ORIGINAL ARTICLE

RESPONSE OF SEVERAL APPLE VARIETIES TO POWDERY MILDEW (*PODOSPHAERA LEUCOTRICHA*) ATTACK IN CENTRAL TRANSYLVANIA CONDITIONS

SESTRAŞ R.

REZUMAT

Făinarea, boală cauzată de agentul patogen *Podosphaera leucotricha*, constituie una dintre cele mai păgubitoare boli ale mărului. La Staţiunea de Cercetare-Dezvoltare pentru Pomicultură Cluj-Napoca s-a studiat comportarea unor soiuri de măr la atacul de făinare pe frunze şi lăstari, pe o perioadă de şapte ani (1990-1996). Dintre 75 de soiuri analizate, 21 (reprezentând 28%) au fost foarte puternic atacate, atât pe frunze, cât şi pe lăstari. Cele mai sensibile s-au dovedit: Jonathan, Jonne Spur, Jonathan Smith, Black John, Jonathan Watson, Nüred Jonathan, Delia, Aromat de vară, Roşu de Cluj. Soiurile Gloster, Starkrimson şi Prima au fost înregistrate cu cel mai scăzut atac, însă nici unul dintre soiuri nu a fost complet neatacat de boală.

ABSTRACT

The response of apple cultivars to powdery mildew attack – *Podosphaera leucotricha* (Ell. et Everh.) Salm. – on leaves and shoots, for seven years (1990-1996), emphasised a large variability for this character existing within 75 apple varieties tested in an experimental field at the Fruit Research Station in Cluj-Napoca, Central Transylvania, Romania. The experimental results confirmed that the cultivars of the Jonathan group are highly susceptible to powdery mildew (e.g. Jonathan, Jonne Spur, Jonathan Smith, Black John, Jonathan Watson, Nüred Jonathan, Delia, Aromat de vară, Roşu de Cluj). Cultivars Gloster, Starkrimson and Prima were registered with a low attack degree. None of the tested cultivars were included in the category "No attack". Out of all varieties, 21 of them representing 28.0% were registered with a very high attack, both on leaves and shoots.

KEY WORDS: apple, varieties, response, powdery mildew, attack

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DETAILED ABSTRACT

The response of apple cultivars to powdery mildew attack – *Podosphaera leucotricha* (Ell. et Everh.) Salm. – on leaves and shoots, for seven years (1990-1996), emphasised a large variability for this character existing within 75 apple varieties tested in an experimental field at the Fruit Research Station in Cluj-Napoca, Central Transylvania, Romania.

The variation limits for the attack degree on leaves were estimated between 0.2% and 53.7%, and on shoots between 0.1% and 58.1%.

The experimental results confirmed that the cultivars of the Jonathan group are highly susceptible to powdery mildew (e.g. Jonathan, Jonne Spur, Jonathan Smith, Black John, Jonathan Watson, Nüred Jonathan, Delia, Aromat de vară, Roşu de Cluj). Cultivars Gloster, Starkrimson and Prima were registered with a low attack degree (these are potential sources for further breeding programmes). None of the tested cultivars were included in the category "No attack". Out of all varieties, 21 of them representing 28.0% were registered with a very high attack, both on leaves and shoots.

A very strong positive phenotypic correlation between the attack degrees with powdery mildew on leaves and shoots was noted (r_p=+0.905^{xxx}). Climatic conditions of the experimental years influenced the frequency, intensity and, thus, the attack degree of the cultivars tested. High temperature and drought favoured the development and expend of the pathogen.

INTRODUCTION

Powdery mildew, caused by the fungus *Podosphaera leucotricha* (Ell. et Everh.) Salm., is one of the most damaging diseases of apple in Transylvania, Romania.

There is a wide variability of reaction to powdery mildew attack in cultivated apple: some varieties are susceptible to and other resistant against this disease (Sestraş, 1997; Ardelean and Sestraş, 1999; Bucarciuc, 2003).

Kellerhals (1989) evaluated papers containing studies about the response of some apple varieties to powdery mildew attack and he mentioned the following authors: Bondarenko, 1965; Gollmick, 1950; Kock, 1927; Misic, 1966; Sarasola, 1963; Schander, 1958; Soskic, 1965; Volvac, 1965; Jeger et al., 1986. They have recorded different levels of powdery mildew resistance in apple cultivars, which means that the cultivated apple provides a complete range of reaction from full susceptibility to what is often described as immunity.

Alston (1969) examined approximately 2,000 apple cultivars concerning their response to powdery mildew attack; he concluded that it is improbable that a real immunity exists within the cultivated varieties. Lateur and Populer (1994) observed that only 4% of 281 apple varieties possessed a marked resistance to powdery mildew attack.

MATERIAL AND METHOD

The study was carried on 75 apple cultivars, planted in 1987 in an experimental field at the Fruit Research Station from Cluj-Napoca, Central Transylvania, Romania.

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 powdery mildew 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 powdery mildew attack were estimated on leaves and shoots, in August, for each year.

RESULTS AND DISCUSSION

Table 1 displays data regarding the climatic conditions in Central Transylvania, during the research period (Fruit Research Station, Cluj-Napoca).

Table 1: Climatic Conditions Throughout Experimental Years

Agricultural Year	Average Air Temperature (°C)	Total Rainfall (mm/m^2)	General Climatic Evaluation
1989-1990	9.1	355.4	Warm and very droughty
1990-1991	9.0	529.9	Warm and droughty
1991-1992	8.7	513.1	Droughty
1992-1993	8.1	520.2	Droughty
1993-1994	10.5	497.6	Hot and droughty
1994-1995	9.2	509.2	Warm and droughty
1995-1996	7.9	621.9	Cold and rainy
Normal average	8.6	573.0	-

In comparison with the normal average, the average air temperature was lower in 1992-1993 and 1995-1996, while total rainfall was higher only in 1995-1996 (the only year with marked deviations from the general trend: warm and possibly droughty).

Table 2 displays average values of the attack degree (AD%) for powdery mildew on leaves and shoots, in 75 apple cultivars, as a mean of the whole research period (1990-1996).

Table 2: Attack Degree (AD%) of Powdery Mildew on Leaves and Shoots in the Apple Varieties Examined (Average Values 1990-1996)

Variety	AD%		Variety	AD%	
	leaves	shoots		leaves	shoots
Jonathan	40.9^{xx}	58.1^{xxx}	Priam	11.2	15.2
Ancuţa	6.2	6.6	Sir Prize	14.8	6.5
Black John	39.1^{xx}	52.1^{xxx}	Priscilla	7.7	12.5
Belle Fleur Jaune	2.6	7.8	Florina	4.9	7.1
Creţesc	4.7	9.8	Liberty	4.3	5.3
Delia	53.4^{xx}	48.1^{xxx}	Azusa	23.4	15.7
Feleac	9.9	18.0	Fuji Aki-fu	3.3	3.2
Gloster	0.2$^{(o)}$	0,4	Fuji Naga-fu	1.6	0.9
Gloria	5.7	7.6	Fuji Nfuf	1.2	0.4
Gustav durabil	31.8^{x}	38.5^{x}	Kogetsu	24.7	33.0$^{(o)}$
Granny Smith	16.2	11.2	Jamba ocin	28.2	29.0
Golden spur	9.7	9.2	Mikinoku	9.2	0.3
Idared	17.5	24.7	Nebuta	11.8	3.2
Jamba	1.7	2.4	Red Jonagold	47.3^{xxx}	39.0^{xx}
Jonathan Smith	35.5^{x}	47.0^{xxx}	Sekai ichi	6.2	1.0
Jonathan Watson	28.1	34.7^{x}	Subotsugam	36.0^{x}	43.8^{xx}
Nüred Jonathan	21.8	32.7$^{(x)}$	Wagener premiat	48.5^{xxx}	36.3^{x}
Jonagold	11.8	16.0	Akane	25.9	13.1
James Grieve	8.7	8.1	Ardelean	19.3	11.6
Jonne spur	47.3^{xxx}	42.5^{xx}	Cardinal	15.9	6.3
Kidd's Orange Red	16.1	9.4	Close	11.8	14.8
Starkrimson	0.5$^{(o)}$	0,1	Romus 3	4.7	8.8
London Pepping	7.7	9.9	Discovery	1.5	0.1
Mutzu	7.6	3.5	Empire	2.7	4.8
NJR 2/11-20	2.5	3.8	Frumos de Voineşti	9.9	10.1
NJR 64	8.4	5.3	NJR 64C	38.9^{xx}	36.6^{x}
Reinette Baumann	3.1	4.1	Parmain d'or	21.6	20.8
Reinette Canada	16.5	6.3	Wealthy	1.4	0.1
Ribston Pepping	25.4	29.4	Wellspur	4.4	1.0
Red Delicious	2.3	18.4	Aromat de vară	43.8^{xxx}	34.8^{x}
Roşu de Cluj	53.7^{xxx}	48.2^{xxx}	Clar alb	16.5	17.9
Şovari	1.7	4.7	Jersey Mac	39.4^{xx}	27.6
Fălticeni	12.4	7.5	Mollie Delicious	16.3	23.6
Kaltherer Böhmer	16.8	12.2	NJR 60	9.4	6.6
Pionier	11.7	0.9	Romus 2	4.2	7.8
Prima	0.8$^{(o)}$	0.6	Italia	4.3	10.0
Voinea	3.4	4.5	Roz de Virginia	19.3	18.0
Generos	5.1	5.6	Mean of exper. (Ct)	15.7	15.7
DL 5% =	16.0	17.6		16.0	17.6
DL 1% =	21.0	23.1		21.0	23.1
DL 0.1% =	27.0	29.6		27.0	29.6

There may be noted that there are obvious differences between the varieties tested, regarding the attack degree of powdery mildew on leaves and shoots, but no variety proved to be immune to the pathogen. The average attack degree for the whole experiment is 15.7%, both on leaves and shoots. The AD% on leaves oscillated between 0.2% (Gloster) and 53.7% (Roşu de Cluj) and the AD% on shoots between 0.1% (Starkrimson, Discovery and Wealthy) and 58.1% (Jonathan).

The results confirm the high susceptibility to powdery mildew of the variety Jonathan and also of some cultivars belonging to the Jonathan "family": Jonne Spur, Jonathan Smith, Black John, Jonathan Watson, Nüred Jonathan, Red Jonagold, Delia, Aromat de vară, Roşu de Cluj. These varieties registered an AD% significantly higher than the experiment average (control). The last two varieties (Aromat de vară and Roşu de Cluj), created in Cluj from the common genitor Jonathan, inherited the susceptibility to powdery mildew (Sestraş et al., 1995). The lowest AD% for powdery mildew on leaves and shoots was recorded in Gloster (0.2% and 0.4%), Starkrimson (0.5% and 0.1%), as well as at one of the varieties with genetic resistance to apple scab, Prima (0.8% and 0.6%).

Table 3 classifies in six groups the 75 varieties, based on the average AD% of powdery mildew on leaves and shoots from the seven research years.

Table 3: Groups of Response to Powdery Mildew of the Cultivars Experimented

Attack evaluation	Cvs. attack on leaves		Cvs. attack on shoots	
	No.	%	No.	%
No attack (AD% = 0)	-	-	-	-
Very weak attack (AD%=0.1-1)	3	4.0	11	14.7
Weak attack (AD%=1.1-5.0)	20	26.7	9	12.0
Average attack (AD%=5.1-15)	21	28.0	27	36.0
Strong attack (AD%=15.1-20)	10	13.3	7	9.3
Very strong attack (AD%>20.1)	21	28.0	21	28.0
Cultivars total	75	100.0	75	100.0

None of the cultivars tested were registered in the category "No attack"; this confirms previous data, according to which it is improbable that a real immunity to disease exists within the cultivated varieties. Out of all cultivars tested, 21 (representing 28.0%) were very severely attacked, both on leaves and shoots.

Even though the graphic for AD% on leaves is quite close to the one for AD% on shoots, their peaks were different: 1991 for leaves and 1992 for shoots (Figure 1).

The coefficient of phenotypic correlation between the attack degree on leaves and the attack degree on shoots in the 75 apple varieties was very significant ($r_p = +0.905^{xxx}$). This suggests the fact that the susceptibility to powdery mildew attack on leaves is strongly correlated with the susceptibility to powdery mildew attack on shoots.

Table 4 displays the way climatic conditions influenced the frequency, intensity and attack degree for powdery mildew at the cultivars studied.

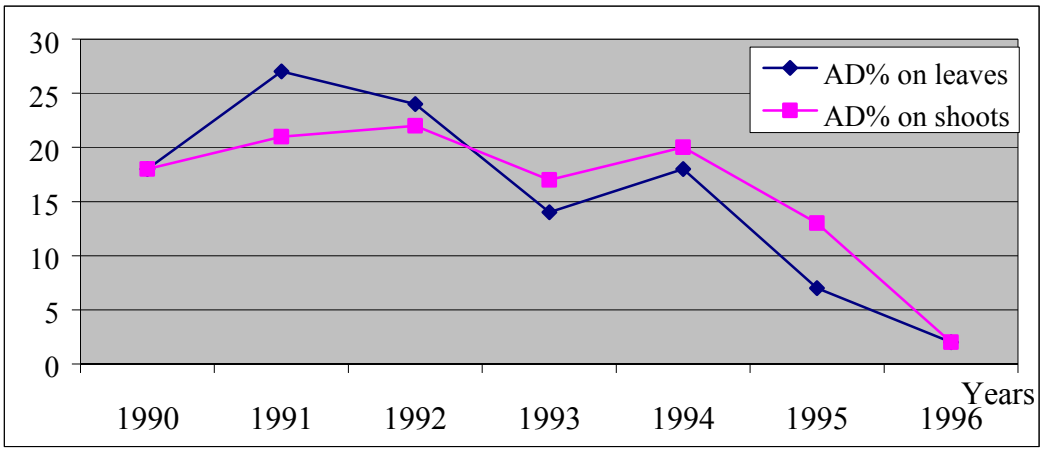
Table 4: Phenotypic Correlations (r_p) Between Average Yearly Temperature (°C), Total Yearly Rainfall (mm/m^2) and Powdery Mildew Attack (1990-1996)

Specification	Attack on Leaves			Attack on Shoots		
	F%	I%	AD%	F%	I%	AD%
Mean temperature/year	+0.277	+0.403	+0.283	+0.520	+0.432	+0.486
Total rainfall/year	-0.567	-0.381	-0.401	-0.450	-0.296	-0.287

r 5% = 0.666

There can be concluded that high temperature favours the frequency and intensity of the powdery mildew on leaves and shoots, while heavy rainfall decreases the level of powdery mildew attack.

Figure 1: Attack Degree AD% Variation for Powdery Mildew on Leaves and Shoots at 75 Apple Cultivars, During the Period 1990-1996



CONCLUSIONS

1. Powdery mildew, caused by the fungus *Podosphaera leucotricha* (Ell. et Everh.) Salm., is one of the most damaging diseases of apple in Transylvania, Romania.
2. There is a wide variability of reaction to powdery mildew attack in 75 apple varieties tested during seven years in an experimental field in Cluj-Napoca. The variation limits for the attack degree on leaves were estimated between 0.2% and 53.7%, and on shoots between 0.1% and 58.1%.
3. The most susceptible to powdery mildew attack were the cultivars of the Jonathan group (e.g. Jonathan, Jonne Spur, Jonathan Smith, Black John, Jonathan Watson, Nüred Jonathan, Delia, Aromat de vară, Roşu de Cluj).
4. Out of all varieties, 21 of them representing 28.0% were registered with a very high attack, both on leaves and shoots. None of the tested cultivars were included in the category "No attack", but the cultivars Gloster, Starkrimson and Prima were registered with a low attack degree and these are potential sources for further breeding programmes.
5. The high temperature increased the frequency and intensity of the powdery mildew on leaves and shoots, while heavy rainfall diminished the level of powdery mildew attack.

REFERENCES

[1]. Alston F.H., 1969: Response of Apple Cultivars to Mildew (*Podosphaera*), Rep. E. Malling Res. Str. for 1968, 133-135.
[2]. Ardelean, M., Sestraş, R., 1999: Ameliorarea plantelor horticole, Ed. Osama, Cluj-Napoca.
[3]. Bucarciuc, V. F., 2003: Studiul soiurilor de măr şi ameliorarea genetică a mărului în Republica Moldova, Teză de doctor habilitat în ştiinţe agricole, Institutul de Genetică al A.Ş.R.M, Chişinău.
[4]. Cociu, V., Oprea, St., 1989: Metode de cercetare în ameliorarea plantelor pomicole, Ed. Dacia, Cluj-Napoca.
[5]. Kellerhals, M., 1989: Breeding of Pome Fruits with Stable Resistance to Diseases, Development of Diseases Resistant Pome Fruit Varieties, In: OILB Work. Gr. Int. Contr. Pome Fruit Disease, WPRS Bull. XII/6, 11, p. 116-129.
[6]. Lateur, M.C., Populer, C., 1994: Valorisation of Fruit Tree Genetic Resources, Acta Hortic. 355, Plant Breeding for Mankind, p.163-172.
[7]. Sestraş, R., Ghidra, V., Râureanu, V., 1995: Particularităţi ale unor soiuri de măr create la Cluj-Napoca comparativ cu soiul Jonathan. III. Alternanţa producţiei de fructe şi comportarea faţă de atacul principalelor boli şi dăunători, Bul. USAMV, A-H, 49/1, p 25-32.

[8]. Sestraş, R., 1997: Ameliorarea mărului, Ed. Quo Vadis, Cluj-Napoca.

ADDRESS OF AUTHORS

Radu Sestraş: rsestras@email.ro; rsestras@yahoo.co.uk

University of Agricultural Sciences and Veterinary Medicine,
Faculty of Horticulture, Cluj-Napoca, Romania
Phone: +40-264-596384
Fax: +40-264-593792