BREEDING OF PLUMS AND PRUNES RESISTANT TO PLUM POX VIRUS

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Summary. – At Hohenheim we started a plum breeding programme to get new sharka-resistant cultivars with better fruit quality. In the last years we have recognized that the resistance of all cultivated plums is based on quantitative criteria and therefore relative. For this reason we changed our strategy for the resistance breeding. For the first breeding cycle we used special donors with quantitative resistance. Today, the qualitative resistance is more integrated. We intend to combine both types of resistance in the hexaploid genome of *Prunus domestica* to obtain an absolute and durable resistance. To achieve this aim, we have to consider the evaluation of resistance, the genetic resources, the inheritance of the resistance and also the breeding methods. The results of our resistance breeding study are presented.

Key words: plum; breeding; sharka; quantitative and qualitative resistance

Introduction

Plum pox virus (PPV) is spread in nearly all important plum growing regions in Europe. It is one of the most important viruses in fruit trees and causes damage of high economical value to stone fruit production. The eradication of infected trees and the production of virus-free plant material are in most cases not sufficient to control the disease. The fruit production in highly infected regions is only possible with tolerant or resistant cultivars (Hartmann, 1997; Kegler and Hartmann, 1998). Trees of such cultivars may be also infected by the virus but mostly only a little damage is evident. Some resistance tests have been developed to look for such cultivars. It has been found that there exist some cultivars with fairly good resistance but their fruit quality in most cases is not adequate for the German market. Consequently, we started at Hohenheim an own plum breeding programme (Hartmann, 1993).

The problems connected with sharka cover a wide field. In resistance breeding we have to take into consideration the evaluation of resistance, the inheritance of resistance and also the breeding methods.

To date, all sharka-resistant cultivars are quantitatively resistant. That means they are not free of virus and the resistance is always relative. This may explain different results of resistance testing. Since there exist no sharka-immune types of plums, we have to look for another way to get absolutely resistant varieties. We have to develop a strategy for obtaining absolutely resistant plums.

Materials and Methods

The pollination was made without emasculation of the flowers. Therefore self-fertile varieties were pollinated 1 – 3 days before opening of the flowers. Seedlings were produced by the technique of embryo culture, planted for 1 – 2 years in the nursery and afterwards in the orchard at a distance of 4 x 1.25 m. The main criteria for selection were as follows: fruit set, taste, ripening season, size, shape, colour, firmness of fruits and flesh adherence to the stone. After 3 years of evaluation promising hybrids were tested for virus status and grafted on the rootstock of cv. St. Julien GF 655/2 for further selection in the second step in different regions.

Promising hybrids were also subjected at this stage of selection to sharka resistance tests. These tests were made by the Landesanstalt für Pflanzenschutz in Stuttgart. The hybrids of the first breeding cycle were tested by grafting on young, naturally infected trees of cv. Deutsche Hauszwetsche which were produced in tissue culture. For testing the field resistance, 6 virus-free trees per hybrid were planted side by side of the infected trees. The hybrids of the second breeding cycle were tested by grafting on artificially infected rootstock of *P. cerasifera*. In this test, 3 infected trees and 3 healthy trees were planted for testing the field resistance. Symp-

toms on fruits, leaves and bark, as well as dropping of fruits and a change of ripening season were also recorded.

At the research station of Oppenheim, several hybrids were also tested on trees artificially infected by chipping. Promising hybrids were planted also in highly infected orchards in different regions for testing the field resistance. The obtained field-resistant hybrids were pre-tested for hypersensitivity by double grafting. As donors served PPV CG strain-infected budwoods grafted on the rootstock of cv. St. Julien A. Symptoms were recorded and serological tests were made by enzyme-linked immunosorbent assay (ELISA).

Hybrids reacting hypersensitively in this test were grafted on intensively infected trees in two different regions and the shoot growth was recorded. These hypersensitive hybrids served also for grafting of sharka-infected budwoods. The growth of budwoods was recorded and the PPV infection in the hybrids was assayed by ELISA.

Results and Discussion

Genetic resources

The first data about the sharka-resistance of cultivars have been obtained by monitoring of naturally infected orchards. Christoff (1951) and Jovicevic (1967) found in this way the resistant cvs. Stanley, Montfort and Ontario. The aim of this screening was to find resistant cultivars for plum production. For the same purpose, different plum cultivars were tested by artificial infection by Hamdorf (1984). Bivol *et al.* (1987) were looking in extensive experiments especially for genetic resources. Much more research work should be done in the screening of local cultivars and wild types. They may be very useful as genetic resources.

The results of reports about the resistance of various cultivars are not always in accord, they depend on the virus strain, climatic conditions and also the kind of infection. Sometimes there may occur also a mix-up of various cultivars. It is possible to use different ways of infection.

The most usual way is an artificial infection by chipping or budding. According to our experience, we recommend the test performed by infecting rootstocks, testing them for successful infection, and grafting.

Inheritance of PPV resistance

From the polyploidy of *P. domestica* and the types of resistance we can conclude a complicated inheritance. The inheritance of resistance was studied so far only on a small scale. The crossing of two resistant varieties does not always raise the level of resistance (Bivol *et al.*, 1988), but we could obtain highly resistant hybrids by crossing two susceptible cultivars like Cacanska Najbolja raised by crossing cvs. Wangenheims Frühzwetsche and Pozegaca. We can explain this fact by accumulation of genes in the hexaploid genome. Because of this special genome it is also possible to combine the qualitative and quantitative resistance to get a higher resistance level. In national and international breeding programmes, this should be a new approach to get durable and absolutely resistant plums.

Breeding programmes and their results

In the first cycle of the resistance breeding in 1980–1982, we used as parents traditional cultivars such as Ruth Gerstetter, Ersinger or Stanley. There were produced about 1000 seedlings. In testing for the sharka resistance were selected 50 promising hybrids which had at least 1 – 2 resistant or tolerant parents. As a result of our 4-year tests we found 11 resistant and 10 tolerant hybrids. The rate of more than 40% resistant or tolerant hybrids was surprising. Cv. Stanley proved to be a good donor. In 8 of the 10 resistant hybrids this cultivar was one of the parents. The type of resistance found by us was mainly the quantitative one. However, recently we found also a qualitative resistance especially in progenies of crossings with cv. Ortenauer. From this first breeding cycle resulted the resistant or tolerant cvs. Hanita, Katinka, Elena, Tegera, and Presenta.

In the following years crossings were made from very resistant cultivars like Cacanska Najbolja, Mirabelle of Nancy, and hybrids of the own breeding work.

Sutic and Rankovic (1981) reported on the complete resistance of cvs. Scoldus Nr. 1 and Jelta Boutil Covidna. Therefore they were also integrated in our breeding programmes. In the meantime, an infection of this type was found also in Bulgaria (Djouvinov, 1996). Therefore, the two abovementioned wild types were also integrated in our breeding programme. At present we have no knowledge about the existence of really immune types.

An absolute resistance may exist as result of qualitative resistance based on hypersensitivity. The hypersensitive response is one of the most efficient natural mechanisms of defence that is induced by the infection itself. It has two main characteristics, necrosis at and around each point on which the leaf was infected and localization of the parasite.

In some traditional cultivars we can find different degrees of the necrosis (Albrechtová, 1985). The necrosis on leaves, bark or wood of young shoots is regarded as a negative reaction of the plant and evaluated accordingly. But this reaction should be considered today from another point of view. From a breeder's point of view, such cultivars may be valuable donors of hypersensitivity which can involve absolute resistance in the field. In the hexaploid genome of *P. domestica* we try to combine qualitative and quantitative resistance to get a durable and absolute resistance. For this purpose, crossings were made with K-4 hybrid x Cacanska Lepotica. In our extensive breeding material at Hohenheim, we found also some hypersensitive hybrids (Hartmann, 1997).

Some of them are promising for fruit growers, some of them may be only donors for absolute resistance. Different crossings were made with these hypersensitive hybrids in the last years.

Three interesting hybrids were tested for field resistance together with other cultivars. None of the tolerant or resistant cultivars was field resistant. Two years after planting, they all were infected with the exception of cv. Anna Späth. The infection rate ranged between 15% and 78%, and after 6 years in most cultivars all trees were infected while no infection was found in the hypersensitive hybrids (Table 1).

Besides, several promising hypersensitive hybrids are being tested for years in different, strongly sharka-infected orchards. We obtained good results especially with hybrid Ortenauer x Stanley 13. This hybrid is absolutely resistant in all orchards. Since we could never find necrosis on this hybrid in orchard, we conclude that we obtained a good combination of qualitative and quantitative resistance. We obtained also promising data about the cropping and fruit quality. The big elongated fruits (54 g) are blue coloured, they are ripe at the beginning of September like those of cv. Cacanska Rodna, and the fruit quality is fair to good. After artificial infection we could find no virus in this hybrid by a PCR test. By grafting on PPV-infected trees, the hybrid reacts hypersensitively and does not grow. There are differences in the hypersensitive reaction of the tested hybrids. The shoot growing of some was only 1 – 2 cm before dying, while that of others was 20 – 30 cm. The faster was the dying the better was the chance for an absolute resistance.

Kegler and Grüntzig (1992) found that K-4 hybrid was absolutely resistant to CG strain but not DI strain of PPV. Also gradual differences in the resistance were found. We have to take these results in regard in testing hypersensitive hybrids. These tests should be made always with different strains occuring in the region of concern. With some hybrids, the virus isolation by necrosis is incomplete and there is partial dying of shoots. Such hybrids are not recommendable for the fruit growers but they may be useful donors for breeding.

Table 1. Field resistance of plum and prune cultivars

Cultivar	Ratio of infected/total trees	
	1993	1997
Anna Späth	0/6	6/6
Auerbacher	3/6	6/6
Bühler 328	4/6	6/6
C. Lepotica	3/6	6/6
C Najbolja	2/6	5/6
C. Rana	4/6	6/6
C. Rodna	4/6	6/6
Carpatin	1/6	4/6
Centenar	2/6	3/6
Hanita	4/6	6/6
Hauszwetsche	5/6	6/6
Herman	4/6	6/6
Ortenauer	5/6	6/6
Pitestean	4/6	6/6
President	3/6	6/6
R. Gerstetter	1/6	6/6
St. Hubertus	4/6	6/6
Valjevka	3/6	5/6
Valor	3/6	5/5
Verity	2/6	5/6
80/V/13	0/4	0/4
Ort. x Gerst. 17	0/4	0/4
Ort. x Stan. 34	0/5	0/5

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