Diseases Incidence and Severity of *Sweet potato feathery mottle virus* in Sweetpotato in Gianyar Regency, Bali

Ni Kadek Sudani Putri[1], Listihani[1*], I Gusti Ayu Diah Yuniti[1], Putu Lasmi Yulianthi Sapanca[1], Farida Hanum[1], Ni Putu Pandawani[1], Dewa Gede Wiryangga Selangga[2]

[1]Faculty of Agriculture and Business, Universitas Mahasaraswati Denpasar, Bali, Indonesia
[2]Faculty of Agriculture, Udayana University, Denpasar, Bali, Indonesia
*Corresponding author. Email: listihani9@unmas.ac.id

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ABSTRACT

Sweet potato feathery mottle virus (SPFMV) (Potyvirus) was first discovered in Indonesia in 2018. No one has reported information about the incidence and severity of SPFMV disease. Therefore, this study aims to determine the incidence and severity of SPFMV in Gianyar, Bali. The research was carried out directly in the field with observational parameters such as symptoms, incidence and disease severity. Observations were made every week when the plants were 63 to 91 days after planting (DAP). The results showed that SPFMV causes purple ringspot symptoms. The incidence of the disease did not increase when the plants were aged 63 to 91 DAP, while the severity of the disease increased every week. The highest incidence and severity of the disease were 70% and 20.7%. The main cause of SPFMV infection in the field is probably due to the continuous use of stem cuttings from previous crops.

Keywords*: Bali; disease symptom; Potyvirus; SPFMV*

INTRODUCTION

Sweet potato *(Ipomoea batatas* L.*)* is a carbohydrate producing plants frequently consumed by people in the eastern part of Indonesia, especially in East Nusa Tenggara, Maluku, Papua, and West Papua (Badan Pusat Statistika 2017). Sweet potato's main content is carbohydrates. In addition, it also has other nutrition in relative high content such as 562 g sodium, 107 mg calcium, 2.8 g protein, 5,565 SI vitamin A and 32 mg vitamin in every 100 grams of fresh sweet potato (Ngailo *et al*., 2016). The high nutritional value makes sweet potato an alternative food to decrease people's dependence on rice. Several regions even have sweet potatoes as their staple food. Moreover, due to the high export demand, sweet potato is a competitive superior commodity in the industry (Pushpalatha *et al.*, 2017). The largest sweet potato production centers in Indonesia are located in West Java, Papua, East Java, and Central Java.

According to Bali Province Agriculture and Food Security Agency 2021, the sweet potato production in Bali changed between 2016-2020 from 42.952 tons to 26.821 tons, and Gianyar Regency is one of the sweet potato cultivation sites. Based on the data, sweet potato production has a decreasing trend from year to year. Land expansion, cultivation methods, and the presence of pests and diseases attacking sweet potatoes are the cause of sweet potato dropping production. To preserve and improve sweet potato production, efforts in managing production-inhibiting factors are required, including managing the transmission of various pathogens such as viruses.

According to Ames *et al*. (1997), leaves showing chlorosis with purple spots are a symptom of sweet potato feathery mottle virus (SPFMV). However, on some strain, SPFMV does not show purple spot symptoms. Leaves infected by SPFMV have normal healthy-sized leaves and mostly do not show clear symptom. This makes it hard for farmers to identify healthy plants and infected ones. The virus infection symptom variations may occur due to factors like virus strain, plant strain, and environmental differences (Listihani *et al.*, 2018; Listihani *et al.*, 2019; Listihani *et al.*, 2020; Listihani *et al.*, 2021; Listihani & Selangga 2021; Selangga *et al.*, 2021; Selangga & Listihani 2021; Listihani *et al.*, 2022; Selangga & Listihani 2022; Selangga *et al.*, 2022; Selangga *et al.*, 2023). SPFMV is a virus not widely researched in Indonesia, so there is a lack of information especially for farmers, in controlling this virus. SPFMV is mostly found in Japan, Portugal, and Korea where it caused 14-52% of production loss (Adikini *et al.*, 2015).

SPFMV was first reported in Indonesia in 2018 in Bogor, West Java with yellow spot symptoms on sweet potato leaves (Hondo *et al.*, 2018). Until now, information on its distribution in other regions has never been reported. Data on the SPFMV incidence and disease severity in Indonesia are unavailable. Thus, this research aimed to determine the SPFMV incidence and disease severity in Gianyar Regency, Bali, on sweet potatoes. This information is useful in devising an accurate SPFMV control strategy.

MATERIALS AND METHODS

Field summary and observation

The survey and sampling were performed on five locations in Gianyar Regency, Bali. In each location, 30 plants were observed, so the total number of plants observed

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is 150 plants. Observations were performed every week when the sweet potato plants were aged 63 to 91 days after planting (DAP). Observed parameters are disease symptoms, incidence, and severity of purple spots in sweet potato plants.

Disease incidence

Disease incidence was calculated based on the proportion of disease infected plants without considering the severity of the infestation, by using the equation:

$$IP = \frac{n}{N} x\ 100\%$$

Note:
IP = Disease incidence (%)
n = Number of plants showing mosaic symptoms
N = Total number of plants observed

Disease severity

Disease severity was calculated based on the proportion of infected plants in a population by considering the disease severity according to an equation used by Mau *et al.* (2020):

$$KP = \frac{\sum_{i-1}^{n}(ni\ vi)}{N\ X\ Z}\ X\ 100\%$$

Note:
KP = Disease severity (%)
N = The number of plants observed shows a certain score
v = Score for sweetpotato crop
N = Highest score value
Z = Number of all sweetpotato plants

The disease symptom scoring was performed by assessing the visual symptom variations observed in the field and inputting symptom scoring of (0-5) (Morin *et al.*, 2012).
0 = symptomless plants
1 = Mild mosaic symptoms
2 = Moderate mosaic symptoms
3 = Plants show severe symptoms or heavy purple blotches without shrinkage or leaf abnormalities
4 = Plants show symptoms of mosaic or heavy purple blotches with shrinkage or leaf abnormalities
5= Plant show mosaic symptoms or very heavy purple spots with severely shriveled or deformed leaves, stunted, or dead plant.

RESULTS AND DISCUSSION

The sweet potato field condition in Gianyar Regency had the sweet potatoes planted in a monoculture system using the local strain "Selo Sidan" obtained from the previous harvest. Weeding was performed to get rid of plant residues and weeds from the soil. In one location, there were 5-6 rows. In one row there were 20-25 mounds and within one mound four sweet potato stem cuts were planted with spacing based on the farmer's approximation. With the plants being a climbing type makes the plant population turned out dense and many diseases were found in the field.

Based on field observation, sweet potato plants showed purple spot symptoms on young leaves (Figure 1). Sweet potato plants with purple spot symptoms have previously been treated by using reverse transcription-polymerase chain reaction (RT-PCR) by universal primers Potyvirus CiFor/CiRev (Ha *et al.*, 2008) and the sequencing analysis result showed an infection by the sweet potato feathery mottle virus (SPFMV) (Listihani 2022, unpublished data). Healthy sweet potato plant has an even green color in their leaf area and normal-sized leaves (Figure 1a). Symptom variations found in the fields are mild, moderate, and severe purple spots (Figure 1). Sweet potatoes with mild symptoms have some purple spots on the surface of their leaves (Figure 1b). Sweet potatoes with moderate symptoms have purple spots on all surfaces of their leaves (Figure 1c). Sweet potatoes with severe symptoms have purple spots on all surfaces of the leaves along with yellowing (Figure 1d). The characteristic purple spot symptoms caused by SPFMV infection are shaped as a *ringspot*.

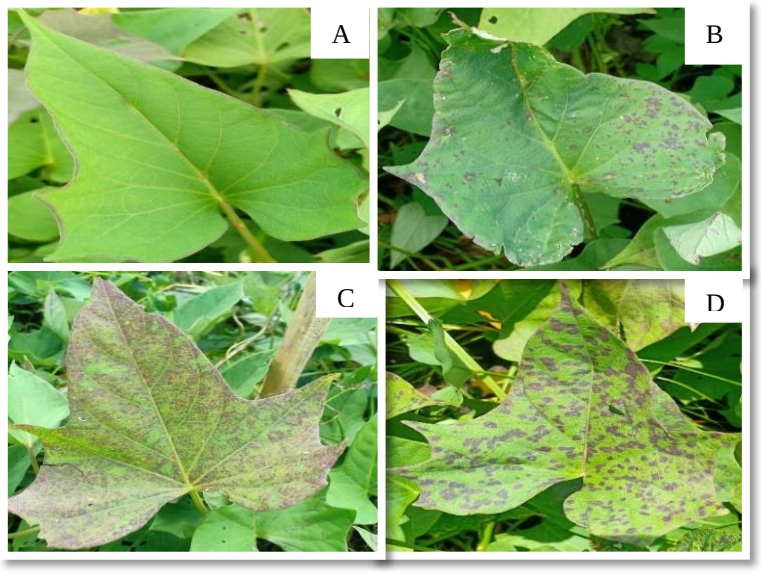

Figure 1. SPFMV symptom variations in sweet potato cultivations in Gianyar Regency: (A) healthy plant, (B) mild purple spots, (C) moderate purple spots, (D) severe purple spots with yellowing leaf

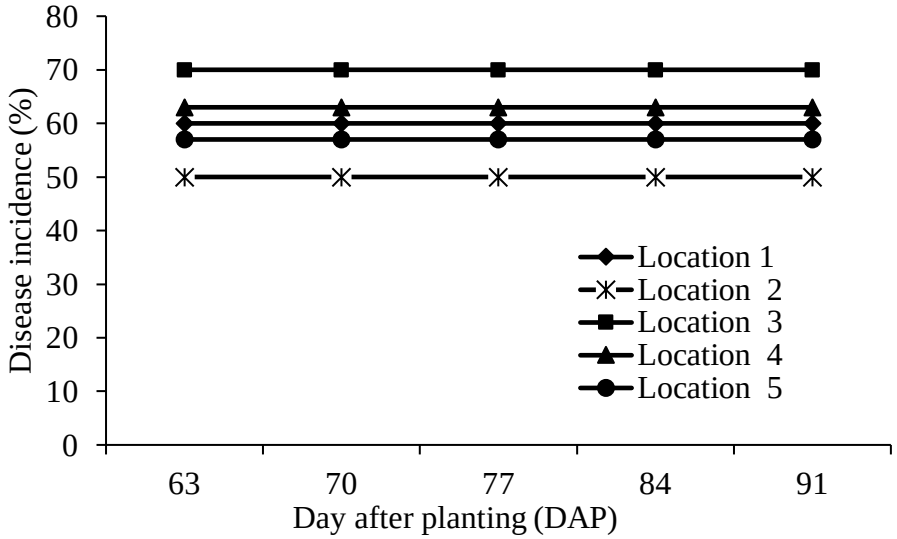

Figure 2. The SPFMV disease incidence in sweet potato

Direct disease incidence observation was performed by observing SPFMV symptoms on sweet potato leaves. The SPFMV disease incidence observation result on several locations for five weeks is presented on Table 1 and Figure 2. Disease incidence showed that no increase was found when the plants were ages 63-91 days after planting (DAP) until before harvest. The disease incidence percentage on location one up to 5 when the plants were aged 63 to 91 DAP are 60%, 50%, 70%, 63%, and 57% (Figure 2). This showed that the disease did not spread during observation period.

Sweet potato feathery mottle virus (SPFMV) is transmitted by aphids (*Myzus persicae* and *Aphis gossypii*) non-persistently (Adikini *et al.*, 2015). Viruses cause varied symptoms depending on the strain and growth condition. Based on the analysis result on purple spot disease incidence, from week to week the value did not increase on all locations. This is because there were no aphids, the vector, on the sweet potato plants so no disease increase occurred during observation. Aphid populations dropped when the environmental temperate was low on average and rainfall also influence the insect population. Aphid population abundance may decrease depending on food sources, shelters, and the temperature in the field. Aphids on plants are tightly linked to plant metabolism activity and the quality and quantity of plant nutrition. Based on a journal released by CABI titled *Sweet potato feathery mottle virus* (internal cork disease of sweet potato), SPFMV disease distribution in the field is transmitted through infected stem cuttings.

SPFMV disease severity shows an increase when the plants were aged 63 to 91 DAP. The disease severity on 63 DAP in location one was 13.3% which turned into 20.7%, in location two was 12.7% which turned into 18.7%, in location three was 16.7% which turned into 20.7%, in location four was 14.7% which turned into 20.7% and in location five was 14.7% which turned into 17.3% (Table 1).

The disease severity continued to increase along with the observation period (Figure 3). Based on the observation, purple spot disease severity in sweet potato plants reached 20.7% (Table 1). The influence of environmental conditions to diseases caused by viruses is highly dependent on the host condition because viruses are unable to perform metabolism by themselves.

Table 1. The SPFMV disease incidence and severity on several locations

Locations	Disease incidence (%) (DAP)					Disease severity (%) (DAP)				
	63	70	77	84	91	63	70	77	84	91
1	60	60	60	60	60	13,3	14,7	17,3	19,3	20,7
2	50	50	50	50	50	12,7	14,7	17,3	18	18,7
3	70	70	70	70	70	16,7	17,3	18,7	20	20,7
4	63	63	63	63	63	14,7	17,3	18,7	19,3	20,7
5	57	57	57	57	57	14,7	15,3	16	16,7	17,3

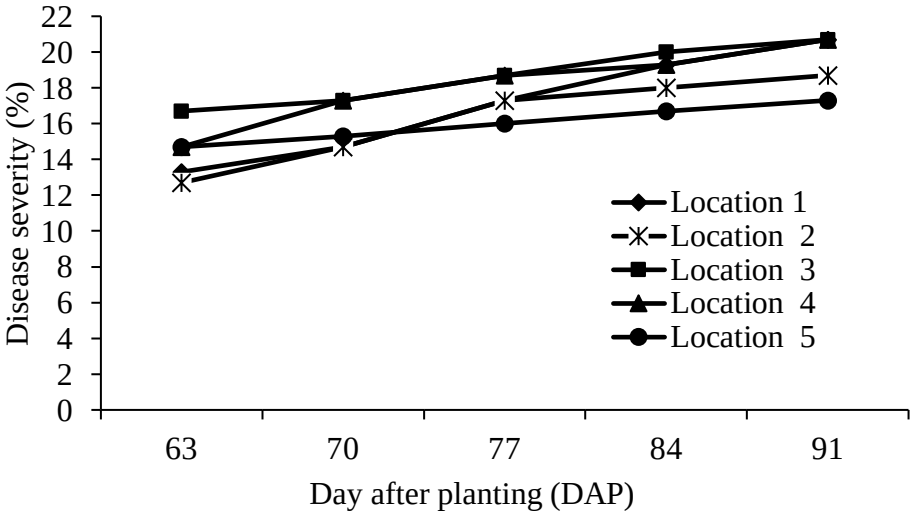

Figure 3. The graph of SPFMV disease severity in sweet potatoes in Gianyar Regency at age 63 to 91 DAP

The occurrence of disease symptoms in plants is caused by the movement of viruses into plant tissues through the phloem and spread into every part of the plants along with the distribution of photosynthate (Yamasaki *et al.*, 2010; Kwak *et al.*, 2015; Mingot *et al.*, 2016; Wokorach *et al.*, 2020). The faster the development and spread of viruses in plant cells, the faster the systemic symptoms appear and the higher the severity. The high disease severity is also caused by virus-infected stems/tubers and the lack of virus-resistant strain, causing infected sweet potatoes to worsen.

SPFMV has been reported for the first time in Indonesia by Hondo *et al.* (2018), which presented SPFMV infected sweet potatoes with yellow spot symptoms. The SPFMV found in Gianyar, Bali, in this research is the second report in Indonesia. The different SPFMV symptoms found in this research from the ones in Hondo *et al.* (2018) research is probably caused by the different sweet potato strains, the plant resistance, the abiotic environmental condition, and the SPFMV strain.

SPFMV has spread all over the world and is considered the most serious sweet potato viral disease (Souza *et al.*, 2018; Tibiri *et al.*, 2019; Zhao *et al.*, 2020). SPFMV has caused sweet potato production loss up to 40%, while mixed infection of SPFMV + SPCSV caused even greater loss of 60-95% (Adikini *et al.*, 2015). Although it is transmittable by aphids, the most important transmission is from the use of infected plants (Zhao *et al.*, 2020). The use of virus infected stem cutting can spread the virus rapidly due to the repeated use of infected vine plants during replication. The use of SPFMV resistant sweet potato strain is important to reduce SPFMV infection in the field.

CONCLUSION

SPFMV infection in Selo Sidan sweet potato cultivar caused purple spot symptoms. The disease incidence in Gianyar Regency, Bali, when the plants were aged 63 to 91 DAP showed no changes occurring, whereas the disease severity showed increase every week. The highest disease incidence and severity values are 70% and 20.7%.

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AUTHORS CONTRIBUTIONS

NKSP, L, IGADY, and PLYS considered and planned the experiment. NKSP, FH, and L carried out the sampling and field observations of disease incidence and severity of symptoms on sweetpotato. NPP and DGWS identification of SPFMV. L and NKSP performed analysis data. All the authors prepared the 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

Declare conflicts of interest or state “The authors declare no conflict of interest.”

REFERENCES

Adikini, S., Mukasa, S. B., Mwanga, R. O. M., & Gibson, R. W. (2015). Effects of Sweet Potato Feathery Mottle Virus and Sweet Potato Chlorotic Stunt Virus on the Yield of SweetPotato in Uganda. *Journal of Phytopathology, 164,* 242–254.

Ames, T., Smit, N. E., Braun, A. R., O’Sullivan, J. N., & Skoglun, L. G. (1997). *Sweet Potato Major Pests,*

Diseases, and Nutritional Disorders. Peru (PE): International Potato Center.

Badan Pusat Statistika. (2017). *Produksi tanaman pangan di Indonesia tahun 2015-2018*. Jakarta: Badan Pusat Statistika.

Distanpangan Provinsi Bali. (2021). *Kinerja produksi ubi jalar Provinsi Bali 2016-2020.* Bali: Distanpangan Provinsi Bali.

Ha, C., Coombs, S., Revill, P.A., Harding, R.M., Vu, M., & Dale, J.L. (2008). Design and application of two novel degenerate primer pairs for the detection and complete genomic characterization of potyviruses. *Archives of Virology, 153*(1), 25–36. https://doi.org/10.1007/s00705-007-1053-7

Hondo, A., Damaiyanti, K. C., Hafizh, M. F., Amanatillah, N., & Damayanti, T. A. (2018). Penyakit bercak kuning ubi jalar di Bogor, Jawa Barat. *Jurnal Fitopatology Indonesia, 14*(2), 69-73. https://doi.org/10.14692/jfi.14.2.69

Kwak, H. R., Kim, J., Kim, M. K., Seo, J. K., Jung, M. N., Kim, J. S., Lee, S., & Choi, H. S. (2015). Molecular characterization of five potyviruses infecting Korean sweet potatoes based on analyses of complete genome sequences. *Plant Pathol J, 31*(4), 388-401. https://doi.org/10.5423/PPJ.OA.04.2015.0072

Listihani, & Selangga, D. G. W. (2021). Molecular identification of *Sweet potato virus* C on Sweetpotato in Bali, Indonesia. *Jurnal Perlindungan Tanaman Indonesia, 25*(1), 56-63. https://doi.org/10.22146/jpti.64545

Listihani, Hidayat, S. H., Wiyono, S., & Damayanti, T. A. (2019). Characteristic of *Tobacco mosaic virus* isolated from cucumber and tobacco collected from East Java, Indonesia. *Biodiversitas 20*, 2937-2942. https://doi.org/10.13057/biodiv/d201023

Listihani, L., Damayanti, T. A., Hidayat, S. H., & Wiyono, S. (2020). First report of cucurbit aphid-borne yellows virus on cucumber in Java, Indonesia. *J Gen Plant Pathol, 86*(3), 219-23. https://doi.org/10.1007/s10327-019-00905-2

Listihani, L., Damayanti, T. A., Hidayat, S. H., & Wiyono, S. (2018). Moleculer characterization of *Papaya ringspot virus* type P on cucumber in Java. Jurnal Fitopatologi Indonesia, 14(3), 75. https://doi.org/10.14692/jfi.14.3.75

Listihani, Selangga, D. G. W., & Sutrawati, M. (2021). Natural infection of *Tobacco mosaic virus* on butternut squash in Bali, Indonesia. *J Trop Plant Pests Dis, 21*(2), 116-122. https://doi.org/10.23960/j.hptt.221116-122

Listihani, Yuniti, I. G. A. D., Phasmidi, P. E., & Lestari, P. F. K. (2022). First report of *Sweet potato leaf curl virus* on sweetpotato in Indonesia. *Indian Phytopathology, 75*, 595-598. https://doi.org/10.1007/s42360-022-00489-6

Mau, Y. S., Ndiwa, A. S. S., & Oematan, S. S. (2020). Brown spot disease severity, yield and yield loss relationships in pigmented upland rice cultivars from East Nusa Tenggara, Indonesia. *Biodiversitas, 21*(4), 1625-1634. https://doi.org/10.13057/biodiv/d210443

Mingot, A., Valli, A., Rodamilans, B., San León, D., Baulcombe, D. C., García, J. A., & López-Moya, J. J. (2016). The P1N-PISPO trans-frame gene of sweet potato feathery mottle potyvirus is produced during virus infection and functions as an RNA silencing suppressor. *J Virol, 90*(7), 3543-3557. https://doi.org/10.1128/JVI.02360-15

Morin, L., Aveyard, R., Lidbetter, J., & Wilson, P. G. (2012). Investigating the host-range of the rust fungus *Puccinia psidii* sensu lato across tribes of the family Myrtaceae present in Australia. *Plos One, 7*(4), e35434. https://doi.org/ 10.1371/journal.pone.0035434

Ngailo, S., Shimelis, H., Sibiya, J., Amelework, B., & Mtunda, K. (2016). Genetic diversity assessment of Tanzanian sweetpotato genotypes using simple sequence repeat markers. *South African Journal of Botany, 102*, 40-45. https://doi.org/10.1016/j.sajb.2015.08.001

Pushpalatha, M., Vaidya, P., & Adsul, P. (2017). Effect of graded levels of nitrogen and potassium on yield and quality of sweet potato (*Ipomoea batatas* L.). *International Journal of Current Microbiology and Applied Sciences, 6*(5), 1689-1696. https://doi.org/10.20546/ijcmas.2017.605.183

Selangga, D. G. W., & Listihani, L. (2021). Molecular identification of Pepper yellow leaf curl Indonesia virus on chili pepper in Nusa Penida Island. *Journal of Tropical Plant Pests and Diseases, 21*(2), 97-102. https://doi.org/10.23960/jhptt.22197-102

Selangga, D. G. W., & Listihani, L. (2022). *Squash leaf curl virus*: species of begomovirus as the cause of butternut squash yield losses in Indonesia. *Hayati Journal of Biosciences, 29*(6), 806-813. https://doi.org/10.4308/hjb.29.6.806-813

Selangga, D. G. W., Listihani, L., Temaja, I. G. R. M., Wirya, G. N. A. S., Sudiarta, I. P., & Yuliadhi, K. A. (2023). Determinants of symptom variation of *Pepper yellow leaf curl Indonesia virus* in bell pepper and its spread by *Bemisia tabaci*. *Biodiversitas, 24*, 869-877.

Selangga, D. G. W., Temaja, I. G. R. M., Wirya, G. N. A. S., Sudiarta, I. P., & Listihani, L. (2022). First report of

Papaya ringspot virus-watermelon strain on melon (*Cucumis melo* L.) in Bali, Indonesia. *Indian Phytopathology, 75*(3), 911-914. https://doi.org/10.1007/s42360-022-00519-3

Selangga, D. G. W., Widnyana, I. K., & Listihani, L. (2021). The existence of *Papaya ringspot virus*-Papaya strain on cucumber in Gianyar, Bali. *Jurnal Perlindungan Tanaman Indonesia, 25*(1), 48-55. https://doi.org/10.22146/jpti.64703

Souza, C. A., Rossato, M., Melo, F. L., & Pereira-Carvalho, R. C. (2018). Complete genome sequences of *Sweet potato feathery mottle virus* and *Sweet potato virus G* from Brazil. *Genome Announc, 6*(5), e01567-17. https://doi.org/10.1128/genomeA.01567-17

Tibiri, E. B., Somé, K., Pita, J. S., Tiendrébéogo, F., Bangratz, M., Néya, J. B., Brugidou, C., & Barro, N. (2019). Effects of sweet potato feathery mottle virus, sweet potato chlorotic stunt virus and their coinfection on sweet potato yield in Western Burkina Faso. *Open Agriculture, 4*, 758-766. https://doi.org/10.1515/opag-2019-0076

Wokorach, G., Otim, G., Njuguna, J., Edema, H., Njung'e, V., Machuka, E. M., Yao, N., Stomeo, F., & Echodu, R. (2020). Genomic analysis of Sweet potato feathery mottle virus from East Africa. *Physiological and Molecular Plant Pathology, 110*, 1-8. https://doi.org/10.1016/j.pmpp.2020.101473

Yamasaki, S., Sakai, J., Fuji, S., Kamisoyama, S., Emoto, K., Ohshima, K., & Hanada, K. (2010). Comparisons among isolates of Sweet potato feathery mottle virus using complete genomic RNA sequences. *Arch Virol, 155*(5), 795-800. https://doi.org/10.1007/s00705-010-0633-0

Zhao, F., Zhang, Z., Li, H., Qiao, Q., Wang, S., Tian, Y., Wang, Y., Qin, Y., & Zhang D. (2020). First report of sweet potato feathery mottle virus infecting *Amaranthus blitum* in China. *J Plant Pathol, 102*, 965. https://doi.org/10.1007/s42161-020-00533-2