Plum pox virus and the estimated costs associated with sharka disease

M. Cambra[1], N. Capote[1], A. Myrta[2] and G. Llácer[1]

[1]*Instituto Valenciano de Investigaciones Agraria (IVIA), Moncada, Valencia (Spain); e-mail: mcambra@ivia.es*
[2]*Istituto Agronomico Mediterraneo, Valenzano, BA (Italy)*

Since first being recorded in 1917–18 in Bulgaria, sharka (plum pox) disease has progressively spread via infected plant material to be present in most *Prunus*-growing nations today. The disease has serious agronomic and political consequences because it causes enormous economic losses. In countries in which sharka is endemic, a high percentage of apricot and European plum production is unmarketable because of the disease. To these figures should be added the costs of sanitary controls, surveys and eradication programmes against sharka virus. Estimated costs associated with sharka management worldwide in the last 30 years exceed 10 000 million euros. However, improvements in knowledge of the disease and in techniques used to identify the disease are significantly aiding disease control and management.

Sharka (plum pox) disease was first described by Atanassov (1932) although the disease appeared in Bulgaria as early as 1917–18 on *Prunus domestica* cv. Kjustendil. In 1933 it appeared on apricot trees (Németh, 1994) and since then has progressively spread to a large part of the European continent, around the Mediterranean basin, and even reached the Near and the Middle East (Roy & Smith, 1994). It has also been found in South and North America (Chile, Argentina, USA and Canada) (Roy & Smith, 1994; Dal Zotto *et al*., 2006; Levy *et al*., 2000; Thompson *et al*., 2001) and in Asia (Kazakhstan and China) (Spiegel *et al*., 2004; Navrátil *et al*., 2005). Historical reviews of the disease have been written by Németh (1994) and Dunez *et al*. (1994). Despite the considerable efforts made in many countries, sharka has been reported in all the most important *Prunus* industries worldwide except Australia, New Zealand, South Africa and California (USA). The current situation of sharka disease in *Prunus*-growing nations worldwide is described by national experts in the series of country summaries following this review.

Illegal traffic and insufficiently controlled exchanges of infected yet symptomless propagative plant material has been the main pathway of plum pox spread over long distances. Then, once sharka has become established in an orchard, aphid species transmit the disease locally. For decades there has been no awareness nor reliable detection methods suitable for large-scale application. Consequently, plum pox disease has easily escaped visual inspections and other inefficient control methods employed, spreading worldwide.

The causal agent of sharka disease is *Plum pox virus* (PPV), a member of the *Potyvirus* genus in the *Potyviridae* family (López-Moya *et al*., 2000). Nowadays PPV is well characterized molecularly (Olmos *et al*., 2006; James & Glasa, 2006) and even used as a vector in biotechnology (García *et al*., 2006). The numerous PPV isolates differ in biological and epidemiological properties such as aggressiveness, aphid transmissibility and symptomatology. These differences have been serologically and molecularly documented (Cambra *et al*., 2006; Candresse & Cambra, 2006) leading to the clustering of PPV isolates into six types or strains: PPV-D (Dideron), PPV-M (Marcus), PPV-EA (El Amar), PPV-C (Cherry), PPV-W (Winona) and PPV-Rec (recombinant between D and M); the main PPV types being D and M (Candresse & Cambra, 2006; James & Glasa, 2006). An integrated approach, which includes biological indexing and serological and molecular assays using validated reagents and methods, has been recommended in the EPPO protocol for PPV detection and characterization (OEPP/EPPO, 2004).

Sharka occurrence has serious agronomic, economic and political consequences. The reduced fruit quality and premature fruit drop caused by sharka disease make apricot and European plum production very problematic. In addition, the fact that PPV is easily transmitted by aphids and by vegetative multiplication makes the production of PPV-free plants difficult. Special regulatory and control strategies need to be implemented to curb the disease in nurseries. This implies that considerable efforts must be made by nurserymen and that inspectors need to be endowed with control responsibilities. The disease does not kill infected trees thus, if they are not removed, a permanent reservoir of PPV is created. Technical and political decision-making with respect to eradication must be supported by reliable data. Such data should include the incidence of the disease and its epidemiological behaviour in different hosts and geographical areas. Moreover, specific laws and a policy of compensation to affected growers should be implemented. There are also political implications of the disease, given that the quarantine status of plum pox creates trade restrictions and sanitary laws have had to be established at international, national and even at a local level. The presence of sharka may or may not be very detrimental to fruit quality, but it certainly makes the production of PPV-free plants very difficult to manage. The control of plum pox or the reduction of its impacts requires co-ordinated efforts by fruit growers, nurserymen, breeders, researchers, decision-makers and politicians.

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Sharka is the most devastating disease of stone-fruit trees. Surprisingly only minimal data about the economic and social impact of the disease is available. The costs associated with the disease involve not only direct losses in stone-fruit production, commercialization, eradication, compensatory measures and lost revenue, but also indirect costs including those from preventive measures such as quarantine, surveys, inspections, control of nurseries, diagnostics and the impact on foreign and domestic trade.

Eradication of sharka disease has been very difficult in countries with economically important stone-fruit industries basically due to the lack of reliable methods and reagents for routine and large-scale diagnosis. Eastern and Central European countries practised coexistence with the disease, which frequently became endemic with the proportion of infected trees in some orchards reaching 100% in the Balkans. Sporadic local eradication programmes were not efficient enough to stop the continuous spread of PPV ultimately leading to important losses in both apricot and European plum cultivars. Subsequently, the disease spread to other European and Mediterranean countries causing severe impacts mainly in apricot production.

Global apricot production in countries where PPV is present reached approximately 1.5 million metric tonnes in 2005 (data estimated from http://faostat.fao.org). A conservative estimate of the losses incurred from unmarketable apricot fruits is 0.6 million metric tonnes/year. This would imply that 18 million metric tonnes have been lost in the last 30 years with an estimated value of 3600 million euros (with an average price of 0.2 euros/kg). Moreover, the occurrence of sharka has changed the types of apricot cultivated. As early apricot cultivars are much more sensitive in terms of symptoms expression on fruits than late cultivars, many early local cultivars have progressively been substituted by later ones, which are 'agronomically' more tolerant to PPV. In spite of some temporary decreases that have occurred mainly in Eastern and Central European countries, global apricot production has increased worldwide.

An estimation of plum losses is difficult to calculate because the main sources of statistical data group *P. domestica* and *P. salicina* productions together. Based on FAO data, the global production in countries in which PPV is spreading or is endemic was close to 3 million metric tonnes for European plums and about 0.9 million metric tonnes for Japanese plums in 2005. While production losses in European plum have historically been very severe, production in Japanese plums has hardly been affected. Losses in European plum-fruit production are estimated at 1.5 million metric tonnes/year, representing 45 million metric tonnes in the last 30 years with an estimated value of 5400 million euros (with an average price of 0.12 euros/kg). Following similar calculations, the losses derived from sharka disease in Japanese plum production reached 18 000 metric tonnes/year (average of only 5% losses of the fruits from PPV infected trees) leading to 126 million euros in the last 20-year period when Japanese plum production became economically important.

The production of peaches was first strongly affected in Eastern and Central European countries in which aggressive PPV-M isolates were present and spreading. More recently, this PPV strain was introduced to some Mediterranean countries that have important peach industries. Based on FAO data, the global production in countries in which PPV-M is spreading was close to 3.2 million metric tonnes in 2005. Losses due to PPV-M in peach-producing countries could be estimated at 5% of the annual production. This estimation of 160 million kg/year of unmarketable fruits could imply, over the last 20 years, accumulated losses of about 576 million euros. In addition, in Canada and USA, the mandatory eradication programmes of PPV-D caused direct economic losses to the peach industry estimated at about 4.8 million euros (removal of 264 000 trees in Canada and about 190 000 in Pennsylvania, USA). The success of eradication measures undertaken in North America will largely compensate these occasional losses suffered by local peach industries.

The management of sharka disease is associated with field surveys in stone fruit orchards, control of *Prunus* nurseries, use of diagnostics for virus identification, and eradication measures when the disease is present (at national or local level). The cost of the surveys conducted in different countries is difficult to evaluate; in any case, that such surveys are time-consuming increases labour costs.

There are few data about costs of eradication programmes except those provided by Spain, Canada and the USA. Mandatory and/or voluntary eradication programmes in Spain have lead to the removal of more than 2.3 million trees since 1989, with a total cost exceeding 63 million euros, including removal, compensation and production losses. Eradication costs in Canada have risen to around 43 million euros since 2001, including the analysis by DASI-ELISA of about 3 million trees. Since 2001 eradication costs in the USA have exceeded 30 million euros. The cost of surveys and eradication programmes conducted in localized areas or provinces in European countries since 1980 have been estimated at 39 million euros including the analysis of more than 13 million samples.

All in all, sharka has had a great impact on the stone-fruit and nursery industries. Domestic, interstate and international trade has been prohibited or subjected to important restrictions. In addition, the effect in terms of job losses in fruit packing houses and related transport industries could also have been significant ever since the first report on plum pox in 1917.

Grants from the European Union related to PPV have given 4.8 million euros and national projects and bilateral agreements in Europe have invested about 24.5 million euros into research on sharka disease over the last 25 years.

An evaluation of the global cost associated with sharka management worldwide, excluding indirect trade losses, could exceed 10 000 million euros over the last 30 years, with the social impact of the disease also being very important.

Tremendous progress has been made on PPV research in the last 15 years, enabling significant improvements in disease control and management. Accumulated experience in sharka management will undoubtedly prevent the disease from spreading to extensive stone-fruit growing areas that are still free of PPV and will help to better control the disease where present.

Situation actuelle de la maladie de la sharka (*Plum pox virus*) et estimation des coûts pour sa gestion

Depuis qu'elle a été signalée pour la première fois en 1917–18 en Bulgarie, la maladie de la sharka s'est progressivement disséminée via du matériel végétal infecté, et elle est désormais présente dans la plupart des pays producteurs de *Prunus*. La maladie a des conséquences agronomiques et politiques importantes car elle provoque d'énormes pertes économiques. Dans les pays dans lesquels la sharka est endémique, un fort pourcentage de la production d'abricots et de prunes européennes n'est pas vendable à cause de la maladie. Il faut ajouter à ces chiffres le coût des contrôles sanitaires, des programmes de prospections et d'éradication contre le virus de la sharka. Les coûts estimés associés à la gestion de la sharka dans le monde au cours des 30 dernières années dépassent les 10 000 millions d'euros. Cependant, des améliorations dans les techniques d'identification et dans la connaissance de la maladie aident de façon significative à la lutter contre la maladie et à la gérer.

Текущий статус шарки сливы и оценка стоимости борьбы с этим заболеванием

С момента первой регистрации в 1917-18 гг. в Болгарии шарка сливы постепенно распространилась через инфицированный растительный материал и в настоящее время присутствует в большинстве стран, производящих сегодня *Prunus*. Это заболевание имеет серьезные агрономические и политические последствия в силу того, что оно причиняет огромные экономические потери. В тех странах, где шарка эндемична, из-за этого заболевания высокий процент абрикосов и европейского производства сливы не попадает на рынок. К этим цифрам должны быть добавлены затраты на фитосанитарную борьбу, программы обследования и на ликвидацию вируса шарки. Суммарная оценка затрат, связанных с борьбой с шаркой во всем мире за истекшие 30 лет превышает 10.000 миллионов евро. Однако, совершенствование методов, применяемых для выявления этого заболевания, и совершенствование знаний о нем существенно помогают борьбе с ним и управлению.

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