Leaf Rust Occurrence in European Winter Wheat Varieties and Breeding Lines

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Abstract

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In 1998 and 1999, 52 winter wheat varieties and breeding lines originated from ten European countries were tested for their reaction to leaf rust, the inoculum was a mixture of races UN3-61SaBa and UN13-77SaBa. Twenty six varieties and lines stayed in the same group (susceptible, moderately susceptible, moderate, moderately resistant) in both years, with the majority being moderately resistant. Of the Czech varieties Asta, Rexia and Vlada stayed in the same group in both years. Some varieties moved from one group in 1998 to another in 1999. Some of the moderately resistant varieties and lines (Hereward, WW2568, P8634, Trakos, WW2510, Asset, WW2564) showed a hypersensitive reaction (chlorosis, necrosis). There were differences in the number of diseased plants between groups with a different reaction to leaf rust mainly at the beginning of the epidemic.

Key words: *Puccinia recondita* f. sp. *triitici*; winter wheat; cluster analysis; resistance

Leaf rust, together with potentially dangerous yellow rust, is at present the economocally most important rust attacking wheat varieties in the Czech Republic. Over the last years, leaf rust became important of West Europe where usually the yellow rust plays the main role. Higher levels of leaf rust were presumably influenced by higher temperatures of spring and summer months in last years, but changes in populations of that rust could also have participated (BARTOŠ *et al.* 1992).

The aim of these experiments was to study the reaction of European winter wheat varieties and breeding lines to the most frequent races of leaf rust, the similarity of variety disease severity, and the possible influence of climatic changes on the proportion disease severity.

MATERIAL AND METHODS

The most widespread races of leaf rust (*Puccinia recondite* Rob. Ex Desm. f. sp. *tritici*) in the Czech republic are UN3-61SaBa, avirulent to three standard differentials, and UN13-77SaBa virulent to all standard differentials (BARTOŠ *et al.* 1992). The reaction of 52 winter wheat varieties and breeding lines to a mixture of these races was tested in small plot-trials in 1998 and 1999. The tests were inoculated in the beginning of May by the method of spreader rows.

Disease severity was expressed as percentage of leaf area diseased (PETERSON *et al.* 1948) at three sampling dates (SD): 1998 – 25 May, GS (growth stage) 41; 15 June, GS 65; 02 July, GS 71; in 1999 on 24 May. GS 39; 31 May GS 61; 28 June GS 69. From the disease severity data the cumulative proportion of leaf area diseased – CPLAD (VĚCHET & KOCOUREK 1987; BRIERE *et al.* 1994) was counted. The number of diseased plants – NDP for each variety in each sampling date was counted too. Cluster analysis (computer program STATISTICA) was used for grouping wheat varieties and breeding lines based on CPLAD in three SD. Running quantitative dates were expressed by Euclidean matrix. The tested varieties and breeding lines were ranked into four groups (clusters – C): susceptible, moderately susceptible, moderate, moderately resistant. The values of CPLAD and NDP at each SD are shown in a column graph. The growth stages follow Zadoks decimal code (ZADOKS *et al.* 1974).

RESULTS

The level of infection by leaf rust on the winter wheat varieties and breeding lines was higher in 1999 than in 1998, mainly on SD2 and SD3 (Fig. 1).

The dendrogram for 1998 cut on the linkage distance 16.7, showed four distinct clusters (Fig. 2). Cluster C1

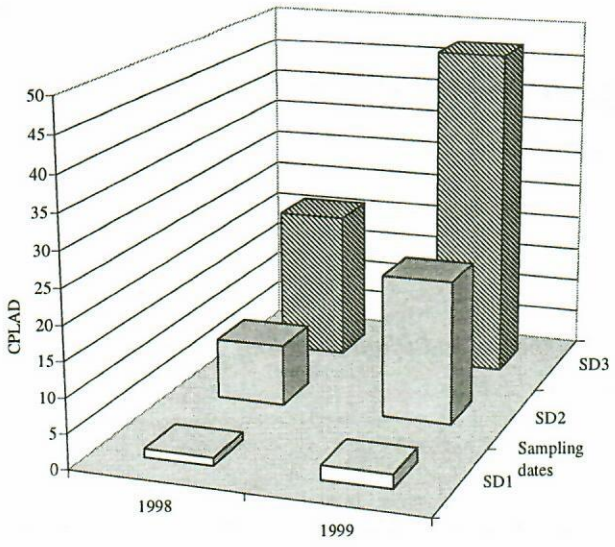

Fig.1. Increase of disease severity (mean value of CPLAD) for all clusters, in the three sampling dates (SD) – 1998 and 1999

was represented by one susceptible variety Frimegu, which had the highest values of CPLAD. Cluster C2 consisted of two groups; in contrast to group C2, group C2´ (variety Jubilejnaja) has higher values of CPLAD mainly on SD2 and SD3. In this cluster were moderately susceptible varieties. Cluster C3 consisted of 13 varieties with moderate reaction. Cluster C4 had 30 moderately resistant varieties, of which RE9712 and Trakos had the lowest disease severity.

The dendrogram for 1999, cut on the linkage distance 60, showed all varieties arranged into four distinct clusters (Fig. 3). Cluster C1 represented two susceptible varieties (WW2570, Zentos) with the highest values of CPLAD on SD3. Cluster C2 encompassed two groups; group C2 consisted of five varieties, and the group C2´ of four varieties. Varieties of group C2 had lower values of CPLAD mainly on SD2 or SD3, than varieties in group C2´. Cluster C3 was formed by 14 varieties with moderate reaction. The largest cluster C4 was created by 29 moderately resistant varieties. In this cluster four subgroups can be distinguished: one subgroup is immune varieties (Terza and RE90001); another of highly resistant varieties (Mikon, P7852, NSLWW17, RE9816, RE9712, P8634, RE8714, Trakos, 941231, Kalász and Charger); a third of medium resistant varieties (Agra, Élét, Hereward, WW2568, Capo, Georg, Pentium, Asset); and a subgroup of varieties with the highest disease severity in cluster C4 (Rexia, Vlada, Tarso, Rexia, WW2564, Jubilejnaja, A3741, WW2510).

Differences in the progress of disease severity of single clusters in two years of the study experiments are shown in Fig. 4 and 5. The most intense development of the disease in 1998 and 1999 was between SD1 and SD2 in all clusters, except for cluster C4 in 1998 (it occurred later, on SD3) and for cluster C1 in 1999 (the highest increase of the disease development on SD3). Differences between the clusters C2 and C2´ in the disease development in SD2 were higher than those on SD3.

In the cluster of susceptible varieties (C1), all plants at all sampling dates in both years showed infection (Fig. 6).

Table 1. Number of varieties and breeding lines included in single clusters (C) in 1998 and 1999

	C1	C2	C3	C4
1998	1	7	13	31
1999	2	9	12	29

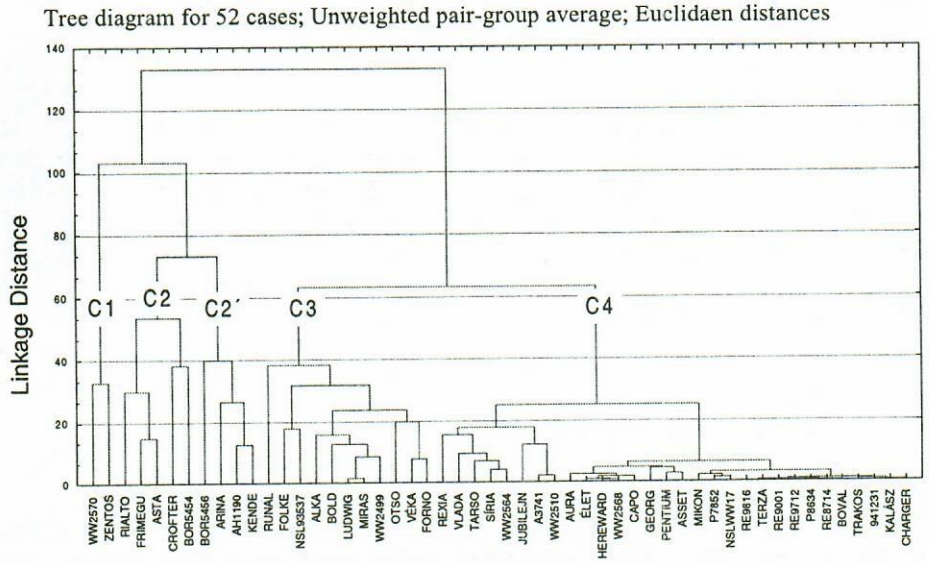

Fig. 2. Dendrogram of the CPLAD showing four distinct cluster groupings of the reaction to leaf rust of 52 winter wheat varieties and breeding lines (1998)

Table 2. Reaction, by cluster, of winter wheat varieties and breeding lines to leaf rust (C1 – susceptible; C2, C2′ – moderately susceptible; C3 – moderate; C4 – moderately resistant). Origin of seeds: D – Denmark, UK – United Kingdom, G – Germany, F – Finland, A – Austria, H – Hungary, S – Switzerland, N – the Netherlands, F – France, CZ – Czech Republic).

Country – variety	1998	1999
CZ – Asta	C2	C2
G – Bold; S – Runal	C3	C3
CZ – Rexia; CZ – Vlada; D – 941231; G – Pentium; F–RE8714; F –RE9001; F – RE9816; F – RE9712; S – Boval; UK – NSLWW17; A – Georg; A – P8634; A – Capo; A – P7852; G – Trakos; G – WW2568; G – WW2564; G – Mikon; H – Kalász; H – Élet; S – Terza	C4	C4
S – Arina; H – Kende; F – Bor5454	C3	C2′
UK – Rialto	C3	C2
G – Zentos; G – WW2570	C3	C1
UK – NSL93–5372; CZ – Alka; A – Ludwig; F – Otso; H – Véka; G – Miras; S – Forno	C4	C3
F – Bor 5456; D – AH1190	C4	C2′
CZ – Síria; D – A3741; UK – Asset; UK – Charger; G–Tarso	C3	C4
D – Frimegu	C1	C2
H – Jubilejnaja; N– Folke; G – WW2499	C2	C3
F – Aura; G – WW2510; UK – Hereward	C2	C4
UK – Crofter	C4	C2

Of the moderately susceptible variants (C2, C2′), 68–77% of the plants were infected on SD3, 85–99% on SD2, and all plants on SD3. In the cluster of varieties with a moderate reaction (C3), nearly 50% of the plants were attacked on SD1, over 75% on SD2, and all or nearly all plants on SD3. The cluster of moderately resistant entries (C4) showed the lowest of infected plants: 11 – 23% on SD1; 54 – 85% on SD2, and 67 – 87% on SD3.

The numbers of varieties included in single clusters were very similar in both years (Table 1).

Twenty four of tested varieties stayed in the same cluster in both years, particularly in cluster C4 (Table 2). Majority of varieties moved from one to another cluster; 16 varieties from a lower (1998) to a higher (1999) cluster, and 12 varieties from a higher (1998) to a lower (1999) cluster. Varieties mostly moved to the next cluster. Some varieties moved across the nearest cluster to a divided cluster. E.g. from a lower (1998) to a higher (1999) cluster moved WW2570, Zentos, Crofter, Bor5456, AH1190, while from a higher (1998) to a lower (1999) moved Aura and WW2510. Most varieties (21) moved from or to the cluster C3, fewer (16) moved from or to C4.

Some varieties showed chlorosis and necrosis especially in 1999 (Hereward, WW2568, P8634, Trakos, WW2510, Asset, WW2564, NSL93-5372). Mainly in the early stages of the infection (SD1) necrosis occurred on the lower leaves (3-, 4-, 5-th leaf from the top), and later (SD2, SD3) chlorosis developed on the upper leaves (1-, 2-, 3-, 4-th leaf).

The period from 01 May to 10 June in 1998 was higher in mean temperature number of days with maximum temperature above 25°C and in radiation, but was lower in rainfall and relative humidity than the same period in1999 (Table 3).

Table 3. Averaged means temperature (Temp.), number of days with temperature higher than 25°C (NDT), rainfall (Rain), relative humidity (RH), radiation j/day (Rad) of periods in 1998 and 1999

		Temp.	NDT	Rain	RH	Rad
1998	01–10.05.	13.9	3	0.3	64.6	174 345 20
	11–20.05.	14.6	2	0.02	56.0	188 006 40
	21–31.05.	14.4	3	2.7	70.4	216 078 55
	01–10.06.	19.4	6	2.8	67.1	191 980 80
1999	01–10.05.	12.5	0	0.8	63.2	165 536 90
	11–20.05.	13.0	0	0.6	66.1	198 892 80
	21–31.05.	17.2	0	3.4	79.0	185 681 46
	01–10.06.	16.5	0	1.8	72.8	217 468 80

DISCUSSION

Cluster analysis is one of the methods that investigates by similarities more bulky objects by the similarities between them. We chose as variables the disease severity in three sampling dates. The disease severity on different varieties differed as the disease progressed. This method of cluster analysis to group varieties according to disease severity was used by JEGER (1980), LEBEDA and JENDRŮLEK (1988), ANDERSON *et al.* (1990), BRIERE *et al.* (1994).

It seems that lower daily temperatures and radiation, no day with maximum temperature above 25°C and higher values in rainfall and relative humidity in 1999 could be conductive for the development of leaf rust.

In both years the majority of the tested varieties and breeding lines were moderately resistant. Fewer entries

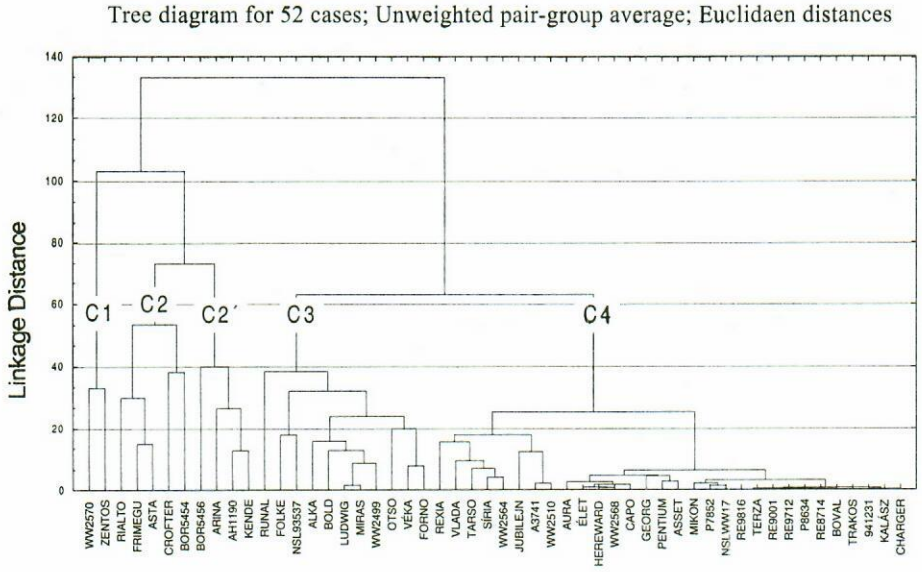

Fig. 3. Dendrogram of the CPLAD showing four distinct cluster groupings of the reaction to leaf rust of 52 winter wheat varieties and breeding lines – 1999

had moderate reaction, few were moderately susceptible, and only one or two varieties and lines were susceptible. The most rapid disease development occurred around the second sampling date in all groups of varieties and breeding lines, except in the cluster of susceptible varieties in 1999 where the same increase of the disease included the third sampling date. This was caused by the rapid start of the disease at the first sampling date in the variety Zentos, and by the slow one in line WW2570.

Mainly in the beginning of the epidemic there were wide differences in the number of diseased plants. The spread of the disease in moderately resistant varieties and breeding lines is slow not only on a single plant, but also from plant to plant. Later in the development of the disease these differences between moderately resistant entries and more susceptible ones got smaller.

Table 3. Averaged means temperature (Temp.), number of days with temperature higher than 25°C (NDT), rainfall (Rain), relative humidity (RH), radiation j/day (Rad) of periods in 1998 and 1999

	Temp	NDT	Rain	RH	Rad
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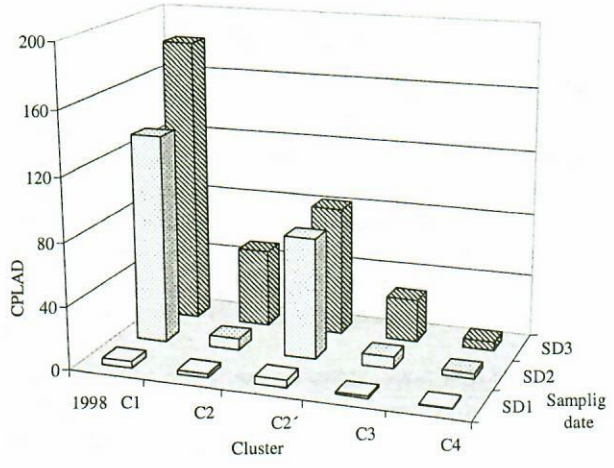

Fig. 4. Mean cumulative disease progress curve for each cluster (C1–C4) at three sampling dates (SD) – 1998

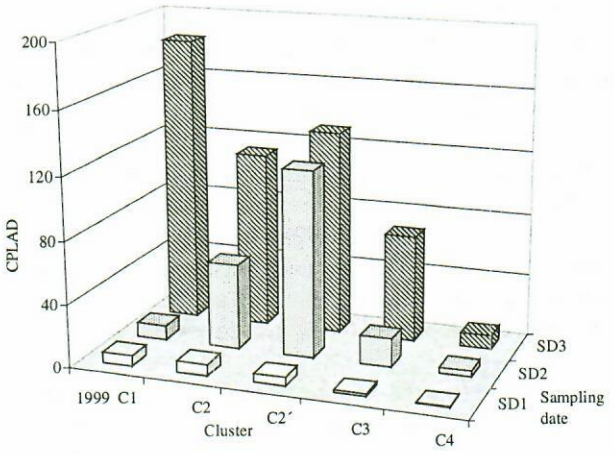

Fig. 5. Mean cumulative disease progress curve for each cluster (C1–C4) in three sampling dates (SD) – 1999

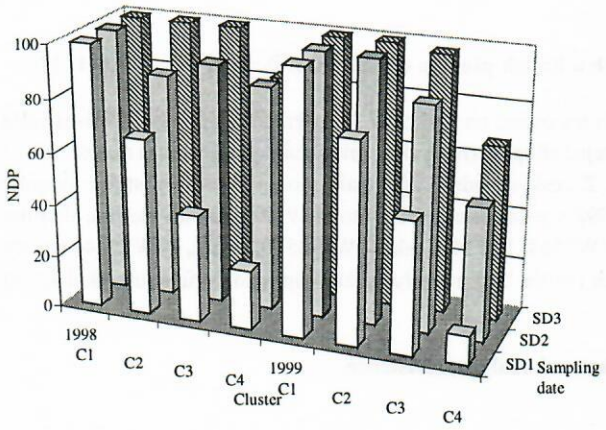

Figure 6. The averaged number of diseased plants in each cluster (C) and sampling date (SD) – 1998 and 1999

The disease level was much higher in 1999 than in 1998. The number of varieties and breeding lines in the same cluster in both years was very similar; it differed by one to two varieties in a cluster. Half of the varieties and lines moved from one cluster in 1998 to another cluster in 1999. It seems that the modification in disease severity between two years could be induced by a change in the genetic mechanism that was influenced by different temperature. PRETORIOUS *et al.* (1998) found that temperature (14–16°C and 20–22°C) influenced genetic mechanism of the host. On the other hand, the other half of varieties and lines stayed in the same clusters in both years; this applied to Czech varieties Asta, Rexia and Vlada. Most varieties were concentrated in the cluster of moderately resistant ones. Presumably, these varieties and breeding lines were stable under dissimilar conditions. Even though the differences between daily mean temperatures in May and June of 1998 and 1999 was only 1.9°C, this dissimilarity was affective for a long time.

Of the Czech varieties Vlada, Rexia and Síria were moderately resistant. BARTOŠ *et al.* (1992) indicated that variety Vlada was immune in the growth stage of the first two leaves in laboratory conditions. This variety possessing the genes of resistance *Lr1*, *Lr3* and *Lr13*; in 1998 it was part of the cluster with a moderately resistant reaction and in 1999 stayed in this cluster. The variety Rexia has one unknown gene of resistance. If we compare our results with the results of tests of winter wheat nursery for adult plant resistance to leaf rust 1996–1998 (WINZELER *et al.* 2000 in press) we see that Vlada, Charger, Boval, Rialto belonged to varieties with resistance in the seedling stage, while Terza, Forno, P8634, Mikon, Kalász. Were resistant in the adult stage. In our experiment these varieties had moderately resistant up to moderately susceptible. The variety Arina determined as susceptible in those tests, but in our experiments it gave a moderate and up to moderately susceptible response.

The varieties and lines Hereward, WW2568, P8634, Trakos, WW2510, Asset and WW2564 showed chlorosis and necrosis (hypersensitive reaction) in 1999, and all were situated in the cluster of moderately resistant varieties. RUBIALES *et al.* (1998) believed that hypersensitive resistance to leaf rust is associated with necrosis of the plant cells during or after haustorium development and arrests or reduces subsequently colony growth.

In conclusion, the cluster analysis is a suitable method to arrange varieties according to certain properties. Multivariate methods become an important tool necessary to breed wheat for disease resistance.

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Abstrakt

VĚCHET L. (2000): **Výskyt rzi pšeničné v evropských odrůdách a liniích pšenice ozimé**. Plant Protect. Sci., **36**: 141–146.

Padesát dva odrůd a linií původem z deseti evropských zemí bylo testováno na reakci ke rzi pšeničné (směs ras UN3-61SaBa a UN13-77SaBa). V obou letech pokusu bylo 26 odrůd a linií ve stejné skupině (náchylná, mírně náchylná, střední reakce, mírně rezistentní). Většina z těchto odrůd patřila k téměř rezistentním. Z českých odrůd zůstávaly v obou letech ve stejné skupině odrůdy Asta, Rexia a Vlada. Některé odrůdy, které byly v roce 1998 v jedné skupipě se v roce 1999 stěhovaly do jiné skupiny a naopak. Některé téměř rezistentní odrůdy a linie (Hereward, WW2568, P8634, Trakos, WW2510, Asset, WW2564) tvořily hypersenzitivní reakce (chlorózy a nekrózy). V počtu napadených rostlin byly rozdíly mezi skupinami s různou reakcí ke rzi pšeničné hlavně na počátku epidemie.

Klíčová slova: *Puccinia recondita* f. sp. *tritici*; pšenice ozimá; klastrová analýza; rezistence

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