Reaction of Selected Winter Wheat Varieties to Autumnal Infection with *Wheat Dwarf Virus*

Lenka ŠIRLOVÁ, Josef VACKE and Michala CHALOUPKOVÁ

Department of Virology, Division of Plant Medicine, Research Institute of Crop Production, Prague-Ruzyně, Czech Republic

Abstract

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The response of 25 registered winter wheat varieties to autumnal infection with *Wheat dwarf virus* (WDV) was studied in small plot trials in two years. The materials were infected by vectors, leafhopper *Psammotettix alienus* Dahlbom, 1851 from three-leaf stage to tillering. The symptoms expression was monitored in spring and plant height, weight of above ground biomass and grain yield were observed in summer. All tested varieties were evaluated as susceptible and divided into three groups: varieties Banquet and Svitava with 87.3–93.1% grain yield reduction as moderately susceptible, varieties Clever, Drifter, Niagara and Rialto with 95.6–97.68% grain yield reduction as susceptible and varieties Apache, Batis, Bill, Complet, Contra, Corsaire, Ludwig, Mladka, Nela, Record, Rheia, Semper, Sepstra, Solara, Sulamit, Tower, Trend, Vlasta and Winsdor with 99.7–100% grain yield reduction as very susceptible. Statistically significant differences were observed between moderately susceptible and susceptible varieties as well as very susceptible ones in absorbency values by means of DAS-ELISA.

Keywords: *Wheat dwarf virus* (WDV); winter wheat; resistance

Wheat dwarf virus (WDV), *Geminiviridae*: *Mastrevirus* is an important pathogen of cereals in the Czech Republic. This virus transmitted by leafhopper *Psammotettix alienus* Dahlbom, 1851 was first described in the former Czechoslovakia in the sixties (Vacke 1961). WDV was later found in other European countries and in North Africa (Pridanceva 1965; Lindsten *et al.* 1970; Gáborjányi *et al.* 1988; Lapiere *et al.* 1991; Conti 1994; Huth & Lesemann 1994; Jilâveanu & Vacke 1995; Najar *et al.* 2000). Two different strains of WDV, wheat strain and barley strain, were identified by Lindsten and Vacke (1991) in the nineties. WDV causes local epidemics in some years in the Czech Republic. Lately, strong infections of winter wheat were recorded in the regions of Slánsko, Velvarsko and Kladensko.

Protection against this virus is provided by agrotechnical measures (timely skimming, ploughing, late sowing) and by chemical arrangements (vector control). Vacke (1989) tested 120 winter wheat varieties and breeding lines in small-plots trials and only 13 varieties were classified as moderately resistant. The other varieties and lines were classified as susceptible. Vacke and Cibulka (2000) tested 40 registered varieties of winter wheat and

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no resistant material was found. Twenty four of tested varieties were classified as very susceptible, 6 varieties as susceptible and 10 varieties as moderately susceptible.

This paper deal with the new findings about influence of early infection by *Wheat dwarf virus* on not yet tested winter wheat varieties.

MATERIAL AND METHODS

In the middle of September 25 registered but not yet tested varieties and two control varieties – Ilona (moderately susceptible) and Hana (very susceptible) were sown according to Vacke and Cibulka (2000). The trial was carried out in two variants, control and infected ones, about 50 plants in each variety. In the 3rd leaf stage, the plants were covered by nylon isolators 1 × 1 m and infected by WDV using viruliferous leafhoppers. They were collected on volunteer cereal plants. Their acquisition feeding on the infection sources (spring wheat cv. Linda, Ru-WDV isolate of the wheat strain) lasted one week and inoculation feeding of two leafhoppers per plant 14 days. Afterward leafhoppers were killed by insecticide Sumithion Super. During the seasons the plots were kept free of leafhoppers and aphids by insecticide spraying. The infectivity of vectors tested by DAS-ELISA according to Clark and Adams (1977) using kit of antibodies and buffers from BIORAD was 53.6% in 2002 and 52.0% in 2003.

The trial was evaluated following year. The intensity of symptoms (yellowing or reddening, dwarfing, occurrence of necrosis) was classified by three point scale (1 – mild, 2 – middle, 3 – strong) for each variety every week. The course of dying plant was observed; the riped plants were harvested. The reduction of plant height (from root collar to top of the youngest leaf or ear in the heading plants), weight of above ground biomass, plant heading and grain yield were used for the classification of resistance (susceptibility).

For ELISA evaluation the plants were collected in shooting stage after full symptom expression. The samples were frozen and stored by –20°C. The DAS-ELISA (Clark & Adams 1977)was used for the comparison of the relative virus content in plant leaves of the tested varieties. Absorbency (A_{405}) was measured at 405 nm wave length 2 h after substrate deposition. Absorbency values were statistically processed by the UNISTAT program.

Table 1. Frost damage of winter wheat varieties (control and infected variant) of trials in 2002–2003

Variety	Percentage of frost damage		Variety	Percentage of frost damage	
	control variant	infected variant		control variant	infected variant
Apache	10.2	80.0	Niagara	4.7	21.7
Banquet	2.4	11.6	Record	27.5	84.6
Batis	6.3	52.1	Rheia	0.0	19.5
Bill	11.7	55.1	Rialto	21.7	44.7
Clever	0.0	61.2	Semper	2.4	86.8
Complet	13.6	60.0	Sepstra	2.0	10.2
Contra	7.1	60.0	Solara	0.0	25.6
Corsaire	38.1	90.0	Sulamit	2.1	52.0
Drifter	11.4	70.0	Svitava	2.0	4.0
Hana (VS control)	**8.6**	**44.0**	Tower	2.1	76.6
Ilona (MS control)	**0.0**	**10.1**	Trend	67.9	68.9
Ludwig	2.2	85.7	Vlasta	2.1	22.7
Mladka	52.2	100.0	Winsdor	3.0	39.0
Nela	4.3	62.2			

RESULTS AND DISCUSSION

Overwintering of wheat varieties and intensity of plot infection

Overwintering of plants in 2002–2003 and in 2003–2004 was quite different. In 2002–2003, strong frosts without snow cover occurred in the Czech Republic and a lot of winter cereals were frozen to death. The frost damage of infected varieties was higher then by control varieties during the winter 2002–2003 (Table 1). The plants were affected by double stress and their response to WDV infection was not typical. In 2003–2004 there was no problem in overwintering. All varieties survived the winter season.

Intensity of infection in the survived plants ranged between 36.4–94.5% (average intensity 64.9%) in 2002 and between 44.0–96.0% (average intensity 78.8%) in 2003. On the other hand Vacke and Cibulka (2000) recorded higher intensity of infection (92.0–100.0%) by similar vector infectivity (52.0–60.0%) using the same test procedure (time of acquisition and inoculation feeding, number of vectors per plant).

Symptom response and DAS-ELISA evaluation

The first symptoms were observed in April as different intensive dwarfing, leaf yellowing

Table 2. Reaction of winter wheat varieties to virus infection in 2003

Variety	Plant height		Plant weight		Reduction of heading	Grain yield	
	cm (I)	100 (I/C) × 100	g (I)	100 (I/C) × 100		g/plant (I)	100 (I/C) × 100
Apache	3.75	92.50	0.26	95.87	100.00	0.00	100.00
Banquet	17.63	78.89	1.14	83.81	53.13	0.01	99.80
Batis	5.50	91.70	0.54	95.75	100.00	0.00	100.00
Bill	5.10	91.43	0.31	97.38	100.00	0.00	100.00
Clever	10.44	81.78	0.79	92.66	86.67	0.00	100.00
Complet	5.10	93.25	0.56	95.48	100.00	0.00	100.00
Contra	4.73	91.70	0.51	93.74	100.00	0.00	100.00
Corsaire	4.25	91.98	0.35	96.78	100.00	0.00	100.00
Drifter	4.42	92.63	0.24	98.00	100.00	0.00	100.00
Hana (VS control)	**4.69**	**90.80**	**0.44**	**93.83**	**100.00**	**0.00**	**100.00**
Ilona (MS control)	**6.14**	**89.47**	**0.48**	**94.55**	**86.49**	**0.00**	**100.00**
Ludwig	4.70	91.90	0.29	95.69	100.00	0.00	100.00
Mladka			frozen to death				
Nela	4.46	92.31	0.35	97.14	100.00	0.00	100.00
Niagara	11.59	81.31	0.77	95.89	79.41	0.01	99.84
Record	3.67	93.08	0.38	96.89	100.00	0.00	100.00
Rheia	5.90	90.12	0.43	96.26	100.00	0.00	100.00
Rialto	2.84	94.49	0.32	97.23	100.00	0.00	100.00
Semper	3.00	95.31	0.30	97.99	100.00	0.00	100.00
Sepstra	4.55	93.07	0.54	97.15	96.88	0.00	100.00
Solara	5.35	91.64	0.35	97.64	96.15	0.00	100.00
Sulamit	6.90	90.18	0.49	96.61	95.83	0.00	100.00
Svitava	11.42	82.51	1.45	91.12	62.79	0.00	100.00
Tower	4.26	93.85	0.39	96.85	100.00	0.00	100.00
Trend	6.50	87.00	0.47	96.80	100.00	0.00	100.00
Vlasta	4.57	93.56	0.42	97.97	100.00	0.00	100.00
Winsdor	4.60	92.81	0.47	98.36	100.00	0.00	100.00

and reddening, necrotic leaf spots, reduction of heading. The first dying was observed in the early May.

The reaction of winter wheat varieties in 2003 was not typical, only eight varieties (Banquet, Clever, Niagara, Sepstra, Solara, Sulamit, Svitava and control variety Ilona) headed and only two varieties (Banquet, Niagara) had some grain, but grain yield reduction was more then 99.0%. All varieties were highly susceptible. The results of evaluation in 2003 are shown in Table 2.

In 2004, with normal owerwintering, the response of tested material to WDV infection was typical. The varieties were divided into three groups according to reduction in height and grain yield.

Table 3. Reaction of winter wheat varieties to virus infection in 2004 and virus extinction (A_{405}) of winter wheat varieties in 2004

Variety	Plant height		Plant weight		Reduction of heading	Grain yield		A_{405}	Degree of susceptibility
	cm (I)	100 (I/C) × 100	g (I)	100 (I/C) × 100		g/plant (I)	100 (I/C) × 100		
Apache	3.85	94.77	1.31	94.21	100.00	0.00	100.00	1.001	VS
Banquet	34.16	57.35	6.39	60.82	21.60	0.86	87.30	0.895	MS
Batis	8.24	91.13	2.57	81.58	89.47	0.01	99.94	1.183	VS
Bill	16.96	80.77	3.34	80.73	45.71	0.01	99.82	0.874	VS
Clever	21.34	73.33	5.03	65.76	36.00	0.28	95.60	0.654	S
Complet	5.34	94.30	2.30	87.23	89.19	0.01	99.86	1.017	VS
Contra	8.05	91.17	2.35	87.99	90.91	0.01	99.87	1.125	VS
Corsaire	12.93	85.06	2.89	82.58	66.70	0.08	98.99	0.958	VS
Drifter	20.84	77.54	4.19	76.93	42.50	0.29	96.88	1.046	S
Hana (VS control)	**6.62**	**91.79**	**2.45**	**85.00**	**99.98**	**0.00**	**100.00**	**0.932**	**VS**
Ilona (MS control)	**40.77**	**45.55**	**6.67**	**59.45**	**9.01**	**0.90**	**88.91**	**0.686**	**MS**
Ludwig	5.57	94.57	1.36	93.53	97.92	0.01	99.99	0.932	VS
Mladka	18.45	78.85	2.85	86.70	50.00	0.03	99.70	0.893	VS
Nela	9.66	88.34	2.32	88.18	96.77	0.01	99.99	0.927	VS
Niagara	20.88	77.82	4.42	81.45	51.35	0.26	97.17	0.875	S
Record	8.52	90.73	2.87	88.27	91.18	0.01	99.92	1.155	VS
Rheia	7.69	91.75	1.90	91.38	89.74	0.01	99.88	0.915	VS
Rialto	21.26	74.23	6.17	72.84	51.61	0.27	97.68	0.933	S
Semper	2.75	96.68	0.92	96.14	100.00	0.00	100.00	1.253	VS
Sepstra	3.54	95.97	1.56	93.34	100.00	0.00	100.00	1.248	VS
Solara	12.88	84.82	2.54	87.31	76.92	0.02	99.76	1.245	VS
Sulamit	7.67	91.63	1.53	93.41	86.05	0.01	99.91	1.268	VS
Svitava	28.93	66.44	7.81	77.60	33.33	1.87	93.10	0.587	MS
Tower	4.05	95.29	1.25	97.98	95.24	0.00	100.00	1.343	VS
Trend	5.25	94.04	1.88	90.73	100.00	0.00	100.00	1.058	VS
Vlasta	13.77	85.61	2.20	88.94	64.86	0.01	99.93	1.321	VS
Winsdor	7.60	90.63	3.15	91.89	82.86	0.01	99.92	1.440	VS

Figure 1. Symptoms of WDV infection in very susceptible variety Ludwig, healthy plant on the right

Figure 2. Symptoms of WDV infection in susceptible variety Clever, healthy plant on the right

The first group involved 19 materials with height reduction of infected plants between 78.0–97.0%. The symptoms of these varieties appeared early, dwarfing of plants and colouring of leaves were very intensive (scale point 3). Necrotic spots and drying of the leaves were observed. Dying of the infected plants was very fast, reduction of heading ranged between 50.0–100.0% and grain yield reduction was nearly 100.0%. The group comprising varieties Apache, Batis, Bill, Complet, Contra, Corsaire, Ludwig (Figure 1), Mladka, Nela, Record, Rheia, Semper, Sepstra, Solara, Sulamit, Tower, Trend, Vlasta, Winsdor and control variety Hana was classified as very susceptible (Table 3).

The second group contained four varieties with a reduction in height of 70.0–78.0%. The symptom severity was classified as the middle (scale point 2), milder necrotic spots and slower plant dying were observed. The heading reduction ranged from 36.0 to 51.6%, but the ears were sterile and grain reduction ranged between 95.6–97.7%. The group included the varieties Clever (Figure 2), Drifter, Niagara and Rialto. This material was classified as susceptible (Table 3).

The third group comprised two varieties with a height reduction less then 70.0%. The symptoms of these varieties appeared later and were less intensive (scale point 1). The necrotic spots and dying prematurely were rarely observed. The heading reduction was less then 36.0% and grain yield reduction ranged from 87.3 to 93.1%. This group, containing varieties Banquet (Figure 3) and Svitava and control variety Ilona was classified as moderately susceptible (Table 3).

The DAS-ELISA evaluation suggested that significant difference (P = 0.05) in relative virus content was determined between very susceptible and others varieties. The difference between susceptible and moderately susceptible was insignificant. Average absorbency (A_{405}) was 1.104 in very susceptible, 0.878 in susceptible and 0.723 in moderately susceptible.

The results in virus titer of leaves and roots of the four varieties, Svitava and control Ilona (mod-

Figure 3. Symptoms of WDV infection in moderately susceptible variety Banquet, healthy plant on the right

erately susceptible) and Ludwig and control Hana (very susceptible) are shown in Table 4. The virus titer ranged between 1/4 (roots of variety Ilona) and 1/128 or 1/256 (others). More considerable differences in virus titer between moderately and very susceptible varieties were not recovered.

No resistant winter wheat variety was found, but some differences between responses of winter wheat varieties to WDV infection were proved. Using of moderately susceptible varieties could play some role in protection against WDV. Vacke and Cibulka (2000) recorded high differences in grain yield reduction between very susceptible (72%), susceptible (35%) and moderately susceptible varieties (21%) infected in spring or summer of following year. Growing of these varieties can confine grain yield losses and can be of some protective measure mainly in the areas with high and periodic virus occurrence.

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Abstrakt

Širlová L., Vacke J., Chaloupková M. (2005): **Reakce vybraných odrůd pšenice ozimé na podzimní infekci virem *Wheat dwarf virus*.** Plant Protect. Sci., **41***:* 1–7.

Ve dvouletých maloparcelkových polních pokusech byla sledována reakce 25 registrovaných odrůd pšenice ozimé na podzimní infekci virem *Wheat dwarf virus* (WDV). Materiály byly infikovány pomocí vektora viru, křísk a polního (*Psammotettix alienus* Dahlbom, 1851) v růstové fázi 3 listů až odnožování. Na jaře byl sledován vývoj symptomů, v letním období byla zjišťována redukce výšky, hmotnosti nadzemní biomasy, metání a výnosu zrna. Všechny testované odrůdy byly vyhodnoceny jako náchylné a rozděleny do tří skupin. Odrůdy Banquet a Svitava s 87,3–93,1% redukcí výnosu zrna byly klasifikovány jako mírně náchylné, odrůdy Clever, Drifter, Niagara a Rialto s 95,6–97,68% redukcí patřily do kategorie náchylných a odrůdy Apache, Batis, Bill, Complet, Contra, Corsaire, Ludwig, Mladka, Nela, Record, Rheia, Semper, Sepstra, Solara, Sulamit, Tower, Trend, Vlasta a Winsdor s 99,7–100% redukcí výnosu zrna jako silně náchylné. Při porovnání hodnot absorbancí testovaných odrůd pomocí DAS-ELISA byly pozorovány statisticky významné rozdíly mezi silně náchylnými a náchylnými odrůdami a stejně tak mezi silně náchylnými a mírně náchylnými odrůdami.

Klíčová slova: *Wheat dwarf virus* (WDV); pšenice ozimá; rezistence

Corresponding author:

Ing. Lenka Širlová, Výzkumný ústav rostlinné výroby, odbor rostlinolékařství, oddělení virologie,
161 06 Praha 6-Ruzyně, Česká republika
tel.: + 420 233 022 438, fax: + 420 233 311 592, e-mail: sirlova@vurv.cz