

Cactus viruses in fasciated plants

Valentyna M. Maliarenko^{1*},

Tatyana P. Mudrak²

^{1,2}Taras Shevchenko
National University of Kyiv,
Institute of Biology

¹O. V. Fomin
Botanical Garden

²Department of Virology

In plants of *Cactaceae* A. L. Juss. family occurrence of fasciated shoots and cristation of stems is often observed. Many studies have shown differences in the intensity of expression growth factors and genes associated with fasciation (cristation). We tested nine samples on viral infection, including *Mammillaria elongata* A. P. de Candolle f. *cristata*, growing on their own roots. The Scions: *Mammillaria elongata* A. P. de Candolle f. *cristata*, *Echinopsis chamaecereus* H. Friedr. & Glaetzle f. *cristata*, *Echinocereus pectinatus* (Scheidw.) Eng. f. *cristata*, *Echinopsis* sp. Zucc. f. *cristata* which grow on the stocks *Eriocereus jusbertii* (Rebut) A. Berg., *Echinopsis macrogona* (Salm-Dyck). Basing on bioassay and morphological properties the detected viruses are related to *Cactus virus 2* and *Cactus virus X* and genus *Tobamovirus*. As the same viral particles were found in the scions and stocks, we can assume that viruses cannot cause fasciation in the investigated species.

Key words: fasciation, *Cactaceae*, *Cactus virus 2*, *Cactus virus X*

INTRODUCTON

Plants with abnormal type of growth are an interesting phenomenon in plant morphology. Teratology of plant studies clarifies the essence that causes an ugly form of growth and finds the origins relevant to plants with normal form of growth. Scientific information about fasciations has been summarized in the works of [1, 2, 3].

Fasciation (in Latin – Fascia) is a deformation of shoots of plants. Stems intergrow each other, branches accrete with the main shoot, several growth points merged into one. The rhythm of cell division and differentiation changes too [4].

This phenomenon is a widespread morphology of plant. It was found in over 100 species of vascular plants [5] and also observed in dicotyledonous and monocotyledonous plants in 39 families and 86 genera [6]. Fasciation is known in family *Rosaceae* A. L. Juss., *Ranunculaceae* A. L. Juss.,

* Corresponding author. E-mail: vmalyarenko12@gmail.com

Liliaceae A. L. Juss., *Euphorbiaceae* A. L. Juss., *Crassulaceae* D. C., *Onagraceae* A. L. Juss., *Asteraceae* Bercht. & J. Presl, *Cactaceae* A. L. Juss., *Asclepiadaceae* R. Br. Occurrence of fasciation among *Pseudotsuga menziesii* (Mirb.) Franco is also known [7].

One of the forms of fasciation is cristation. Consequently, the stems of plants are wide and flat with wavy nature of the further growth.

The main reasons for reviewing are the influence of external factors and genetic changes in the genotype. The factors of the environment include: damage by mycoplasmas [8], gamma radiation [9], growth regulators and light [10]; the bacteria *Rhodococcus fascians* cause fasciation and other violations in plants [6]. Occurrence of fasciation phenotype is associated with mutations of genes that control the development of meristems [11].

Screening of *Cactaceae* plants on virus diseases in the collections of O. V. Fomin Botanical Garden has been conducted. In all collections cactus plants are infected by virus. Basing on morphological properties detected viruses are related to *Cactus virus 2* and *Cactus virus X*. Since in the scion and rootstock the same virus particles were found, we can assume that viruses cannot cause fasciation in *Cactaceae* family.

Our goal is to verify fasciated plants of *Cactaceae* A. L. Juss. family on virus diseases.

MATERIALS AND METHODS

The investigated plants were selected in the collection of succulent plants in O. V. Fomin Botanical Garden. There are 28 species of fasciated plants of *Cactaceae* family. They belong to 20 genera [12]. Most of these plants retained on the stock, but some species are grown on their own roots. Collection of species forms of cristata reproduces by the method of grafting.

Plant Material

We have tested species: *Mammillaria elongata* A. P. de Candolle f. cristata growing on their

own roots. The Scions: *Mammillaria elongata* A. P. de Candolle f. cristata and its stock *Eriocereus jusbertyi* (Rebut) A. Berg., *Echinopsis chamaecereus* H. Friedr. & Glaetzle f. cristata, *Echinocereus pectinatus* (Scheidw.) Eng. f. cristata, *Echinopsis* sp. Zucc. f. cristata, which grow on the stocks *Echinopsis macrogona* (Salm-Dyck) on viral infection.

Plants homogenized with addition of 0.1 M phosphate buffered saline (pH 7,4). For besieging of cellular admixtures low-speed centrifugation 7 000 rpm during 20 min was conducted. Preparations were inflicted on copper stringbags from 0.2% formvar lining. The negative contrasting was conducted by 2% uranyl acetate during 1.5 min. The revision of standards was conducted by electron microscope JEM-1230 (Japan), with a resolution of 0.2 nm. Samples of plants of *Cactaceae* family were analyzed by electron microscopy at a magnification of 30.000 times.

RESULTS AND DISCUSSION

Virus diseases of *Cactaceae* plants have not been sufficiently studied. The most widespread viruses affecting plants of this family are *Cactus virus X* (genus *Potexvirus*, family *Alphaflexiviridae*): virions filamentous, not enveloped; usually flexuous with clear modal length 520 nm and 13 nm wide; *Zygocactus virus X* (genus *Potexvirus*, family *Alphaflexiviridae*): virions are flexuous with clear modal length 519 nm and 10 nm wide; *Opuntia virus X* (genus *Potexvirus*, family *Alphaflexiviridae*): virions filamentous, usually flexuous with clear modal length 520 nm and 13 nm wide [13]; *Sammons' Opuntia virus* (genus *Tobamovirus*) virions rod-shaped, not enveloped, 317 nm long and 18 nm wide [14]; *Cactus mild mottle virus* (genus *Tobamovirus*): virions 320 nm long and 18 nm in diameter [15]; *Saguaro cactus virus* (genus *Carmovirus*, family *Tombusviridae*): virions not enveloped, isometric nucleocapsid, 32 nm in diameter [16]; *Cactus virus 2* (genus *Carlavirus*, family *Betaflexiviridae*): filamentous virions with normal length 650–655 nm and 11–13 nm wide [17].



Fig. 1. A – *Mammillaria elongata* f. *cristata* A. P. de Candolle,
B – *Echinopsis chamaecereus* f. *cristata* H. Friedr. & Glaetzle

The following cacti were assayed and found infected, external symptoms: *Mammillaria elongata* A. P. de Candolle f. *cristata* (Fig. 1A), growing on their own roots. The Scions: *Mammillaria elongata* A. P. de Candolle f. *cristata* and its stock *Eriocereus jusbertii* (Rebut) A. Berg. *Echinopsis chamaecereus* H. Friedr. & Glaetzle f. *cristata* (Fig. 1B), *Echinocereus pectinatus* (Scheidw.) Eng. f. *cristata*, *Echinopsis* sp. Zucc. f. *cristata*, which grows on the stocks *Echinopsis macrogona* (Salm-Dyck).

Indicator plants were inoculated with sap obtained from cactus plants. Necrotic local lesions were observed on *Chenopodium murale* L. and *Gomphrena globosa* L. and mosaic on *Nicotiana alata* Link et Otto (Fig. 2) was typical for *Cactus virus X*.

All studied plants were probably virus infected. To confirm our assumption about virus infection and to study the morphology of the pathogen we carried out transmission electron microscopy.

In the sap of all plants we registered filamentous virions with size $650 \times 12 \pm 2$ nm, which is typical for *Cactus virus 2* (Fig. 3A). Also in *Echinopsis chamaecereus* f. *cristata*, *Echinocereus pectinatus* f. *cristata*, *Mammillaria elongata* f. *cristata* and stocks *Eriocereus jusbertii*, *Echinopsis macrogona* we found filamentous virions with typical size for *Cactus virus X* $580 \times 13 \pm 2$ nm (Fig. 3B).

In the sap of *Echinopsis* sp. f. *cristata* and its stock we found filamentous virions with typical size for *Cactus virus 2* $650 \times 12 \pm 2$ nm. A rod-



Fig. 2. Mosaic symptom on an inoculated *Nicotiana alata* leaf

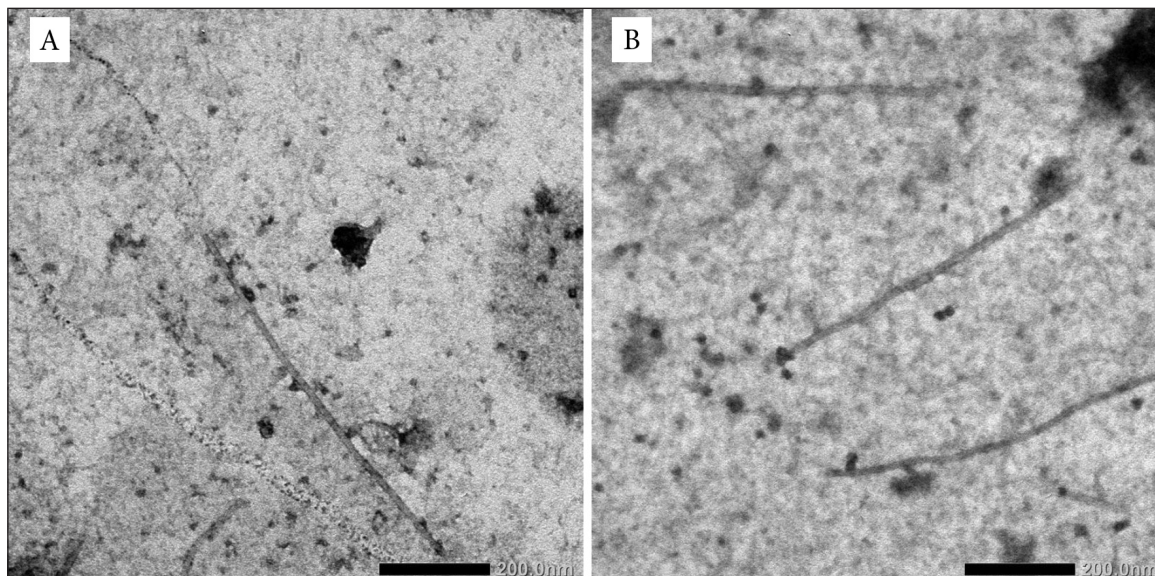


Fig. 3. Electron micrograph of negatively stained crude extract from *Mammillaria elongata* f. *cristata* showing filamentous: A – *Cactus virus 2* ($650 \times 12 \pm 2$ nm), B – *Cactus virus X* ($580 \times 13 \pm 2$ nm)

shaped viral particles with size $317 \times 18 \pm 2$ nm belong to the genus *Tobamovirus*.

It is noteworthy that in species *Mammillaria elongata* f. *cristata* and stock *Echinopsis macrogona* we found three types of virions – two filamentous and one rod-shaped.

The discovered rod-shaped viral particles belong to virus from the genus *Tobamovirus* (Fig. 4). In accordance with literature [14],

the *Sammons' Opuntia* virus infects only the plants of genus *Opuntia*, though quite often a symptomless infection takes place. Virions have length 317 nm and diameter 18 nm. The *Cactus mild mottle virus* affecting different cactus species causes spots and mosaics on plants, virions have length 320 nm and diameter 18 nm [15]. As cactus had mixed infection, it is possible to assume that *Chamaereus*

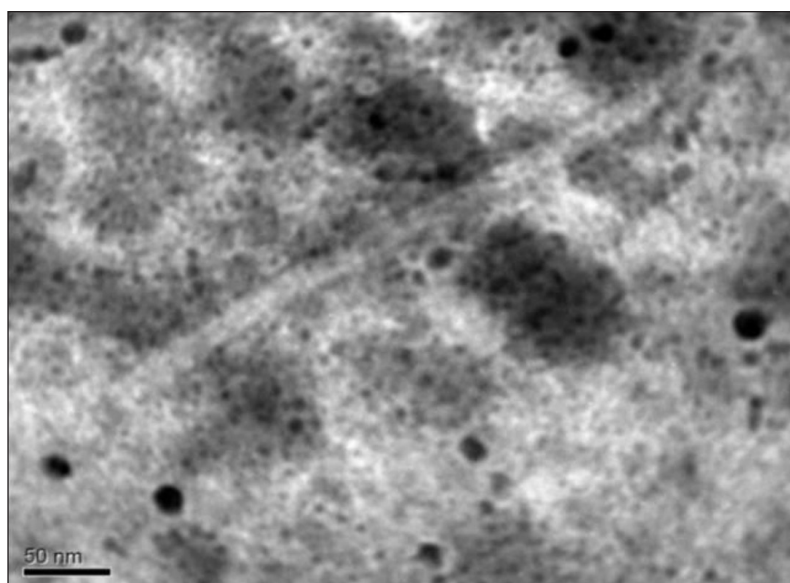


Fig. 4. Electron micrograph of *Tobamovirus*

silvestrii f. *crystata*, *Echinopsis* sp. f. *crystata* and *Mammillaria elongata* f. *crystata* were infected with *Cactus mild mottle virus* [15].

CONCLUSIONS

Viruses were detected in all the studied plants (scions, stocks and fasciated plants growing on their own roots) by electron microscopy. Thus basing on morphological properties the detected viruses are related to *Cactus virus 2* and *Cactus virus X*. The nature of rod-shaped virions are still studied.

The obtained results confirm the high capacity of plant *Cactaceae* family to be infected with viruses. As a result of reproduction of fasciated plants by grafting spread of viral infection becomes possible. Therefore, the method of grafting should not be used to maintain plant collections in botanical gardens.

Since the same viral particles were found in the scions and stocks, we can presume that viruses cannot cause fasciation in *Cactaceae* family.

Received 18 May 2013

Accepted 14 July 2013

References

- White OE. The Biology of fasciation and its relation to abnormal growth. *J Hered* 1945; 36(1): 11–22.
- Binggeli P. Occurrence and causes of fasciation. *Cecid* 1990; 5: 57–62.
- Iliev I, Kitin P. Origin, morphology, and anatomy of fasciation in plants cultured *in vivo* and *in vitro*. *Plant Growth Reg* 2011 March; 63(2): 115–29.
- Encyclopedic Dictionary of Biology. Moscow: MS Gilyarov 1986; Soviet Encyclopedia; Ukraine. p. 831.
- Tang Y, Knap HT. Fasciation mutation enhances meristematic activity and alters pattern formation in soybean. *Int J Plant Sci* 1998; 159(2): 249–60.
- Goethals K, Vereecke D, Jaziri M, Van Montague M, Holsters M. Leafy gall formation by *Rhodococcus fascians*. *Annual Rev Phytopath* 2001; 39: 27–52.
- Duffield JW, Wheat JG. A common fasciation in Douglas fir. *J Hered* 1963; 54(5): 240.
- Stumm-Tegethoff BFA, Linskens HF. Stem fasciation in *Lilium henryi* caused by nematodes. *Acta Bot Neerl* 1985; 34: 83–93.
- Abe K, Osakabe K, Ishikawa Y, Tagiri A, Yamanouchi H, Takyuu T et al. Inefficient double-strand DNA break repair is associated with increased fasciation in *Arabidopsis* BRCA2 mutants. *J Exp Bot* 2009; 60(9): 2751–61.
- Schoof K, Lenhard M, Haecker A, Mayer KF, Jurgens G, Laux T. The stem cell population of *Arabidopsis* shoot meristems is maintained by a regulatory loop between the *CLAVATA* and *WUSCHEL* genes. *Cell* 2000; 100(6): 635–44.
- Fletcher JC. Shoot and floral meristem maintenance in *Arabidopsis*. *Annual Rev Plant Biol* 2002; 53: 45–66. PubMed PMID: 12221985.
- Maliarenko VM, Gajdarji MM, Badanina VA. Proceedings of the International Conference of Young Scientists; 2010 Sep. 21–25; Yalta, Ukraine, Simpheropol: Arial; 2010.
- Koenig R, Pleij CWA, Loss S, Burgermeister W, Aust H, Schiemann J. Molecular characterisation of potexviruses isolated from three different genera in the family *Cactaceae*. *Arch Virol* 2004; 149: 903–14.
- Wetter C, Paul HL. Serologische und physikalische eigenschaften von Sammons' *Opuntia* virus. *Phytopathol* 1967; 60: 92–5.
- Min BE, Chung BN, Kim MJ, Ha JH, Lee BY, Ryu KH. Cactus mild mottle virus is a new cactus-infecting tobamovirus. *Arch Virol* 2006 Jan; 151(1): 13–21.
- Weng Z, Xiong Z. Genome organization and gene expression of Saguaro cactus carmovirus. *J Gen Virol* 1997 March; 78(3): 525–34.
- Fauquet CM, Mayo MA, Maniloff J, Desseberger U, Ball LA. Virus taxonomy: eight

reports of the International committee on taxonomy of viruses. San Diego: Elsevier Academic Press; 2005.

Valentyna M. Maliarenko, Tatyana P. Mudrak

KAKTUSŲ VIRUSAI FASCIJUOTUOSE AUGALUOSE

Santrauka

Cactaceae A. L. Juss. šeimos augaluose dažnai pasitaiko fascijuotų ūglių ir skiauterėtų kamienų. Daugelis tyrimų rodo augimo veiksnių ir genų, susijusių su fasciacijos ekspresijos intensyvumu, skirtumus. Mes ištyrėme devynis virusais infekuotus pavyzdžius: *Mammillaria elongata* A. P. de Candolle f. *crispata* šaknis, *Mammillaria elongata* A. P. de Candolle f. *crispata*, *Echinopsis chamaecereus* H. Friedr. & Glaetzle f. *crispata*, *Echinocereus pectinatus* (Scheidw.) Eng. f. *crispata*, *Echinopsis* sp. Zucc. f. *crispata* ūglius bei *Eriocereus jusbertii* (Rebut) A. Berg., *Echinopsis macrogona* (Salm-Dyck) kamienus. Remiantis bioanalize ir morfologiniais požymiais nustatyta, kad virusai priklauso *Cactus virus 2*, *Cactus virus X* ir *Tobamovirus* sp. Kadangi tų pačių virusų dalelių buvo rasta ant ūglių ir kamienų, mes darome išvadą, kad virusai negali sukelti fasciacijos tirtuose augaluose.

Raktažodžiai: fasciacija, *Cactaceae*, *Cactus virus 2*, *Cactus virus X*