# Express-PRA[1] for *Candidatus* Liberibacter solanacearum

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**Initiation:** Review of the risk of *Candidatus* Liberibacter solanacearum and its vectors for Germany due to massive damage on potatoes and tomatoes in Northern America and New Zealand as well as on carrots in Finland and Spain. *Initiation for the revision: Occurrence on ware potatoes in Spain.* Bactericera *sp. was found. Species not yet identified. Suspicion that* B. trigonica, *the vector for carrots, could be a possible vector also for potatoes. Further detections on carrots in Germany, France, Norway, Austria and Sweden. WTO Notification from Australia on the infestation detection on seeds of celery, parsley and parsnip.*

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| Phytosanitary risk for Germany | high ☒ | medium ☐ | low ☐ |
| Phytosanitary risk for EU-Member States | high ☒ | medium ☐ | low ☐ |
| Certainty of the assessment | high ☐ | medium ☒ | low ☐ |
| Conclusion | The bacterium *Candidatus* Liberibacter solanacearum is endemic in Northern America and may cause massive damage on potatoes, tomatoes and pepper, as well as on carrots and celery. In Germany, Finland, France, Norway, Austria, Sweden and Spain it was found on carrots. Furthermore, it was detected on celery in Spain and in 2016 for the first time on potatoes. The bacterium is transmitted to potatoes by *Bactericera cockerelli* (Sulc) and perhaps by further psyllid species and apparently, also via planting material. So far, *B. cockerelli* does not occur in Germany. If the (infested) vector is introduced, a fast establishment and distribution of the pest have to be expected. The risk increases if also other psyllids (already occurring in Germany/the EU) could serve as a vector. Apparently, also the psyllids *Trioza apicalis* Förster and *B. trigonica* Hodkinson that occur in the EU transmit the bacterium. At present, it is assumed that there is only a transmission to carrots but because of the infestation of potatoes in Spain, a transmission to potatoes cannot be excluded.<br><br>So far, the pest is not listed in the Annexes of the Directive 2000/29/EC; nevertheless, it is included in the EPPO A 1 list, together with the vector *Bactericera cockerelli*. A risk assessment of the EPPO is available.<br><br>Due to the high damage potential, *Ca.* L. solanacearum presents a significant phytosanitary risk for Germany and other | | |

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| | EU-Member States. Especially in potato cultivation areas with particularly suitable conditions for the establishment of the vector *B. cockerelli* (Mediterranean basin) or the presence of other vectors in question heavy economical losses had to be expected. The control of the vectors is difficult (monitoring with yellow traps and massive use of pesticides).<br><br>Based on this risk assessment, it is assumed that the bacterium is capable to establish in Germany or another Member State and to cause significant damage, if vectors have simultaneously been introduced or are present. Thus preventing measures according to § 4a of the Plant Inspection Order should be met against the introduction of *Candidatus* Liberibacter solanacearum and its vectors. Striking symptoms in cultivation and production should be paid attention and checked. Suspected infestations should be confirmed in the laboratory (plant protection service or Julius Kuehn-Institute) and reported to the JKI. If infested, lots should be used safely as food or feed and the vectors should be controlled, if possible. Infested plants should not be used for the production of seed or planting material. Furthermore, the movement of leaves to outside the region is not allowed. |
| **Taxonomy**[2] | *Bacteria, Proteobacteria, Alphaproteobacteria, Rhizobiales, Rhizobiaceae, Candidatus* Liberibacter<br><br>The pest belongs to a species of phloematic, mostly tropical and subtropical bacteria of the genus *Candidatus* Liberibacter. Hansen *et al.* (2008) firstly proposed the species *Ca*. L. solanacearum as a new species of the genus *Candidatus* Liberibacter. At present, there are descriptions for five haplotypes. The haplotypes A and B occur on potatoes and other Solanaceae. So far, the haplotype A was only described in Honduras, Guatemala, South Mexico, the USA and New Zealand; haplotype B also in Mexico and the USA. The haplotypes C, D and E were detected on carrot and celery, but haplotype C was only detected in Finland, France, Sweden, Norway and Germany and the haplotypes D and E in Spain, Morocco and also, in France. The first proof on potatoes in Spain 2016 is obviously the haplotype E that was already detected on carrots and celery. |
| **Trivial name** | -- |
| **Synonyms** | *Candidatus* Liberibacter psyllaurous |

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| **Biology** | *Ca.* L. solanacearum infests Solanaceae, carrots and celery. In its host plants, it acts as a systemic pathogen and it distributes into the plant tissue via the phloem from the inoculation site. |
| **Is the pest a vector?**[3] | No |
| **Is a vector needed?**[4] | Yes, psyllids. *Bactericera cockerelli* (Sulc)*, Hemiptera, Psylloidea, Triozidae*, possibly further species of this genus. The bacterium can be transmitted to carrots by *Trioza apicalis* (Munyaneza 2010a, b) and *Bactericera trigonica* (Alfaro-Fernández et al., 2012 a, b). The transmission to potatoes seems possible, too.<br><br>The observed damage on plants and fruits firstly was ascribed only to the psyllids. However, with the availability of molecular methods it could be proven that the bacterium at least partly is responsible for the symptoms and the damage. The zebra chip-syndrome on potatoes is solely attributed to the bacterium.<br><br>It is remarkable that *Ca.* L. solanacearum was detected in *B. cockerelli* (Northern America) but also in *T. apicalis* and *B. trigonica* (both Eurasia) (Munyaneza *et al.* 2010 a, b, Alfaro-Fernández *et al.*, 2012 a, b).<br><br>In the literature, *T. apicalis* was partly mistaken with *T. viridula* resp. it was used as a synonym, see Laska (2011).<br><br>A study from New Zealand shows that the transmission of *Ca.* L. solanacearum to leaves and potato tubers is also possible via infested seed potatoes (Pitman *et al.* 2011). |
| **Host plants** | Potato (*Solanum tuberosum*), tomato (*S. lycopersicon*), pepper (*Capsicum* spp.), eggplant (*S. melongena*), celery (*Apium graveolens*), *Lycium barbarum, L. chinense, Physalis alkekengi, P. peruviana, S. carolinense, S. dulcamara, S. luteum, S. nigrum, S. nitidibaccatum, S. physalifolium, S. sarachoides, S. triflorum, Daucus carota.* |
| **Symptoms**[5] | Via bacteria:<br>– Potato tubers: necrotic spots in the tuber tissue, more visible after frying =„zebra chips”.<br>– Potato plants: chlorosis of the potato plant with leaf roll, leaf wilt and necrosis, followed by dying of complete plants.<br>– Tomatoes: fruit deformation on some species = „strawberry shaped“.<br>– Plants of tomatoes and peppers: chlorosis and yellowing of |

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| | the leaves, leaf roll and stunting, dying of the plant.<br>– Carrots: carrots in Finland, Spain and France that were infested with *Ca.* L. solanacearum showed plant yellowing, stunting and increased production of side roots, but it is not clear whether these symptoms are also caused by the bacterium or only by the vector (Munyaneza, *et al*. 2010a, b, Alfaro-Fernández *et al.*, 2012 a, b; EPPO Reporting Service, 2012).<br>– Celery: celery plants (*Apium graveolens* var. *dulce* and *A. graveolens* var. r*apaceum*) in Spain that were infested with *Ca.* L. solanacearum showed an increased production of shoots, twisted stems and plant yellowing (Teresani *et al*., 2014).<br>Via *Bactericera cockerelli*:<br>– Plant yellowing (Blood *et al*., 1933; Richards & Blood, 1933; Pletsch, 1947; Wallis, 1955).<br>Via *Bactericera trigonica* and *Trioza apicalis* on carrots:<br>– Plant yellowing, stunting and increased production of side roots (Munyaneza, *et al.* 2010a, b, Alfaro-Fernández *et al.* 2012 b) |
| **Presence of the host plants in Germany**[6] | Widely distributed |
| **Presence of the host plants in the Member States**[7] | Widely distributed |
| **Known infested areas**[8] | **Oceania:** New Zealand (Liefting *et al*., 2009a, b)<br>**North America:** USA (Arizona, California, Colorado, Idaho, Kansas, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, Texas, Utah, Wyoming) (Abad & Bandla, 2008; Crosslin & Bester, 2009; Brown *et al.*, 2010), Canada (Alberta, Ontario), Mexico (Coahuila, Nuevo Leon) (Gudmestad & Secor, 2007; Munyaneza *et al*., 2007, 2009; Abdullah, 2008)<br>**Central America**: Guatemala, Honduras (Rehman *et al.*, 2010), Mexico (Munyaneza, 2009).<br>**Europe:** Germany (EPPO Reporting service 2015b); Finland (Munyaneza *et al*., 2010a, b); France (EPPO Reporting Service, 2012); Norway (Munyaneza *et al*.,2012a); Austria (EPPO reporting Service 2015a); Spain (Alfaro-Fernández *et al*. 2012a, b; Teresani et al, 2014, notification of the official plant protection service on the detection on potatoes); Sweden (Munyaneza *et* |

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| | *al*.,2012b). |
| **Pathways**[9] | Pathway 1: Seed potatoes, possibly ware potatoes<br>Pathway 2: Psyllids (*Bactericera cockerelli, B. trigonica, Trioza apicalis*) that are infested by the pest<br>Pathway 3: Carrots, celery and possibly parsnip (possibly for all three also seeds).<br>Pathway 4: Seedlings of tomatoes, pepper and carrot or young plants for planting<br>Pathway 5: Tomatoes, eggplants, chili and pepper. |
| **Natural distribution**[10] | Via the vector and apparently also via planting material (Pitman *et al*. 2011). |
| **Establishment to be expected and distribution in Germany**[11] | In case of the introduction of the (infested) vector an establishment and fast distribution of the pest has to be expected. If also other psyllids (already present in Germany) could serve as vectors, there was an increased risk. According to Ossiannilsson (1992), *T. apicalis* is present in Germany. According to Hommes (pers. communication) *T. apicalis* as a pest is only present in few regions in Germany. In Norway, Sweden and Finland, *T. apicalis* is dependent on conifers for overwintering. Nevertheless, it is not clear, if this is mandatory – *T. apicalis* was found in Denmark although there are hardly any spruce forests (Láska, 2011). |
| **Establishment to be expected and distribution in the Member States**[12] | In case of the introduction of the (infested) vector an establishment and fast distribution of the pest has to be expected. If also other psyllids (already present in the Member States) could serve as vectors, there was an increased risk. According to Ossiannilsson (1992) *T. apicalis* is widely distributed in the EU. According to Psyl'list (2012) *B. trigonica* is present in Cyprus, the Czech Republic, Greece, Hungary, Italy, and in Spain (Alfaro-Fernández *et al*., 2012a, b) and Switzerland (Burckhardt und Freuler, 2000). There is an increased risk for an establishment after the first detection of the same haplotype E of *Ca.* L. solanacearum in Spain in 2016 on ware potatoes, as on carrots and celery and the obvious possibility that suitable vectors are present as a pathway. |
| **Known damage in infested areas**[13] | Infested potatoes show so-called „zebra chips" after frying. These potatoes can no longer be used for the processing or be marketed. Dying of complete plants. Infested plants of tomatoes and peppers may also die. Comparable damage was reported |

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| | for infested carrot plants.<br>Without control measures or another avoidance strategy against the vectors the bacterium distributed by them can strongly affect the cultivated crops and in case of potatoes even lead to the fact that complete regions can no longer be used for potato cultivation. |
| **Limitation of the endangered area in Germany** | Nightshade family:<br>Companies for the vegetable cultivation in Baden-Württemberg and North Rhine-Westphalia (Southwest part), outdoor crops (potatoes) and greenhouse resp. tunnel crops (tomatoes, pepper). Outdoor crops (potatoes) in Saxonia and in South Saxonia-Anhalt. Regions in Lower and Middle Frankonia (Würzburg, Schweinfurt, Nürnberg). Rhine valley (Karlsruhe to Worms and the Eastern part of Palatinate).<br>Carrots:<br>Carrot cultivation areas: the damp lowland in Schleswig-Holstein, Lower Saxony and North Rhine-Westphalia. Risks exist also for the Eastern part of Rhineland-Palatinate. |
| **Damage to be expected in endangered area in Germany**[14] | *Ca.* L. solanacearum can cause heavy infections or even epidemics on potatoes and tomatoes with subsequent economic losses, outdoors as well as in greenhouses. The damage mainly shows in quality loss of the fruits until non-marketability.<br>Symptom development and crop loss depend on the number of psyllids.<br>The bacterium can also affect carrot cultivation (Munyaneza, *et al*. 2010a, b; Alfaro-Fernández *et al*. 2012a, b). There are still no detailed surveys on the damage. |
| **Damage to be expected in the endangered area in the Member States**[15] | Higher damage than in Germany has to be expected in the Mediterranean countries. |
| **Control feasibility**[16] | Preventing the introduction of the vector and of infested plants/ plant parts is the most effective measure. At present, the import of Solanaceae from infested areas into the EU is prohibited so that this risk can be estimated as low.<br>Fruits intended for the processing industry are cooked, heated or treated otherwise so that neither the pest nor its vector survive.<br>The leaves of carrots or other crops are to be destroyed that |

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| | way that the bacterium cannot be distributed further via vectors (e.g. by ploughing or burning).<br>Infested carrots with leaves should not be marketed outside the region to exclude a further distribution of the bacterium via vectors.<br>The control of the vectors that normally are present underneath the leaves is difficult (monitoring with yellow traps and massive use of specific insecticides for different stages). In the migration phase, the psyllids should regularly be controlled. Although insecticides can protect as much as possible against an establishment of the psyllids, already a small number of psyllids can infest the host plants with *Ca*. L. solanacearum (Munyaneza, 2012c).<br>No effective measure against the bacterium is available. |
| **Detection and diagnosis**[17] | Detection methods for the pest are available (real-time PCR, Li *et al.*, 2009; Teresani *et al*., 2014; Ravindran *et al*., 2011; Munyaneza *et al*., 2009). |
| **Remarks** | See also Schrader et al. (2014).<br>Currently the most important question is whether also other psyllid species that are already present in Germany or in the EU are capable to transmit the bacterium and if so, to which host plants. Another question is how it came to the bacterium-infestation of potatoes in Spain, which vectors play a role and if this could lead to a transmission of the bacterium between the carrots and the potatoes. |
| **Literature** | Abad, J. A., Bandla, M. (2008): First report of the detection of '*Candidatus* Liberibacter' species in Zebra chip disease-infected potato plants in the United States. Plant Disease 93 (1), 108.<br>Abdullah N.M.M. (2008): Life history of the potato psyllid *Bactericera cockerelli* (*Homoptera*: *Psyllidae*) in controlled environment agriculture in Arizona. African Journal of Agricultural Research 3, 60–67.<br>Alfaro-Fernández, A. *et al.* ( 2012a): First report of '*Candidatus* Liberibacter solanacearum' in carrot in mainland Spain. Plant disease 96 (4), 582.<br>Alfaro-Fernández, A. *et al.* (2012b): '*Candidatus* Liberibacter solanacearum' associated with *Bactericera trigonica* – affected carrots in the Canary Islands. Plant Disease 96 (4), 581.<br>Blood, H. L. *et al.* (1933): Studies of psyllid yellows of tomato. |

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| | Phytopathology 23, 930<br>Brown, J. K. *et al.* (2010): First report of “Candidatus Liberibacter psyllaurous” (synonym “Ca. L. solanacearum”) associated with ‘tomato vein-greening’ and ‘tomato psyllid yellows’ diseases in commercial greenhouses in Arizona. Plant Disease 94 (3), 376<br>Burckhardt, D., Freuler, J. (2000): Jumping plant-lice (Hemiptera, Psylloidea) from sticky traps in carrot fields in Valais, Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 73 (3/4), 191-209<br>Crosslin, J. M., Bester, G. (2009): First report of ‘*Candidatus* Liberibacter psyllaurous’ in Zebra Chip symptomatic potatoes from California. Plant Disease 93 (5), 551<br>EPPO Reporting Service, (2012): First report of Candidatus Liberibacter solanacearum on carrots in France, in association with *Trioza apicalis*. no 10, 2012/219<br>EPPO Reporting Service (2015a): First report of Candidatus Liberibacter solanacearum on carrots in Austria. No 02, 2015/029<br>EPPO Reporting Service (2015): First report of Candidatus Liberibacter solanacearum on carrots in Germany; No 9, 2015/165<br>Gudmestad, N. C., Secor, G. A. (2007): Zebra Chip: A new disease of potato. Nebraska potato eyes, 19 (1), 1-4<br>Hansen, A. K. *et al.* (2008): A new huanglongbing species, ‘*Candidatus* Liberibacter psyllaurous,’ found to infect tomato and potato, is vectored by the psyllid *Bactericera cockerelli* (Sulc). Applied and Environmental Microbiology 74 (18), 5862-5865.<br>Laska P. (2011): Biology of Trioza apicalis – a review. Plant Protect. Sci., 47, 68–77.<br>Li, W. *et al*. (2009): Multiplex real-time PCR for detection, identification, and quantification of “*Candidatus* Liberibacter solanacearum in potato plants with zebra chip. J. Microbiol. Methods 78, 59-65<br>Liefting, L. W. *et al.* (2009a): A new ‘*Candidatus* Liberibacter’ species in *Solanum tuberosum* in New Zealand. Plant Disease 92 (10), 1474.<br>Liefting, L. W. *et al.* (2009b): *Candidatus* Liberibacter solanacearum associated with plants in the family *Solanaceae*. International Journal of Systematic and Evolutionary Microbiology 59, 2274-2276. |

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| | Munyaneza, J. E. *et al*. (2007): Association of Bactericera cockerelli (*Homoptera*: *Psyllidae*) with zebra chip, a new potato disease in Southwestern United States and Mexico. Journal of Economic Entomology 100, 656–663<br>Munyaneza, J. E. *et al*. (2009): First report of '*Candidatus* Liberibacter psyllaurous' in potato tubers with Zebra Chip disease in Mexico. Plant Disease 93 (5), 552.<br>Munyaneza, J. E. *et al.* (2010a): First report of "*Candidatus* Liberibacter solanacearum" associated with psyllid-affected carrots in Europe. Plant Disease 95 (5), 639.<br>Munyaneza, J. E. *et al.* (2010b): Association of "*Candidatus* Liberibacter solanacearum" with the Psyllid, Trioza apicalis (Hemiptera: Triozidae) in Europe. Journal of Economic Entomology, 103 (4), 1060-1070.<br>Munyaneza, J. E. (2012): Zebra Chip Disease of Potato: Biology, Epidemiology, and Management. American Journal of Potato Research, 89 (5), 329 – 350.<br>Munyaneza JE, Sengoda VG, Sundheim L, Meadow R (2012a) First report of 'Candidatus Liberibacter solanacearum' associated with psyllid-affected carrots in Norway. Plant Disease 96(3), p 454<br>Munyaneza JE, Sengoda VG, Stegmark R, Arvidsson AK, Anderbrant O, Yuvaraj JK, Rämert, Nissinen A (2012b): First report of 'Candidatus Liberibacter solanacearum' associated with psyllid-affected carrots in Sweden. Plant Disease 96(3), p 453<br>Ossiannilsson, F. (1992): The Psylloidea (Homoptera) of Fennoccandia and Denmark. Fauna Entomologica Scandinavica, 26, 347.<br>Pitman, A. R., Drayton, G. M., Kraberger, S. J., Genet, R. A., Scott I. A. W. (2011): Tuber transmission of *'Candidatus* Liberibacter solanacearum' and its association with zebra chip on potato in New Zealand. European Journal of Plant Pathology 129 (3), 389-398.<br>Pletsch, D. J. (1947): The potato psyllid *Paratrioza cockerelli* (Sulc), its biology and control. Montana Agricultural Experimental Station Bulletin 446, 95.<br>Ravindran A, Levy J, Pierson E & Gross DC (2011): Development of primers for improved PCR detection of the potato zebra chip pathogen, '*Candidatus* Liberibacter solanacearum'. *Plant Disease* **95**, 1542-1546<br>Psyl'list (2012): http://www.hemiptera-databases.com/psyllist/ |

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| | (Webseite aufgerufen am 02.08.2012).<br>Rehman, M. *et al.* (2010): First report of "*Candidatus* Liberibacter psyllaurous" or *Ca*. Liberibacter solanacearum" associated with severe foliar chlorosis, curling, and necrosis, and tuber discoloration of potato plants in Honduras. Plant Disease 94 (3), 376.<br>Richards, B. L., Blood, H. L. (1933): Psyllid yellows of the potato. Journal of Agricultural Research (Washington) 46, 189–216<br>Schrader, G., Müller, P., Stefani, E. (2014): *Candidatus* Liberibacter solanacearum – eine neue Gefahr für den Kartoffel und Tomaten-anbau? Journal for Kulturpflanzen, 66 (5), 169–174.<br>Teresani, G.R.; Bertolini, E. et al. (2014): Association of *Candidatus* Liberibacter solanacearum with a vegetative disorder of Celery in Spain and development of a real –time PCR method for its detection. The American Phytopathological Society 104, 8, 804-811.<br>Wallis, R. L. (1955): Ecological studies on the potato psyllid as a pest of potatoes. *USDA Technical Bulletin.* 1107, 25 |

**Figures**

see

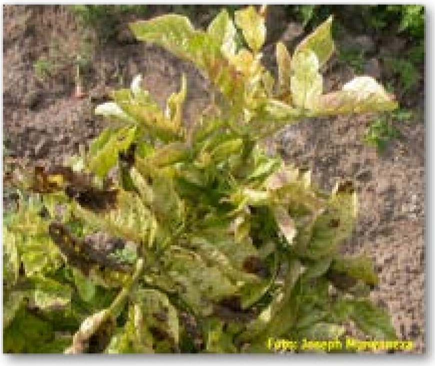
http://www.eppo.int/QUARANTINE/Alert_List/bacteria/Liberibacter_psyllaurous.htm („Zebra chips“ and Bactericera cockerelli);

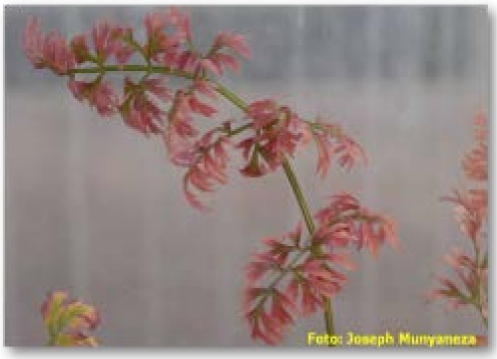
http://www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/documents/candidatusLiberibacterSolanace.pdf

(infestation pictures)

Fig. 1 – 6: Larva of *Bactericera cockerelli*, Imago of *B. cockerelli*, infested potato plant, Zebra chip-disease, infested carrot plant, symptoms on infested potatoes.








**Explanation**

[1] Compilation of the most important directly available information allowing a first preliminary estimation of the phytosanitary risk. This short assessment is necessary for the decision on a notification to EU and EPPO as well as the preparation of a complete risk analysis, for the information of the countries and as a basis for the possible initiation of eradication measures. Regarding the phytosanitary risk especially the possibility of the introduction to and spread in Germany and the Member States as well as possible damage are taken into account.

[2] Taxonomic classification - also subspecies - in the case that the taxonomical classification is uncertain the JKI-scientist initiates the taxonomic classification as far as possible.

[3] If so, which organism (which organisms) is (are) transmitted and does it (do they) occur in Germany/the MS?

[4] If so, which organism serves as a vector and does it occur in Germany/the MS?

[5] Description of the pattern of damage and the strength of the symptoms/damage on the different host plants.

[6] Presence of host plants in protected cultivation, open field, amenity plantings, forest, ....; where, in which regions are the host plants present and to which extent? How important are the host plants (economical, ecological, ...)?

[7] Presence of the host plants in protected cultivation, open field, amenity plantings, forest, ....; where, in which regions are the host plants present and to which extent? How important are the host plants (economical, ecological, ...)?, possible origin

[8] f. e. acc. to CABI, EPPO, PQR, EPPO Datasheets.

[9] Which pathways are known for the pest and how important are they for the possibility of introduction. Primarily the transport of the pest over long distances is meant, normally with infested traded plants, plants products or other contaminated articles. This does not comprise the natural spread resulting from introduction.

[10] Which pathways are known for the pest and of which relevance are they in respect of the probability of the spread? In this case the natural spread resulting from introduction is meant.

[11] Under the given prevalent environmental conditions.

[12] Under the given prevalent environmental conditions (native areas and areas of introduction).

[13] Description of the economic, ecological/environmental and social damage in the area of origin resp. areas of occurrence up to now.

[14] Description of the economic, ecological/environmental and social damage to be expected in Germany, as far as possible and required, differentiated between regions.

[15] Description of economic, ecological/environmental relevant and social damage to be expected in the EU /other Member States, as far as possible and required, differentiated between regions.

[16] Can the pest be controlled? Which possibilities of control are given? Are plant health measures conducted in respect to this pest (in the areas of current distribution resp. by third countries)?

[17] Description of possibilities and methods for detection. Detection by visual inspections? Latency? Uneven distribution in the plant (sampling)?