Occurrence of dwarf virus of winter wheat and barley in several regions of Slovakia during the growing seasons 2001–2004

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ABSTRACT

The aim of the study was to monitor the incidence and to detect the presence of viruses of yellow dwarfness in barley (BYDV-PAV, BYDV-RMV), of yellow dwarfness in cereals (CYDV-RPV) and dwarfness in wheat (WDV) in stands of winter wheat and winter barley in Slovakia. During the period 2001–2004 a total of 292 samples coming from 150 localities were analyzed. This involved 190 samples of winter wheat (39 varieties and 13 breeding lines) and 102 samples of winter barley (17 varieties and 7 breeding lines). The detection of viruses was carried out with the aid of the method DAS and TAS ELISA. During the years surveyed, the occurrence of the various viruses differed. In 2001, the most represented virus proved to be the WDV (68%); in 2002, it was the strain PAV of the virus BYDV (93%); in 2003, the most numerous were the virus WDV (71%) and the strain PAV of virus BYDV (67%). Similarly, in 2004, two viruses were represented about evenly, WDV and BYDV-PAV (75%). The more frequent of the two species was the virus BYDV, with the strain BYDV-PAV predominating. The intensity of viral infection of stand cereals differed during the experimental years, being highest in 2002 when the blight occurred both locally and also on a large-scale. The highest frequency of the disease was in Western and Eastern Slovakia.

Keywords: winter wheat; winter barley; occurrence; viruses; barley yellow dwarf (BYDV); cereal yellow dwarf (CYDV); wheat dwarf (WDV); ELISA

The cereal production potential may be affected by several environmental factors. Such are, besides abiotic agents, various biotic stressors, also including viral diseases. Among the most frequent and economically the most serious of these is viral dwarfness. It may be caused by the infection of the plant by the barley yellow dwarf virus (BYDV), the wheat dwarf virus (WDV) or the cereal yellow dwarf virus (CYDV). These viruses are often cited as limiting factors for cereal producing areas in many European countries (Conti et al. 1990, Huth and Lesemann 1994, Hofmann and Kolb 1998, McKirdy et al. 2002).

The virus BYDV was first described in California – USA (Oswald and Houston 1953). Since then, it has also been identified on other continents of the world (Makkouk et al. 1987, Lister and Ranieri 1995). Its strain BYDV-PAV is spread worldwide and its most significant transmitter is the aphid *Rhopalosiphum padi*.

The wheat dwarf virus (WDV) is the most abundantly present in Central Europe. Its transmitter is the leafhopper *Psammottetix alienus*. However, it has been found in other European countries and even in North Africa (Conti 1994, Bauske et al. 1997, Najar et al. 2000). For the first time the WDV virus was found in the former Czecho-Slovakia (Vacke 1961). The viruses of cereal dwarfness are persistently transmitted by several species of aphids and leafhoppers (Rochow 1969, Miller et al. 2002).

Yellowing of leaves and dwarfness of plants are common macroscopic symptoms of viral infection of cereals but at the same time, a reduction of the root system may be observed (Vacke 1972). Among the most characteristic symptoms of this disease are growth inhibition, disorders in offshoot formation, reduced number of spikes, their partial or complete sterility, and in the case of strong infection, even total necrosis of the plants (Riedell et al. 2003). An increased incidence of viral dwarfness of cereals during the last years in Hungary is reported by Szunics et al. (2000), in Turkey by Pocsai et al. (2003) and in the Czech Republic by Červená and Markytánová (2005). An enhanced occurrence of cereal dwarfness in Slovakia was repeatedly recorded in 2000, which was the reason for initiating the monitoring of this disease.

The present study summarizes the results of a four-year survey (2001–2004) of the incidence of viral dwarfness of stand cereals (winter wheat and barley) in Slovakia.

MATERIAL AND METHODS

Plant material

During the periods March till June 2001–2004, plant specimens of winter wheat and winter barley were collected from cultivated areas in Slovakia for serological determination of the occurrence of BYDV, CYDV and WDV. The collection was done in cooperation with regional phyto-inspectors and was carried out according to the methodological directives of Central Control and Testing Institute of Agriculture in Bratislava (CCTIA). Plant specimens showing symptoms of disease were collected. A total of 292 samples were analyzed – comprising 190 samples of winter wheat and 102 samples of winter barley coming from 150 localities. 39 varieties of winter wheat were tested (Alana, Alka, Arida, Astella, Atrium, Balada, Bety, Boka, Brea, Bruta, Clever, Corsaire, Estica, Eva, Hana, Charger, Ilona, Istrodur, Klea, Košútka, Landi, Lívia, Malvína, Malyska, Mladka, Pegassos, Petrana, Rada, Rex, Samanta, Sana, Solara, Šarka, Torysa, Trend, Vanda, Viginta, Vlada, Zerda) as well as 13 breeding lines. In the case of winter barley, the tests included 17 varieties (Angela, Angora, Babylone, Bogesa, Haller, Hanna, Kamil, Landi, Luran, Luxor, Madonna, Monaco, Montana, Okál, Petra, Polana, Tiffany) and 7 breeding lines. The breeding lines of the two species were recorded under a code and a numeric marking. They came from test localities in which CCTIA Bratislava had a testing station of varieties. Ten to fifteen plants were collected from each locality and, packed in nylon sacks, were transferred to the laboratory. Prior to picking of leaves for serological analyses, the plant samples were visually and microscopically controlled. The leaf samples were frozen and kept at the temperature of –70°C until the serological ELISA analysis.

Chemical analysis

The leaf samples of plants, in the amount of l g were homogenized with the addition of 5 ml of ELISA extraction buffer with pH 7.2. Viral diagnosis was performed with the aid of the immuno-serological DAS and TAS ELISA method according to Clark and Adams (1977). The plant samples were tested for the presence of viruses WDV, BYDV-PAV, BYDV-RMV and CYDV-RPV. Because of a lack of antibodies, the presence of BYDV-RMV was not tested in 2003 and 2004. The antisera were produced by Sanofi Pasteur Phyto-Diagnostics (France). Serologic reactions were evaluated with the aid of the Labsystems Multiskan Plus Photometer at 405 nm. Absorbance in the form of yellow staining was determined 30, 60 and 120 min after addition of the substrate (4-*p*-nitrophenylphosphate). To evaluate the presence of viruses and the positivity of the sample, we determined the mean values of absorbance after 2 hours. Plant samples with absorbance up to 0.499, were rated as the degree of infection 1 (moderate infection), samples with absorbance in the range 0.500 up to 1.000 as the degree of infection 2 (medium infection) and samples with absorbance over 1.000, as the degree of infection 3 (strong infection). The absorbance values were statistically evaluated by Student *t*-test

RESULTS

The results of monitoring for the occurrence of viral dwarfness of cereals in 2001–2004 in Slovakia are shown in Tables 1 and 2. During this period, 52 varieties and breeding lines of winter wheat coming from 104 localities, and 24 varieties and breeding lines of winter barley from 62 localities were tested. Serological analyses of 292 leaf samples confirmed the presence of all three types of viruses BYDV, CYDV and WDV in various regions of Slovakia, whose dynamism depended on the particular year, species or variety, and locality.

In 2001, we analyzed 74 samples, 66 of which were wheat samples from 46 localities, and 8 were barley samples from 7 localities. The presence of at least one of the tested viruses was found in 50 of the samples, i.e. 67.6% (Table 3). In 2002, the first weak incidence of WDV and BYDV (degree 1 of infection) was proved by laboratory tests already towards the end of April. In early May, infection occurred more frequently and was also confirmed in samples of winter wheat, and by the end of May, in winter barley, too. In the first half of June, the incidence of infection was strong (degree 3) primarily in varieties of winter wheat and this was noted in several localities of Western Slovakia. In the first year of our monitoring (2001), we did not find any major differences in the incidence of the various viruses. The most widespread was WDV, which was found in 31 out of 43 samples of wheat (72.1% – Table 1), and in 3 out of 7 samples of barley (42.8 % – Table 2). Second most frequent virus was BYDV with a predominance of the strain BYDV-RMV. The virus BYDV, in both its strains BYDV-RMV and BYDV-PAV, was found in 25 samples of winter wheat (58.1%) and in all 7 samples of winter barley. The virus CYDV-RPV was determined in 23 samples of winter wheat (53.5%) and in 6 samples (85.7%) of winter barley. Mixture's infection of two or all three viruses was detected in 26 samples of winter wheat and in 6 samples of winter barley, representing 60.5 and 85.7% of the samples tested, respectively (Tables 1 and 2).

In the spring 2002, a more extensive yellowing and dwarfing of plants was observed, particularly in stand cereals of winter barley, to a lesser degree in wheat in several localities of Western and Eastern Slovakia. With regard to the total number of 163 tested samples and the ascertained presence of the pathogen in 159 of them (97.5%), the year 2002 proved to have been the most critical (Table 3). During the course of that year, a total of 89 wheat samples from 48 localities and 74 samples of winter barley from 46 localities were monitored. The presence of the pathogen was established in

Table 1. Incidence of wheat dwarf virus (WDV), barley yellow dwarf virus (BYDV) and cereal yellow dwarf virus (CYDV) of winter wheat in tested fields of Slovakia during the years 2001–2004

Year	Number of varieties and breeding lines	Number of tested localities	Number of infected fields	WDV		BYDV-PAV		BYDV-RMV		CYDV-RPV		Mixture infection	
				degree of infection*	number of samples	degree of infection*	number of samples	degree of infection*	number of samples	degree of infection*	number of samples	type	number of samples
				1	11	1	0	1	16	1	19	WDV + BYDV	4
				2	6	2	2	2	2	2	4	WDV + CYDV	9
2001	24	46	43	3	14	3	2	3	3	3	0	BYDV + CYDV	4
												WDV + BYDV + CYDV	9
				Σ	31	Σ	4	Σ	21	Σ	23	Σ	26
				1	16	1	15	1	18	1	6	WDV + BYDV	30
				2	1	2	23	2	6	2	1	WDV + CYDV	0
2002	30	48	85	3	21	3	36	3	11	3	0	BYDV + CYDV	3
												WDV + BYDV + CYDV	4
				Σ	38	Σ	74	Σ	35	Σ	7	Σ	37
				1	11	1	1	not detected		1	5	WDV + BYDV	4
				2	0	2	3	not detected		2	0	WDV + CYDV	4
2003	14	16	14	3	1	3	3	not detected		3	0	BYDV + CYDV	0
								not detected				WDV + BYDV + CYDV	1
				Σ	12	Σ	7	not detected		Σ	5	Σ	9
				1	0	1	0	not detected		1	0	WDV + BYDV	2
				2	0	2	0	not detected		2	0	WDV + CYDV	0
2004	8	4	3	3	3	3	2	not detected		3	0	BYDV + CYDV	0
								not detected				WDV + BYDV + CYDV	0
				Σ	3	Σ	2	not detected		Σ	0	Σ	2

*degree 1 (slight infection) = samples with the absorbance lower than 0.499; degree 2 (medium infection) = samples with the absorbance in the range 0.500–1.000; degree 3 (strong infection) = samples with the absorbance over 1.000

Table 2. Incidence of wheat dwarf virus (WDV), barley yellow dwarf virus (BYDV) and cereal yellow dwarf virus (CYDV) of winter barley in tested fields of Slovakia during the years 2001–2004

Year	Number of varieties and breeding lines	Number of tested localities	Number of infected fields	WDV		BYDV-PAV		BYDV-RMV		CYDV-RPV		Mixture infection	
				degree of infection*	number of samples	degree of infection*	number of samples	degree of infection*	number of samples	degree of infection*	number of samples	type	number of samples
				1	2	1	0	1	0	1	5	WDV + BYDV	0
				2	0	2	1	2	0	2	1	WDV + CYDV	0
2001	6	7	7	3	1	3	1	3	6	3	0	BYDV + CYDV	3
												WDV + BYDV + CYDV	3
				Σ	3	Σ	2	Σ	6	Σ	6	Σ	6
				1	1	1	5	1	20	1	16	WDV + BYDV	8
				2	2	2	21	2	16	2	1	WDV + CYDV	0
2002	18	45	74	3	6	3	48	3	15	3	1	BYDV + CYDV	17
												WDV + BYDV + CYDV	1
				Σ	9	Σ	74	Σ	51	Σ	18	Σ	26
				1	2	1	2	not detected		1	1	WDV + BYDV	3
				2	0	2	4	not detected		2	0	WDV + CYDV	0
2003	6	11	10	3	3	3	3	not detected		3	0	BYDV + CYDV	0
								not detected				WDV + BYDV + CYDV	1
				Σ	5	Σ	9	not detected		Σ	1	Σ	4
				1	0	1	0	not detected		1	0	WDV + BYDV	0
				2	0	2	0	not detected		2	0	WDV + CYDV	0
2004	4	3	1	3	0	3	1	not detected		3	0	BYDV + CYDV	0
								not detected				WDV + BYDV + CYDV	0
				Σ	0	Σ	1	not detected		Σ	0	Σ	0

*degree 1 (slight infection) = samples with the absorbance lower than 0.499; degree 2 (medium infection) = samples with the absorbance in the range 0.500–1.000; degree 3 (strong infection) = samples with the absorbance over 1.000

85 samples of winter wheat (95.5%) and in all the 74 samples of winter barley (100%) (Table 3). In winter wheat that year the incidence of BYDV – strain PAV was predominant; it was determined in 74 samples (87.05%), while the strain BYDV-RMV was found in 35 samples (41.2%). As regards the frequency second was WDV, noted in 38 samples (44.7%) and the virus with the lowest occurrence

Table 3. Review of tested samples for individual years

Year	Wheat		Barley		Wheat and barley	
	analyzed samples	positive samples	analyzed samples	positive samples	analyzed samples	positive samples
2001	66	43	8	7	74	50
2002	89	85	74	74	163	159
2003	27	14	16	10	43	24
2004	8	3	4	1	12	4
Total	190	145	102	92	292	237
		76.32%		90.20%		81.16%

Figure 1. Map of Slovakia showing localities with the occurrence of dwarf virus of cereals

was CYDV-RPV, detected only in 7 samples (8.2%) of winter wheat (Table 1). Likewise, in 2002, the occurrence of BYDV was dominant in 13 varieties and 5 breeding lines of winter barley deriving from 46 localities.

The virus BYDV-PAV was detected in all of the 74 analyzed samples (100%), and 51 of them (68.9%) were found to be simultaneously infected with BYDV-RMV; it was followed by CYDV-RPV with confirmed occurrence in 18 samples (24.3%); the lowest frequency was noted in WDV, found only in 9 samples (12.2%) of winter barley (Table 2). In 37 samples (43.5%) of winter wheat (Table 1) and 26 samples (35.1%) of winter barley (Table 2) we found a mixture of infection. In that year, the great majority of positive samples came from Western and Eastern Slovakia, the highest number being from the Nitra Region (38 samples from 24 localities). Also 5 triticale samples were diagnosed as infected with both strains of BYDV. That year viral infections were so intensive in several localities that it acquired a regional character and cereal stands had to be prematurely ploughed in. That involved 17.8% of barley stands, 2.6% of wheat and 2.7% of triticale. As evident from Figure 1, stands most affected by viral infection were those of winter wheat and barley in Western and Eastern Slovakia, though occasional incidence was noted also in Central Slovakia. The occurrence of viruses in one locality of Western and two localities of Eastern Slovakia was confirmed for three years in succession.

In 2002, besides a primary viral infection in several plant samples, we also observed damage to the root system. On a transversals cut across the roots we observed under a microscope a disruption of vascular bundles. Visible were also local necroses and damage to leaves caused by abrupt changes of temperature in April. Sudden warming up in May resulted in an increased incidence of certain fungous diseases observed on cereal stands.

In 2003, the number of monitored samples became substantially reduced – down to 43, including 27 wheat and 16 barley samples (Table 3). 12 varieties and 2 breeding lines of winter wheat from 16 localities and 5 varieties and one breeding line of winter barley from 11 localities were monitored. From the total number of 43 samples, occurrence of viruses was confirmed in only 24 (i.e. in 55.8%) (Table 3), the presence of WDV was found in 12 samples of wheat (85.7%) and 5 samples of barley (50.0%). The virus BYDV-PAV was confirmed in 7 samples of wheat (50.0%) and in 9 samples of barley (90 %). CYDV-RPV was found in 5 samples of wheat (35.7%) and in one sample of barley (10.0%). In 9 samples of wheat (64.3%) and 4 samples of barley (40.0%) we found an infection of mixed origin (Tables 1 and 2).

In autumn 2003, sowing of cereals was followed by a spell of dry weather, without precipitations and with lower mean temperatures, as a result of which, cereals sprouted poorly and unevenly. In the spring 2004, we only had 12 samples – 8 of wheat and 4 of barley coming from 6 localities – and the occurrence of viruses was established only in four of them (in three of winter wheat and in one of winter barley). WDV was determined in all the samples of wheat but not in those of

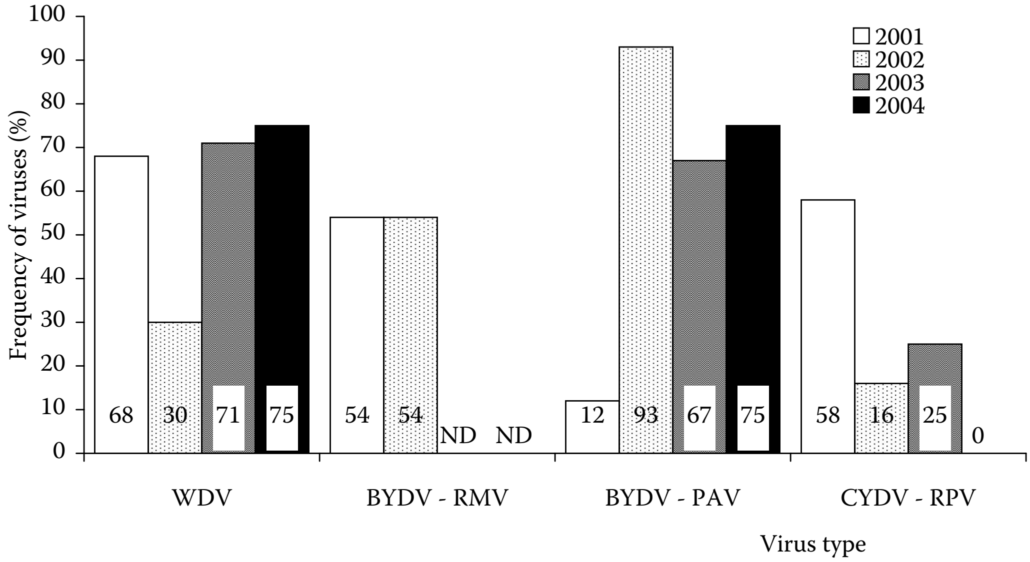

Figure 2. Occurrence of individual dwarf viruses (WDV, BYDV-PAV, BYDV-RMV and CYDV-RPV) in % during the 2001–2004 growing seasons; ND – not detected

barley. The occurrence of the virus BYDV-PAV was likewise detected in two wheat and one barley samples but that of CYDV-RPV was not recorded at all in 2004 (Tables 1 and 2). Mixed infection by WDV and BYDV was found only in two samples of wheat (Table 1).

As it is evident from Figure 2, the frequency of viruses (WDV, BYDV and CYDV) differed in the individual years. In 2001, the highest incidence was noted with WDV (68%), in 2002 it was the strain PAV of virus BYDV that predominated (93%), in 2003 the virus WDV held sway (71%) and again the strain PAV of virus BYDV (67%). In 2004, the viruses WDV and BYDV-PAV were equally represented (75%). During the four-year monitoring period, BYDV was the most frequently detected virus, both in the species of winter wheat and barley, with the dominant position being held by the strain BYDV-PAV.

In 55 samples (45 of wheat and 10 of barley), making up 18.8% of the total number of tested samples, serological tests failed to detect the presence of viruses (Table 3). Out of 39 varieties of winter wheat, Brea was most frequently tested. In 2001, we detected the presence of viruses in 19 samples coming from 18 localities. The species Zerda ranked second with 6 out of 9 samples proved to be virus-positive, followed by Hana where at least one of the viruses was detected in four out of 7 cases. In 2002, the species Brea was repeatedly tested – as many as 17 times, with viral presence being detected in 16 samples. Solara was second, tested 10 times, with positive findings in 9 cases. In the third place was the species Vlada, tested 6 times, with positive results in 5 cases. In 2003, the species Malyska had the highest presence of viruses, confirmed in 6 cases. In 2004, the number of wheat varieties was relatively low and none of the 8 cultivars was tested twice.

From the varieties of winter barley, most often tested was Babylone – three times in 2001 and as many as 32 times in 2002, with all the samples coming from 29 localities being positive. In 2003, the species Tiffany proved virus-positive in 3 out of 6 cases. The species Babylone was also tested three times but viral positivity was proved in one single case. In 2004, none of the varieties of winter barley was tested twice. All the varieties and breeding lines of winter barley proved sensitive and highly prone to the two most frequent viruses, viz. WDV and BYDV. A comparison of absorbance values of the tested varieties of winter wheat and barley revealed differences of statistical significance between strongly infected species with absorbance over 1.000 (infection degree 3) and those weakly infected with absorbance up to 0.499 (infection degree 1).

As regards macroscopic symptoms of viral dwarfness in cereals, a striking growth depression and an intensive change in leaf colouring were noted in barley attacked by the viruses WDV and BYDV, and in wheat infested with WDV. Leaf yellowing (chlorosis) and loss of green colour prevailed more visibly on older infected plants. In barley plants, yellowing often started from top and from the edges and progressed inwards to the middle of the leaves.

Figure 3. Symptoms of viruses (BYDV-RPV and BYDV-PAV) infection in Brea, a very susceptible variety of winter wheat

Although viruses BYDV and WDV were detected in most varieties of winter wheat, they did not cause such a typical dwarfness in these plants as in the case of the species of winter barley (Figures 3 and 4). A far more important growth depression was caused in the spring period by the virus WDV. Wheat spikes were reduced and remained partly sterile. In the case of general large-scale infections that occurred in 2002, stands of wheat and barley failed to develop stalks and spikes. The intensity of

Figure 4. Symptoms of virus (BYDV-PAV) infection in Tiffany, a very susceptible variety of winter barley

infection of stands with viral dwarfness was evaluated at 105 localities, 15% of which were judged to be strongly infected, 36% medium and 49% weakly infected. As for the strongly affected stands, a mixed infection was usually detected there.

DISCUSSION

Growth and development of plants under natural conditions is the outcome of interference of two essential components: the genetic potential of the various species of plants and external factors (Pahlich 1995). Climatic and environmental conditions also play a key role in the incidence of the viral disease of cereals causing virus dwarfness. According to Huth (2000) tolerance to infection in general is the result of an interaction, "aggressiveness" (virulence) between the pathogen and the metabolic power of the host, where several environmental agents affect growth of both tolerant and non-tolerant cultivars.

The results achieved permit us to state that only some varieties of winter wheat, as Astella, Lívia, Samantha and Torysa showed a moderate tolerance to viral infections of dwarfness, while the tested varieties of winter barley were all sensitive. Širlová et al. (2005) tested 25 varieties of winter wheat, including Corsaire, that were also represented in our experiment, where all the species were evaluated as sensitive to infection by the virus WDV. However, according to Huth (2000), certain German varieties of winter wheat and some lines of spring wheat are sufficiently tolerant to BYDV-PAV. We found no such varieties resistant to WDV in the assortment tested in Slovakia. The interspecies difference and a higher sensitivity of winter barley – as opposed to winter wheat – to viral infection of yellow dwarfness, is also documented by the higher percentage (90% against 76%) of positive samples determined during the four-year period of our monitoring. According to Lister and Ranieri (1995) the BYDV is the most widespread virus causing cereal dwarfness; the PAV strain is then considered to be the most frequently-occurring strain of this virus (Plumb 1995), which was also confirmed in our survey.

In 2002 its rate of occurrence was recorded as 94% and in 2003 as 72%. It was found more frequently in winter wheat than in winter barley. The highest frequency of incidence of BYDV was in winter wheat, followed by winter barley, and the lowest was in spring barley, as it is reported by Lindsten and Lindsten (1999). WDV ranked second as for the incidence frequency. The least detected was CYDV-RPV. Similar results of the occurrence of viruses in winter wheat, winter and spring barley were obtained by Pocsai et al. (2003) in Turkey.

As to the incidence of various species of viruses, in 2001, the highest number of infections was due to WDV and slightly less due to CYDV; in 2002, BYDV infections predominated, while in 2003, the ratio of infections caused by BYDV and WDV was fairly balanced; in 2004, the virus WDV clearly predominated. The incidence and frequency of the viruses probably corresponded to vector activity, primarily in the autumn, but also in the spring period, whereas the extent and source of infection differed in individual years. The extensive and enormous incidence of BYDV-PAV in 2002 had been preceded by massive invasions of various species of aphids in the autumn. Their 500-fold proliferation ascribed to the weather conditions (warm) had been signalized by CCTIA in autumn 2001. It probably caused an extensive infection of cereal stands in their early development and a calamitous occurrence of disease in 2002. In this connection, we may subscribe to Vacke's statement (1983) that favorable climatic conditions help to prolong vector migration, enhance their concentration and thereby their potential to attack cereal stands. A critical situation similar to that in Slovakia in 2002, as regards the occurrence of viral dwarfness of cereals, affected the neighboring Czech Republic as well. According to Červená and Markytánová (2005), some 1000 ha of winter wheat and 6000 ha of winter barley were ploughed in regions of Southern and Northern Moravia in the Czech Republic. The enhanced occurrence of virus dwarfness of cereals precisely in Western and Eastern Slovakia may be related to conditions prevalent in lowland areas in which the mean annual temperatures are higher than on the rest of the territory, and which are thus more favorable to the proliferation of vector-borne viruses.

In the epidemiology of vector-transmitted pathogens, dry and warm weather is especially decisive among climatic factors; among cultivating procedures, it is primarily the date of sowing. The results of our monitoring have shown that autumn infections of cereals are particularly dangerous, as was the case in 2001; it resulted in an enormous increase in viral dwarfness of cereals in 2002. In the autumn 2002 and 2003, the date of sowing in several localities was delayed because of lower precipitations and lower mean temperatures, which resulted in a decrease of the infection in 2003 and 2004, probably due to decreased vector activity.

Losses in yields are, according to McKirdy and Jones (1997), affected by sensitivity of species, virulence of viral strains, time of infection, date of sowing of cereals and environmental factors. Cereal infections at an earlier growth stage, already in autumn, caused greater losses in yields than the spring infections did – we noted higher grain losses in winter barley (from 10 to 100%), than in winter wheat (from 5 to 90%). Grain yield was directly proportional to the degree of viral infection of the stands.

The decrease of grain yield in winter wheat and barley affected by viral infection is the result of the negative impact of this disease on both growth and certain physiological-biochemical parameters of the infected plants. Henselová and Bukvayová (2006 in preparation) found that in selected varieties of winter wheat and barley virus dwarfness of cereals brings about a decrease in both fresh and dry weight of plants, lowers the content of photosynthetic pigments, as also causes the activity of photosystem PS 2 in the process of photosynthesis to decline.

Viral infection was not serologically confirmed in 18% of samples even though the plants showed both chlorotic symptoms of disease as well as partial growth retardation. These symptoms may have been caused by abiotic factors, e.g. drought, eventually a deficiency of some nutrient element of plants in some rather arid areas of Western Slovakia whence the majority of these samples came. For this reason, a serological analysis is indispensable for establishing the presence of virus dwarfness in cereals.

Viral dwarfness of cereals under conditions now prevailing in Slovakia is not a quarantine disease, but is of such economic significance that CCTIA Bratislava follows and monitors it further. In 2005, a total of 107 cereal samples were monitored with a confirmation of disease in 41 of them, which can show that this disease is under control in the Slovak Republic at present. The problem of viral dwarfness of cereals could be resolved by acquiring varieties tolerant or resistant to viruses. Even though some studies report the resistance of certain varieties, according to Ayala et al. (2002) there is the essential question of the tolerance to virus, where minor or no viruses at all may occur. We may agree with Huth's view (2000) as he states that resistance or tolerance of some variety is hard to follow because the plant's reaction is very strongly dependent on environmental factors that may differ every year. In addition, the plants stressed by viral infections must react to other stressful factors and changes in environmental conditions with a much greater effort than the plants of tolerant cultivars.

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