and leaf spot disease caused by the fungus *Cladosporium* sp., but wildfire disease was caused by the bacteria *Pseudomonas syringae* pv. *tabaci* was discovered only in polyculture fields (Figure 1).

Table 1. General conditions on monoculture and polyculture tobacco fields.

Fields information	Farming systems	
	Monoculture	Polyculture
Coordinates	110º10′59″ EL – 6 55′20″ NL	110º10′17″ EL – 6 55′41″ NL
Altitude (m asl)	7	7
Topography	Flat	Flat
Area (m^2)	5.000	5.000
Soil type	Alluvial	Alluvial
Plant population	5.000	5.000
Cropping system	Tobacco only	Tobacco and rice
Varieties	Semboja	Serumpung
Origin of seedlings	Farmers group	Farmers group
Planting distance	60 cm x 60 cm	30 cm x 30 cm
Fertilizers	TSP, ZA, and Urea	TSP and Urea
Fertilizing frequency	4 times: 1 week before planting, 2 WAP (TSP and Urea), 4 and 7 WAP (ZA and Urea)	4 times (every 2 weeks)
Pesticide	Curacron 500 EC	Curacron 500 EC
Weed intensity	Medium	Medium
Weeding interval	Every 1 week	Every 1 week
Irrigation	Rainfed	Rainfed and irrigated
Major pests	Grasshopper, armyworm, aphids, whitefiels	Grasshopper, armyworm, aphids
Surrounding crops	Banana, eggplant	Maize, mungbean
Previous crop	Okra	Rice

Table 2. Disease incidence and severity of leaf curl disease

Variables	Farming systems	Disease incidence and disease severity in-n week after planting (%)[a]			
		14	15	16	17
Disease incidence	Monoculture	54.0 a	58.0 a	58.0 a	58.0 a
	Polyculture	12.0 b	28.0 b	44.0 a	44.0 a
Disease severity	Monoculture	33.5 a	36.0 a	37.5 a	38.5 a
	Polyculture	5.5 b	14.5 b	22.5 b	22.5 b

[a]Average scores from 50 samples, means followed by same letters are not significantly different by Mann-Whitney test at α = 5%.

Table 3. Disease incidence and disease severity of mosaic in tobacco

Variables	Farming systems	Disease incidence and severity in n-week after planting (%)			
		14	15	16	17
Disease incidence	Monoculture	76.0 a[c]	78.0 a	78.0 a	78.0 a
	Polyculture	96.0 a	100.0 b	100.0 b	100.0 b
Disease severity	Monoculture	32.8 a[c]	36.0 a	37.2 a	38.4 a
	Polyculture	19.2 a	25.2 a	30.0 a	32.8 a

[a]Average scores from 50 samples, means followed by same letters are not significantly different by Mann-Whitney test at α = 5%.

Leaf curl. The observations in both fields revealed evidence of leaf curl disease. Tobacco plants infected with leaf curl disease were identified on immature leaves or leaf shoots, exhibiting signs such as curled or shriveled leaves, rolled leaf edges, chlorosis on the leaves, and plant stunting (Figure 1a). *Tobacco leaf curl virus* infection can result in curled leaves, changes in leaf vein color, uneven leaf surfaces, and stiff leaves (Aidawati *et al.* 2002). This disease is spread by whiteflies (*Bemisia tabaci*). The incidence of leaf curl disease increased every week in both observation fields. In both the first and second observations, monoculture field had a higher incidence of leaf curl disease than polyculture's. Upon the completion of observation, the severity of leaf curl disease in monoculture land was significantly higher than in polyculture field (Table 2).

Mosaic. Tobacco plants with mosaic disease exhibit symptoms such as chlorotic leaves that eventually turn mosaic (Figure 1b). These mosaic symptoms were observed throughout the polyculture area. Table 3 shows how mosaic disease is produced by *Tobacco mosaic virus* (TMV) confirmed by specific symptomatology.The incidence and severity of mosaic disease in both fields increased every week. The disease incidence peaked at 100% on the latest observation of the polyculture field. At 14 to 16 WAP, mosaic disease was substantially more common in polyculture land than in monoculture land. The severity of mosaic disease did not differ considerably between monoculture and polyculture sites. TMV virus causes a variety of symptoms in host plants, including mosaic, spots, necrosis, stunting, leaf curl, and yellowing of plant tissue. This virus is easily spread when infected leaves rub against healthy plant leaves, via contaminated instruments, or by farmer actions. This disease can then spread quickly across the land (Scholthof 2000). The high incidence of mosaic disease in polyculture land is also due to the shorter planting distances compared to monoculture land, which accelerates transmission through direct contact.

Anthracnose. Stem rot disease was discovered in monoculture land with symptoms of extensive white to blackish brown blotches on the stem, making the stem soft or rotten and dry (Figure 1c), and microscopically detected conidia of *Colletotrichum* sp. in the shape of cylinders with blunt ends, non-septate, and hyaline (Figure 1d). The prevalence of anthracnose disease in monoculture land is 15%. This disease causes plants to wilt and then die. *Colletotrichum* sp. causes anthracnose disease in tobacco and several other valuable plants. Anthracnose disease can also damage preceding plants, namely okra plants, causing their leaves to wilt and fall off, as well as gray patches on the stalks. The fungus can thrive on infected plant debris and soil (Directorate of Horticultural Crop Protection 2020).

Leaf spots. *Cladosporium* sp. causes the disease, which is characterized by grayish brown spots with a dark gray or brown core (Figure 1e) and oval-shaped to curved conidia (Figure 1f). This disease is prevalent in monoculture land, accounting for 15%.

Wildfire. The bacteria *Pseudomonas syringae* pv. *tabaci* developed a disease in polyculture land with signs of leaf burning (wildfire). Small light brown patches with a yellow halo are the first signs observed on local serumpung variations (Figure 1g). Infected leaves create necrotic rings with a yellow surround which corresponds to the symptoms described by CABI (2018). This disease affects 10% of the sampled plants under polyculture.

There were no anthracnose or leaf spot symptoms recorded on the polyculture fields. This is because, at the time of observation, it was already the harvesting season. Farmers had already plucked plants displaying symptoms of wilted leaves and dried stems. Planting patterns also have an impact on tobacco disease diversity. The downside of monoculture planting patterns is that high cultivar homogeneity accelerates the spread of plant pests, making plants more susceptible to pests and diseases (Syahputra *et al.* 2017). The difference between the two fields is the usage of ZA fertilizer. However, this does not affect the types of diseases found. ZA fertilizer contains sulfur, which in tobacco plants improves color, aroma, leaf elasticity, and leaf count (Soemarah *et al.* 2020).

The AUDPC value and tobacco yields

AUDPC is a standard for observing the progression of disease over time. The AUDPC value increases as the disease progresses, and vice versa (Simko and Piepho 2012). Leaf curl and mosaic diseases are prevalent in both crops. The AUDPC for both diseases is lower in polyculture crops than in monoculture areas (Table 4).

Tobacco harvest data based on planting patterns revealed that the average yield on monoculture land did not differ considerably from that on polyculture field. The decline in yield in this study was driven by the disease's increasing incidence and severity week after week. When compared to polyculture field, the low yield on monoculture planting was directly proportional to the high AUDPC value of mosaic and leaf curl disease severity. Farmers typically collect leaves with a perfect shape and a yellowish green color. If the leaves become infected with leaf curl disease, their shape deteriorates, and farmers are unable to harvest the tobacco leaves. Leaf curl virus infection inhibits tobacco plant development, thickens the leaf veins, and causes the leaves to shrivel. The earlier a plant becomes infected, the higher the growth inhibition. This reduces the amount of productive leaves that can be harvested (Dalmadiyo and Kartamidjaja 2000).

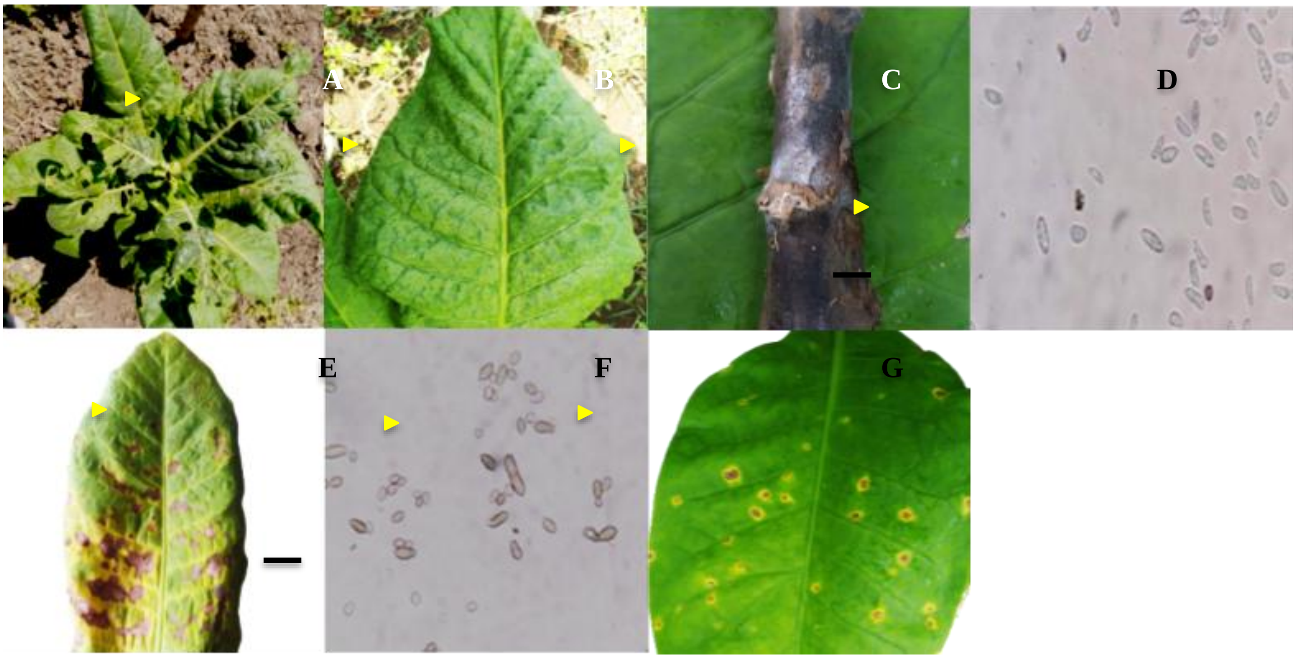

Figure 1. Symptoms of tobacco diseases observed in both tobacco cropping systems include a. leaf curl by *Tobacco leaf curl virus*, b. *Tobacco mosaic virus*, c. anthracnose on the stem by *Colletotrichum* sp., d. conidia of *Colletotrichum* sp., e. Cladosporium leaf spot, f. conidia of *Cladosporium* sp., f. wildfire disease by *Pseudomonas syringae* pv. tabaci. Bar: 5 µm.

Table 4. The AUDPC value and yield data

Farming systems	AUDPC[a]		Yield (g)
	Leaf curl	Mosaic	
Monoculture	109.25 a	108.80 a	618.00 a[c]
Polyculture	51.00 a	81.60 a	626.50 a

[a]Average scores from 50 samples, means followed by same letters are not significantly different by Mann-Whitney test at α = 5%.

Monoculture field had a higher prevalence and severity of leaf curl disease, which could have contributed to the decline in output. The leaf curl virus is transmitted by the whitefly *Bemisia tabaci*, but no vector insects were discovered during the observation. One of the contributing elements is dry weather, which has a direct impact on the activity of vector insects, causing viral transmission to increase (Trisno *et al.*, 2014). Polyculture field has a higher incidence of mosaic disease than monoculture land because the planting distance is narrower (30 x 30 cm) in polyculture land, accelerating the spread of pathogens through direct contact, but this has no effect on harvest results in polyculture plantings. Plants infected with TMV exhibit symptoms that are frequently overlooked by tobacco growers since infected tobacco does not die and can continue to generate results (Hanadyo 2013).

CONCLUSION

Differences in the tobacco farming system result in variations in fungal and bacterial infections, disease incidence and severity, and production in tobacco plantations in Patebon District, Kendal Regency. Land with monoculture cropping system has a broader range of diseases than polyculture land, as well as a higher incidence and severity. The presence of leaf curl and mosaic diseases in both fields significantly reduces tobacco harvests due to disease incidence and severity.

AUTHORS CONTRIBUTIONS

TAD and HSK conceptualized the experiment. VJ carried out the farmers' interviews, data collection, and data analysis. TAD and HSK observed the microscopic structures of fungi and verified the virus symptoms.
VJ, TAD, and HSK interpreted the data. VJ prepared the original manuscript. The authors provided responses and comments on the research flow, data analysis, and interpretation as well as the shape of the manuscript. All the authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Aidawati, N., Hidayat, S.H., Suseno, R., & Sosromarsono, S. (2002). Transmission of an Indonesian isolate of *tobacco leaf curl virus (Geminivirus)* by *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae). *The Plant Pathology Journal. 18*(5):231-236. https://doi.org/10.5423/ppj.2002.18.5.231

Central Bureau of Statistics, Kendal District. (2021). Banyaknya curah hujan 2013-2020. https://kendalkab.bps.go.id/indicator/151/66/1/banyaknya-curah-hujan.html

CAB International. (2018). *Pseudomonas syringae* pv. *tabaci*. https://www.plantwise.org/knowledgebank/datasheet/45016

Cooke, B.M. (2006). *Disease Assessment and Yield Loss. In: The Epidemioloy of Plant Disease 2th ed.* Cooke, B.M., Jones, D.G., & Kaye B. (Eds). Dordrecht: Springer.

Dalmadiyo, G. & Kartamidjaja, M.A. (2000). Pengaruh penyakit kerupuk terhadap hasil dan mutu delapan varietas tembakau Virginia. *Jurnal Penelitian Tanaman Industri*. *6*(2):33-36.

Directorate of Horticultural Crop Protection. (2020). *Okra si lady's finger hortikultura*. http://ditlin.hortikultura.pertanian.go.id/index.php/artikel/detail/Okrasi-Ladys-Finger-Hortikultura

Hanadyo, R., Hadiastono, T., & Martosudiro, M. (2013). Pengaruh pemberian pupuk daun cair terhadap intensitas serangan *Tobacco mosaic virus* (TMV), pertumbuhan, dan produksi tanaman tembakau (*Nicotiana tabacum* L.). *Jurnal Hama Penyakit Tumbuhan.* 1(2):28-36.

Herminingsih, H. 2014. Hubungan adaptasi petani terhadap perubahan iklim dengan produktivitas tembakau pada lahan sawah dan tegalan di Kabupaten Jember. *Jurnal Sosial Ekonomi Pertanian*. 7(2): 31-44.

Rachmat, M. & Nuryanti, S. (2009). Dinamika agribisnis tembakau dunia dan implikasi bagi Indonesia.

Forum Penelitian Agro Ekonomi. *27*(2):73-91. https://doi.org/10.21082/fae. v27n2. 2009.73-91

Scholthof, K.B.G. (2000). *Tobacco mosaic virus. The Plant Health Instructor*. https://doi.org/doi:10.1094/PHI-I-2000-1010-01

Simko, I. & Piepho, H.P. (2012). The area under the disease progress stairs: calculation, advantage, and application. *The American Phytopathological Society*. *102*:381-389. https://doi.org/10.1094/PHYTO-07-11-0216

Siregar, A.Z. (2016). Literasi inventarisasi hama dan penyakit tembakau deli di perkebunan Sumatera Utara. *Jurnal Pertanian Tropik*. *3*(3): 206-213.

Soemarah, T.K.D., Supriyadi, T., Suprapti, E., & Haryuni. (2020). Pengaruh jenis pupuk terhadap produksi daun tembakau (*Nicotiana tabacum*). *Jurnal Ilmiah Agrineca*. *20*(2):68-75.

Suhara, C. & Yulianti, T. (2017). Efektivitas vaksin Carna-5 (*Cucumber mosaic virus associated* RNA-5) terhadap infeksi *Cucumber mosaic virus* (CMV) pada tanaman tembakau Cerutu (*Nicotiana tabacum* L.). *Buletin Tanaman Tembakau, Serat dan Minyak Industri*. *9*(1):24-33. https://doi.org/10.21082/btsm. v9n1.2017.24-33

Syahputra, N., Mawardati, & Suryadi. (2017). Analisis faktor yang mempengaruhi petani memilih pola tanam pada tanaman perkebunan di Desa Paya Palas ,Kecamatan Ranto Peureulak, Kabupaten Aceh Timur. *Jurnal Agribisnis Universitas Malikussaleh* . *2*(1):41-50.

Triono, D. (2017). Analisis dampak tarif cukai hasil tembakau terhadap penerimaan negara dan produk tembakau domestik. *Jurnal Pajak Indonesia*. (1)1:124-129.

Trisno, J., Hidayat, S.H., Jamsari, Manti, I., & Habazar T. (2009). Detection and sequence diversity of Begomovirus associated yellow leaf curl disease of pepper (*Capsium annum* L.) in West Sumatra, Indonesia. *Journal Microbiol Indones*. *3*(2):61-66.

Trisno, J., Rifqah, R.A., & Martinius. (2014). Temuan penyakit baru penyakit kerupuk tembakau di Sumatera Barat. *Jurnal Fitopatol Indones. 10*(6):210-213.

Wang, H.C., Wang, J., Li, W.H., Huang, Y.F., Xia, H.Q., Wang, M.S., Lu, M.S., Guo, Y.S., & Zhang CQ. (2014). *Cladosporium cladosporioides* identified in China on tobacco seeds. *Plant Dis*. *98*(7):1002-1004. https://doi.org/10.1094/PDIS-12-13-1203-PDN