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Swedish University of Agricultural Sciences

SLU Risk Assessment of Plant Pests

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Potential establishment of the priority pest *Bactericera cockerelli* in Sweden

Background and terms of reference

The European Commission has established a list of 20 priority pests (Commission Delegated regulation (EU) 2019/1702). The pests have been selected among the Union quarantine pests as the pests for which the potential economic, environmental and social impact is assessed to be the most severe in the EU.

For each priority pest Member States shall carry out annual surveys (article 24 in EU regulation 2016/2031). However, the regulation further states that:

"The surveys shall not be required to be carried out for pests for which it is unequivocally concluded that they cannot become established or spread in the Member State concerned due to its ecoclimatic conditions or to the absence of the host species."

For some of the priority pests it is currently uncertain whether the ecoclimatic conditions or host availability in Sweden allow their establishment in whole or part of the country.

The Swedish Board of Agriculture has requested SLU Risk Assessment of Plant Pests to assess whether certain priority pests are able to establish in Sweden and further, when relevant, identify the area of potential establishment. This report provides the assessment of the potential establishment of *Bactericera cockerelli* (EPPO code: PARZCO).

Short description of *Bactericera cockerelli*

Bactericera cockerelli (tomato/potato psyllid) is a small psyllid species, 2.5 – 2.75 mm long as adults (EPPO, 2013). The pest causes damage to potatoes and other solanaceous plants. The psyllid nymphs cause feeding damage (referred to as 'psyllid yellows'), but mainly damages are due to the transmission of *Candidatus* Liberibacter solanacearum (e.g. causing 'zebra chip disease' of potato tubers)(EPPO, 2013; EFSA, 2019a; CABI, 2020). The psyllid is found in the American continents and reported from USA, Canada, Mexico, Guatemala, El Salvador, Honduras, Nicaragua and Ecuador (EPPO, 2020). It is also reported from Australia (first record in 2017), New Zealand (first record in 2006) and the Norfolk Islands (first record in 2015)(Thomas et al. 2011; ProMED posting, 2015; IPPC, 2017; EPPO, 2020).

Host are mainly found in the Solanaceae family, but susceptible species are also found in an additional 19 families (EFSA, 2019a).

One life cycle is reported to be completed in 3-5 weeks depending on the conditions (EPPO, 2013). Eggs are generally placed on the leaves and nymphs go through five instars before moulting into adults (EPPO, 2013). Studies indicate that the species does not appear to exhibit true diapause but instead may overwinter in a state of dormancy induced by low temperatures (Horton et al. 2015a).

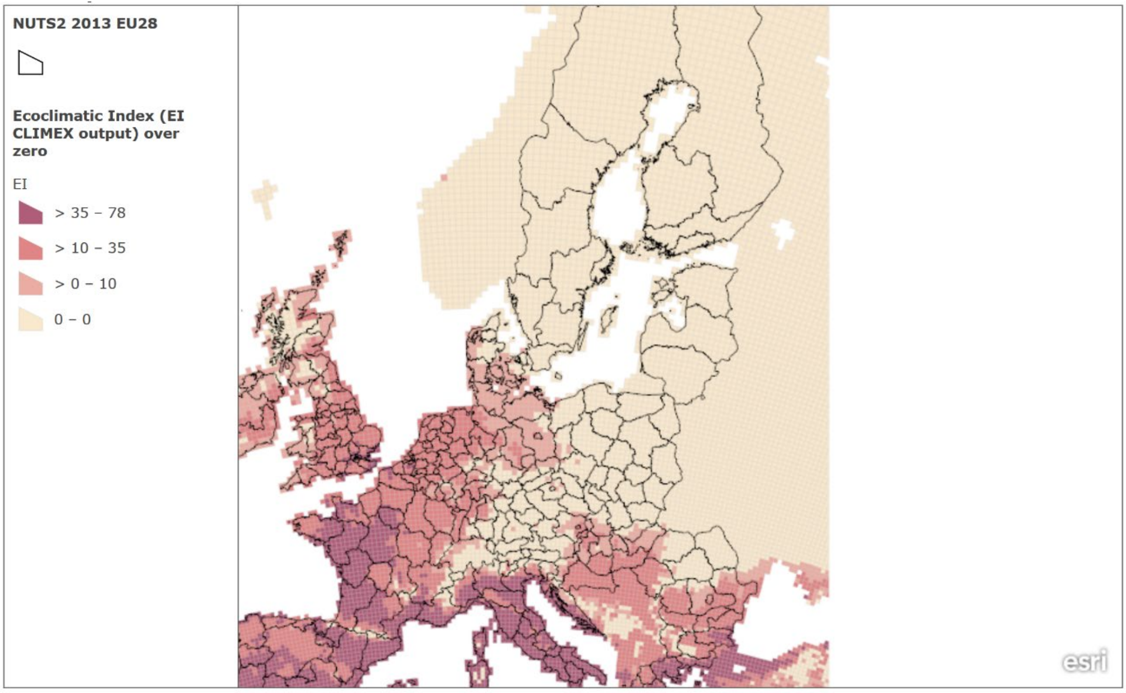
Ecoclimatic conditions

CLIMEX analyses

EFSA analysed the potential establishment of *B. cockerelli* in the EU in a recent pest report (EFSA, 2019a) using the climate niche model CLIMEX (Sutherst and Maywald, 1985). The analysis was based on the pest specific parameter values for CLIMEX published by EPPO (2012b), using the parameter set adjusted to fit the distribution of the pest in New Zealand (EFSA, pers. comm. 6 April 2020). EFSA used climate data for the time period 1998-2017 for the analysis (EFSA, 2019b). EFSA (2019a) concluded that *B. cockerelli* would be able to establish in southern and central parts of the EU as well as in northern parts with mild winters.

We further explored the data provided by EFSA via the interactive site https://arcg.is/0iH1Sq0. Using the tools provided there, the Ecoclimatic Index (EI) values across Europe could be visualized (Figure 1). The EI values of nearly all of Sweden was equal to 0 and thus the model indicate that the climatic conditions are unsuitable for establishment of the species (Kriticos et al. 2015). Only one of the grid cells with an EI of 1 included a small area of Sweden, i.e. a part of the peninsula Kullaberg.

The area with suitable climate in Europe predicted by the modelling by EFSA (2019a) is, for to us unknown reasons, smaller than that predicted by the previous CLIMEX modelling by EPPO (2012b). The latter indicate that the climatic conditions in the southern part of Sweden (approximately south of *Limes Norrlandicus*) would be suitable (to varying degrees) for the establishment of *B. cockerelli* (EPPO, 2012b). Since it was not possible to evaluate which of the two CLIMEX analyses that provides the best prediction, we here treat the deviation between the predictions as contributing to an increased uncertainty in our assessment of the likelihood of establishment in Sweden.



ESRI, HERE

Figure 1. *This map is an additional output from the Report of the Expert Knowledge Elicitation by the EFSA Working Group on EU Priority Pests (EFSA, 2019a). The map shows the Ecoclimatic Index (EI) from the bioclimatic model CLIMEX for* B. cockerelli*. The map was accessed via the interactive site https://arcg.is/0iH1Sq0 and modified using ESRI ArcGIS Online.*

Analysis based on the current distribution and Köppen-Geiger climate zones

In Canada and the northern parts of USA, *B. cockerelli* was previously described as consisting only of transient populations. The psyllid was described to overwinter and breed in the area of south-western USA and northern Mexico and to annually migrate to the northern parts of its range in northern USA and Southern Canada (EPPO, 2013; CABI, 2020). *Bactericera cockerelli* was considered to be unable to overwinter and establish in Canada (EPPO, 2013). However, later observations of overwintering individuals has been reported from the Pacific Northwest (e.g. Murphy et al. 2013). That there is indeed an established population is also supported by genetic studies suggesting that a haplotype of the species is native to this region (Swisher et al. 2013).

Recently, during a monitoring program between 2015-2017 in Canada, *B. cockerelli* was found in Alberta, Saskatchewan and Manitoba, although at very low population levels (Johnson et al. 2017). It was suggested that the population mostly consisted of individuals from a local population, rather than by migrants, since the first trapped specimens did not seem to have undertaken long distance flights. The range of *B. cockerelli* in these areas in Canada seems to have remained the same the years following the program (D. Johnson, pers. comm. 1 April 2020).

In order to analyse the climatic conditions associated with the recent observations made in Canada, the locations were extracted from the maps included in the report by Johnson et al. (2017) and plotted on a map with the Köppen-Geiger climate zones by Beck et al. (2016) using qGIS (Appendix 1). Most findings of *B. cockerelli* fall within the climate zone BSk, described as arid, steppe and cold (Beck et al. 2016). A few records were found in the climate zone Dfb and Dfc, which corresponds to the climate zones found in Sweden (Figure 2). However, whether these observations represents established pest populations is not known.

In New Zealand, where *B. cockerelli* was introduced, the main Köppen-Geiger climate zone is Cfb, which is a climate zone expected to expand northwards in Scandinavia in the future (Figure 2a and 2b). Notably, based on the distribution of the pest in North America the climatic conditions in New Zealand would not have been expected to be suitable for establishment (EPPO, 2012b).

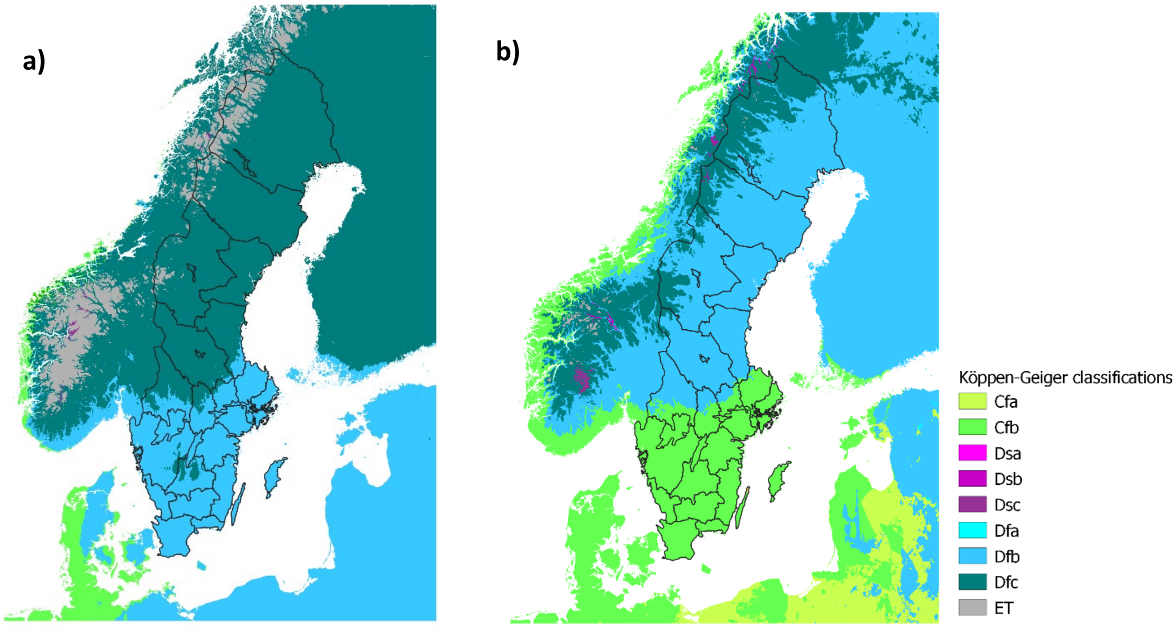


Figure 2. *Köppen-Geiger climate classifications in Sweden and surrounding areas based on a) the climate during the time period 1980-2016 and b) the predicted climate according to scenario RCP 8.5 for the time period 2071-2100 (modified maps from Beck et al. 2016; www.gloh2o.org/koppen; available under the CC BY-NC 4.0 license). The map of the counties in Sweden is from SCB (2020).*

Overwintering

Both nymphs and adults are reported to be cold hardy and can survive very low temperatures (EPPO, 2012a). Nymphs, for example, were able to survive -15°C and 40% of adults survived at -10°C for 24h in experimental settings (Henne et al. 2010). Overwintering has been suggested to depend on the availability of host plants during spring times (Horton et al. 2015b), see further under section 'Presence and distribution of hosts'.

Thermal requirements for development

Thermal requirements to complete one life cycle (i.e. egg to adult) has been estimated to 358 DD above 7.1°C for psyllids reared on potato and 368 DD above 7.5°C on tomato (Tran et al. 2012). The thresholds were estimated in an experiment in New Zealand, presumably on local psyllid colonies.

We analysed whether the temperature requirements for development were met in Sweden using the R code by Korycinska (2020) and gridded MARS-AGRI4CAST temperature data from JRC for the time period 1999-2018 (JRC, 2020). Based on the threshold of 358 DD above 7.1°C, *B. cockerelli* would be able to complete up to four generations per year in some parts of Sweden (Figure 2). Only small areas in the mountains do not fulfill the thermal requirements for one generation.

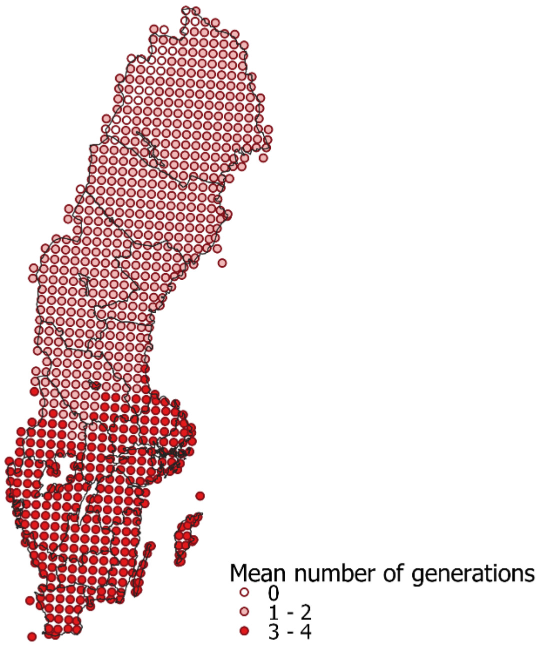


Figure 2. *Mean number of generations per year of* B. cockerelli *based on 358 degree days above 7.1 °C for one generation from Tran et al. (2012). Calculated using climate data for the period 1999-2018 (JRC, 2020). The map of the counties in Sweden is from SCB (2020).*

Establishment under protected cultivation

Bactericera cockerelli is reported as a serious pest in greenhouse production of Solanaceae plants in both North America and New Zealand (e.g. Al-Jabr and Cranshaw, 2007; Teulon et al.

2009; Walker et al. 2015). In New Zealand, the pest is found in greenhouse production of tomatoes and peppers as well as outdoors (Teulon et al. 2009; Hodge et al. 2019). Since *B. cockerelli* was first reported in British Columbia in a tomato greenhouse in 1996, its occurrence frequency has fluctuated widely (McGregor, 2013 citing other sources). For example, *B. cockerelli* was reported to occur in 88% of greenhouses surveyed in 2007 in British Columbia, but it was further stated that efficient management prevent serious damage (Greenhouse Canada, 2011).

Our assessment is that *B. cockerelli* can establish in greenhouses in Sweden where tomato or peppers are produced. This assessment is in agreement with the conclusion of the EPPO PRA for *B. cockerelli* (2012a) which assessed the probability of establishment in greenhouses to be high, with low uncertainty.

Presence and distribution of hosts

Main host species are aubergine (*Solanum melongena*), peppers (*Capsicum* sp.), tomato (*Solanum lycopersicum*) and potato (*Solanum tuberosum*) (EFSA, 2019a). Of these, only potato is cultivated outdoors in Sweden. Statistics from 2019 shows that 23 650 ha of agricultural land were cultivated with potato in 2019 (Jordbruksverket, 2019). Almost half of the area (10 669 ha) was located in Skåne (Figure 3).

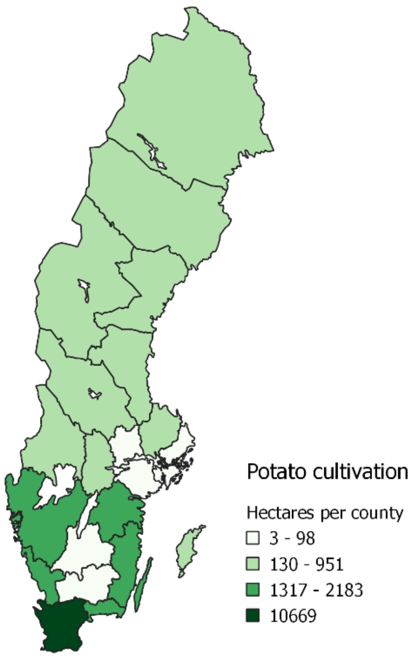


Figure 3. *Area of potato cultivation in 2019 per county in Sweden in hectares. Based on data from Jordbruksverket (2019). Map of the Swedish counties from SCB (2020).*

Capsicum annuum and *Solanum lycopersicum* are produced commercially in greenhouses. In 2017, *C. annuum* (chili and sweet peppers) was produced in 7 230 m^2 of greenhouse while *S. lycopersicum* was produced in 401 295 m^2 of greenhouse (Jordbruksverket, 2018). More than

50% of the latter (213 859 m^2) was located in Skåne. *Solanum melongena* was not reported to be produced in Sweden during 1999-2017 by Jordbruksverket (2018). There are however, according to Karlsson (2019), currently some small-scale production.

Other hosts listed by EFSA (2019a), which are considered to be established in Sweden according to SLU ArtDatabanken (2020), are listed here:

- *Convolvulus arvensis* (åkervinda)
- *Lycium* spp. (as *L. barbarum* (Bocktörne) and *L. chinense* (bredbladig bocktörne)
- *Medicago sativa* (Lusern), mainly cultivated
- *Mentha* spp., as e.g. *M. arvensis* (åkermynta)
- *Nepeta* spp., as e.g. *N. cataria* (kattmynta)
- *Physalis* spp., as e.g. *P. alkekengi* (japansk lykta)
- *Solanum* spp., as e.g. *S. dulcamara* (besksöta)

Although feeding has been reported on many plant species not all appear to be suitable for the species reproduction (EPPO, 2012a).

Establishment in areas where *B. cockerelli* overwinters has been suggested to be dependent on the availability of hosts acting as a 'bridge' and supporting populations before potato emergence in the spring (Horton et al. 2015b). *Solanum dulcamara*, which is an introduced species in North America, have for example been shown to host overwintering populations in the north-eastern states of USA and have been suggested to play a role in the epidemiology of the pest in this region (Horton et al. 2015b). In Sweden, *S. dulcamara* is found in humid environments, such as swamps and along rivers and lakes in the southern parts of Sweden and in the north along the eastern coast (SLU ArtDatabanken, 2020, Naturhistoriska Riksmuseet, 1996).

Host plants are available in Sweden both outdoors and in protected cultivation. It is, however, not known whether *S. dulcamara*, or any other host plants, could play a similar role for overwintering populations of *B. cockerelli* in Sweden as suggested for the north-eastern USA.

Conclusion

Based on the information presented above our assessment is that establishment of *Bactericera cockerelli* in greenhouse conditions in Sweden could occur.

The information regarding the potential for establishment outdoors was not consistent and associated with large uncertainties. To summarize; modelling work indicate that the climatic conditions in Sweden mostly is unsuitable. Temperature during summer appear to support at least one and up to four generations per year. Several stages of the pest also appear to be cold hardy, but the species appear to lack true diapause and has been suggested to be dependent on the availability of host plants early after the winter. Although there are records of *B. cockerelli* in Canada in Köppen-Geiger climate zones corresponding to those found in Sweden it has not been confirmed that these are established populations. Further, using the distribution in North America to predict the potential of establishment elsewhere is difficult which was shown by the example of New Zealand. Based on the information provided, our assessment is that it is unlikely that *B. cockerelli* could establish in Sweden. However, the assessment is associated with a very high degree of uncertainty and it cannot be totally excluded that *B. cockerelli* could establish in at least parts of southern Sweden.

Acknowledgement

We would like to thank Daniel Johnson (University of Lethbridge) for sharing his knowledge about the distribution of *B. cockerelli* in Canada and EFSA for answering questions related to the pest report on *B. cockerelli*.

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Appendix 1. Distribution of *Bactericera cockerelli* in Canada

During a monitoring program in Canada (2015-2017) *Bactericera cockerelli* was found in Alberta, Saskatchewan and Manitoba (Johnson et al. 2017). Presence and absence locations were extracted from the maps included in the report using qGIS (QGIS Development Team, 2020) and mapped on the Köppen-Geiger climate zones by Beck et al. (2016). Most observations were found in regions with Köppen-Geiger climate zone BSk (arid, steppe, cold) while a few were found in the climate zones Dfb (cold, no dry season, warm summer) and Dfc (cold, no dry season and cold summer) (Figure 1).

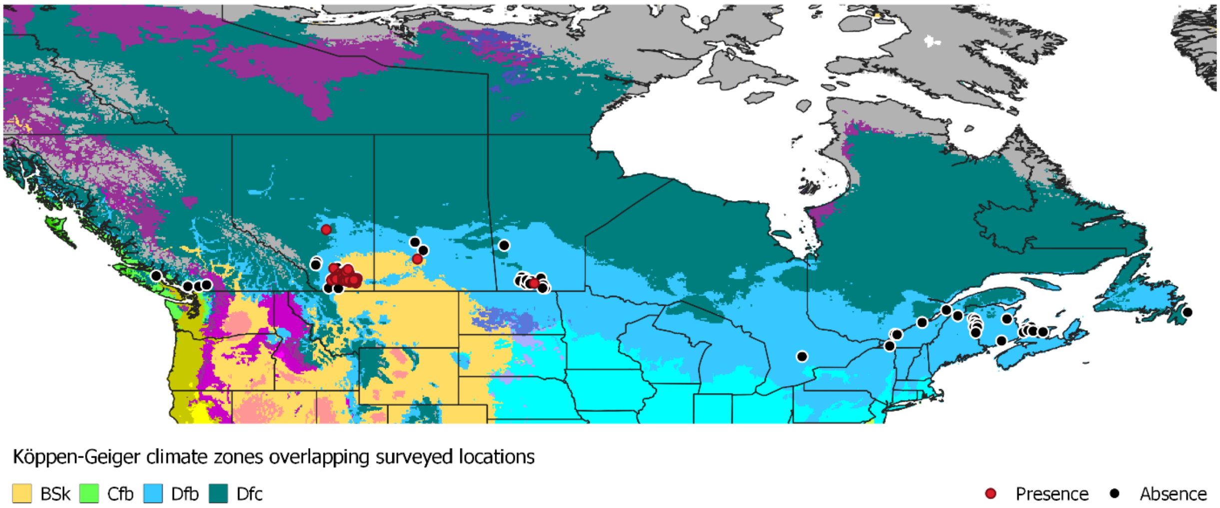

Figure 1. *Distribution of* Bactericera cockerelli *found in Canada during a monitoring program 2015-2017 (Johnson et al. 2017). Record locations were georeferenced from maps in Johnson et al. (2017) using the qGIS tool Georeferencer. Köppen-Geiger climate classifications maps are from Beck et al. (2016) and based on the climate during the time period 1980-2016 (available under the CC BY-NC 4.0 license, downloaded from www.gloh2o.org/koppen and here displayed in a modified version). The map of the states and provinces are from naturalearthdata.com.*

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