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Host Range of Wheat Striate Virus

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Okruh hostitelů viru proužkovitosti pšenice

Na sání přirozeně infikovaného přenašeče viru proužkovitosti pšenice (VPP) křísa *Calligypona pellucida* F. reagovaly charakteristickými příznaky v poměrně značném rozsahu *Bromus arvensis* L., *B. mollis* L., *Avena fatua* L., *A. nuda* L. (HOEJ.), *Triticum aestivum* L. s. s., *T. compactum* HOST., *T. dicoccum* SCHRANK a *Hordeum murinum* L., v menším podílu pak *Lolium multiflorum* LAM., *L. perenne* L., *Bromus tectorum* L., *Poa annua L.*, *Avena strigosa* SCHREB., *A. sterilis* L., *Triticum spelta* L., *T. durum* DESF., *T. turgidum* L. a *T. polonicum* L. Dalších 42 rostlinných druhů ze 6 čeledí v této testaci neonemocnělo. Negativně vyzněl i pokus o umělé nakažení *Phleum pratense* L.,třebaže u tohoto rostlinného druhu jsme v přírodě pozorovali typické příznaky VPP. Máme za to, že některé negativní výsledky byly asi v příčinné spojitosti se značně kolísající přenašečskou účinností vektora, známou již z dřívějších prací.

V kulturách pícnin prvního užitkového roku v místech s nadměrně hojným výskytem larev *Calligypona pellucida* bylo při terénních pozorováních zaznamenáno v některých lokalitách na Českomoravské vysočině silnější napadení VPP u *Lolium multiflorum*. Charakteristické příznaky VPP jsme při tom zjistili i na *Phleum pratense*, *Lolium perenne* a *Bromus mollis*.

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Summary

The following plants reacted to acquisition feeding by an infected leafhopper, *Calligypona pellucida*, vector of the wheat striate virus (WSV) with characteristic symptoms to a relatively marked extent, — *Bromus arvenis* L., *B. mollis* L., *Avena fatua* L., *A. nuda* L. (HOEJ.), *Triticum aestivum* L. s. s., *T. compactum* HOST., *T. dicoccum* SCHRANK and *Hordeum murinum*. L., to a lesser degree *Lolium multiflorum* LAM., *L. perenne* L., *Bromus tectorum* L., *Poa annua L.*, *Avena strigosa* SCHREB., *A. sterilis* L., *Triticum spelta* L., *T. durum* DESF., *T. turgidum* L. and *T. polonicum* L. A further 42 plant species from 6 families remained uninfected in this test. An attempt to infect *Phleum pratense* artificially gave negative results even though typical symptoms of WSV were found in this variety in nature. It is probable that some negative results were connected with the considerable vacillation of the transmittable efficacy of the vector, already known from previous work.

During field observation of fodder crops in the first year in some districts of the Czecho-Moravian Highlands, where the occurrence of *Calligypona pellucida* larvae was abnormally profuse, a stronger infection of WSV in *Lolium multiflorum* was recorded. At the same time, characteristic symptoms of WSV were also confirmed on *Phleum pratense*, *Lolium perenne* and *Bromus mollis*.

Introduction

A first brief report of wheat striate virus was made in Czechoslovakia with relation to the discovery of the oat sterile-dwarf virus, which caused considerable damage to oat crops in extensive regions of the Czecho-Moravian Highlands (PRŮŠA 1958, PRŮŠA et. al. 1959). The most important characteristics of this virus were dealt with in further work (PRŮŠA 1960a, 1960b, 1960c, PRŮŠA and VACKE 1960a, PRŮŠA and VACKE 1960b) and its obvious identity with the European cereal (wheat) striate mosaic virus described in England (SLYKHUIS and WATSON 1958) was proved.

It must be mentioned from published data having direct relation to this work, that receptivity to European cereal striate mosaic virus was proved in barley, wheat, oats, rye, *Lolium multiflorum* LAM. and *L. perenne* L. (SLYKHUIS and WATSON 1958); in Czechoslovakia, *Avena fatua* L. and *Poa annua* L. (PRŮŠA et al. 1959) and also *Lolium multiflorum* LAM., *L. perenne* L., *Bromus arvensis* L. and *B. mollis* L. (VACKE 1960). In addition to wheat, oats and barley, were subsequently successfully infected with WSV. As far as natural occurrence is concerned, characteristic symptoms of WSV were ascertained in Czechoslovakia not only in cereals (most often wheat), but also in some other kinds of grass (*Lolium multiflorum, L. perenne, Bromus mollis, Phleum pratense* (growing in the region where the larvae of the natural WSV vector, leafhopper *Calligypona pellucida*, hibernate (VACKE 1960). This proved that WSV was also of certain economic importance for fodder grasses and supplied the impulse for a more detailed study of its possible hosts with the aim of examining conditions important for the preservation and rotation of this

virus in nature. Testing for receptivity of WSV in many types of plants and a thorough exploration of disease symptoms in plants in both cultivated and natural surroundings, were carried out in the years 1959 and 1960.

Material and Methods

WSV was spread by naturally infected larvae of *Calligypona pellucida* in glass-house experiments. The larvae originated from mixed clover-grass crops from the Zachotín locality of the Pelhřimov district (the district in which an epidemic of the oat sterile-dwarf virus disease occurred in the years 1954 to 1956). The infectivity of each experimental insect was confirmed before hand by two individual tests on oats of the Valečovský white variety. The degree of infectivity of the larvae fluctuated in individual passages and series from 7 to 22%. Because parallel studies were made of the receptivity of the tested plants to the oat sterile-dwarf virus, larvae infected with this virus were also left in the experiment. Larvae free of both viruses were separated and tested apart as controls. In this way, the percentage of larvae capable of WSV infection in the experimental series rose to 32. Checked and separated larvae were then placed individually (for the technique of transferring, see PRŮŠA and VACKE 1960a) on the experimental plants grown in wooden boxes spaced 5 × 6 cm. apart. Escape of the vectors was prevented by glass tubes, the lower edge of which was let into the ground and the top closed with silon material after the introduction of the insects.

The period of infectious feeding of the larvae lasted from 7—8 days. The test plants were infected during the vegetative phase of 2—4 leaves. The number of examined plants fluctuated between 36 and 64. Plants covered with non-infected larvae acted as controls. The temperature in the glass-house during the period of infection was between 14—26° C and the relative humidity between 25—85%. The initial 3—4 weeks' growth of the infected plants was passed in a glass-house under similar conditions to those which existed during the infections period. At the end of May and during the other summer months, the boxes with the plants were placed in a glass-house which had all its glass panes exchanged for transparent and porous silon material.

Sixty plant species from the families *Poaceae (Gramineae)*, *Polygonaceae*, *Fabaceae*, *Solanaceae*, *Plantaginaceae* and *Asteraceae* were tested for receptivity to WSV.

Field observation of the occurrence of WSV on naturally infected plants was carried out both in areas of natural incidence and in cultivated crops. Greatest attention was paid to areas strongly invaded with larvae *Calligypona pellucida*, i.e. two or more year crops in the year of planting and in the following year. Research was also carried out on temporary and perennial meadows, grassy boundaries, the edges of woods and other areas of possible temporary sojourn of the transmitter leafhoppers. In plants where symptoms of WSV were found, the degree of damage was also estimated.

Results and Discussion

As can be seen in tab. 1, glass-house infection experiments with the vector *C. pellucida* demonstrated receptivity to WSV in 18 species from the family *Poaceae*. Typical striping developed in these species: *Poa annua* L., *Lolium multiflorum* LAM., *L. perenne* L., *Bromus mollis* L., B. *arvensis* L., *B. tectorum* L., *Hordeum murinum* L., *Triticum dicoccum* SCHRANK, *T. spelta* L., *T. durum* DESF., *T. turgidum* L., *T. aestivum* L. s. s., *T. compactum* HOST., *T. polonicum* L., *Avena fatua* L., *A. strigosa* SCHREB., *A. sterilis* L., *A. nuda* (L.) HOEJ. A rather high percentage of transmission was achieved in *Bromus arvensis*, *B. mollis*, *Hordeum murinum*, *Avena nuda*, *A. fatua* and several species from the *Triticum* genus. On the other hand, very little transmission

was remarked in *Lolium perenne*, *Bromus tectorum*, *Avena strigosa*, *Poa annua* and a few representatives of the genus *Triticum*. Artificial transmitting of WSV was unsuccessful in *Rumex acetosella* L. and *Fagopyrum tataricum* L. (GÄRTN) from the family *Polygonaceae*, *Trifolium arvense* L., *T. repens* L. and *T. montanum* L. from the family *Fabaceae*, *Nicotiana tabacum* L. and *Datura stramonium* L. from the family *Solanaceae*, *Plantago lanceolata* L. from the family *Plantaginaceae*, *Taraxacum officinale* WEB., *Sonchus arvensis* L., *Achillea millefolium* L. and *Cirsium arvense* (L.) SCOP. from the family *Asteraceae*, *Festuca pratensis* HUDS., *Festuca rubra* L., *Poa pratensis* L., *P. trivialis* L., *P. nemoralis* L., *P. palustris* L., *Glyceria aquatica* (L.) WAHLB., *Dactylis glomerata* L., *Briza media* L., *Cynosurus cristatus* L., *Melica transsilvanica* SCHUR, *Elytrigia repens* L. (DESV.), *Triticum monococcum* L., *Bromus inermis* LEYSS., *Nardus stricta* L., *Arrhenatherum elatius* (L.) PRESL, *Trisetum flavescens* (L.) P. BEAUV., *Anthoxanthum odoratum* L., *Calamagrotis epigeios* (L.) ROTH., *Agrostis stolonifera* L., *Alopecurus pratensis* L., *Molinia coeruelea* (L.) MOENCH., *Digitaria ischaemum* (SCHREB.) MUEHLENB., *Echinochloa crus-galli* (L.) P. BEAUV., *Panicum miliaceum* L., *Setaria glauca* (L.) P. BEAUV., *Sorghum vulgare* PERS., *S. saccharatum* L. (MOENCH) and *Zea mays*. L. from the family *Poaceae*. Similarly negative were attempts to infect *Phleum pratense* L., which, however, in certain cases in fodder crops in the Czecho-Moravian Highlands, showed typical symptoms of WSV on a considerable number of individual plants. In view of marked oscillation in the efficacy of the vector (WATSON and SINHA 1959, PRŮŠA 1959, 1960, PRŮŠA and VACKE 1961a), it is still not possible, however, to consider negative results as definite.

Field research in many districts of the Czecho-Moravian Highlands (Pelhřimov, Dobrá Voda, Zachotín, Čejkov, Turovka, Sázava, Horní Ves and Bystrá

Table 1. Positive results of receptivity test of plants from the family *Poaceae*

Variety of infected plants	No. of plants for feeding	No. of successful infections	Percentage of successful infections	Length of incubation period (days)
Poa annua L.	31	2	6·5	28—30
Lolium perenne L.	61	2	3·3	30—45
L. multiflorum LAM.	64	7	10·9	27—40
Hordeum murinum L.	56	22	39·3	16—28
Triticum dicoccum SCHRANK.	64	13	20·3	18—32
T. spelta L.	61	6	9·8	18—32
T. durum DESF.	37	2	5·4	24—30
T. turgidum L.	55	3	5·5	20—36
T. aestivum L. s. s.	63	13	20·6	18—32
T. compactum HOST.	60	11	18·3	19—32
T. polonicum L.	64	6	9·4	18—32
Bromus mollis L.	64	12	18·7	22—32
B. arvensis L.	64	26	40·6	20—32
B. tectorum L.	31	1	3·2	29
Avena fatua L.	58	12	20·7	17—29
A. strigosa SCHREB.	62	3	4·8	23—26
A. sterilis L.	62	8	12·9	18—26
A. nuda (L.) HOEJ.	43	9	20·9	18—34

in the Pelhřimov district; Hojkov and Nová Ves in the Jihlava district; Dubí and Skorkov in the Havlíčkův Brod district) showed that symptoms similar to those obtained in glass-house experiments appear naturally in *Lolium multiflorum*, *L. perenne* and *Bromus mollis*. Besides this, symptoms characteristic for WSV were observed in *Phleum pratense*. In fodder crops (clover-grasses), *Lolium multiflorum* was regularly the most affected. Indeed,

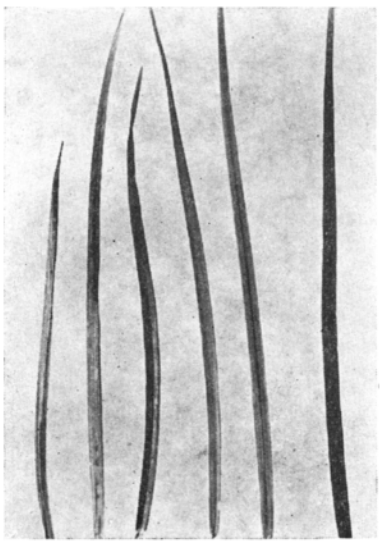

Fig. 1. Leaves of *Bromus mollis* L. artificially infected with WSV. Leaf of healthy plant on the right.

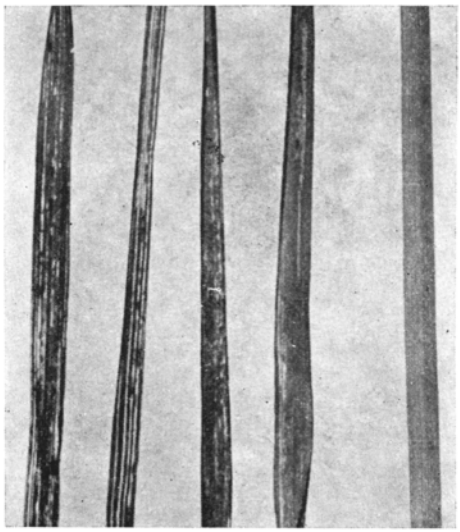

Fig. 2. Leaves of *Lolium multiflorum* LAM. artificially infected with WSV. Leaf of healthy plant on the right.

in the Zachotín district, symptoms of WSV were found in this variety on 32% of the plants. On the same land, 10% of *Lolium perenne*, 5% of *Phleum pratense* and 2% of *Bromus mollis* were infected. Similar tendencies to infection could be observed in further districts, although the percentage of diseased plants was considerably lower. No symptoms of WSV were ascertained in four districts. The extent of infection was reviewed at the end of June and the beginning of July, when the majority of plants infected in the Autumn had died. It can therefore be supposed with certainty that in reality, there is a far greater number of grasses infected with WSV. Single diseased plants were found on grassy boundaries in the Zachotín district in the immediate vicinity of fodder crops. No plants with symptoms of WSV were observed on further natural areas such as meadows, waysides and the edges of woods.

The infection of grasses with WSV was dependent in all cases on the places where development of the *Calligypona pellucida* larvae takes place. The in-

tensity of infection is in direct ratio to the population density of the transmitters. This is again dependent on the types of cover crops and on microclimatic conditions in the crop. The greatest number of diseased plants was found in fodder crops where the cover crop was oats. In fodder crops undersown into other cereals, especially into rye, striped plants appeared only singly.

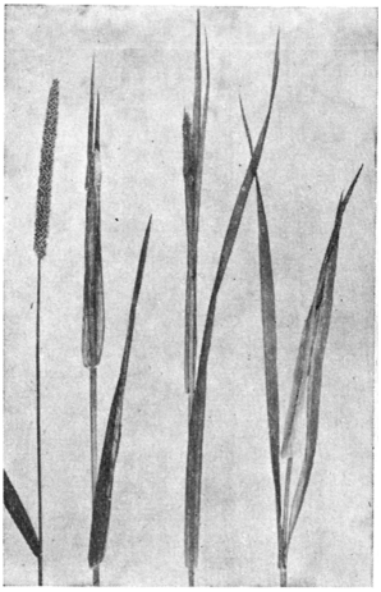

Fig. 3. *Phleum pratense* L. naturally infected with WSV. Healthy plant on the left.

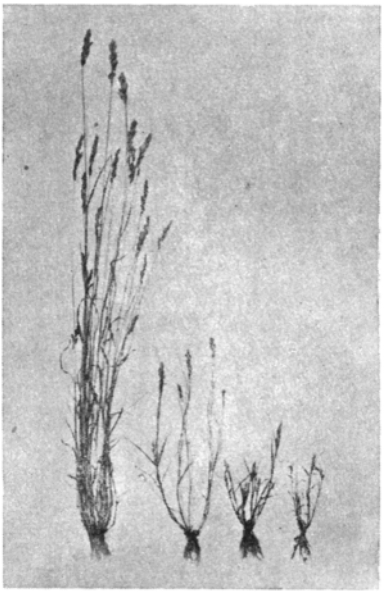

Fig. 4. *Bromus mollis* L. naturally infected in the field. Plant without symptoms of WSV on the left.

More diseased grasses were found in places shaded by woods or bushes where the temperature was lower and the relative humidity higher than were found in the sunshine.

The fact that WSV causes noticeably greater damage on fodder crops of the grass type rather than cereal type is most likely connected with the length of sojourn of the transmitter on them. *Calligypona pellucida* spends the greater part of its development on fodder crops in the year in which they are sown and the beginning of the following year. The period following hatching of the larvae (July, August) up to development into adult insects and migration to cereals (the end of May and June of the following year), after subtracting 4—5 months of hibernation or low activity, totals 5—6 months. For the whole of this period, the transmitter is able to infect receptive plants. On cereals, however, the period of possible infection is much shorter—lasting 2—3 months if the time from the attack until the growing phase of the plant when WSV can still damage it is taken into consideration.

Without a doubt, the concentration of leafhoppers on area units plays a great part in the infection of grasses. The concentration of adult insects on 1 m² of cereals rarely reached 20—30 in number in the years of our research. In fodder grasses where the cover-crop was oats, however, there were on an average 450—1300 larvae to 1 m². The possibility of infection under these conditions is naturally many times greater than in the former case. Of course, the irregular power of the leafhopper to transmit WSV and the greater mobility of the adult vector than its larvae on the plants must be taken into account.

Just as in the glass-house experiments, certain differences in the destructivity of WSV on individual types of host plants were also ascertained in nature. According to the degree of dwarfing, the following varieties suffered most from WSV: *Bromus mollis* (average shortening of the stalk being 72%), then followed *Phleum pratense* (the plants were shorter by 69·5%), further *Lolium multiflorum* (stunting of growth 64·9%) and finally *Lolium perenne* (height reduced by 60%). This field observation of the given hosts was in agreement with the results from infection experiments in the glass-house.

Contrary to the results from glass-house experiments, more frequent infection in *Lolium multiflorum* than in *Bromus mollis* was met with in natural conditions. This is probably related to the suitability of these grasses as food for the larvae of the vector. *Bromus mollis* is possibly not very attractive for the leafhopper larvae, because of the profuse hairiness of its leaves, leaf sheaths and stalks, or at least, these conditions make feeding difficult. Vice versa, *Lolium multiflorum* has smooth leaves and stalks which is most likely more favourable for the feeding of the *Calligypona pellucida* larvae.

From information on the attacking of some cultivated forms of grass grown in fodder mixtures, it is palpable that WSV can reach remarkable intensity of infected crops, depending on the population density and degree of infectiousness of the leafhopper vector. If the considerable destructivity of the studied virus for its hosts is taken into consideration, it is obvious that overmultiplying of *Calligypona pellucida* can cause certain depression in fodder crops when varieties of grass receptive to WSV form the whole or main part of the fodder mixtures.

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Растения — хозяева вируса полосатости пшеницы

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На сосание естественно инфицированного переносчика вируса полосатости пшеницы (ВПП) цикадки *Calligypona pellucida* F. реагировали характеристическими признаками в значительных размерах *Bromus arvensis* L., *B. mollis* L., *Avena fatua* L., *A. nuda* L. (HOEJ.), *Triticum aestivum* L. s. s., *T. compactum* HOST., *T. dicoccum* SCHRANK., *Hordeum murinum* L., меньше потом *Lolium multiflorum* LAM., *L. perenne* L., *Bromus tectorum* L., *Poa annua* L., *Avena strigosa* SCHREB., *A. sterilis* L., *Tricitum spelta* L., *T. durum* DESF., *T. turgidum* L., *T. polonicum* L. Дальнейших 42 растительных вида из 6 семейств в этом опыте не заболело. Негативные результаты были получены а опыте с искусственным заражением *Phleum pratense* L., хотя у этого вида мы в природе наблюдали типичные признаки ВПП. Мы полагаем, что некоторые негативные результаты находятся в причинной взаимосвязи с значительно колеблющейся переносящей эффективностью вектора, известной уже из предыдущих работ.

В культурах кормовых злаков первого года выколашивания в местах с исключительной насыщенностью личинками *Calligypona pollucida* при полевых наблюдениях на некоторых местонахождениях Чешско-моравской возвышенности найдено более сильное поражение ВПП у *Lolium multiflorum*. Характеристические признаки ВПП обнаружены у *Phleum pratense*, *Lolium perenne* а *Bromus mollis*.