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Field Evaluation of Traditional Apple Cultivars to Induced Diseases and Pests

János BÁLINT[1,2*], Rezső THIESZ[1], Imre-István NYÁRÁDI[1], Károly-Attila SZABÓ[1]

[1]*Sapientia University, Faculty of Technical and Human Sciences, Department of Horticulture, str. Sighisoara 1C. Tirgu-Mures, Romania; balintjanos@ms.sapientia.ro (*corresponding author)*

[2]*Corvinus University of Budapest, Faculty of Horticultural Science, Department of Entomology, Budapest, Hungary*

Abstract

During the survey we studied traditional old apple cultivars in order to test disease resistance, as part of an apple breeding program. Diseases and pests assessments were made throughout the two growing season in 2008 and 2009 in traditional apple cultivars ('Batul', 'Pónyik', and 'Sóvári') from stray and commercial ('Golden Delicious' and 'Starkrimson') apple orchards. Our data add to a body of evidence indicating that traditional apple cultivars under natural selection and without pesticide regime are highly and/or moderately resistant to fire blight, apple powdery mildew and apple scab. High resistance was observed for green apple aphid ('Sóvári') and rosy leaf-curling aphid (all cultivars, except 'Sóvári') throughout the assessment. Susceptibility from mediate to high level was observed for fruit peel moth and pear-leaf blister moth, while resistance and/or moderate resistance for spotted tentiform leafminer and codling moth. The codling moth damages were significantly correlated with seed number in fruits throughout the whole vegetation period. We can conclude that old apple cultivars sustained in their original regions could be a significant source of genes for apple breeding programs.

Keywords: breeding program, diseases, insect pests, resistance

Introduction

Apple is host to a wide range of diseases and pests, many of which are present in all apple producing regions in the world (Way *et al*., 1990). In order to manage this pest complex and produce a marketable crop, growers have relied on 10 to 18 applications of crop protection chemicals (MacHardy *et al*., 2001), at an annual cost of $200 to 125/ha (Reganold *et al*., 2001; Zhang *et al*., 2009). Apple-growers usually adopt a zero tolerance policy towards pathogens and major insect pests (Percival and Boyle, 2005). Consequently, the economics of fruit production requires frequent application of synthetic pesticides throughout the growing season (Eccel *et al*., 2009).

Increased pathogen and pests insensitivity to synthetic pesticides, coupled with public demand to reduce pesticide use stimulated by greater awareness of environmental and health issues, has placed more emphasis on alternative pest control strategies (Percival, 2008; Schnabel and Parisi, 1997; Schneider *et al*., 1997; Stanis and Jones, 1985). However, there are limited possibilities to control the diseases and pests, especially in organic apple systems (Bryk and Broniarek-Niemiec, 2008; Valiuškaitė *et al*., 2009). Therefore, the availability of apple cultivars resistant to diseases and pests is essential for a successful fruit production (Gelvonauskienė *et al*., 2008; Godec, 2004).

We started our research with the aim of screening domesticated apple genetic resources. We selected traditional old apple cultivars in order to check disease resistance, as part of an apple breeding program (Tóth *et al*., 1994; 2005 a, b).

Materials and methods

Site description

Diseases and pests assessments were made throughout the two growing season in 2008 and 2009 in traditional apple cultivars from stray and commercial apple orchards. Traditional cultivars ('Batul', 'Pónyik' and 'Sóvári' total of 117 tree) were found in rural environments, in two villages in central Transylvania, Mures County, 20 km north of town Târgu Mureş (46°39'39.81" N, 24°43'45.68" E and 46°38'41.29" N, 24°44'43.63" E). The average tree maturity was evaluated to be over 40, and in a few cases even 60 to 80 year-old trees were found. Neither pesticides nor fertilizers were used in any of the sites. Additional investigations in the same sites were made to test the codling moth damages in cultivars 'Téli aranypármen', 'Bőralma', 'Cigányalma' and 'Tányéralma' a total of 17 (Tab. 1).

The commercial apple trial sites consisted of randomly selected 40 trees from each cultivar ('Golden Delicious' and 'Starkrimson') (Tab. 1). The sites are located in central Transylvania, Mureş County, 10 km Târgu Mureş (46°38'53.62" N, 24°27'30.14" E). This is a 10 km distance from the investigated rural sites in the same environment (woodland area of medium high mountains). Trees were planted in 1980 in black forest soil (4-6% organic matter, pH of 5.2) and trained under the central-leader system to an average height of 30 cm above the soil level with mean trunk diameters of 35 cm for 'Golden Delicious' and 28 cm for 'Starkimson'. Weeds were controlled chemically using glyphosate once a year throughout the experiments.

Tab. 1. The number of investigated traditional and commercial apple cultivars

Varieties	'Batul'	'Bőralma'	'Cigányalma'	'Pónyik'	'Sóvári'	'Tányéralma'	'Téli aranypármen'	'Golden Delicious'	'Starkimson'
Number of trees	40	5	4	50	27	3	5	40	40
Samles/tree	40	40	40	40	40	40	40	40	40

No watering, fertilization or pesticides were applied during the two years' trial.

Field trials

During the experiment, the following disease and pest evaluations were made periodically:

fire blight (*Erwinia amylovora*)
apple powdery mildew (*Podosphera leucotricha*)
apple scab (*Venturia inaequalis*)
woolly apple aphid (*Eriosoma lanigerum*)
green apple aphid (*Aphis pomi*)
rosy leaf-curling aphid (*Dysaphis devecta*)
fruit peel moth (*Adoxophyes reticulana*)
pear-leaf blister moth (*Leucoptera scitella*)
spotted tentiform leafminer (*Phyllonorycter blancardella*)
codling moth (*Cydia pomonella*)

Weekly assessments were made during the vegetation season from April until the end of October, both in the commercial and stray plots. Trees were inspected randomly, both their leaves and fruit. In each investigation period, ten branches of similar maturity were randomly selected from the northern, southern, eastern and western parts of the trees (n = 40/tree for each cultivar, Tab. 1), and the infestation level of flowers, branches and fruits (for fire blight) and leaves, respectively fruits for apple scab were assessed. Fruits were harvested each time after evaluation. For powdery mildew and apple scab, the method described by Krüger (1994) was used. Each leaf and fruit was classified in four different groups, according to foliar discoloration, discoloration and subsequent scab infection as follows:

1 = healthy (0 or less than 5% foliar and fruit damage by discoloration, scab infection, leaf deformation)
2 = slight infestation (5% to 30% damage)
3 = moderate infestation (30% to 60% damage)
4 = severe infestation (60% to 100% damage)

As for aphids (green apple aphid and rosy leaf-curling aphid) and two moth pests (pear-leaf blister moth and spotted tentiform leaf miner), the individuals were counted weekly in 40 randomly selected branches with leaves and fruits from each tree.

Tree trunks and older branches were also investigated weekly, to determine the infestation level with woolly apple aphid. The fruit peel moth damages were assessed in a similar way in April and May 2008 and 2009 in ten randomly selected branches from the northern, southern, eastern and western part of the trees (n = 40).

The codling moth damage was surveyed from spring to harvest in ten randomly selected fruits from the northern, southern, eastern and western part of the trees (n = 40). In all cases fruits were harvested and both seed number and fruit-mass determined for each apple cultivar.

Data analysis

A general infestation level of pathogen and insect pests and an average seed number were calculated for each cultivar considering the number of infested leaves and fruits from each investigated branch/tree. Analyses of variance (rank ANOVA for powdery mildew and apple scab) were performed and similarities were compared using the O'Brien and Levene tests to determine the differences in infestation level for each pathogen and pest. Values of F and p were computed using SPSS software and confidence limits of $p < 0.05$ were considered significant. Pearson's linear correlation was computed to compare the codling moth damage with seed number for each cultivar. To avoid pseudoreplication, analyses were performed by using the means of the cumulative data of infestation level and seed number for each cultivar.

Results

All traditional apple cultivars were completely free of fire blight during the two-year assessment and moderate resistance was observed for commercial cultivars; however, the bacterium made severe damages in both pear and quince trees all over the region. Mean foliar damage was significantly different for apple powdery mildew and apple scab. Relatively low infection of powdery mildew was observed for all cultivars (except 'Pónyik') ($df = 4, F = 7.03, p = 0.002$), while the apple scab clearly dominated the commercial cultivars both on leaves ('Golden Delicious' $df = 4, F = 2.15, p = 0.0001$, 'Starkrimson' $df = 4, F = 2.42, p = 0.0002$) and fruits ('Golden Delicious' $df = 4, F = 4.65, p = 0.0002$, 'Starkrimson' $df = 4, F = 2.22, p = 0.0002$) (Fig. 1).

Traditional cultivars were completely free of woolly apple aphid during the whole vegetation period, moderate resistance was observed for commercial cultivars. Incidence of apple aphid and rosy leaf-curling aphid differed substantially among the cultivars, with a range of < 3 (for old cultivars) to nine colonies in ten branches (for apple aphid in 'Golden Delicious' and 'Starkrimson') ('Golden Delicious' $df = 4, F = 13.37, p = 0.003$, 'Starkrimson' $df = 4, F = 9.94, p = 0.003$) (Fig. 2). 'Golden Delicious' and

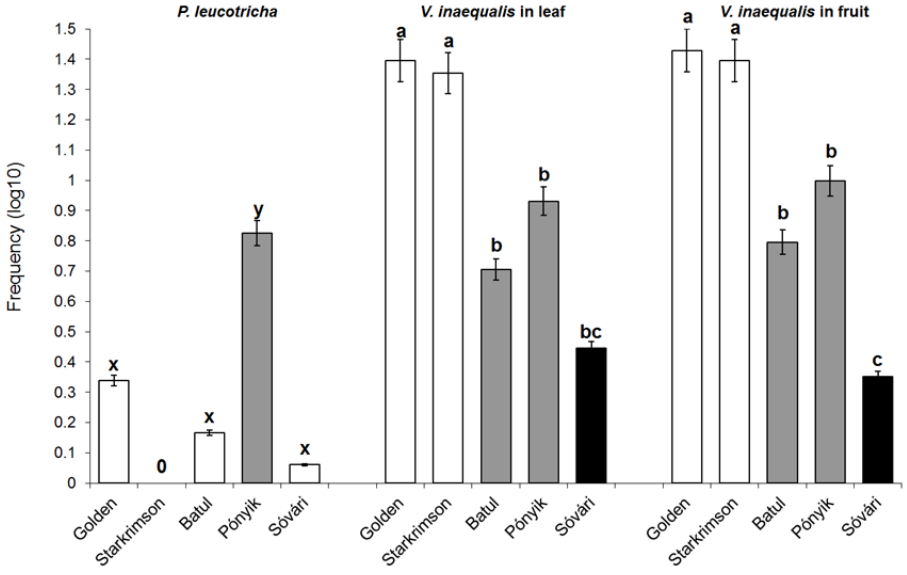

Fig. 1. The powdery mildew (*P. leucotricha*) and apple scab (*V. inaequalis*) infection of the commercial and traditional apple cultivars. Data of powdery mildew were analysed separately. Different letters $p < 0.01$ (rank ANOVA)

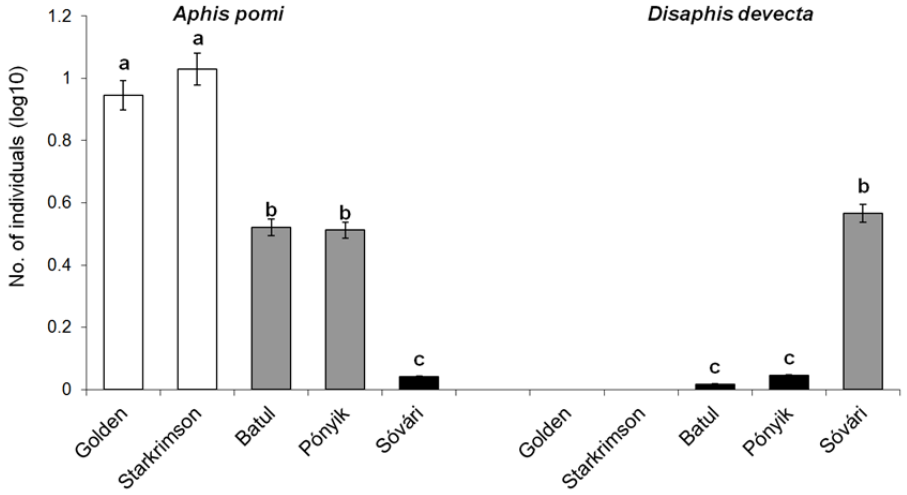

Fig. 2. The green apple aphid (*Aphis pomi*) and rosy leaf-curling aphid (*Dysaphis devecta*) infection of the commercial and traditional apple cultivars. Different letters $p < 0.01$ (ANOVA)

'Pónyik' presented the highest range susceptibility for fruit peel moth ('Golden Delicious' $df = 4$, $F = 8.71$, $p = 0.001$ and 'Pónyik' $df = 4$, $F = 4.62$, $p = 0.002$). All traditional cultivars had a midrange of susceptibility for pear-leaf blister moth and low susceptibility for spotted tentiform leafminer (Fig. 3).

Codling moth was the most problematic pest. Even under relatively low average yearly temperature, it was able to complete three generations each year. There was a positive and significant correlation between average percent of fruit injury and average seed number of the cultivars ($R = 0.86$, $p = 0.01$) (Fig. 4).

Discussion

These data add to a body of evidence indicating that traditional apple cultivars under natural selection and without pesticide regime are highly and/or moderately resistant to fire blight, apple powdery mildew ('Batul' and 'Sóvári') and apple scab ('Sóvári'). Previous studies confirmed that 'Batul' and 'Pónyik' showed high resistance following artificial inoculation with fire blight bacteria (Kása *et al*., 2005; Tóth *et al*., 2005 a, b). The general scab severity of leaves and fruit was lower for traditional cultivars than for commercial ones (Tab. 2). Since resistance and/or susceptibility levels are often known to vary among

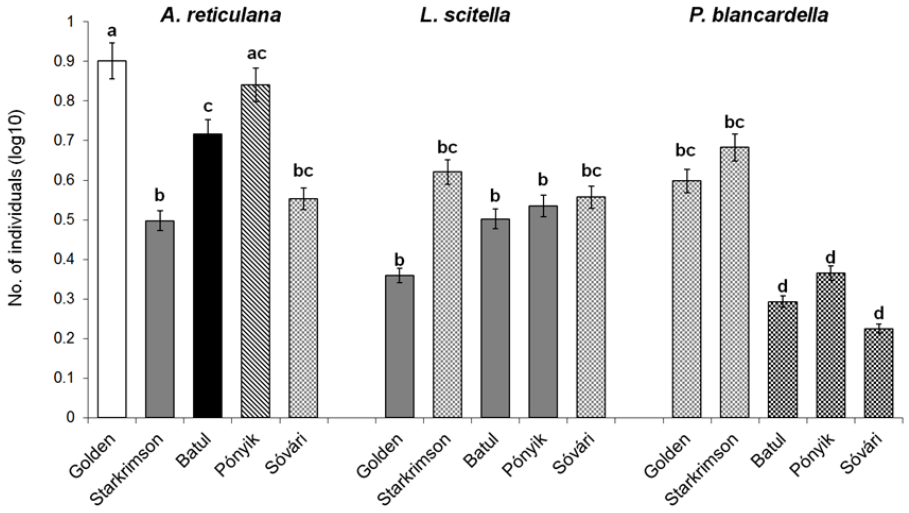

Fig. 3. The fruit peel moth (*A. reticulana*), pear-leaf blister moth (*L. scitella*) and spotted tentiform leafminer (*P. blancardella*) infection of the commercial and traditional apple cultivars. Different letters $p < 0.01$ (ANOVA)

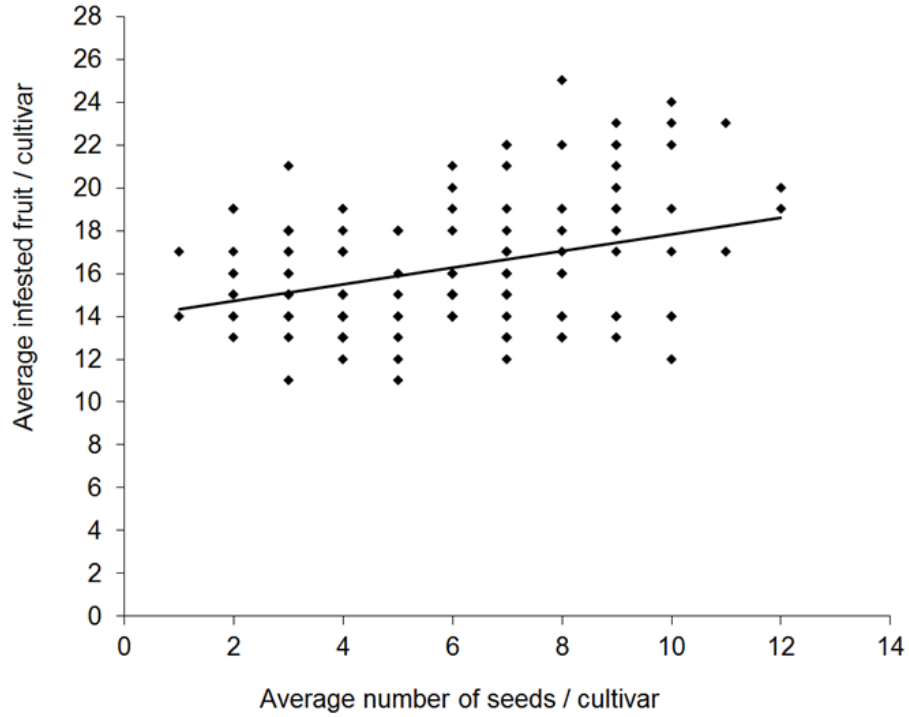

Fig. 4. Pearson's linear correlation between the mean seed number and the codling moth infection of the commercial and traditional apple cultivars. Test based on the mean of the cumulative data of 40 fruit/week collected from each tree during the vegetation season 2008 and 2009

genetically identical plants and/or organs of different ages (Bellon *et al*., 2001), further assessment is required to investigate the genetical and physiological background of old apple cultivar resistance (Holb, 2009). Other disease resistance mechanisms, such as physiological approaches (e.g. systemically acquired natural resistance) might be involved in the practice of a successful apple disease management. Either way, the host resistance approach will receive great attention in the future, as basically this seems to be the least costly option for growers and the most environmentally friendly approach for effective disease management (Holb, 2009). Cool and wet spring conditions in the region maintained foliage in a succulent condition for an extended period of time, which was favourable for aphids, but unfavourable for natural enemies. Cool weather also delayed aphid development, thus prolonging their time period, however high was the resistance of cultivars for green apple aphid ('Sóvári') and rosy leaf-curling aphid

Tab. 2. Different susceptibility levels of the most common commercial and traditional apple cultivars

Diseases	'Golden Delicious'	'Starkrimson'	'Batul'	'Pónyik'	'Sóvári'
E. amylovora (Burrill)	mod. resistant	mod. resistant	highly resistant	highly resistant	highly resistant
P. leucotricha (Ellis & Everh)	mod. resistant	highly resistant	mod. resistant	susceptible	mod. resistant
V. inaequalis (Cooke) in leaf	highly susceptible	highly susceptible	susceptible	susceptible	susceptible
V. inaequalis in fruit	highly susceptible	highly susceptible	susceptible	susceptible	mod. resistant
Pests					
E. lanigerum (Hausmann)	mod. resistant	mod. resistant	highly resistant	highly resistant	highly resistant
A. pomi (De Geer)	highly susceptible	highly susceptible	mod. resistant	mod. resistant	highly resistant
D. devecta (Walker)	highly resistant	highly resistant	highly resistant	highly resistant	mod. resistant
A. reticulana Hübner	highly susceptible	susceptible	susceptible	highly susceptible	susceptible
L. scitella Zeller	susceptible	susceptible	susceptible	susceptible	susceptible
P. blancardella F.	susceptible	susceptible	mod. resistant	mod. resistant	mod. resistant
C. pomonella L.	susceptible	mod. resistant	mod. resistant	mod. resistant	susceptible

(all cultivars, except 'Sóvári') throughout the two-year assessment.

Historically, the cultivars were exposed to moth pest injury throughout a considerable time of the growing season from two generations of fruit peel moth and three generations of pear-leaf blister moth, spotted tentiform leafminer and codling moth. Susceptibility from mediate to high level was observed for fruit peel moth and pear-leaf blister moth, while resistance and/or moderate resistance for spotted tentiform leafminer (all old cultivars) and codling moth ('Starkrimson', 'Batul' and 'Pónyik').

The codling moth damages were significantly correlated with seed number in fruits throughout the whole vegetation period. Although the number of trees tested from other cultivars were limited ('Téli aranypármen' (n=5), 'Bőralma' (n=5), 'Cigányalma' (n=4) and 'Tányéralma' (n=3)), the correlation without these was even better (R = 0.89, p = 0.001). This could be a significant factor in structuring codling moth populations and it may help in identifying the origin, number of invasions and the spread of the infestation (Franck and Timm, 2010; Hogmire and Miller, 2005; Roderick, 1996).

Conclusions

Furthermore, we can conclude that old apple cultivars sustained in their original regions could be an important source of genes for apple breeding programs. The main purpose of apple breeding is to produce resistant/tolerant apple cultivars against diseases and pests. The necessary background for this purpose can be found in regional old varieties.

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