INVESTIGATION ON THE PLUM POX VIRUS RESISTANCE IN DIFFERENT APRICOT GENOTYPES

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Summary. – In our three-year investigation, 164 apricot trees of different old German varieties cultivated in the Mansfelder Land region were tested for the plum pox virus (PPV) resistance by double grafting in greenhouse conditions using an isolate of PPV D strain from our region. We selected 25 genotypes with quantitative resistance and two with immunity. The first results of field trials are comparable with those from greenhouse. With cvs. Virosia and Brevira, two local quantitatively resistant varieties will be available from autumn 1998. The origin of both trees, which were found to be immune, is still unclear. They will be used for propagation only after the variety identification.

Key words: plum pox virus; apricot; German cultivars; Virosia; Brevira; Mansfelder Land region; quantitative resistance; immunity

Introduction

PPV represents a serious danger for apricot cultivation in the Mansfelder Land region, a traditional cultivation area of this fruit species in Germany. In connection with the implementation of a research project supported by the Ministry for Regional Planning, Agriculture and Environment of Saxony-Anhalt as well as by the EU, a three-year programme has been proposed. This programme comprises seven separate steps: registration and charting of all apricot trees in the Mansfelder Land region, visual evaluation of symptoms of sharka disease, testing of all symptomless trees by enzyme-linked immunosorbent assay (ELISA), testing of selected virus-free trees of different varieties for virus resistance by double grafting under greenhouse conditions, propagation of resistant genotypes, cultivation of vegetatively propagated progenies under natural infection pressure, and provision of resistant nursery apricot trees for planting in intensively used plantations or orchards.

The present report is restricted to the evaluation of old German apricot cultivars for resistance to PPV and gives results of a three-year investigation.

Materials and Methods

The testing of selected trees for PPV resistance by double grafting in greenhouse turned out to be the decisive step (Kegler *et al.*, 1994; Fuchs *et al.*, 1997). Twigs of apricot genotypes were double grafted with evidently PPV-infected graft sticks using the PPV isolate 12/6 (D strain) from this region. Both were grafted on virus-free rootstocks of cv. St Julien INRA with 5 replications for each of the selected trees for testing. After extensive preliminary examination (visual evaluation, ELISA, general health of tree, fruit quality and others), 164 trees of different varieties such as cvs. Ambrosia, Breda, Frühe Deutsche, Schnake, and Magdeburger Frühe, the selection of cv. Marena as well as varieties of unknown origin were checked by means of the greenhouse test. All the trees were cultivated in the Mansfelder Land region.

In further experiments lasting several years, we examined the virus distribution in selected susceptible, quantitatively resistant as well as immune genotypes, always in comparison to varieties with known resistance such as cvs. Harlayne, Stark Early Orange and Goldrich. In these experiments, grafted greenhouse trees used 24 weeks after double grafting and one- or two-year-old grafted trees growing in the open ground, single branches of which were inoculated with PPV, served as test materials. The last mentioned trees were inoculated with PPV in August of the years 1996 and 1997 (altogether 13 and 12, respectively). Three virus-infected buds

were inserted into branch per tree using again the PPV isolate 12/6 (D strain).

Results

According to preliminary experiments on apricots (Fuchs *et al.*, 1997), three different reaction types could be expected after virus inoculation by double grafting in greenhouse.

Type 1. Unhindered virus immigration into the graft stick is characteristic and virus multiplication takes place in most of the grafted trees, symptoms appear on all young shoots, which are evenly penetrated by the virus. This behaviour is referred to as the susceptibility.

Type 2. Virus immigration into the graft stick to be tested is hindered and delayed. The first symptoms occur only after week 8 post inoculation (p.i.) and normally only on single leaves of some of the grafted trees. The virus distribution is irregular. Only single leaves (usually those with symptoms) contain the virus. All these traits are characteristic for so-called quantitative (partial) resistance. The nature of this reaction type under field conditions has still to be investigated. It is supposed that these genotypes remain healthy under natural infection pressure.

Type 3. The virus is unable to penetrate the top graft stick. Obviously, there is a barrier which cannot be overcome by the virus. So far, no reasons for this phenomenon are known. The graft stick is obviously virus-free. This reaction type is designated as immunity.

The results of the greenhouse test allowed to assess the checked 164 apricot trees according to their behaviour to PPV. We found 25 trees (15.2%) exhibiting quantitative resistance and two trees (1.2%) showing immunity. All the other trees (83.6%) proved to be extremely susceptible (Table 1). The infection rates for the graftings growing in greenhouse served as basis for this estimation. Eight weeks after double grafting, susceptible trees showed infection rates of 26 – 100%. Twenty-four weeks p.i., the infection rates of the trees with quantitative resistance were below 25%. The graftings of immune trees remained virus-free during the whole observation period.

With regard to virus distribution after double grafting, susceptible individuals (the first 5 trees including cv. Goldrich in Table 2) showed uniform virus distribution. On the average, 91.2% of all leaves responded PPV-positively. The doubly grafted greenhouse trees of the original trees B/S 1, S/A 3, S/A 6, S/A 13, S/A 14, S/B 35, S/B F, Mö 3 and Qu 3 showed virus infection only in 3.8% of all leaves. Cv. Stark Early Orange was classified as a representative of the last mentioned group with 3.6% of infected leaves. The two trees Ku 9 and Ku 10 (unknown varieties) were assessed as immune by analogy with cvs. Harlayne and Orange Red. No leaves showed virus symptoms, and they remained virus-free as far as tested.

As regards the examination of PPV-inoculated trees in the open, in June–July 1997 and June 1998, all the leaves of inoculated branches were inspected for virus symptoms and separately retested by ELISA (Table 3). On the whole, these results are comparable with those obtained by double grafting in greenhouse. Susceptible genotypes showed uniform virus distribution also in this experiment. On the average,

Table 1. Results of greenhouse tests with 164 apricot trees from the Mansfelder Land region in 1996–1998

Weeks after double grafting	Number of tested trees	Number of trees with infection rates of graftings in the following groups				
		76-100%	51-75%	26-50%	1-25%	0%
4	164	7	12	24	35	86
5	164	20	31	36	21	56
6	164	32	38	34	19	41
7	164	70	35	24	12	23
8	164	93	25	15	14	17
9	29[a]	–	–	–	13	16
11	29	–	–	2	14	13
14	27[a]	–	–	–	18	9
24	27	–	–	–	25	2[b]

[a]The graftings of susceptible trees were eliminated.
[b]Trees with immunity: Ku 9, Ku 10.

Table 2. Detection of PPV in all single leaves of graftings by ELISA 24 weeks after double grafting in greenhouse

Original tree/Cultivar	Number of tested graftings	Number of tested leaves	Percentage of PPV-positive leaves
BS Sch	1	37	97.3
Ep 1	1	36	88.9
Hó 2/5	2	80	81.2
Hö 2/6	2	54	98.1
cv. Goldrich	1	53	96.2
B/S 1	4	75	4 0
S/A 3	2	42	4.8
S/A 6	7	316	5.1
S/A 13	4	163	1.8
S/A 14	4	93	3 2
S/B 35	6	218	1 8
S/B F	2	68	4.4
Mö 3	4	115	4.3
Qu 3	3	58	5.2
cv. Stark Early Orange	10	264	3.4
Ku 9	4	196	0.0
Ku 10	5	128	0 0
cv. Harlayne	6	218	0 0
cv. Orange Red	2	122	0.0

Table 3. Detection of PPV in all single leaves of PPV-inoculated branches by ELISA one year post inoculation (field trial)

Original tree	Number of tested leaves	Number of PPV-positive leaves	
		Absolute	Relative (%)
S/B 35	357	15	4.2
S/A 3	247	3	1 2
S/A 6	265	8	3.0
S/A 13	494	19	3 8
S/Mö 28	64	33	51.6
F 6	107	63	58.9
F 47	118	51	43.2
Hó 2/2 (cv Stark Early Orange)	305	0	0 0
Ho 2/10 (cv. Orange Red)	147	0	0.0

50.9% of all tested leaves responded PPV-positively. Graftings of trees with quantitative resistance were characterized by limited and delayed virus distribution. The percentage of infected leaves amounted to 3.3 %. The leaves of immune genotypes (for example cv. Orange Red) remained virus-free without symptoms as far as tested. In this field trial, cv. Stark Early Orange could not be infected. In the second year after inoculation, the virus remained limited to single leaves of the inoculated branch. In susceptible genotypes, however, systemic distribution set in. It will be interesting to observe the distribution of PPV within the treetop in the next years.

Discussion

The most efficient method of control of the sharka disease is the breeding and cultivation of PPV-resistant cultivars. At the same time, this is also the only possibility to preserve the apricot cultivation in the Mansfelder Land region, the largest closed area under cultivation of this fruit species in Germany. By means of double grafting in greenhouse we could find quantitatively resistant and immune genotypes selected from old German cultivars.

We interpret the uneven and delayed virus distribution in an inoculated tree as an important indication of quantitative resistance. The result with cv. Goldrich is remarkable. Whereas some authors describe cv. Goldrich as resistant (Dosba *et al.*, 1988; Karayiannis, 1988; Karayiannis and Mainou, 1993, 1994), our results show that it is extremely susceptible. Our results are in accord with those of Polák and Komínek (1995), Polák *et al.* (1995), and Krška *et al.* (1997), who noted PPV susceptibility of cv. Goldrich. Obviously, the PPV resistance is developed only in combination with specific virus strains and/or with specific climatic conditions. On the other hand, cv. Harlayne showed immune behaviour as already described (Dosba *et al.*, 1992; Polák *et al.*, 1995, 1997).

At present, we examine reactions of the trees with quantitative resistance or immunity under natural infection pressure. The necessary experimental arrangements have been made. In spring 1996, we produced the first graftings using 10 trees with quantitative resistance and rootstocks of cv. Brompton. In autumn 1996, most of those graftings were planted in the open ground under conditions of natural infection. In the following year the planting of resistant material in the field was continued.

In connection with a subsequent research project which deals with the mechanism of the sharka resistance in apricot trees, it is planned (1) to investigate the reaction of quantitatively resistant and immune trees after inoculation by natural vectors (aphids), and (2) to examine the influence of different PPVstrains (M, D, El Amar and Ch) on the resistance level.

As everybody knows, M strains are more aggressive and therefore more suitable for the resistance examination (Dosba *et al.*, 1992). According to our investigation, the apricot trees of the Mansfelder Land region are obviously infected with D strains only.

In conclusion, it may be stated that the efforts towards selection of sharka-resistant apricots from local German varieties were successful. After extensive propagation of two quantitatively resistant genotypes in summer 1997, it will be possible to offer the first two local resistant varieties in autumn 1998.

Cv. Virosia is a medium-early ripening apricot. Its fruits are very suitable for fresh consumption, and they have an ochre-yellow, on the sunny side an orange-yellow or weakly reddish-yellow colour. The fruit flesh is firm, comes off the stone easily, and is characterized by a juicy, sweet and fine aromatic flavour.

On the other hand, the early ripening cv. Brevira is extremely suitable for preserving and baking. The orange-yellow, on the sunny side weakly reddened fruits are characterized by a fine, weakly pineapple-like flavour.

So far, the origin of both trees (Ku 9 an Ku 10) that were found to be immune is still unclear. They will be used for propagation only after doubtless variety identification. At present, we attempt to determine the variety by means of isoenzyme pattern. The first results revealed some differences from American varieties with known PPV resistance.

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