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Host Range and Symptom Differences between Isolates of Turnip Mosaic Virus Obtained from *Sisymbrium loeselii*

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Abstract. Twenty-four isolates of turnip mosaic virus (TuMV) from spontaneously infected *Sisymbrium loeselii* plants were collected in Bohemian localities. Single lesions on leaves of *Nicotiana tabacum* cv. Samsun served for inoculating petunia plants used as infection sources for twelve host species. In no case were two identical isolates obtained. 15 isolates could be transmitted to *Vicia faba*, a new TuMV host. Almost all isolates infected *Phaseolus vulgaris* cv. Prince locally and *Trifolium incarnatum* systemically. Seven isolates were transmissible to *Pisum sativum*. No substantial differences between isolates were observed with infected *An aranthus caudatus*, *Chenopodium quinoa*, *Datura innoxia* and *Sinapis alba* plants. Several isolates could not infect *Nicotiana glutinosa* at all, other isolates caused in it latent systemic infection and some isolates only local infection contrary to normal local and systemic infections of *N. glutinosa*. Attempts to transmit one isolate to cereals failed.

In Bohemia isolates of turnip mosaic virus (TuMV, syn.: cabbage black ring virus) from wild plants were described showing peculiarities in host range and symptoms (BRČÁK and POLÁK 1963, BRČÁK and PROCHÁZKOVÁ 1976). This suggested that also in *Sisymbrium loeselii* JUSL. special TuMV strains could occur. Natural TuMV infections in *S. loeselii* are very common in Bohemia and this plant may be an important source of TuMV (POLÁK and CHLUMSKÁ 1978). However, spontaneous TuMV infections of *S. loeselii* may differ by symptoms from those originally described by USCHDRAWEIT and VALENTIN (1957). Therefore, an analysis of TuMV strains occurring in *S. loeselii* was performed, based on host plant reactions.

MATERIAL AND METHODS

S. loeselii plants of various age were collected in the autumn 1977 at localities reported by POLÁK and CHLUMSKÁ (1978) — Table 1; one to three isolates were got from each locality. Leaves of *Nicotiana tabacum* cv. Samsun were rubbed with crude sap from *S. loeselii* leaves and single lesions from *N. tabacum* served then for infections of *Petunia hybrida* cv. Láska used as an infection source for the following further 12 hosts: *Amaranthus caudatus* L. *atropurpureus*, *Datura innoxia* MILL., *Chenopodium quinoa* WILLD., *Nicotiana glutinosa* L., *Nicotiana megalosiphon* HEURCK et MUELL.

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TABLE 1

Reactions of twelve host plants to infections by twenty four isolates of turnip mosaic virus from *Sisymbrium loeselii*

Host plant (date) / TuMV isolate	*Phaseolus vulgaris* cv. Prince (March 7)	*Vicia faba* (March 7)	*Trifolium incarnatum* (March 30)	*Petunia hybrida pendula grandiflora* cv. Lavina (March 30)	*Nicotiana sylvestris* (April 10)	*Nicotiana megalosiphon* (April 10)
Benešov 2	0	LC, (1,3)+	Vcl, SMg, Dw (2,5)	Vcl,SM,De,Dw (5, 4)	LNL (4,3)	LCL
Brandýs 1	0	0 —	SMgy (3,2)	Vcl,SM,De,Dw (5,4)	LNL (5,3)	LCL → LNL
Brandýs 2	LCR (1,3)	LNL (1,3)+ LN	SMgy,Dw (2,4)	Vcl,SM,De,Dw (5,4)	LNL (5,4)	LCL → LNL
Děčín 1	0	LNL (1,2)+	0	Vcl,SM,De (1,3)	LNL (3,3)	0
Děčín 2	LCR (2,3)	LN (1,2)+	SM,Dw (1,5)	Vcl,SM,De,Dw (4,4)	LNL (5,3)	LCL
Hodkovičky 2	0	0 —	SMg,Dw (1,5)	Vcl,SM,De,Dw (5,5)	LNL (5,3)	LCL → LNL
Kolín	LCR (2,3)	LNL (1,2)+	SMgy,Dw (1,4)	Vcl,SM,De,Dw (5,4)	LNL (5,4)	LCL → LNL
Kralupy 1	LCL (1,1)	0 —	0	SM (1,1)	LCL (3,1)+	LCL
Kralupy 2	LCL, LCR (1,2)	0 —	Vcl,SM (4,1)	SC (2,2)	LCL (3,1)+	LCL
Litoměřice 1	LCR (1,3)	0 —	Vcl,SMgy,Dw (5,4)	SM,De,Dw (4,4)	LNL (4,2)	LCL → LNL
Litoměřice 2	LCL (1,1)	0 —	Vcl,SMgy,Dw ,5,5)	Vcl,SM,De (1,3)	LNL (3,3)	LCL → LNL
Lovosice 1	LCL, LCR (2,2)	LNL (1,2)+	Vcl,SMg,Dw (4,3)	Vcl,De,Dw (3,4)	LNL (5,4)	LCL, LNL
Lovosice 2	LCL, LCR (1,2)	LN (1,3)+	Vcl,SMg,Dw (2,3)	Vcl,SM,De,Dw (5,5)	LNL (5,5)	LCL → LNL
Lysá n./Lab.	LCR (3,3)	LNL (1,2)+	Vcl,SMgy (3,2)	Vcl (3,2)	LNL (3,2)+	LCL → LNL
Mělník 1	LCL, LCR (2,2)	0 —	SM,Dw (1,3)	Vcl,SM,De,Dw (1,4)	LNL (5,4)	LCL
Mělník 2	LCL, LCR (2,2)	LLI (1,1)+	SMg (5,1)	Vcl,Dw (3,4)	LNL (5,4)	LCL
Pardubice 1	LCL, LCR (3,3)	LN (1,3)+	Vcl,SMy,Dw (2,5)	Vcl,SM,Dw (4,5)	LNL (4,5)	LCL → LNL

Sinapis alba cv. Přerovská (April 21)	*Amaranthus caudatus atropurpureus* (May 3)	*Nicotiana glutinosa* (May 3)	*Datura innoxia* (May 30)	*Pisum sativum* cv. Libochovický (May 30)	*Chenopodium quinoa* (May 30)
SM,Dw (5,5)	LNL (2,2)	LNL,SC,Dw (5,4)	SM (5,5)	0 —	LCL,LNL,SC (5,4)
SM (5,3)	LNL (3,2)	LNL,SC,SMy,De Dw (5,5)	SM (3,5)	0 —	LCL,LNL,SC (5,3)
SM (3,3)	LNL (1,1)	LNL,SC,SMy (5,4)	SM (5,5)	0 —	LCL,LNL,SC (5,3)
SM (5,3)	LNL (3,3)	LNL,SC (5,3)	SM (1,4)	0 —	LCL,LNL (4,3)
SM (3,3)	LNL (3,2)	LNL,SC,SM (5,3)	SM (1,5)	SM (1,1) +	LCL,LNL,SC (5,3)
SM (4,4)	LNL (4,3)	LNL,SMy,Dw (5,5)	SM (4,5)	0 —	LCL,LNL,SC (5,5)
SM (5,4)	LNL (3,2)	LNL,SC,SM,Dw (5,5)	SM (5,5)	0 —	LCL,LNL,SC (5,4)
SM (5,4)	LNL (4,2)	LSI (2,2) +	SC (2,3)	SM (1,1) +	LCL,LNL,SC (5,3)
SM (2,3)	LNL (4,3)	LNL,SI = 0 — (2,1)	SC (2,3)	SM (1,1) +	LCL,LNL,SC (5,3)
SM (5,4)	LNL (2,2)	LCL,SI = 0 — (2,1)	SM (3,5)	0 —	LCL,LNL (5,4)
SM (3,4)	LNL,LC (3,2)	LSI (2,2) +	SM (2,4)	0 —	LCL (3,2)
SM (2,2)	LNL (3,2)	LNL,SM (5,4)	SM (5,5)	0 —	LCL,LNL,SC (4,3)
SM (5,3)	LNL (3,2)	LNL,SM (5,4)	SM (5,5)	SM (1,1) +	LCL,LNL,SC (5,3)
SM (3,4)	LNL (4,2)	0 —	SC (3,3)	0 —	LCL,LNL,SC (5,4)
SM (5,4)	LNL (2,2)	LNL,LCL (3,2) +	SM (5,5)	0 —	LCL,LNL,SC (5,5)
SM (4,3)	LNL (2,2)	LNL,SMg,Dw (5,5)	SM (5,5)	0 —	LCL,LNL,SC (5,4)
SM (3,4)	LNL (5,3)	LNL,SM,Dw (5,5)	SM (5,5)	SM (1,1) +	LCL,LNL,SC (5,5)

Host plant (date) / TuMV isolate	*Phaseolus vulgaris* cv. Prince (March 7)	*Vicia faba* (March 7)	*Trifolium incarnatum* (March 30)	*Petunia hybrida pendula grandiflora* cv. Lavina (March 30)	*Nicotiana sylvestris* (April 10)	*Nicotiana megalosiphon* (April 10)
Pardubice 2	LCL,LCR (3,3)	0 —	SMg (4,1)	Vcl,SM,De,Dw (4,5)	LNL (5,2)	LCL → LNL
Pardubice 4	LCL,LCR (3,3)	LNL,LNR (1,2)+	0	Vcl,SM,De (1,3)	LNL (5,4)	LCL
Práče	LCR (1,3)	LN (1,2)+	Vcl,SMg,Dw (2,5)	Vcl,SM,De,Dw (5,4)	LNL (5,3)	LCL → LNL
Rokytka	LCL,LCR (4,2)	LN (1,2)+	Vcl,SMg,Dw (4,5)	Vcl,SM,De,Dw (5,4)	LNL (5,3)	LCL → LNL
Štětí 1	LCL,LCR (4,2)	LLI (1,1)+	Vcl,SMgy,Dw (5,5)	Vcl,Dw (3,4)	LNL (5,3)	LCL → LNL
Štětí 2	LCL,LCR (4,2)	0 —	Vcl,SMy,Dw (1,4)	SC,De (2,3)	LCL(3,1)+	LCL → LNL
Zbraslav	LCR (1,3)	LLI(1,1)+	Vcl,SMgy,Dw (3,4)	Vcl,SM,De,Dw (5,4)	LNL((5,4)	LCL

ARG., *Nicotiana sylvestris* SPEG. et COMES, *Petunia hybrida* hort. ex VILM. *pendula grandiflora* cv. Lavina, *Phaseolus vulgaris* L. cv. Prince, *Pisum sativum* L. cv. Libochovický, *Sinapis alba* L. cv. Přerovská, *Trifolium incarnatum* L., *Vicia faba* L.

Most of the differential hosts were chosen according to BRČÁK and PROCHÁZKOVÁ (1976). Due to troubles of greenhouse-growing no species of the genus *Brassica* were employed, despite the fact that their reactions used to be important for strain differentiation (*cf.* references in LISA and LOVISOLO 1976). Nevertheless, several authors failed to infect (by manual inoculation) some *Brassica* species with some TuMV isolates (*e.g.* TOMPKINS 1939, BRČÁK and POLÁK 1963, LAPIERRE and GRISON 1969, BRUNT 1976, LISA and LOVISOLO 1976). *Vicia faba* known as non-host of TuMV (TOMPKINS 1939, PROVVIDENTI 1978) was tested again.

Individual species of differential hosts were inoculated in large sets with all TuMV isolates in the same conditions and on the same day. The sequence of hosts (Table 1) corresponds to the terms of inoculations. Localities are arranged alphabetically. Host plant reactions are abbreviated as follows:

De — deformations;
Dw — dwarfing;
LC — local chlorosis (large chlorotic blotches);
LCL — local chlorotic lesions;
LCR — local chlorotic rings;
LLI — latent local infection;
SC — systemic chlorosis;
SI — systemic infection;
SM — systemic mosaic;
SMg — green systemic mosaic;
SMy — yellow systemic mosaic;
Vcl — vein clearing;
0 — no reaction;

Sinapis alba v. Přerovská (April 21)	*Amaranthus caudatus atropurpureus* (May 3)	*Nicotiana glutinosa* (May 3)	*Datura innoxia* (May 30)	*Pisum sativum* cv. Libochovický (May 30)	*Chenopodium quinoa* (May 30)
SM (2,3)	LNL (4,3)	LNL,SMg,Dw (5,5)	SM (5,5)	0 —	LCL,LNL,SC (5,4)
SM (4,4)	LNL (3,2)	LNL,SC (5,4)	SM (4,5)	0 —	LCL,LNL,SC (5,3)
SM (3,2)	LNL (1,2)	LNL,SC (1,3)	SM (2,5)	0 —	LCL (3,2)
SM,Dw (1,5)	LNL (2,2)	LNL,SC,LSI (3,2) +	SM (4,5)	SM (2,1) +	LCL,LNL,SC (5,4)
SM,Dw (5,5)	LNL (3,3)	LNL,SC (5,3) +	SM (5,5)	SM (2,2) +	LCL,LNL,SC (5,4)
0	LNL,LCL (1,1)	0 —	0	0 —	0
SM (4,4)	LNL (1,2)	LNL,SC (5,3)	SM (5,5)	0 —	LCL,SC (5,2)

LN — local necrosis in rubbed leaves;
LNL — local necrotic lesions;
LNR — local necrotic rings;
LSI — latent systemic infection;

\+ — positive results of back inoculations;
—— — negative results of back inoculations;
⟶ — alteration of symptoms (*e.g.* necrotization of chlorotic lesions);

(2,3) — classification degrees of susceptibility (first cipher) and sensitivity (second cipher), as by BRČÁK and BRČÁK JR. (1980). The susceptibility (0 to 5) is classified as relative amounts of local lesions on *Phaseolus vulgaris*, *Nicotiana sylvestris*, *Amaranthus caudatus* and *Chenopodium quinoa*, or as percent of infected plants with *Vicia faba*, *Trifolium incarnatum*, *Petunia hybrida*, *Sinapis alba*, *Nicotiana glutinosa*, *Datura innoxia* and *Pisum sativum*. The sensitivity (0 to 5) is evaluated according to the size of local lesions with *P. vulgaris*. With *V. faba*, *N. sylvestris*, *A. caudatus*, and *C. quinoa* not only the size of the lesions but also the alterations of latent local infection into chlorotic or necrotic lesions are classified. Then the sensitivity is evaluated as intensity of systemic symptoms with *T. incarnatum*, *P. hybrida*, *S. alba*, *N. glutinosa*, *D. innoxia* and *P. sativum*. *E.g.* degrees of susceptibility of *N. glutinosa* to TuMV isolates are as follows: 0 . . . no infection at all, 1 . . . local infection (only on rubbed leaves), no systemic spread of the virus, 2 . . . latent systemic

infection, or very mild systemic chlorosis, 3 . . . systemic chlorotic rings without necrosis, 4 . . . severe systemic chlorosis and necrosis, 5 . . . systemic mosaic, necrosis and dwarfing. The sensitivity of other hosts is characterized similarly by abbreviations (Table 1).

All inoculated test plants were observed for 30 days at least. Latent infections and doubtful symptoms were verified by back inoculation trials to *N. tabacum* cv. Samsun.

RESULTS AND DISCUSSION

Table 1 summarizes the results concerning identity or differences in local and systemic reactions of twelve hosts to 24 TuMV isolates. Some details, as lesion size with *N. sylvestris* (Fig. 1) or mosaic symptoms in *T. incarnatum* (Fig. 3) were not included in the abbreviations. None of our TuMV isolates caused systemic infection in *N. sylvestris*, as reported by RAO *et al.* (1977); this plant also proved to be unsusceptible to one TuMV isolate (USCHDRAWEIT and VALENTIN 1957). *V. faba* was shown to be a new TuMV host, as proved with 15 TuMV isolates in our experiments.

Two TuMV isolates could not be transmitted to *N. glutinosa* at all, as proved by repeated attempts and several back inoculation trials performed in various seasons. This phenomenon was already observed with other TuMV isolates by TOMPKINS (1939), USCHDRAWEIT and VALENTIN (1957) and LAPIERRE and GRISON (1969). Two of our TuMV isolates caused merely latent systemic infection in *N. glutinosa* and two others caused only local but not systemic infection in *N. glutinosa*, as described by TOMPKINS (1939) and LISA and LOVISOLO (1976). Therefore, *N. glutinosa* may be an unreliable indicator plant for TuMV.

All TuMV isolates were transmissible to *Petunia hybrida* usually reacting differently to various isolates. However, even this species does not belong to universal TuMV hosts, as shown by TOMPKINS (1939) and USCHDRAWEIT and VALENTIN (1957). TuMV symptoms in *Datura innoxia* were very similar with many isolates, but exceptionally this species does not react to some TuMV strains, as reported by USCHDRAWEIT and VALENTIN (1957) and BRČÁK and PROCHÁZKOVÁ (1976). A possible systemic TuMV infectioni n *Amaranthus caudatus* was not investigated in the present paper, however it was reported *e.g.* by USCHDRAWEIT and VALENTIN (1957) and LISA and LOVISOLO (1976).

Seven TuMV isolates were transmissible to *Pisum sativum* proved to be a potential TuMV host simultaneously by FISCHER and LOCKHART (1976) and BRČÁK and PROCHÁZKOVÁ (1976) and later by PROVVIDENTI (1978). With the exception of four isolates all others could cause local chlorotic lesions or rings in *Phaseolus vulgaris* (Fig. 2), as formerly reported by BRČÁK and PROCHÁZKOVÁ (1976) and LISA and LOVISOLO (1976). Almost uniform symptoms were obtained in *Sinapis alba* (SM), *Amaranthus caudatus* (LNL), *Datura innoxia* (SM) and *Chenopodium quinoa* (LCL, LNL and frequently SC).

Table 1 contains also ciphers indicating degrees of susceptibility and sensitivity proposed and used for a computer evaluation by BRČÁK and BRČÁK JR. (1980), dealing with a part of the presented results.

Hitherto only BRUNT (1976) ascertained transmissibility of TuMV to some monocotyledonous plants. Therefore, we tried to transmit one of our isolates (Pardubice 1) to some cereals. However, all back inoculations done 56 days

after rubbing young seedlings (in June) failed to prove either local or systemic infections of oat plants cv. Tiger, maize plants cv. Friga, spring barley cv. Sladár and spring wheat cv. Zlatka.

Our results showed that all TuMV isolates differed from each other and that in some localities different isolates were obtained from *S. loeselii* plants growing very near. The epiphytological importance of these TuMV "wild strains" might be a further step of our investigation, focussed first on their pathogenity for crop plants.

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Figures at the end of the issue.

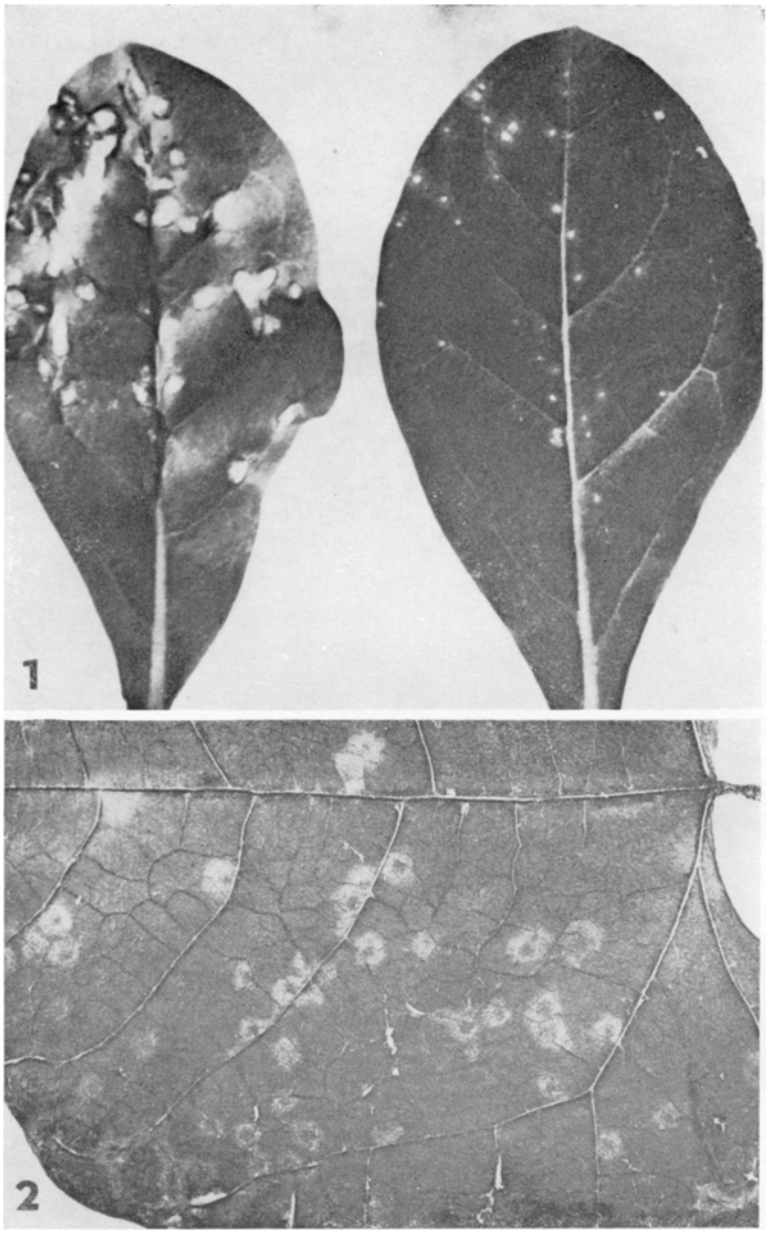

Fig. 1. Differences in size of local necrotic lesions in *Nicotiana sylvestris* leaves between turnip mosaic virus isolates from *Sisymbrium loeselii:* Pardubice 1 (large lesions left) and Štětí 1 (small lesions right).
Fig. 2. Local chlorotic rings in *Phaseolus vulgaris* cv. Prince caused by the turnip mosaic virus isolate obtained from *S. loeselii* at Rokytka.

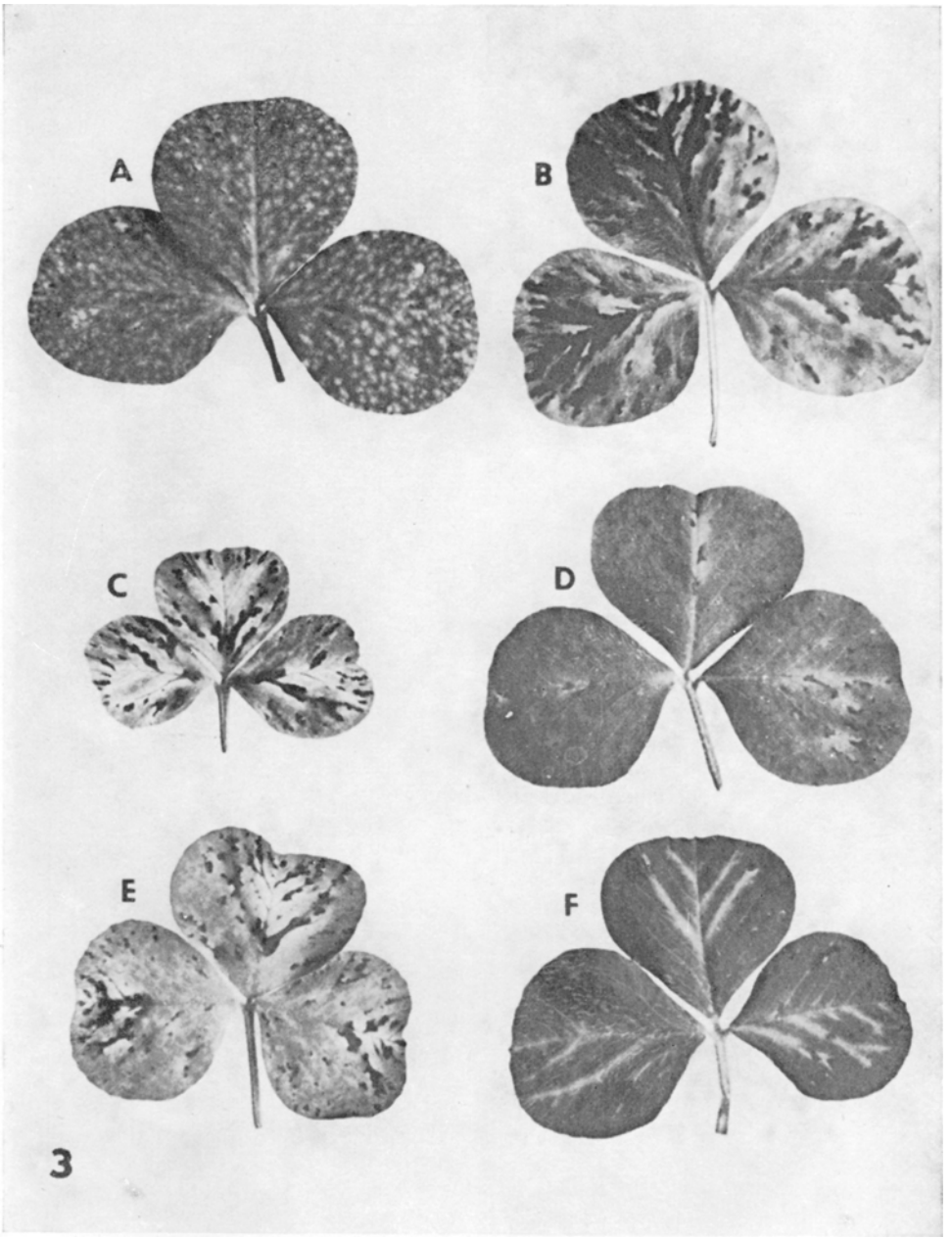

Fig. 3. Systemic symptoms in *Trifolium incarnatum* by turnip mosaic virus isolates from *S. loeselii:* A — Lysá n/Lab., B — Lovosice 1, C — Pardubice 1, D — Kralupy 2, E — Litoměřice 1, F — Kolín. (All photographs by dr. J. Brčák).