BIBLIOGRAPHY

LAN-EW, JULIET K. May, 2013. Preliminary Documentation of Viral Diseases of Strawberry (*Fragaria ananassa*) in Swamp , La Trinidad, Benguet, Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted to document, collect and identify virus diseases affecting strawberry plants in Swamp La Trinidad and to identify this virus diseases through symptomatology.

Results of the study showed that strawberry grown in Swamp La Trinidad showed symptoms like crinkling, distortion and yellowing of the plants which is attributed to virus infection. The viral disease was confirmed through sap inoculation using Gotukola (*Centella asiatica*) as indicator plant (Toclo and Ligat, 2012. The Gotokula inoculated with strawberry mottle virus showed vein clearing and mottling symptoms. On the other hand, the Gotokula inoculated with strawberry crinkle virus showed distorted crinkling of the leaves and chlorotic spotting symptoms. This result confirms that the symptoms observed on the assessed strawberry plants in the Swamp area in La Trinidad was caused by strawberry mottle virus and strawberry crinkle virus.

RESULT AND DISCUSSION

Disease symptoms of strawberry viruses

The symptoms observed were based and similar to the virus infection of strawberry mottle virus disease as discussed by Leone *et al* (1992). The symptoms observed and identified to be caused by strawberry mottle virus disease were vein clearing, mild mottling and distortion on the leaves. The leaves showed small chlorotic spots that were scattered, veins that were cleared, leaves becoming bright in color or mild mottling and distortion of the leaves as compared to the normal leaves. The other symptoms observedwere the distorted and crinkled appearance on the strawberry leaves.In addition, the leaves showed small chlorotic spotting. These symptoms were identified to be caused by strawberry crinkle virus. Symptoms were similar to the virus disease characteristics as discussed by Yokishawa *et al* (1986). Symptoms of collected specimens from the 4 areas are shown in Figures 1and2.

All commercial strawberry cultivars infected with the virus, although symptomless were observed to have reduced vigor and yield.

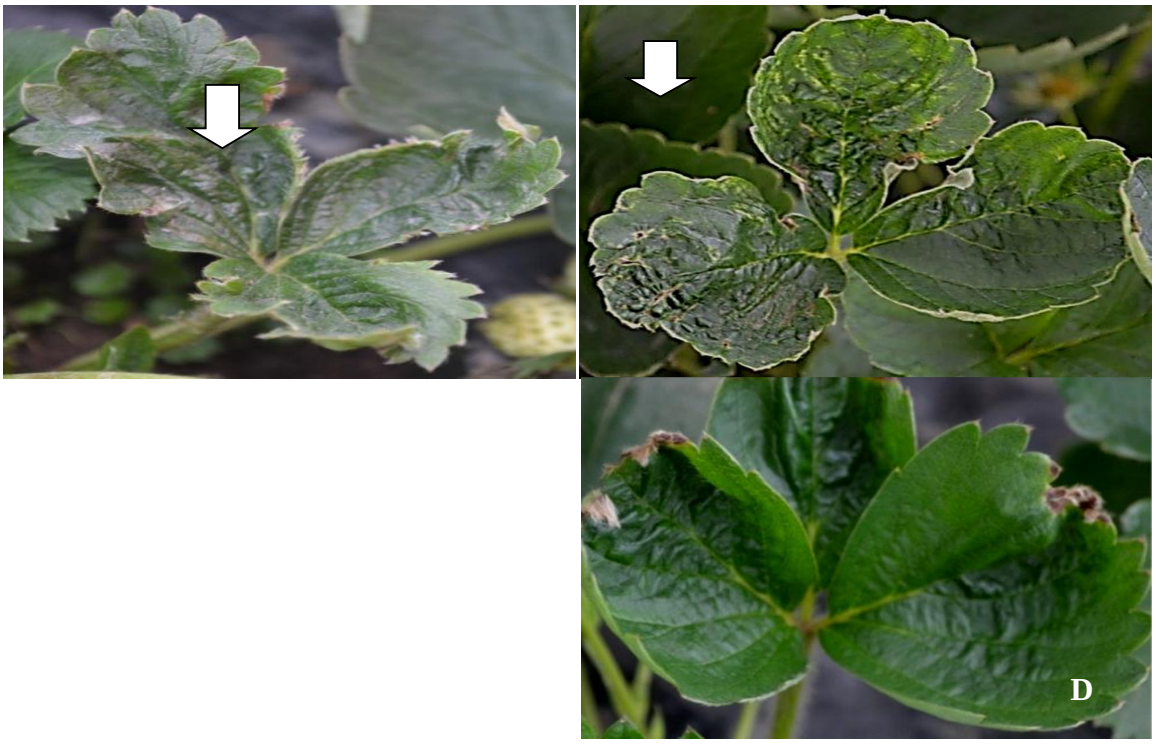


Figure 1- Strawberry crinkle virus disease symptom. A- Distorted crinkledsymptom,B-small chlorotic spotting and distorted crinkled symptom, C&D-distorted crinkled symptom

Figure 2-(A, B, C&D) Strawberry mottle virus disease symptom.A-showsleaf mottle symptom,B-C, & D- shows that there is chlorotic spotting and mottling on the leaves

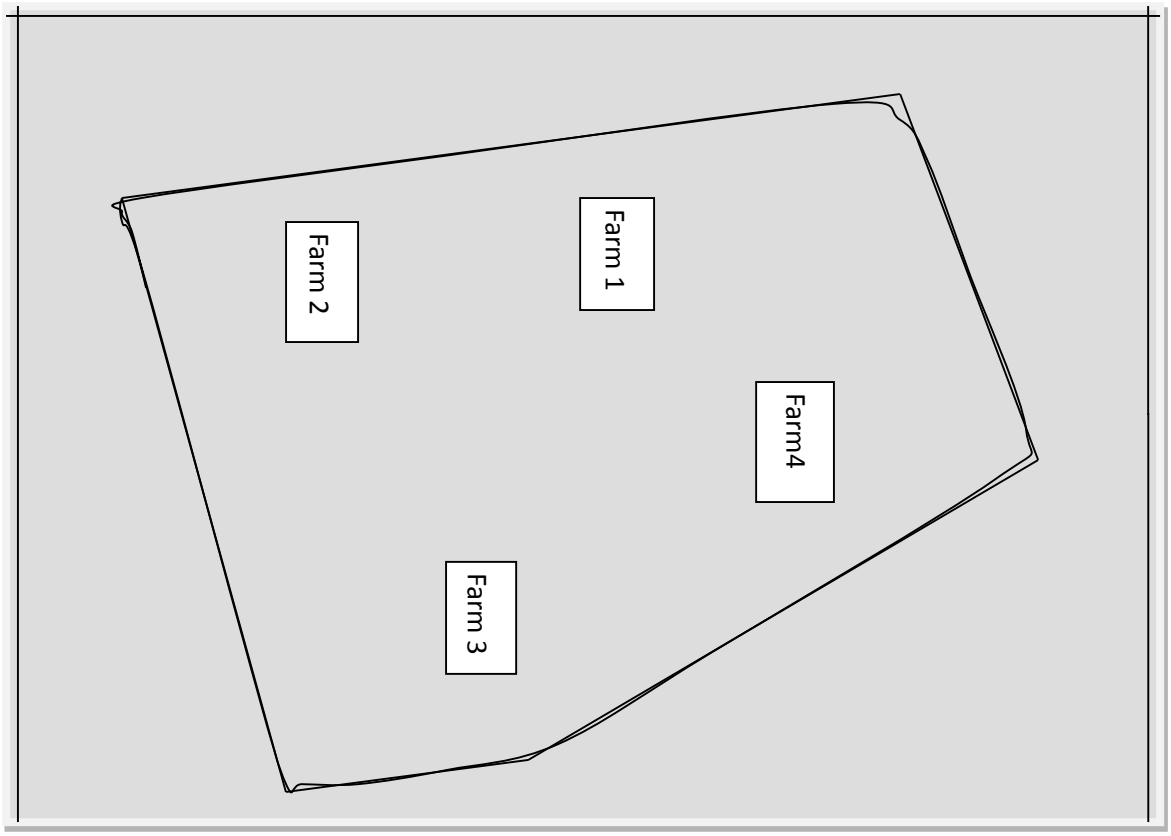
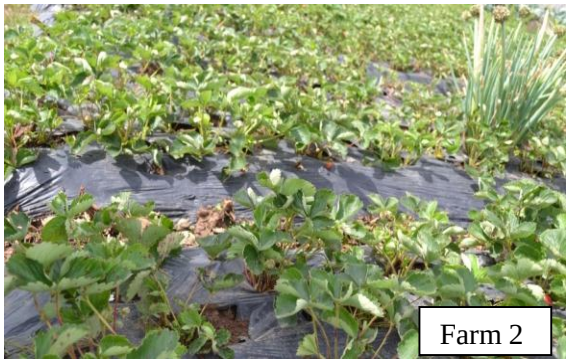


Figure 3- BSU ATBI/ IC Farm (2013-2018) Locator map

Farm 3

Farm 4



Incidence of Strawberry Virus and aphid in the Field

Table 1 shows the disease incidence in the four sampling sites. Results revealed that differences in virus incidence ineach area maybe caused by the way the farmers manage their farms. The four farmersplanted the same variety of strawberry, which is Sweet Charlie, and runners were of the second generation from BSU tissue cultured strawberry runners. Farm 3 had the highest disease and aphid incidence. When interviewed, the farmercontrols pest and diseases depending on his observation in the field. He only schedules his spray when he sees that insects like aphids are present and uses green labeled chemicals like Black hawk. The weeds that are present in the field that may serve as alternate host for the aphid are removed. As no crop rotation is practiced, the increase in population of the aphids was observed. Farm 4 had the lowest incidence of virus diseases. In this farm, the population of aphids was kept under control as spraying done at 15 days interval. The farmer used green labeled chemicals like Ortus. The farm is also kept clean of weeds that may serve as alternate host for the aphids. Rotation of lettuce before strawberry was done.

Even though the planting material were free of virus disease infection, Insects typically aphid are able to transmit virus diseases by acquiring then transmitting the disease from the infected plant to the un infected plant, (Tarr 1966). Aside from aphid, mites were also present in the field, colonies of mites have needle-like stylets that pierce and suck the plant sap, usually from the under surface of the leaves, which properly might make them vector of plant diseases, (Towsend 1996).

Table 1. Incidence of strawberry mottle and crinkle viruses in the field

Sampling sites	Strawberry mottle	Strawberry crinkle
Farm 1 (Manangwe, N)	17.33	12.00
Farm 2 (Bartolome, B.)	10.67	16.00
Farm 3 (Pa-at,A)	14.33	18.67
Farm 4 (Puyao, J)	7.33	9.33

Table 2. Aphid incidence in the field

Sampling sites	Aphid incidence on strawberry mottle	Aphid incidence on strawberry crinkle
Farm 1 (Manangwe, N)	29.6	30.3
Farm 2 (Bartolome, B.)	44.5	46.3
Farm 3 (Pa-at, A)	46.7	48.3
Farm 4 (Puyao, J)	27.7	27.00

The aphid had the great potential in transferring the disease because of acquiring the disease from the infected plant then transfer to another healthy plant that makes the disease to spread. The aphid *Chaitosiphon fragaefolii* were seen on the leaves of the strawberry and it is one of the factors to consider why there was virus infection even if the planting materials were tissue cultured from BSU which are supposed to be free from virus infection.Aphid as vectors which quickly lose their ability to fly are likely to be less effectively in spreading viruses than those which retain the ability, Tarr (1966). During their initial flight, aphids tend to feed on a succession of plants before finally settling, and

this type of behavior expedites the spread of viruses, particularly those viruses which are rapidly acquired and transmitted.

Strawberry crinkle virus is transmitted in a persistent propagative manner by the aphids. The aphid remains infective for day or weeks, often for life. The length of transmission cycle is in nature dependent on temperature conditions. Low temperature extends incubation period in strawberry and latent period of the virus in the vector has been reported to be about 2 weeks. Severe occurrence of strawberry crinkle virus shows the symptoms of crinkling of leaves, leaflets unequal in size and small irregular shaped, chlorotic spots. Mild strain result no symptoms on strawberry (Tripathi, 2004).

Strawberry mottle virus is known to transmit the virus in semi-persistent manner. The virus is lost by the vector when it molts and it does not multiply in vectors gut. The advantages of virus persistence in the vector are partly nullified by the short flight period and short life of migrating aphids, especially if there is a prolonged latent period during which the aphid is not infective, Frazier *et al*, (1988).

Viruses which infect strawberry plants include strawberry mottle virus and crinkle virus are transmitted from plant to plant by insects, typically aphid.

Figure 4- The aphid from the strawberry leaf showing symptom of virus infection

Aside from the aphid, mites were also present in all plants in the area, Towsend (1996) stated that colonies of mites occur mainly on the underside of leaves, sheltered by strands of fine webbing. They have needle-like stylets that pierce and suck the plant sap, usually from the under surface of the leaves, which properly might make them vector of plant diseases, Agrios (2005) stated that mites carry plant viruses on their stylets and can acquire and inoculate the virus after feeding from the virus infected plants

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Figure 5- Mites present in the underside of the strawberry leaves.

Confirmation of Virus Disease Using Indicator Plant

The indicator plant Gotukola exhibited similar symptoms of the strawberry showing the virus infection. The infection showed finely cleared veins, mild mottling and distorted and crinkled leaves.

The Gotukola as indicator plant was inoculated with the extracted sap of strawberry leaves that showed the symptoms of strawberry mottle virus disease infection. The indicator plant also showed the symptoms of mottle virus disease infection, the same as the symptoms were observed in the strawberry plant. The symptoms did not appear from the first day of inoculation but it started to appear 2 days after inoculation at 1.80 and 1.60

respectively which is equivalent to 1-10% infection then the severity continued to increase, (Table 3).

Table 3. Disease severity of virus infection in Gotukola

Virus	Observation period in days after inoculation			
	1	2	3	4
Strawberry crinkle virus disease	0.00	1.80	4.65	6.65
Strawberry mottle virus disease	0.00	1.60	3.90	5.90

Figure 6. Gotukola as indicator plant

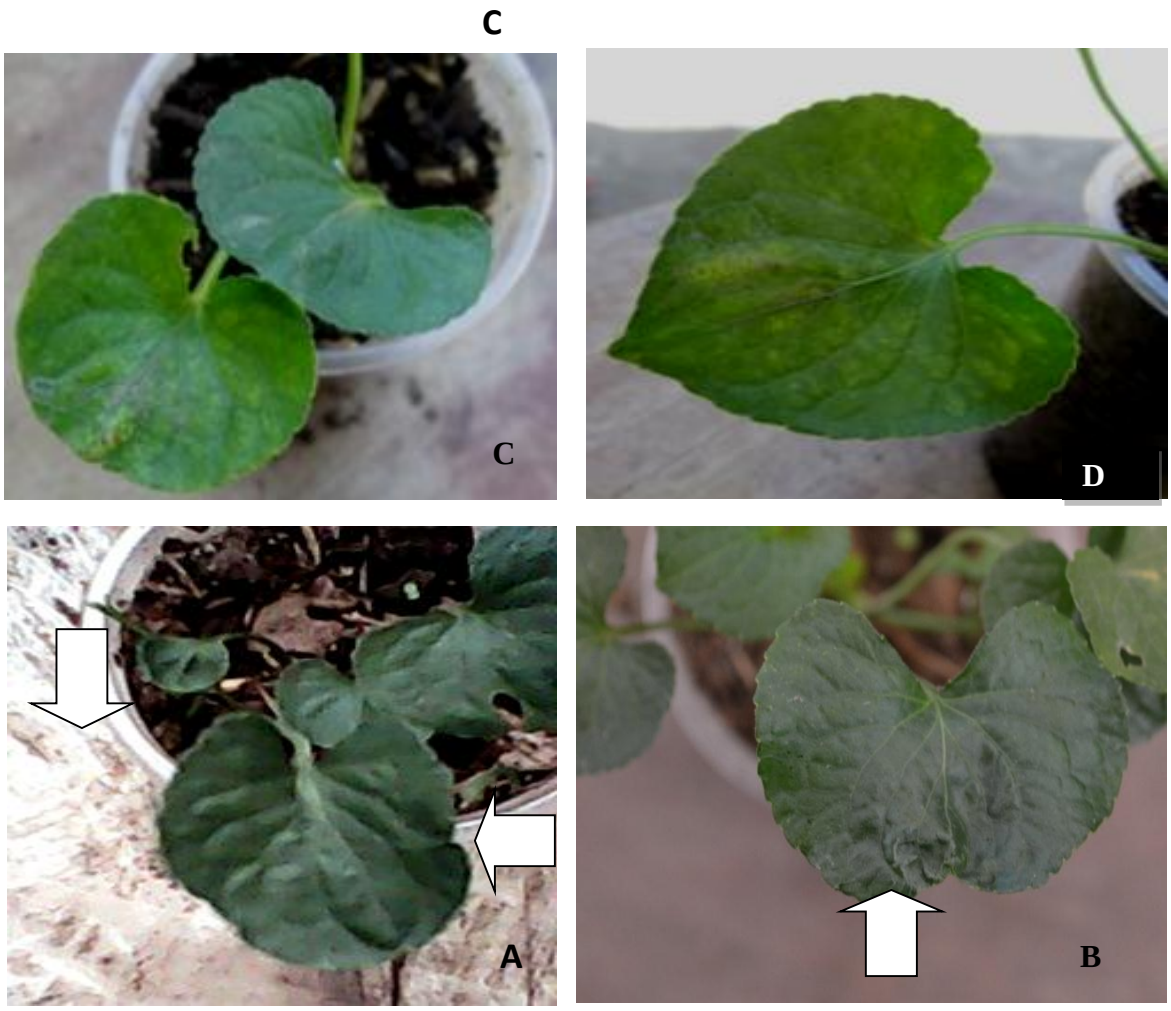
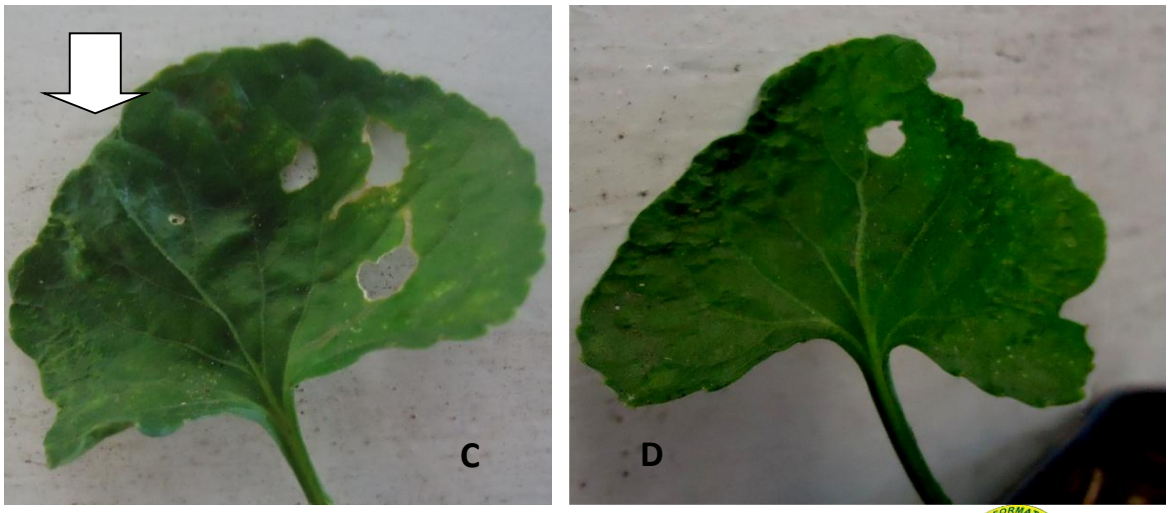


Figure 7-.A-not inoculated test plant. B, C&D- inoculated test plant showing mild mottling and minor leaf distortion

Figure 8-A- shows uneven leaf blade and distorted crinkled leaves, B, C&D- showed chlorotic spotting, distorted crinkled leaf and un even leaf blades.



SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

Fourstrawberry farms measuring 500 square meters served as collection sites. Strawberry plants having the symptoms of virus disease infection like mottling and crinkling on the leaves werecollected then brought in the laboratory for confirmatory studies using Gotukola as indicator plant.

The infection of crinkle and mottle viruses in strawberry was confirmed using Gotukola (*Centella asiatica)* as indicator plant (Toclo and Ligat, 2012). Result showed that the inoculated Gotukola showed more distinct symptoms three days after inoculation.Symptoms includemild mottling and minor leaf distortion, chlorotic spotting, distorted crinkled leaves and uneven leaf blades.

Data on aphid incidence gathered in every 6 plants surrounding the virus infected strawberry plant revealed the presence of aphids which may have caused the infection of other strawberry plants. The differences in virus incidence in each area maybe caused by the way the farmers control the aphids which is viruses' vector.

Conclusion

Confirmation test showed that symptoms of strawberry mottle virus and the strawberry crinkle virus infection were present in the four strawberry farms. Confirmation of infection using indicator plant showed symptoms like mottling and crinkling of leaves.Virus infection of crinkle virus disease and mottle virus disease appeared on the indicator plant 3 days after inoculation. In addition, the Gotukola plant that was used as indicator plant was effective as indicator plant for virus symptom specifically strawberry

mottle virus and strawberry crinkle virus. The presence aphids must be controlled tolessen if not to prevent the spread of virus disease infection in the field.

Recommendation

It is recommended that plants showingsymptoms of viral infection in the field should be removed and burned to avoid the spread of the disease. The use of virus free planting materials for establishment of the new plantation is needed to decrease potential sources of infection. Weeds must be removed in the field because it may serve as alternate host for the viruses like strawberry mottle virus and strawberry crinkle virus that will allow for these viruses to survive even in the absence of the host. Vector control can help reduce the chances of disease spread to some extent because they transmit the disease through transferring from one place to another. Gotukola can be used for indexing crinkle and mottle virus of strawberry in the production of clean planting materials of strawberry.

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