RESPONSE OF SEVERAL APPLE VARIETIES TO APPLE SCAB (*VENTURIA INAEQUALIS*) ATTACK IN CENTRAL TRANSYLVANIA CONDITIONS

COMPORTAREA UNOR SOIURI DE MĂR LA ATACUL DE RAPĂN (*VENTURIA INAEQUALIS*), ÎN CONDIȚIILE DIN CENTRUL TRANSILVANIEI

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REZUMAT

La Staţiunea de Cercetare Dezvoltare pentru Pomicultură Cluj-Napoca, România, a fost studiată comportarea unor soiuri de măr la atacul de rapăn − *Venturia inaequalis* (Cke.) Wint. Au fost analizate în acest scop 75 de soiuri, privind intensitatea, frecvenţa şi gradul de atac pe frunze şi fructe, într-o perioadă de şapte ani (1990-1996). Dintre cele 75 de soiuri, 38 au fost înregistrate cu diferite nivele de atac, cele mai sensibile dovedindu-se cultivarurile de origine japoneză (ex. Fuji Aki-fu, Nebuta, Sekai ichi). În unii ani, în funcţie şi de condiţiile climatice, au fost puternic atacate, îndeosebi pe fructe, şi soiuri cunoscute şi răspândite în cultură, cum sunt: Kaltherer Böhmer, Starkrimson, Red Delicious, Mutzu, Wellspur, Jersey Mac. Din totalul soiurilor studiate, 31 (reprezentând 41,3%) nu au fost atacate de rapăn, nici pe frunze şi nici pe lăstari, printre acestea situându-se şi soiurile cu rezistenţă genetică la rapăn Prima, Priscilla, Sir Prize, Liberty, Florina, Priam, Pionier, Voinea, Generos.

ABSTRACT

Among 75 varieties of apple, verified at the Fruit Research Station in Cluj-Napoca, Central Transylvania, Romania, during seven years (between 1990-1996), 38 registered with certain attack degree with apple scab on leaves and fruits. Susceptible on apple scab – *Venturia inaequalis* (Cke.) Wint. – were the varieties with Japanese origin (i.e. Fuji Aki-fu, Nebuta, Sekai ichi), and in certain years even well known cultivars, as Kaltherer Böhmer, Starkrimson, Red Delicious, Mutzu, Wellspur, Jersey Mac which were strongly infected, especially on leaves. Out of all varieties, 31 of them, representing 41.3% were registered with "No attack", both on leaves and fruits, including genetically resistant varieties Prima, Priscilla, Sir Prize, Liberty, Florina, Priam, Pionier, Voinea, Generos.

KEY WORDS: apple, varieties, response, apple scab, attack

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DETAILED ABSTRACT

Among 75 varieties of apple, verified at the Fruit Research Station in Cluj-Napoca, Central Transylvania, Romania, during seven years (between 1990-1996), 38 registered with certain attack degree with apple scab on leaves and fruits.
Susceptible on apple scab – *Venturia inaequalis* (Cke.) Wint. – were the varieties with Japanese origin (i.e. Fuji Aki-fu, Nebuta, Sekai ichi), and in certain years even well known cultivars, as Kaltherer Böhmer, Starkrimson, Red Delicious, Mutzu, Wellspur, Jersey Mac which were strong infected, especially on leaves.
Out of all varieties, 31 of them, representing 41.3% were registered with "No attack", both on leaves and fruits: Ancuţa, Black John, Gloria, Granny Smith, Idared, Nüred Jonathan, NJR 2/11-20, NJR 64, Ribston Pepping, Şovari, Pionier, Prima, Voinea, Generos, Priam, Sir Prize, Priscilla, Florina, Liberty, Azusa, Akane, Ardelean, Cardinal, Romus 3, Discovery, NJR 64C, Clar alb, NJR 60, Romus 2, ItaliaCj, Roz de Virginia (these are potential sources for further breeding programmes). Among them were included genetically resistant varieties Prima, Priscilla, Sir Prize, Liberty, Florina, Priam, Pionier, Voinea (all of them with vertical resistance, determined by the *Vf* gene) and Generos, with horizontal resistance.
The susceptibility of the cultivars to apple scab attack on leaves was significantly correlated with the susceptibility to apple scab attack on fruits. Their response to apple scab was influenced by the climatic conditions. During the rainy years the intensity and the Attack Degree on the fruits of the apple scab were greater.

INTRODUCTION

Apple scab, caused by the fungus *Venturia inaequalis*, is one of the major diseases in Transylvania apple orchards, which together with the fungus *Podosphaera leucotricha* can hamper apple production (Sestraş, 1997).

Apple scab strongly affects apple quality and yield when it is not strictly controlled by frequent application of fungicides. Such a large amount of chemical treatments raises numerous ecological problems and consumer health concerns, in addition to the economic cost (Cociu, 1990; Lespinasse, Y. et al., 2002).

Crosby, J. A. et al., showed in 1992 that in European orchards, chemical treatments cost 180 million ECU per year, with the overwhelming majority going towards scab and mildew control (15 to 20 specific treatments per year). Such a number of treatments raises numerous ecological problems and consumer health concerns, in addition to cost.

This is the reason for which, in the World there are many programmes for genetic improvement of apple and for creating new cultivars with durable resistance of apple to scab and powdery mildew (Hough et al., 1988; Crosby, J. A. et al., 1992; Janick, J, 2002; Lespinasse, Y. et al., 2002).

Growing cultivars resistant to apple scab eliminates the need for control of this fungal disease. Apple breeding strategies, based on monogenic resistance from wild related species, have been developed for 50 years, creating new resistant varieties (Braniţte and Andreieş, 1990; Crosby, J. A. et al., 1992).

By 2000, a total of 18 scab-resistant cultivars containing the *Vf* gene derived from *Malus floribunda* 821, were released by PRI alone or jointly with others and about 50 cultivars derived from PRI germplasm have been released by breeders world wide (Janick, J, 2002).

MATERIAL AND METHOD

There were studied 75 apple varieties as regards their response to the apple scab attack. The experiment, took place in an experimental field at the Fruit Research Station from Cluj-Napoca, Central Transylvania, Romania.

The apple varieties were planted in 1987, the rootstock used was MM 106 and the trees were planted at 4.5 x 2.0 m (1,110 trees/hectare); for each cultivar, there were eight replicates.

The response of cultivars to apple scab attack was assessed in natural conditions of infection, with the same fungicide treatment as in commercial orchards, uniformly applied to all the cultivars (6-8 treatments/year). Frequency (F%) and Intensity (I%) were determined and thus the Attack Degree was calculated: AD%=F x I/100 (Cociu and Oprea, 1989).

The investigation lasted seven years (1990-1996) and encountered different climatic conditions. The frequency and intensity to apple scab attack were estimated on leaves and fruits, in August, for each year.

RESULTS AND DISCUSSION

Table 1 displays values of the frequency (F%), intensity (I%) and attack degree (AD%) for apple scab on leaves and fruits, in 75 apple cultivars, in the years in which the pathogen appeared during the research period (1990-1996).

Attack Degree of apple scab on leaves in the apple varieties oscillated strongly, depending on the genotype and the climatic conditions of the year. The variation of the AD% was comprised between 0.002% (Close variety, in 1992) and 85.26% (Sekai ichi variety, in 1991). The most susceptible were the varieties of Japanese origin Fuji Aki-fu (AD=18.0% in 1996), Fuji Naga-fu (25.0% in 1996), Fuji Nfuf (68.2% in 1991), Nebuta (72.9% in 1991), Sekai ichi (85.26% in 1991). Other strongly attacked cultivars were: Kaltherer Böhmer (20.35% in 1991), Starkrimson (36.0% în 1996), Red Delicious (45.8% in 1991), Mutzu (53.5% in 1996), Wellspur (48.96% in 1991), Jersey Mac (60.48% in 1991).

Among the 75 varieties, 37 did not presented symptoms of apple scab attack on the leaves: Ancuţa, Black John, Creţesc, Feleac, Gloria, Gustav durabil, Granny Smith, Idared, Nüred Jonathan, NJR 2/11-20, NJR 64, Reinette de Canada, Ribston Pepping, Şovari, Fălticeni, Pionier, Prima, Voinea, Generos, Priam, Sir Prize, Priscilla, Florina, Liberty, Azusa, Akane, Ardelean, Cardinal, Romus 3, Discovery, NJR 64C, Parmain d'or, Clar alb, NJR 60, Romus 2, ItaliaCj, Roz de Virginia. They include also the genetically resistant varieties: Prima, Priscilla, Sir Prize, Liberty – of American origin, with vertical resistance, determined by the *Vf* gene; Florina, Priam – of French origin, with vertical resistance, determined by the *Vf* gene; Pionier, Voinea – Romanian cvs., with vertical resistance, determined

by the *Vf* gene; Generos – Romanian cv., with horizontal resistance, derived from *Malus kaido* (Branişte and Andreieş, 1990; Şerboiu, 1990).

Table 1a: Frequency (F%), Intensity (I%) and Attack Degree (AD%) of Apple Scab on Leaves and Fruits in the Apple Varieties Examined (During the Period 1990-1996)

Variety	Years with attack	Leaves			Fruits		
		F%	I%	AD%	F%	I%	AD%
Jonathan	1991	21.0	15.0	3.15	3.0	1.0	0.03
Belle Fleur Jaune	1992	0.5	2.0	0.01	-	-	-
Creţesc	1993	-	-	-	1.0	0.5	0.005
	1996	-	-	-	1.0	1.0	0.01
Delia	1991	3.0	1.0	0.03	-	-	-
	1996	1.0	1.0	0.01	-	-	-
Feleac	1993	-	-	-	2.0	4.0	0.08
	1996	-	-	-	1.0	1.0	0.01
Gloster	1991	35.0	20.0	7.0	7.0	8.0	0.56
Gustav durabil	1996	-	-	-	1.0	1.0	0.01
Golden spur	1991	3.0	1.0	0.03	83.0	3.0	2.49
	1992	0.2	4.0	0.008	-	-	-
	1996	30.0	10.5	3.15	10.0	5.0	0.5
Jamba	1991	12.0	3.0	0.36	-	-	-
Jonathan Smith	1991	5.0	2.0	0.1	1.0	1.0	0.01
	1996	1.0	1.0	0.01	-	-	-
Jonathan Watson	1996	1.0	1.0	0.01	-	-	-
Jonagold	1996	1.0	1.0	0.01	-	-	-
James Grieve	1996	1.0	1.0	0.01	-	-	-
Jonne spur	1991	12.0	6.0	0.72	3.0	2.0	0.06
	1996	1.0	1.0	0.01	-	-	-
Kidd's Orange Red	1991	8.0	7.0	0.56	-	-	-
	1995	1.0	1.0	0.01	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Starkrimson	1991	73.0	39.0	28.5	15.0	4.0	0.6
	1992	6.0	8.0	0.5			
	1995	10.0	10.0	1.0	2.0	2.0	0.04
	1996	60.0	60.0	36.0	50.0	50.0	25.0
London Pepping	1991	14.0	5.0	0.7	1.0	0.5	0.005
	1996	-	-	-	1.0	1.0	0.01
Mutzu	1991	81.0	66.0	53.5	5.0	3.9	0.20
	1996	-	-	-	1.0	1.0	0.01
Reinette de Canada	1991	2.0	1.0	0.02	-	-	-
	1992	1.0	4.0	0.04	-	-	-
	1994	1.0	1.0	0.01	-	-	-
	1995	1.0	1.0	0.01	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Red Delicious	1991	88.0	52.0	45.8	3.0	1.0	0.03
	1992	11.0	12.0	1.32	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Fălticeni	1991	-	-	-	4.0	1.0	0.04
	1996	1.0	1.0	0.01	1.0	1.0	0.01
	1996	-	-	-	1.0	1.0	0.01

Table 1b: Frequency (F%), Intensity (I%) and Attack Degree (AD%) of Apple Scab on Leaves and Fruits in the Apple Varieties Examined (During the Period 1990-1996)

Variety	Years with attack	Leaves			Fruits		
		F%	I%	AD%	F%	I%	AD%
Kaltherer Böhmer	1991	55.0	37.0	20.35	31.0	8.0	2.48
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Fuji Aki-fu	1991	22.0	7.0	1.54	5.0	1.0	0.05
	1996	40.0	45.0	18.0	1.0	1.0	0.01
Fuji Naga-fu	1991	9.0	3.0	0.27	4.0	0.5	0.02
	1992	14.0	15.0	2.1	-	-	-
	1996	50.0	50.0	25.0	4.0	5.0	0.2
Fuji Nfuf	1991	96.0	71.0	68.2	12.0	3.0	0.36
	1992	18.0	17.0	3.06	-	-	-
	1996	50.0	55.0	27.5	4.0	5.0	0.2
Kogetsu	1991	41.0	19.0	7.8	7.0	4.0	0.28
	1992	15.0	16.0	2.4	-	-	-
	1996	30.0	35.0	10.5	3.0	4.0	0.12
Jamba ocin	1991	36.0	12.0	4.32	2.0	1.0	0.02
	1996	8.0	8.0	0.64	2.0	2.0	0.04
Mikinoku	1991	27.0	8.0	2.16	-	-	-
	1992	8.0	9.0	0.72	-	-	-
	1996	15.0	16.0	2.4	3.0	3.0	0.09
Nebuta	1991	89.0	82.0	72.9	2.0	1.0	0.02
	1992	4.0	7.0	0.28	-	-	-
	1996	30.0	30.0	9.0	-	-	-
Red Jonagold	1991	51.0	36.0	18.36	2.0	1.0	0.02
	1992	6.0	8.0	0.48	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Sekai ichi	1991	98.0	87.0	85.26	3.0	2.0	0.06
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Subotsugam	1991	49.0	22.0	10.78	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Wagener premiat	1991	13.0	5.0	0.65	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Close	1991	18.0	7.0	1.26	-	-	-
	1992	0.2	1.0	0.002	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Empire	1991	21.0	11.0	2.31	-	-	-
	1992	13.0	8.0	1.04	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Frumos de Voineşti	1991	26.0	17.0	4.42	-	-	-
	1992	0.8	1.5	0.012	-	-	-
	1996	1.0	1.0	0.01	1.0	1.0	0.01
Parmain d'or	1996	-	-	-	1.0	1.0	0.01
Wealthy	1991	42.0	37.0	15.54	2.0	1.0	0.02
	1992	11.0	13.0	1.43	-	-	-
Wellspur	1991	68.0	72.0	48.96	3.0	1.0	0.03
	1992	14.0	27.0	3.78	-	-	-
	1996	1.0	1.0	0.01	-	-	-
Aromat de vară	1991	21.0	7.0	1.47	-	-	-
Jersey Mac	1991	84.0	72.0	60.48	-	-	-
Mollie Delicious	1991	23.0	15.0	3.45	-	-	-

The apple scab attack on fruits appeared at 34 varieties, with limits between 0.005% (London Pepping, 1991; Crețesc, 1993) and 25.0% (Starkrimson, 1996). The most susceptible was Starkrimson, in 1996, with a frequency and an intensity of the attack of 25.0%. Values of over 1 AD% on fruits were also registered at the cultivars Golden spur and Kaltherer Böhmer (both with AD=2.5% in 1991). The following 41 varieties did not present any trace of fungus on the fruits: Ancuța, Black John, Belle Fleur Jaune, Delia, Gloria, Granny Smith, Idared, Jamba, Jonathan Watson, Nüred Jonathan, Jonagold, James Grieve, NJR 2/11-20, NJR 64, Reinette Baumann, Ribston Pepping, Şovari, Pionier, Prima, Voinea, Generos, Priam, Sir Prize, Priscilla, Florina, Liberty, Azusa, Akane, Ardelean, Cardinal, Romus 3, Discovery, NJR 64C, Aromat de vară, Clar alb, Jersey Mac, Mollie Delicious, NJR 60, Romus 2, ItaliaCj, Roz de Virginia.

Out of the entire amount of 75 apple varieties analysed, 49.3% were not attacked on leaves and 54.7% on fruits (Table 2). None of the varieties were included in strong and very strong attack categories.

Table 2: Groups of Response to Apple Scab of the Cultivars Experimented

Attack evaluation	Cvs. attack on leaves		Cvs. attack on fruits	
	No.	%	No.	%
No attack (AD% = 0)	37	49.3	41	54.7
Very weak attack (AD%=0.1-1)	19	25.3	32	42.7
Weak attack (AD%=1.1-5.0)	11	14.7	2	2.6
Average attack (AD%=5.1-15)	8	10.7	-	-
Strong attack (AD%=15.1-20)	-	-	-	-
Very strong attack (AD%>20.1)	-	-	-	-
Cultivars total	75	100.0	75	100.0

A number of 31 varieties were not attacked neither on leaves or fruits: Ancuța, Black John, Gloria, Granny Smith, Idared, Nüred Jonathan, NJR 2/11-20, NJR 64, Ribston Pepping, Şovari, Pionier, Prima, Voinea, Generos, Priam, Sir Prize, Priscilla, Florina, Liberty, Azusa, Akane, Ardelean, Cardinal, Romus 3, Discovery, NJR 64C, Clar alb, NJR 60, Romus 2, ItaliaCj, Roz de Virginia.

Figure 1 shows the AD% medium variation on leaves and fruits for all varieties during the whole period of research (1990-1996). The graphic points out the high degree of the attack on the leaves in 1991, compared to the other years.

The coefficient of phenotypic correlation between the attack degree on leaves and the attack degree on fruits in the 75 apple varieties was significant ($r_p = +0.301^{x(x)}$). This suggests the fact that the susceptibility to apple scab attack on leaves is significantly correlated with the susceptibility to apple scab attack on fruits. This correlation suggests that the resistance of the plants to apple scab attack on leaves is linked to their resistance to apple scab attack on fruits.

It can be used in apple breeding as a selection index, even if this correlation is not always certain.

Climatic conditions had some influence upon the frequency, intensity and attack degree for apple scab at the cultivars studied, as shown in Table 3.

The values of the coefficients of correlation were significantly assured for the next pairs of characters: total rainfall/year – intensity attack on the fruits (r_p=0.708); total rainfall/year - Attack Degree on the fruits (r_p=0.690). It results that, during the period of testing, in the rainy years the intensity and the Attack Degree on the fruits of the apple scab were greater.

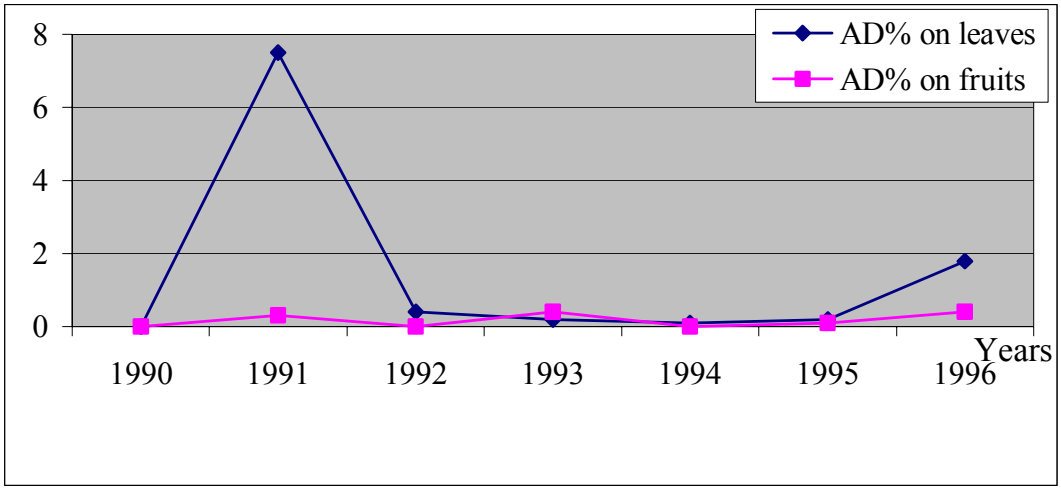
Although the mean temperature/year was not significantly correlated with the intensity, the frequency and the Attack Degree on the leaves and fruits, negative values of "r_p" suggest that in Transylvania conditions the apple is less susceptible to scab.

Table 3: Phenotypic Correlations (r_p) Between Average Yearly Temperature (°C), Total Yearly Rainfall (mm/m^2) and Apple Scab Attack (1990-1996)

Specification	Attack on Leaves			Attack on Fruits		
	F%	I%	AD%	F%	I%	AD%
Mean temperature/year	-0.105	-0.192	-0.072	-0.414	-0.545	-0.506
Total rainfall/year	+0.229	+0.395	+0.263	+0.616	+0.708	+0.690

r 5% = 0.666

Figure 1. Attack Degree AD% Variation for Apple Scab on Leaves and Fruits at 75 Apple Cultivars, During the Period 1990-1996



CONCLUSIONS

1. Apple scab, caused by the fungus *Venturia inaequalis* (Cke.) Wint., is one of the major diseases in Transylvania apple orchards, which together with the fungus *Podosphaera leucotricha* can hamper apple production.
2. Out of 75 apple varieties studied during seven years in an experimental field in Cluj-Napoca, the most susceptible to apple scab proved to be Japanese cultivars (i.e. Fuji Aki-fu, Nebuta, Sekai ichi), and in certain years even well known cultivars, as Kaltherer Böhmer, Starkrimson, Red Delicious, Mutzu, Wellspur, Jersey Mac.
3. Out of all varieties, 31 of them, representing 41.3% were registered with "No attack", both on leaves and fruits (these are potential sources for further breeding programmes), including genetically resistant varieties to apple scab: Prima, Priscilla, Sir Prize, Liberty, Florina, Priam, Pionier, Voinea (all of them with vertical resistance, determined by the *Vf* gene) and Generos, with horizontal resistance.
4. The susceptibility of the cultivars to apple scab attack on leaves was significantly correlated with the susceptibility to apple scab attack on fruits.
5. The response of the cultivars to apple scab was influenced by the climatic conditions. During the rainy years the intensity and the Attack Degree on the fruits of the apple scab were greater.

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