THE INCIDENCE OF MOP-TOP AND AUCUBA POTATO VIRUSES IN SEVERAL ROMANIAN AREAS (PRELIMINARY STUDIES)

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Abstract

PMTV (Potato Mop-Top Virus) an PAMV (Potato Aucuba Mosaic Virus) are new Romanian damaging pathogens of potato crop. They can cause serious reduced yield and decrease of the tuber's quality. In case of these viruses, infected plants do not allways show symptoms and symptom depends on potato cultivar, virus strain and the environment. PMTV and PAMV infection of material plants can produce spraing in tubers of sensitive varieties. PMTV cause heavy losses in northen Europe and it is very difficult to control. Foliar symptoms include bright yellow blotch (Aucuba), a 'V'-shaped yellow pattern, deformed leaves and internode shortening. PAMV is a helping virus for devlopment of dangerous potyvirus like Potato Virus Y (PVY). Elimination of all these pathogens from potato supply is essential for potato production and the choice of resistant varieties to the infection with these viruses could be one of the measures recommended for farmers and producers. The results of this preliminary study show that PMTV and PAMV were not found in the material collected from the following varieties: Armonia, Azaria, Christian, Cosiana and Millenium (samples collected from the counties Braşov, Covasna, Harghita, Suceava in 2019 and 2020).

Key words: potato mop-top virus, potato aucuba mosaic virus, symptoms

Potato virus diseases lead to the reduction of farmer's income from agricultural or national communities. Damages and economic losses are due primarily to the reduction of plant growth leading to reduced production or even its destruction (Valkonen J.P.T., 2007). This is why protective measures of culture against viral infections, diagnosis and control of virus diseases play an important role in potato production technology and multiplication (Bădărău C.L. *et al*, 2014 & 2016).

Potato Mop Top Virus (PMTV, family *Virgaviridae*, genus *Pomovirus*) and Potato Aucuba Mozaic Virus (PAMV, family *Alphaflexiviridae*, genus *Potexvirus*) are new viruses identified in the Romanian potato fields.

PMTV can be transmitted by planting infected tubers (Calvert E.L., 1968; Browning I. *et al*, 2001) and by zoospores of plasmodiophorid *Spongospora subterranea*, the powdery scab (Arif M. *et al*, 1995). PMTV tippically produced slightly raised lines and rings on the tubers surface and/or brown arcs and lines, commonly described as spraing, in the flesh of tubers of sensitive cultivars (Harrison B.D. and Jones R.A.C., 1971; Kurppa A.H.J. *et al*, 1989; Loebenstein G., 2008a). Plants produced from infected tubers may also produce misshapenor

cracked tubers (Calvert E.L., 1968) often with reticulated surface cracking, sometimes known as

elephant hide blemishing, on the skin (Calvert E.L., 1968; Tenorio J. *et al*, 2006). Symptoms may also develop on the foliar foliage of the plants, depending on the sensitivity of the cultivar (*figure 1*). There are three type of foliar symptomes: yellow blotching or V'-shaped chevrons on the leaves, disortion of leaflets in a dwarfed appearance, internode shortening wich is the classic „mop-top" pattern that gives the virus its name.

In some cases, only a proportion of the stems may bear symptoms of PMTV infection (Calvert E.L., 1968; Torrance L. *et al*, 1991; Torrance L., 2008; Carnegie S.F. *et al*, 2010). Cooper J.I. *et al* (1976) found that tubers from plants with foliar symptoms produced only a proportion (c. 50%) of daughter plants with foliar symptoms in the following generation (Carnegie S.F. *et al*, 2009&2010). With insensitive cultivars, PMTV infection can result in no symptoms developing on the foliage (Davey T. *et al*, 2006 & 2008) but the extent to wich symptomless foliar

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infection might occur in crops containing plants with foliar symptoms has not been examined.

Potato Aucuba Mosaic Virus (PAMV) is transmitted mechanically and by *Myzus persicae* in a nonpersistent manner; aphid transmission requires a helping potyvirus such as PVA or PVY (Loebenstein G., 2008b). Nucleotide sequence analysis of the coat protein gene of PAMV indicated that amino acids residues 14 and 16 from the N-terminus have the DAG sequence (Loebenstein G., 2001b). This sequence, also found in the coat of potyviruses, is required for aphid transmissibility (Loebenstein G., 2001b).

Symptoms of PAMV differ depending on virus strains and potato cultivar (*figure 2*). Several virus isolates cause yellow leaf flecking, whereas other cause deformation and stunting. Some cultivars develope necrosis in the tubers or sunken patches on the tuber surface; such symptoms occur when tubers are stored at high (20-21^{o}C) temperature. The Potato Aucuba Mosaic virus symptoms resemble those of Potato Mop-Top virus; both viruses cause necrosis on the tuber surface, but those of PAMV are less clearly patterned than the necrotic rings caused by PMTV (Loebenstein G., 2001 a&b).

Host ranges, propagation species for PMTV and PAMV are presented in table 1 and several foliar symptoms of these viruses in figures 1 and 2.

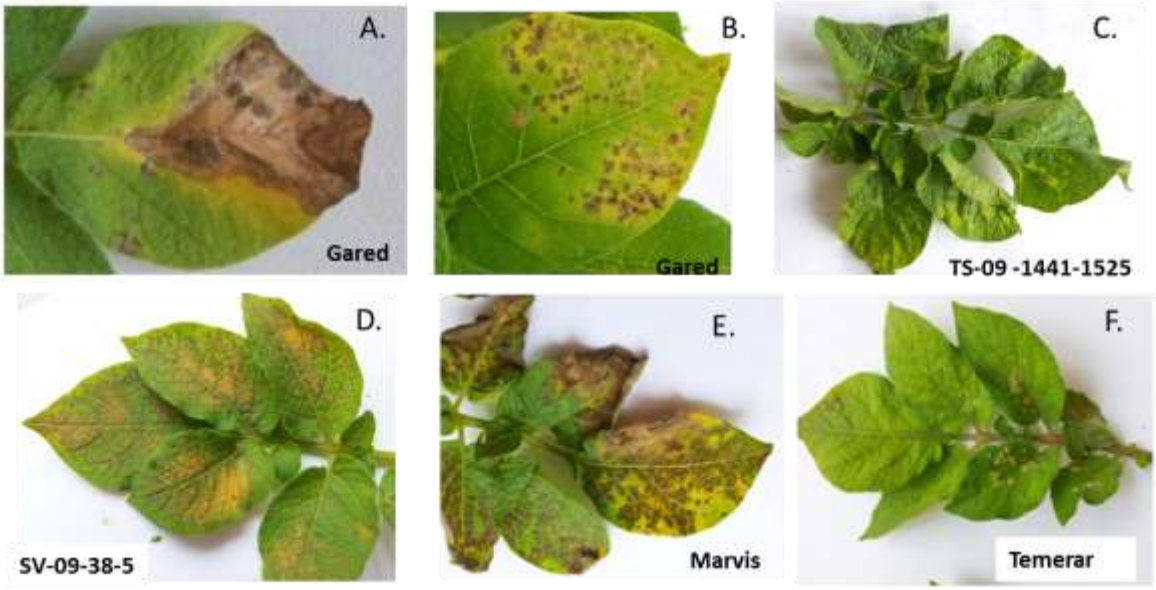

Figure 1 **Foliar symptoms of PMTV infected plants (primary infection) for several varieties tested in the project (material infected used for estimate the varieties resistence to virus infection). A- necrose and yellow spots; B- necrotic points; C-mosaic and deformation; D-specific mosaic; E-chlorotic spots; F- yellow points and mosaic.**

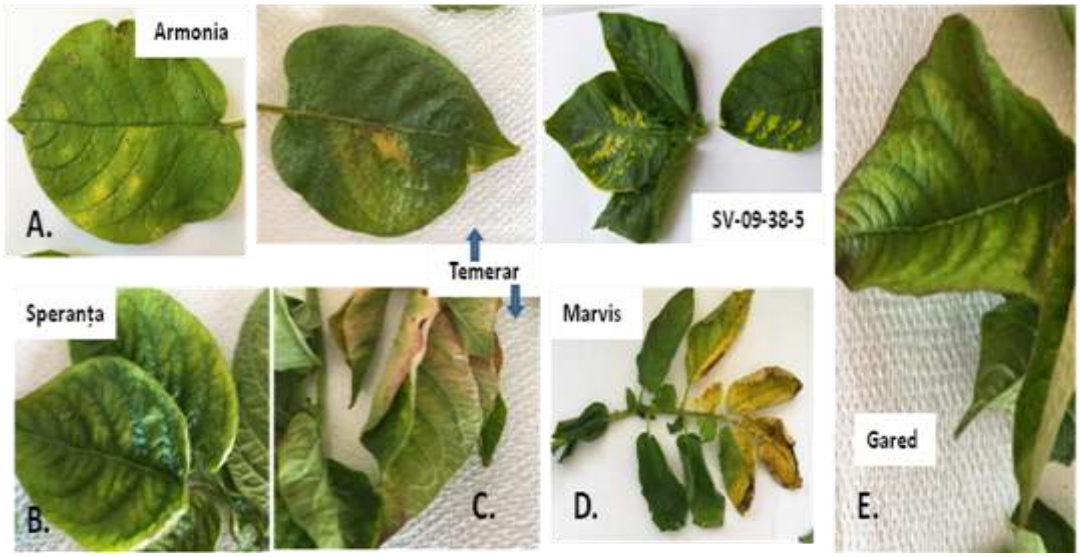

Figure 2 **Foliar symptoms of potato plants PAMV infected for several varieties tested in the project (material infected used for estimate the varieties resistence to virus infection). A- yellow spots; B-mosaic; C-antocians; D-necrotic spots; E- deformation and mosaic.**

Massive imports of potato in last years, the continuous "migration" of seed potatoes from one area to another, climate change, inadequate treatments for disease vector control (especially aphids), viral pressure, resistance of varieties are just some of the factors that may favor the spread of these new viruses that recently appeared in the culture. In order to limit the spread of these infections there are useful to conduct research work for:

✓ Determining the virus in most cultivated varieties in our country;
✓ Estimation of geographical areas with epidemiological risk;
✓ Identification, promotion and usage of potato lines and varieties with high resistance or tolerance to infection with PMTPV and PAMV;
✓ Assessment of viruses strains ecology;
✓ Improvement of potato micro-zoning

This research work could help the spread limiting of these pathogens by identifying and implementing methodological control solutions of these viruses in the context of climate change. This concept includes a holistic approach for the development of innovative technologies to streamline control of these viruses (Bădărău C.L. *et al,* 2014 & 2016).

Potato Aucuba Mosaic Virus (PAMV) has several similar aphids vectors like another dangerous pathogen of potato Potato Virus Y Necrotic (PVYN) (Galvino-Costa S.B.F. *et al*, 2012). These is the raison because in this research work, the samples collected for testing PAMV were examined in addition for PVYN. The damage caused by these pathogens agent is both quantitative (reduction of production) and qualitative (commercial depreciation of tubers). In case of cultivation of sensitive varieties under favorable conditions, financial losses can be important both for potato consumption (it can become unmarketable) as for seed potatoes (it will be downgraded).

This study aimed to present some of the most important problems caused by the spread of PMTV and PAMV (recently founded in the potato areas) and to present preliminary results regarding the level of infection with these viruses to several varieties cultivated in different Romanian counties in 2019 and 2020.

MATERIAL AND METHOD

The potato samples were taken from the following geographical regions of our country (different potato seed producers and farmers): Brasov, Covasna, Harghita and Suceava.

The varieties tested were:

- Christian, Sevastia, Brașovia, Castrum, Azaria, Cosiana, Gared, Armonia, Millenium, Temerar (Romanian varieties);
- Bellarosa, Riviera, Sante, Hermes şi Carrera (foreign varieties).

The analysis was performed following the protocol Clark and Adams (1977) (Clark M.F. and Adams A.N., 1977) and for testing the tubers (collected in 2019 ans 2020) we used sap from tubers and from their sprouts (Bădărău C.L. *et al*, 2014 & 2016). Rinsed microplates filled with substrate solution (p-nitro-phenyl-phosphate) were incubated one hour and the absorbance values were estimated at 405 nm (A_{405}) using a TecanSunRise reader (software Magellan). The samples that have A_{405} values exceeding the cut-off (two times the healthy control samples average) were considered virus infected (Bădărău C.L. *et al*, 2014 & 2016). The material was tested for 8 viruses (Potato Mop-Top Virus, Potato Aucuba Mosaic Virus, Potato virus Y, Potato Leaf roll Virus, Potato virus M, Potato virus X, Potato virus S and Potato virus A) and we keep only the infected material with the necrotic viruses. This biological material was retested using monoclonal antibodies (mAb) or polyclonal (PCA) (Bioreba, Switzerland).

Table 1

Host ranges and propagation species for PMTV and PAMV

Name of virus / sinonims	Experimental host ranges and propagation species
Potato Mop-Top Virus PMTV	Natural host: *Solanum tuberosum* and *Chenopodium album*. Experimental host: *Datura stramonium*, *Lycopersicon chilense, Solanum muricatum* and *Physalis peruviana* and *Chenopodium quinoa, Spinacia oleracea*. Propagation species- *Nicotiana benthamiana.* (Harrison B.D., 1970; Jones R.A.C., 1988; Loebenstein G., 2001a).
Potato Aucuba Mosaic Virus PAMV Potato virus F (PVF) Potato virus G	*Capsicum annuum, C. frutescens* - necrotic local lesions, then epinasty, systemic mosaic and necrosis; young plants are killed. *Nicotiana glutinosa* -light green mottle with dark vein banding. *Datura stramonium, Lycopersicon esculentum* – another experimental host ranges Propagation species- *Nicotiana tabacum* cv. *Xanthi*-nc (Loebenstein G., 2001b).

RESULTS AND DISCUSSIONS

The results of the tests of samples collected from 4 geographical areas of Romania (know like potato seed producers) are presented in brief in the figures 3 and 5.

As show in figure 3, in case of samples collected in 2019 and 2020, the highest infection level with PMTV and PAMV was noticed to varieties Carrera, Bellarosa, Hermes and Riviera.

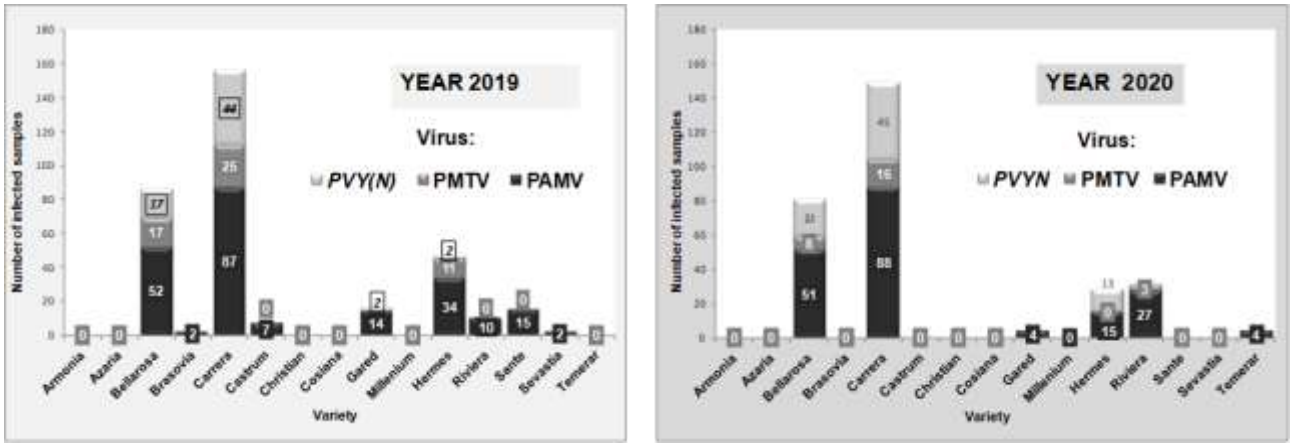

Figure 3 **Results regarding the number of infected samples with PAMV, PMTV and PVY (necrotic) identified in the material tested in 2019 and 2020 (several varieties more cultivated by seed potato producers). PMTV= Potato Mop Top Virus; PAMV = Potato Aucuba Mosaic Virus; PVYN = Potato Virus Y Necrotic.**

The highest level of infection with PVY(N) was identified in samples from Carrera, Bellarosa and Hermes varieties. The data presented synthetic in figure 3 and 5 will be used in the future for identify favorable and risk areas and improving potato microzoning - based on spatial and temporary assessment of necrotic viruses PAMV, PMTV and PVY(N), the degree of infection with these viruses correlated with climate change in Romania. So, the source of the samples tested in this study was several geographical areas, different counties (9 producers from Brasov, 11 farmers from Covasna, 5 from Harghita and 5 from Suceava). Regarding the total number of samples tested, 920 samples were taken from Brasov, 1080 from Covasna, 650 from Harghita and 250 from Suceava (*figure 4*).

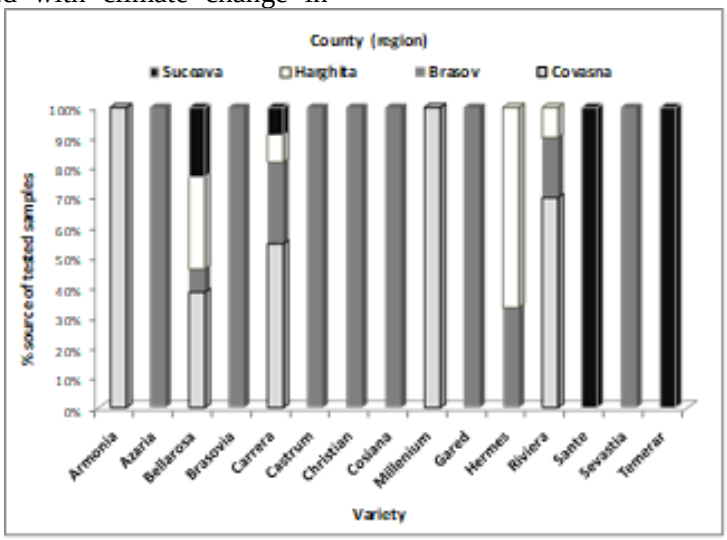

Figure 4 **Source of samples tested (the counties from that the samples were collected in 2019 and 2020)**

These results are preliminary because we have to continue the experiments minimum 3 years. Because of this reason, this paper didn't purpose to make a statistical analysis. Also, the main objective was to identify some varieties non infected and noninfected with PMTV, PAMV and PVY (necrotic strains), material collected from several Romanian counties.

These varieties found total noninfected in our study (in the conditions of the studied counties in

2019 and 2020) were the following: Armonia, Azaria, Christian, Cosiana and Millenium (*figure 3*). Regarding the most favorable regions for seed potato producing (in case of varieties collected in this study) we cannot give more results until this moment because it is necessary to repeat the experiments in the future. However, some preliminary data are presented in figure 3 and 5.

It is important to identify the more PMTV and PAMV sensitive varieties because symptomless infection by these pathogens is known to occur in potato tubers (Sokmen M.A. *et al*, 1988) but its occurence in foliage is less documented (Browning *et al*, 2001; Montero-Astua *et al*, 2008). The foliar symptoms of PMTV is influenced especially by environmental temperature (Carnegie S.F. *et al*, 2009 & 2010). Some varieties never or rarely develop foliar symptoms because they are insensitive to PMTV infection on foliage (Davey *et al*, 2008).

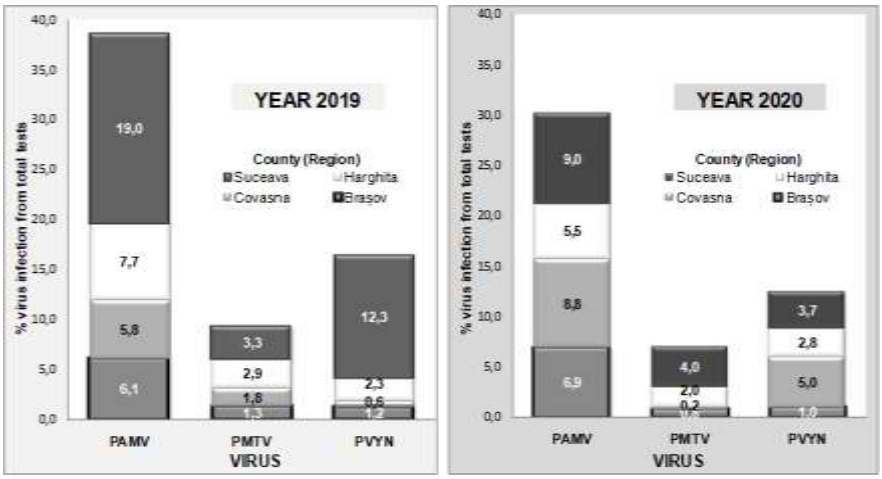

Figure 5 **Percentages of samples infected with PMTV, PAMV and PVY (N) (% of total number of samples collected in each region), in function of the county. The material was collected in 2019 and 2020. PMTV= Potato Mop Top Virus; PAMV = Potato Aucuba Mosaic Virus; PVYN = Potato Virus Y Necrotic.**

In the context of intensify the measures to prevent and control necrotic viruses, the contribution of this paper to the current state of research will result in estimation of PMTV, PAMV and PVY(N) spread to some genotypes grown in our country in order to assess the degree of infection with these viruses to several national and foreign varieties more cultivated in different geographical areas of the country and to identify some potato varieties with high resistance or tolerance to infection with viruses PMTV, PAMV. Also, we tested the sampes for another necrotic virus PVY(N) because this pathogen favors the presence of PAMV. Transmission of PAMV occurs in the presence of a potyvirus helping virus, (viruses A and Y are the most effective); both viruses can be acquired simoultaneously by several same aphids (*Myzus persicae*, *Aulacorthum circumflexus*, *A. Solani* și *Aphis nasturtii)*.

The viruses that are the subject of this study (PMTV, PAMV, PVYN) are not diagnosed in the seed material certification process. No detailed studies have been done on the presence of these pathogens in potato crops in our country. So, it will useful to continue the research work regarding these necrotic viruses, especially for the farmers worried about the emergence of news symptoms in potato plants.

CONCLUSIONS

In our country, although it is known that financial damage brought by necrotic viruses are major in case of growing susceptible varieties under favorable conditions both for consumption potatoes (it can become unmarketable) and for seed potato (it will be downgraded or rejected from certification), to date there has not been conducted a comprehensive study on a spatial expansion of the spectrum of these viruses in our country, study that will contribute to the development of the control of emerging necrotic potato virus like PAMV, PMTV and PVY(N).

In this preliminary study, between the varieties tested in 2019 and 2020 (samples collected from the following counties: Suceava, Brasov, Harghita and Covasna) the lowest level of infection with PMTV, PAMV and PVY (necrotic strains) had the following varieties: Armonia, Azaria, Christian, Cosiana and Millenium.

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REFERENCES

Arif M., Torrance L., Reavy B., 1995 - *Acquisition and transmission of potato mop-top furovirus by a culture of Spongospora subbterranea* f.sp. *subbterranea derived from a single cystosorus.* Annals of Applied Biology, 126: 493-503.

Bădărău C.L, Damşa F., Chiru N., 2014 - *Effects of some electrotherapy treatments of PVX infected potato plantlets cv. Roclas, on several biological development indicators*. Journal of Horticulture, Forestry and Biotechnology, 18(3): 25- 29.

Bădărău C.L., Chiru S.C., Rakosy E., Aurori A., Olteanu Gh., Ghinea A., Nistor A., Cioloca M., 2016 – *Preliminary srudies regarding the incidence of potato virus Y in seed potato in Romania (for several cultivars)*. Lucrări științifice.Seria Agronomie, 56(1): 43-48.

Browning I., Craigid J., Darling M., Darling D., Holmes R., 2001 - *Studies on the detection, transmission to progeny and symptom expression of potato mop top virus in potato*. Abstracts of Virology section Meeting of EAPR, 7-13 october 2001, Havlicckuv Brod Trest (Czech Republic). Potato Research 45(2):106.

Calvert E.L., Harrison B.D., 1966 - *Potato mop-top, a soil borne virus.* Plant pathology, 15:134-139.

Calvert E.L., 1968 - *The reaction of potato varieties to potato mop-top virus*. Report of Agriculture Research Minister Agriculture North Ireland, 17: 31-40.

Carnegie S.F., Davey T., Saddler G.S., 2009 - *Effects of the temperature on the transmission of Potato Mop Top Virus from seed tuber and by its vector, Spongospora subterranea.* Plant Pathology, 59:22-30.

Carnegie S.F., Cameron A.M., McCreath M., 2010 - *Symptoms caused by Potato mop-top virus on potato plants during vegetative propagation in scotland and their association with tuber yield, speriang and tuber infection*. Potato Research, 53 (2), p.83-92.

Clark M.F. and Adams, A.N., 1977 - *Characterization of the microplate method of the enzyme-linked immunosorbent assay for the detection of plant virus*. Journal of General Virology, 34:475-483

Cooper J.I., Harrison B.D., 1976 - *Field and glasshouse experiments on the control of Potato mop top*. Annals of Applied Biology, 83: 215-230.

Davey T., Browning I., Carnegie S.F., Saddler G.S., 2006 - *The importance of potato mop top virus (PMTV) in Scotish seed potatoes*. Proceedings Crop Protection in Northen Britain 2006:375-380

Davey T., Browning I., Carnegie S.F., Mitchell W.J., Saddler G.S., 2008 - *Soil: the principal source of Potato Mop Top virus (PMTV) infection*. Proceedings Crop Protection in Northen Britain 2008:205-210.

Galvino-Costa S.B.F., Figueira A., Camargos V.V., Geraldino P.W., Hu X., Nikolaeva O.V., Kerlan C., Karasev A.V., 2012 - *A novel type of Potato virus Y recombinant genome, determined for the genetic strain PVY^{E}.* Plant Pathology, 61:388-398.

Harrison B.D., Jones R.A.C., 1970 - *Host range and some properties of potato mop-top virus*. Annals of Applied Biology, 65:393-402.

Harrison B.D., Jones R.A.C., 1971 - *Factors affecting the development of spraing in potato tubers infected with potato mop-top virus*. Annals of Applied Biology, 68:281-289.

Jones R.A.C., 1988 - *Epidemiology and control of Potato mop top virus*. In: Cooper J.I., Asher M.J.C., (eds), *Developments in Applied Biology 2: viruses with fungal vectors*. Association of Applied Biologists, Wellwsbourne, UK, p.255-270.

Kurppa A.H.J., 1989 - *Reaction of potato cultivars to primary and secondary infection by potato mop-top furovirus and strategies for virus detection*. *EPPO Bulletin,* 19:593-598.

Loebenstein G., 2001a – *Potato Mop-Top Virus (PMTV; Genus Pomovirus).* In: Loebestein G., Berger P.H., Brunt A.A., Lawson R.H. (eds), *Virus and Virus-like Diseases od Potatoes and Production of Seed-Potatoes.* Springer, Dordrecht, p. 95-100.
https://doi.org/10.1007/978-94-007-0842-6_14

Loebenstein G., 2001b – *Potato Aucuba Mosaic Virus (PAMV; Genus Potexvirus).* In: Loebestein G., Berger P.H., Brunt A.A., Lawson R.H. (eds), *Virus and Virus-like Diseases od Potatoes and Production of Seed-Potatoes.* Springer, Dordrecht, p. 117-119.
https://doi.org/10.1007/978-94-007-0842-6_14

Montero-Astua. M., Vasquez V., Turechek WW., Merz U., Rivera C., 2008 - *Incidence, distribution and association of Spongospora subterranea and Potato Mop Top virus in Costa Rica.* Plant deseases, 92:1171-1176.

Sokmen M.A., Barker H., Torrance L., 1988 - *Factors affecting the detection on potato mop top virus in potato tubers and improvement of tests procedures for more reliable assays.* Annals of Applied Biology, 133:55-63.

Tenorio J., Franco Y., Chuquillanqui C., Owens R.A., Salazar L.F., 2006 - *Reaction of potato varieties to Potato mop top virus infection in the Andes.* American Journal for Potato research, 83: 423-431.

Torrance L., Cowan GH., Scott KP., Pereria LG., Roberts IM., Reavy B., Harrison BD., 1991 - *Detection ans diagnosis of potato mop top virus.* Annual report of Scottish Crop Research Institute for 1991:9-82.

Torrance L., 2008 – *Enciclopedia of Virology (third edition).* Brian W.J., Mally and Marc H.V., Van Regenmortel (eds), p. 282-287

Valkonen J.P.T., 2007 – *Viruses economical losses and biotechnological potential.* In: Valkonen J.P.T. (ed), *Potato Biology and Biotechnology. Advances and perspectives*, Chapter 28, p. 619-641.