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Emerging Pests of Potato in Europe: Early Warning, Risk Analyses and Regulation

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Abstract Potato is a major crop across Europe, at risk from a wide range of introduced pests. Phytosanitary measures such as restrictions on imports of seed potatoes reduce those risks. Of the pests which have become established in Europe, some continue to spread while others are effectively controlled by quarantine measures. A number of emerging risks to European potato crops are described, including *Epitrix* flea beetles and '*Candidatus Liberibacter solanacearum*', the cause of zebra chip disease in the USA. Among the recommendations for helping to mitigate risks from these and other emerging pests are the adoption of good practice in disposal of waste and soil from potato processing, raising awareness of symptoms, targeted surveillance, prompt reporting of suspect findings and contingency planning for management of outbreaks. Effective dialogue between the potato industry and National Plant Protection Organizations is essential for the successful implementation of these measures.

Keywords *Candidatus Liberibacter solanacearum* · Emerging pests · *Epitrix* · Nematodes · Pest risk analysis · *Solanum tuberosum*

Introduction

Potato is a major staple crop worldwide. In the past, pests of potatoes, such as late blight (*Phytophthora infestans*) and Colorado beetle (*Leptinotarsa decemlineata*) have had dramatic impact on potato production and therefore on food security in Europe. This triggered the implementation of international cooperation in plant health and the definition of phytosanitary requirements for potato tubers (Ebbels 2003; Dehnen-Schmutz et al. 2010), see Box 1. In Europe, strict requirements apply to movement of both seed and ware potatoes (Anonymous 2000, 2002). They include in particular the prohibition of imports of seed and ware potatoes from outside the EU as well as the implementation of certification schemes for the production of certified seed potatoes

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which define requirements to a certain standard with regard to a number of important pests.

These regulatory policies may explain why few new pests have been recorded on this crop over the last decades (Dehnen-Schmutz et al. 2010). However, trade patterns are changing, with for example more imports of potatoes in European non-EU countries from overseas. This article highlights potato pests recently identified as emerging in other parts of the world but that could be a threat in Europe, some pests newly recorded in Europe as well as some already regulated pests whose distribution or impact is changing.

Box 1. EPPO and its Panel on Phytosanitary Measures for Potato

The European and Mediterranean Plant Protection Organization was created in 1951 by 15 European countries. After World War II, European agriculture was faced with many difficulties, and in particular, a significant food crop, potato, was threatened by the spread of Colorado beetle (*Leptinotarsa decemlineata*). These 15 countries felt that by creating an international organization, they would control this pest more efficiently. EPPO's work then extended to preventing the introduction of other dangerous pests from other parts of the world and limiting their spread within Europe if they were introduced. These activities which can broadly be labelled as 'plant quarantine' have been EPPO's main priority in its more than 60 years of existence. Today, 50 European and Mediterranean countries (including the 28 members of the European Union) are members of the Organization. Our partners are the National Plant Protection Organizations (NPPOs), i.e., the official services, which are responsible for plant protection in each country. EPPO is financed by individual contributions paid by its member governments.

The technical activities of EPPO are performed by specialized panels of experts. The Panel on Phytosanitary Measures for Potato was created in 1997. Its composition and terms of reference are available at http://www.eppo.int/ABOUT_EPPO/panel_composition/potatomeasures.htm. The Panel considers all aspects of risk management to prevent the introduction and spread of quarantine pests and regulated non-quarantine pests in potato. Standards developed by the Panel are freely available on EPPO website (www.eppo.int).

What are Emerging Plant Pests?

Pests are considered as emerging when their incidence is increasing, or their geographical or host range is increasing, or when they are new to science. Possible causes of emergence are linked to accidental introduction of pests in new regions (often linked to trade), the spread of insect vectors, or modifications in the environment (modifications of cultural practice, reduction of use of pesticides, climate change, etc.). Progress in science also allows detection and identification of new pathogens and a better understanding of their aetiology. In practice, the detailed pathways and history of pest introductions are often difficult to retrace.

The European and Mediterranean Plant Protection Organization, Early Warning and Pest Risk Analysis

The European and Mediterranean Plant Protection Organization (EPPO) identifies emerging pests of concerns for its member countries. This is done by managing an early warning system (EPPO Alert List, available at http://www.eppo.int/

QUARANTINE/Alert_List/alert_list.htm) and maintaining a database of relevant pest information, PQR (Roy 2014; Griessinger and Roy 2014). If relevant, possible risks presented by potential invasive pests are then evaluated by pest risk analysis (PRA). The PRA is a framework for organizing biological and other scientific and economic information and using it to assess risk (Petter et al. 2010). Its content and structure have been agreed at a global scale in the framework of the International Plant Protection Convention (IPPC 2007). It evaluates scientific evidence to determine whether an organism is a pest. If so, the analysis evaluates the probability of introduction and spread of the pest and the magnitude of potential economic consequences in a defined area, using biological or other scientific and economic evidence. If the risk is deemed unacceptable, the analysis may continue by suggesting management options that can reduce the risk to an acceptable level. Subsequently, pest risk management options may be implemented through phytosanitary regulations.

In recent years, two potato pests have been submitted to PRA in the EPPO framework. They are presented below.

'*Candidatus Liberibacter solanacearum*': a Pest New to Science

Since the early 1990s, a new disease of potatoes called 'zebra chip' (or 'papa manchada' in Spanish) has been reported in the Americas (e.g., Guatemala, Mexico and the Southwestern USA). The disease caused severe economic losses, in particular to the potato chip industry because chips (crisps) made from infected tubers present dark stripes becoming markedly more visible after frying which is unacceptable for manufacturers. Observations made in affected potato fields strongly suggested that the disease was transmitted by the potato/tomato psyllid, *Bactericera cockerelli*. In New Zealand, a new disease of glasshouse tomatoes was observed in Auckland in January 2008. *B. cockerelli*, a recently introduced pest, was reported to occur in all tomato glasshouses where the disease was observed. In May 2008, symptoms resembling zebra chip disease were observed in potatoes. Large numbers of *B. cockerelli* were observed on the diseased crops. Investigations carried out in parallel in the USA and New Zealand revealed the presence in diseased Solanaceous crops of a previously undescribed species of *Liberibacter*, tentatively named *Candidatus Liberibacter solanacearum* (Hansen et al. 2008; Liefting et al. 2008). Another haplotype of this pathogen was later observed causing damage in carrot in Finland, Norway and Sweden associated with *Trioza apicalis* (Munyaneza et al. 2010) and in carrot and celeriac in Spain associated with *T. apicalis* and several indigenous *Bactericera* species (Alfaro-Fernández et al. 2012a,b).

The PRA conducted in the EPPO framework EPPO (2012a) considered that the potential impact of *Ca. L. solanacearum* in the EPPO region would be massive. The pathogen with its vector causes severe damage in potato, tomato and pepper in its current area of distribution, both in terms of losses in yield and quality. Pest control requires effective control strategies against the vector, leading to increased spraying and higher costs in the open field as well as in glasshouse. In New Zealand, in the first report of zebra chip on potato, the mean yield from potato crops was approximately 60% less than expected, and harvested tubers had less dry matter (13%) than normal (19%). Control of the psyllid in 2008/2009 often required up to 14–18 applications of insecticides, where prior to *B. cockerelli* introduction, insecticide spray programmes

were typically 4–6 applications across the crop. Impact in seed potato production is debated. In New Zealand, certain growers have stopped producing seed potatoes because of zebra chip disease. There is uncertainty as to how frequently potato plants grown from infected tubers would be infected and in turn would produce infected daughter tubers. Some authors (e.g., Henne et al. 2010a) showed plants grown from infected seed potatoes to grow poorly and produce fewer, smaller or no tubers, reducing the possibility that natural spread (e.g., through volunteer potatoes) would be significant. However, Pitman et al. (2011) indicates transmission of *Ca. L. solanacearum* to plants grown from infected potatoes (symptomatic or asymptomatic). Galaviz et al. (2010) consider infected seed as an important source of inoculum in Mexico.

EPPO (2012a, b) considered that, as the vectors known in Europe do not feed on potato, there is no risk of transfer from carrot crops to potato crops. As it is forbidden to import seed potatoes from the affected areas into most countries of the region, the possibility of introduction and impact of the bacterium on potato is mainly linked to the introduction of infectious *B. cockerelli*, e.g., with tomato or Capsicum fruits (in particular truss tomatoes) or plants for planting. It is considered that the probability of establishment of this pest is high if it were to be introduced. Phytosanitary measures are now being considered by the EU to prevent entry of these new pests from other parts of the world. Currently, there are no restrictions on the import of tomato and other Solanaceous fruits from infested parts of the world to the EU.

Epitrix spp. Damaging Potato Tubers: New Pests in Europe Originating in North America

Epitrix similaris and *Epitrix cucumeris* are North American insects that were first identified in Europe in Portugal in 2008, although symptoms (superficial lesions on the tubers) started to be observed in 2004 in the north of the country near Porto (Boavida and Germain 2009). Symptoms on the tubers are due to external larval feeding (worm tracks). However, larvae usually leave tubers immediately after potatoes are lifted and cannot be detected in the tubers harvested. Leaf shoot holes caused by adults were not identified at that time. Following the appearance of the first symptoms on tubers, several causes were investigated (including viruses and fungi) and it was only in 2008 when symptoms were recognized as possibly caused by *Epitrix* species, that targeted sampling of adults and larvae were conducted which allowed the identification of *E. cucumeris* and *E. similaris*. These flea beetles have rapidly spread to the main potato producing areas in Portugal. *E. similaris* was then reported from Galicia (Spain).

Five flea beetles of the genus *Epitrix* are reported to feed on foliage and/or tubers of potatoes in North America: *E. cucumeris* (potato flea beetle), *Epitrix hirtipennis* (tobacco flea beetle), *E. similaris* (no common name), *Epitrix subcrinita* (Western potato flea beetle) and *Epitrix tuberis* (tuber flea beetle). It should be noted that the great morphological similarity of these *Epitrix* species makes separation between them in the field very difficult. This has meant that identification to species level has not been regularly undertaken and *Epitrix* species have often been considered together as a pest complex. Data on distribution of individual species is therefore not fully reliable.

The EPPO PRA (EPPO 2011) considers that these pests can enter or spread within the EPPO region with seed or ware potato tubers with soil or plant debris attached. It should be noted that although *E. tuberis* and *E. cucumeris* had been recommended for regulation by EPPO in 1987 and 2001, respectively, they were not specifically regulated by the EU. The main pathway was closed by a prohibition on the import of potatoes from the American continent. However, a derogation for the import of seed potatoes from Canada into the EU was granted in 2003 (Anonymous 2003). This may have created a pathway for the introduction of the pests into Portugal. At that time, phytosanitary requirements in the derogation focused on *Potato spindle tuber viroid* and *Clavibacter michiganensis* ssp. *sepedonicus*. It has now been revised to cover also *Epitrix* species (Anonymous 2011).

Most of the negative impact of these flea beetles is due to the impact on cosmetic quality of tubers, as *Epitrix* damage does not affect eating quality. Because of quality requirements for tubers to be marketed (in particular where tubers are washed before marketing), this can nevertheless cause lot rejection and therefore complete economic loss to the grower. In addition, for *E. tuberis* and *E. similaris*, larval feeding may cause holes up to 1 cm into the tuber flesh which cause problems in ware potatoes both for home consumption and processing (Boavida et al. 2013). In North America, insecticide treatments are generally applied against *E. tuberis*, targeting the first generation. When the first generation is not correctly controlled, up to seven insecticide treatments may be required during the growing season. In Europe, insecticide treatments are applied against aphids and/or Colorado beetle and may partially control the pests. However, specific surveillance (to identify the best treatment period) and additional sprays will be needed, in particular early in the growing season. These pests may be problematic for organic crops as well as in countries where Colorado beetle does not occur and therefore no insecticide treatments are currently applied. Emergency phytosanitary measures have been implemented in the EU (Anonymous 2012) to prevent further entry and spread of these species, as well as other *Epitrix* species damaging potato tubers such as *E. tuberis* and *E. subcrinita*. So far, control measures have succeeded in areas infested by *E. similaris* and *E. cucumeris* in Portugal and Spain as damage is maintained to an acceptable level and infested areas are not increasing.

Nematodes: Spreading Pests?

Potato cyst nematodes (*Globodera rostochiensis* and *Globodera pallida*) and root-knot nematodes (*Meloidogyne chitwoodi* and *Meloidogyne fallax*) are regulated pests within the EU (Anonymous 2000). Their distribution is difficult to assess because of the limitations of surveys for soil borne pests. Nevertheless, they seem to be spreading to new areas. Some new infestations are reported to be linked with the international movement of infested ware potatoes or other host material for processing. For example, *G. pallida* was first reported in Slovenia in 2011. It is suspected that *G. pallida* was introduced via infested ware potatoes, as a ware potato processing facility is situated in very close proximity to the infested fields. It is noted that this processing unit regularly imports ware potato from countries where the nematode occurs and that waste waters from potato tuber washing have been discharged onto the grassland field (EPPO 2012b). In 2013, the NPPO of the UK reported a new outbreak of *M. fallax* in an organic

crop of leeks (*Allium ampeloprasum*) in one field in Staffordshire (EPPO 2013). The source of this infestation is unknown. The leek plants were supplied by a UK propagator in March 2013 and had been grown from seed in peat blocks. One possibility is that the pest could have been introduced into the infested field with plant waste and soil resulting from the on-site processing of leeks produced in other EU member states. The infested field is close to the packhouse and for many years has received processing waste.

During the EPPO workshop on the management of *G. rostochiensis* and *G. pallida* in 2013 (Suffert 2014) and the EPPO Workshop on the Phytosanitary risks associated with soil attached to potato tubers and potato waste in 2014, the experts identified the need to limit the risk of spread of pests with soil and plant waste. The EPPO Panel will develop guidance on good practices addressed to potato producers and other relevant stakeholders.

Potato cyst nematodes are currently managed in part by the use of resistant cultivars. It is therefore important to prevent the introduction of new populations of nematodes from outside Europe for which no resistant cultivars exist (EFSA Panel on Plant Health 2012).

Other nematodes are also emerging as significant potato pests (Viaene 2014).

Major Potato Pathogens: Under Control Thanks to Quarantine

Potato ring rot (*Clavibacter michiganensis* subsp. *sepedonicus*) and brown rot (*Ralstonia solanacearum*) are major potato diseases and a threat for seed production in particular. They are regulated in EU countries (Anonymous 2000) and subject to routine surveys in seed and ware production. Infested consignments are regularly detected in trade during official inspection by National Plant Protection Organizations. Outbreaks occur occasionally but are usually successfully eradicated thanks to the implementation of quarantine measures. As an illustration in 2012–2014, outbreaks were reported to the EPPO Secretariat in Finland, France, Norway and Slovakia for *C. michiganensis* subsp. *sepedonicus* and in France and Czech Republic for *R. solanacearum*.

Potato wart disease (*Synchytrium endobioticum*) was a major potato disease in the first part of the twentieth century. Cultivation of resistant varieties and strict quarantine measures (scheduling of fields for over 20 years) effectively limited the spread of potato wart. Not only it has been recently reported as eradicated from Austria and Northern Ireland, but it was also recently found for the first time in Bulgaria (Dimitrova et al. 2011). Obidiegwu et al. (2014) underline that early successes of control of this disease are currently challenged by new pathotypes evolving and the increased risk of dissemination by potato tuber trade.

In addition, it may be noted that *Dickeya* species were first reported on potato in the Netherlands in the 1970s and have since been detected in many other European countries. Since 2004–2005 a new pathogen, with the proposed name '*D. solani*', has been spreading across Europe via trade in seed tubers and is reported to cause increasing economic losses (Toth et al. 2011).

Identification of Emerging Risk and Communication with Stakeholders

As illustrated with the cases of zebra chip disease and *Epitrix* species, it may be difficult to identify a new emerging pest. Often, symptoms are not specific or the growers do not

report damage until it is at a high level. It is necessary to be sure of the identity of the pest to be able to elaborate appropriate control strategies, drawing on the strategies used in the area of origin of the pest if relevant. EPPO maintains a database on diagnostic expertise available in the EPPO region (see http://www.eppo.int/DATABASES/diagnostics/diag_quest.htm) which facilitates contact with relevant experts. It is important that emerging and new harmful organisms are reported by growers, scientists and other stakeholders to National Plant Protection Organizations so that appropriate measures may be taken to mitigate the risk. On the other hand, it is a role for EPPO, and NPPOs to communicate on risks identified on their territories to raise awareness in other countries before the pest is introduced and allow for targeted surveillance, effective contingency planning and a quick reaction to any findings. When a pest is added to the EPPO Alert List or submitted to a PRA within the EPPO framework, this is then discussed by relevant Panels, presented to the EPPO Working Party on Phytosanitary Regulation and Council where all EPPO countries are represented. The Alert List and all PRAs are available freely on EPPO website (www.eppo.int). Nevertheless, EPPO relies to some extent on NPPOs to relay information at national level and ensure that it is well targeted at those groups whose awareness of new risks needs to be raised.

Conclusion

To avoid the introduction of new pests, strict quarantine on potato seed should be maintained. Good practice should also be applied to reduce the amount of soil moved with ware potatoes and ensure correct management of potato waste and associated soil. This also addresses the risk of spreading unknown soil borne pests. Potato pests may also spread with other host plants or plant products that are not regulated (e.g., Solanaceous fruits or other root crops). Awareness raising and dialogue between National Plant Protection Organizations and the potato industry are needed to limit the spread of pests already present, and ensure that suspected new pest outbreaks are investigated and reported quickly and managed effectively, ideally through implementation of a contingency plan which has been agreed in advance.

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