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A revision of emergent pests in major agricultural and horticultural crops in Finland

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Climate change and changes in agricultural production will benefit pest species in Northern Europe by decreasing climatic restrictions and increasing availability of host plant species. We reviewed changes in the status of agricultural and horticultural pests that were identified in 2011 as potential future threats to Finnish plant production and identified species that were not mentioned in the previous review but are considered emergent pests now. In field crops, the emergent weed species were *Echinochloa crus-galli* and *Solanum nitidibaccatum*, the emergent plant pathogens *Zymoseptoria tritici*, *Fusarium graminearum* and *F. langsethiae* and rusts (*Puccinia* spp.) in cereals, as well as Potato mop-top virus (PMTV) and emerging species of potato blackleg bacteria *(Dickeya* and *Pectobacterium* spp.). The migrant Lepidopteran, *Autographa gamma*, the established alien sawfly *Athalia rosae* in oilseed crops, the alien *Bruchus rufimanus* in faba beans, native *Chaetocnema* spp. in spring cereals and wireworms (Elateridae) in potato were the emergent arthropod pests of field crops. In horticultural crops, *Aculops lycopersici, Bemisia tabaci, Rhagoletis batava, Igutettix oculatus, Hoplocampa flava and Hoplocampa minuta* and *Otiorhynchus* spp. were emergent alien arthropod pests, while the greenhouse whitefly, various aphids, thrips, and *Phytonemus pallidus* and *Tetranychus urticae* were emerging mainly due to withdrawal of chemicals. Warm early summers, banning of chemicals and importation of plants and seeds were considered the major drivers of the change. Several pests not considered potential future threats in 2011 are now emergent pests in Finland, underlining rapid changes in pest emergence and the challenges of their prediction. Utilization of citizen science platforms is encouraged to enhance early observation of emerging pests.

Key words: arthropod, climate change, plant health, plant pathogen, biological invasions, weed

Introduction

Agricultural pests respond to environmental conditions and the availability and management of host plants. In northern Europe, these factors have constrained the distribution and occurrence of many pest species (Rautapää 1992, Hakala et al. 2011, Hyvönen et al. 2011, Hyvönen et al. 2012, Jalli et al. 2020, Björklund et al. 2024). During recent decades, changing climate, crop diversification and adoption of more environment-friendly management practices has weakened these constraints (Hakala et al. 2011). Finland, as the northernmost agricultural country in the world, is expected to get new pest species due to these changes (Hakala et al. 2011, Hyvönen et al. 2012).

Finland is located between latitudes 60° and 70°, has an agricultural area of 2.3 million hectares (ha), of which spring cereals comprise 47% and forage grasses 34% (Natural Resources Institute Finland 2025a). Horticultural production in the open covers 18 338 ha (vegetables 54% and berries 37%) and 452 ha in greenhouses (vegetables 43%) and tunnels (berries 25%) (Natural Resources Institute Finland 2025a). In 2019, 79% of the total volume of pesticides used were herbicides and 17% were for disease control, whereas insecticides and growth regulators together only accounted for 4% of the total volume (Natural Resources Institute Finland 2025b). On average, these figures reflect the importance of different pest groups in Finnish agriculture and horticulture. The proportions of different pesticides used vary according to the crop species, but even so, the ranking of herbicides first, fungicides second and insecticides+growth regulators third mostly remains the same, irrespective of the crop (Räsänen et al. 2025). Exceptions are food potato (*Solanum tuberosum* L.), strawberry (*Fragaria × ananassa* Duchesne), currants (*Ribes* spp.) and apples (*Malus domestica* Borkh.), for which disease control usually requires more effort than the control of weeds (Natural Resources Institute Finland 2025b).

Some impacts of the climate change have already been realised in the Finnish field crop production. Sowing dates, but not harvesting dates, are earlier (Peltonen-Sainio and Jauhiainen 2014), several crops such as wheat

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(*Triticum aestivum* L.), pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.) and oilseed crops are grown on larger areas and more northern regions (Peltonen-Sainio and Jauhiainen 2020, Natural Resources Institute Finland 2025a). Furthermore, more productive and late maturing cultivars have been taken into cultivation (Peltonen-Sainio and Jauhiainen 2020). At the same time, crop rotations have become more diverse in many regions (Peltonen-Sainio and Jauhiainen 2019) and are encouraged by crop rotation planning tools (Peltonen-Sainio et al. 2020), since the climate change is predicted to amplify the pest problems associated with large monocultures (Ma et al. 2025). In horticultural production, the use of lightweight tunnels instead of open field cultivation of strawberries and raspberries (*Rubus idaeus* L.) is increasing, providing protection against extreme weather conditions, prolonging the production period and favouring the use of biological pest control (Natural Resources Institute Finland 2025c). Climate warming combined with import of horticultural plants for planting from commercial plant hubs in other European Union (EU) countries and online market of ornamental plants increase the chances of establishment of pest species (Gullino et al. 2022).

Certain changes in crop production practices have likely favoured emergence of new pest species. Introduction of wildflower seed mixtures, cover crops and new crops (e.g. caraway (*Carum carvi* L.)), as well as increase in the cropping area (e.g. faba bean and wheat) has likely favoured immigration of new host plants for pests (Huusela-Veistola and Jauhiainen 2006). Early summer droughts have likely reduced crop growth, and the exposure of crop stands to pests. Longer, warmer growing seasons have a potential to result in increased numbers of generations per summer of multivoltine arthropod pests such as aphids, thrips, whiteflies and moths, which accelerates their population growth or adaptation, potentially resulting in more frequent pest outbreaks (see Altermatt 2010). High summer temperatures and longer growing seasons may have facilitated the reproduction of some weed species in southern Finland although crop-weed competition plays a key role in the establishment (see Hyvönen and Ramula 2013). Berry production in tunnels has increased thrips, spider mite and powdery mildew problems, but decreased problems with soil-borne diseases (Tuovinen et al. 2010). Change in tillage practices to favour minimum tillage has facilitated increased incidence of straw-borne plant diseases such as tan spot (causal agent *Pyrenophora tritici-repentis* (Died.) Drechs.), especially in wheat monoculture (Jalli et al. 2021). Restrictions in the use of pesticides due to toxicological risks to the environment or users (Kudsk and Matthiassen 2020, Robin and Marchand 2023) have reduced availability of active ingredients and application doses in the European Union. Decreased chemical control (e.g. Slavíková et al. 2024), particularly in monocultures where natural enemies often are insufficient to control pests effectively (Chikte et al. 2024), has contributed to the growth of pest populations elsewhere. Such evidence is accumulating also in Finnish horticulture, where availability of insecticides e.g. for greenhouse tomato (*Solanum lycopersicum* L.) and cucumber (*Cucumis sativus* L.) crops is minimal or non-existent and thus provides no support to biocontrol.

Here, we reviewed changes in the status of agricultural and horticultural pests that were identified in 2011 as potential future threats to Finnish plant production and identified species that were not mentioned in the previous review but are considered emergent (i.e. recent increase in abundance or distribution) pests now. Previous comprehensive review of Finnish pest species focused on alien species and were published in 2011 in a special issue of Agricultural and Food Science, *Alien pest species in agriculture and horticulture in Finland* (Hyvönen 2011). The special issue provided updated reviews on the status of major groups of alien pest species in Finland, including plant pathogens (Lemmetty et al. 2011, Hannukkala et al. 2011, Jalli et al. 2011, Lilja et al. 2011), arthropod pests (Vänninen et al. 2011) and weeds (Hyvönen and Jalli 2011) as well as the driving forces for the changes (Hakala et al. 2011). The major focus in the reviews was to predict the potential for the range expansion and establishment of permanent populations with respect to increased immigration pressure, changing climate and introduction of new crop species. Changes in pest status have not been reviewed recently, although there is an urgent need for such information to prioritize pest management. Here, we aimed at reviewing changes in the status of pests classified as potential or emergent in the reviews of arable weeds (Hyvönen & Jalli 2011), plant pathogens of cereals (Hakala et al. 2011, Jalli et al. 2011) and potato (Hannukkala et al. 2011), as well as arthropod pests of horticultural and arable crops (Vänninen et al. 2011). In addition, we identified emerging pests not considered potential threats in the earlier reviews.

Material and methods

Primary species lists for the exploration (Appendix 1) were obtained from 2011 special issue reviews with the following criteria. For arable weeds, ten species listed as weed species of concern were selected (Hyvönen and Jalli 2011). For cereal crop diseases, the fungal pathogens mentioned in the publications by Jalli et al. (2011)

and Hakala et al. (2011) as potential pathogens were selected. For potato diseases, the pathogens identified by Hannukkala (2011) as the most important were selected.

For invertebrate pests of arable and horticultural crops, the list of species having received a risk index of 0.3 or higher in the 2011 review based on SOM-analysis (a horizon scanning method) (Vänninen et al. 2011) was used as the primary species list. The underlying assumption in the SOM (Self-Organizing Map) method (based on neural network computation) is that certain species of plant pests tend to co-occur in particular regions around the world because of specific combinations of environmental factors. Such combinations can be clustered according to their similarity to identify missing species from a target region's (e.g. Finland) pest profile. The method computes statistical weights for the species in the clusters of pest profiles, and these weights are used to determine the species' risk of establishment (the values can be understood as a likelihood or an index varying between 0 and 1) in the target area. The SOM method does not take a position on whether the species will reach the target area, but operates only on the likelihood of the species forming permanent populations in case they pass the transport stage of invasion.

This list is not crop-specific but includes arthropod pest species known to affect arable or horticultural crops (CABI 2003). An additional list included 77 alien pest species that had either established in Finland or been transported there at least once (see Vänninen et al. 2011). The additional list was reviewed to include invertebrates other than insects and mites that had either entered Finland at least once or established here before 2011.

Regarding all pest groups, information for the review on the occurrence and harmfulness of pest species were collected from scientific and grey literature as well as from unpublished data sources such as personal observations of advisors and researchers and the LukeKasKas service (https://www.luke.fi/fi/luonnonvaratieto/tiedetta-ja-tietoa/kasvinterveys/lukekaskas). LukeKasKas is used by farmers (more than 11 000 users) to record their own weed, plant disease and insect pest observations, and has been used on a larger scale since 2023–2024.

The collection of information by pest groups was completed as follows. For weeds, the results of the latest weed survey of spring cereal fields provided information on the recent changes in the distribution and abundance of major weeds in cereal production (Salonen et al. 2023). The following platforms were also used to obtain information on the recent changes in weed species distribution in Finland and neighbouring countries: Finnish Biodiversity Information Facility (https://laji.fi/en) (FinBIF), Swedish Artdatabanken (https://www.slu.se/artdatabanken/) and Norwegian Biodiversity Information Centre Artsdatabanken (https://artsdatabanken.no/).

For plant pathogens of cereals, the information was completed with the observations from official cereal variety trials in Finland, efficacy trials of plant protection products and from farmers' samples analyzed by the Finnish Food Authority. The official variety trials are carried out annually in growing zones I – IV (between latitudes 60° and 66°), while the plant protection trials are mainly conducted in southern Finland. Information on potato pests was completed with personal communications with representatives of the Finnish Food Authority and Finnish seed potato companies. Potato late blight (Phytophthora infestans (Mont.) de Bary) genotype information was obtained from the EuroBlight network (https://agro.au.dk/forskning/internationale-platforme/euroblight).

For insect pests of field crops, the information was completed with observations from Luke long-term field trials, personal and subsequently expert verified observations by the food industries, and observations from FinBIF. For arthropod pests in horticulture, the information from FinBIF was completed with observations made by researchers (observations of authors with entomology expertise) and advisors and suppliers of biological control agents. These actors regularly visit plant producers and receive samples to be identified. The identifications of pest species by advisors as mentioned in this publication were verified by research entomologists. In addition, observations made by the members of the virtual Facebook group Puutarhan parhaaksi, a citizen science platform with over 26 000 members and moderated by a horticultural scientist knowledgeable in entomology, were included. The moderator makes the first-stage identification and contacts entomology experts thereafter to verify the identifications. These observations include mainly those from home gardens, which can serve as stepping stones from which pests could subsequently expand their distribution to professional fruit and berry crops. An emergent pest was defined as a pest species, either native or alien of origin, whose populations or impacts have recently grown and resulted in increased damage of crop plants. Consequently, pest species considered earlier to be of secondary importance may have become target species for management/control, or the populations of species of primary importance have become more difficult to control. Evaluations of the status of pests were done as expert evaluations by the authors based on all the available data listed above. The attribution of scientific names of species are given in Tables 1 and 2 or in the text when mentioned the first time.

Limitations of the revision

Observations recorded in FinBIF do not, in themselves, indicate whether a species is harmful to crop plants. Moreover, the database does not provide up-to-date information on the establishment status of all species. This is particularly relevant for alien species, which may still be in the transport or colonization stages of invasion, or in the early stages of establishment (Hellman et al. 2008). The same uncertainty applies to citizen observations recorded on other platforms, such as LukeKasKas. Additionally, observations from greenhouse crops appear to be less current in FinBIF than those from outdoor crops. Therefore, such data must be supplemented with information from other sources, as was done in this review.

The review by Vänninen et al. (2011) was a horizon-scanning study based on hundreds of species—both alien and native—for which the likelihood of establishment indexes was calculated. Other reviews began with a smaller number of species, focusing on alien species that were already established in Finland or were at least in the transport stage of invasion. Despite these methodological differences, the longtime span since 2011 allows us to identify which of the initially assessed species have since become established, as well as to detect newly established species that were not included in the earlier reviews.

Virus and viroid pathogens, along with other pathogens affecting horticultural crops, were included in the 2011 reviews but are absent from the current review due to the unavailability of experts to conduct such an analysis. In addition, no systematic survey of pathogens affecting oilseed crops has been conducted since the 2011 reviews, so these have also been excluded.

Results and discussion

Weeds

The review of Hyvönen and Jalli (2011) listed ten harmful weed species occurring as casual aliens in Finland with the highest risk of naturalization: *Amaranthus retroflexus* L., *Anagallis arvensis* L., *Avena sterilis* L., *Chrysanthemum segetum* (L.) Fourr., *Cynodon dactylon* (L.) Pers., *Datura stramonium* L., *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) P. Beauv., *Lolium temulentum* L. and *Papaver rhoeas* L. Only *E. crus-galli* fulfilled the criteria of emergent weed species in the current review (Table 1).

Here, we focused on weed species which have recently been found or have potential to increase their severity as problematic arable weeds in Finland. Based on the number of observations in FinBIF 2011–2024, most species listed by Hyvönen and Jalli (2011) have not been found (*C. dactylon* and *A. sterilis*) or have been rare (*A. arvensis*, *D. sanguinalis* and *L. temulentum*), or have been found mainly outside fields (*D. stramonium* and *P. rhoeas*) in Finland. Low number of observations suggests that those species have not been able to increase their occurrence, most likely due to lack of effective migration pathways. In contrast, *D. stramonium* invades Finland regularly in birdseed mixtures but it is unclear if it can produce viable seeds in the Finnish climate. *Papaver rhoeas* prefers calcareous soils (e.g. Andreasen and Skovgaard 2009), which are rare in Finland.

Echinochloa crus-galli has had severe infestations locally while its distribution is still limited in Finland. It is one of the world's worst weeds, with wide distribution and adaptation ability (Bajwa et al. 2015). *Echinochloa crus-galli* typically occurs in maize (*Zea mays* L.) fields in Central Europe (de Mol et al. 2015) and was supposed to be limited by climate and lack of suitable crops in Finland (Hyvönen and Ramula 2011). Unexpectedly, it has been able to colonize spring cereals in Finland and Norway (VKM 2016). *Echinochloa crus-galli*, like *Amaranthus retroflexus* L. and *Setaria viridis* (L.) P. Beauv., has higher germination base temperatures than widely distributed weeds of spring cereals in northern regions (Bürger et al. 2020), which limits their competitive ability at an early stage in spring. In southern Finland, early summers have been exceptionally warm in 2019–2024 (Finnish Meteorological Institute 2025), which likely has facilitated its success. *Setaria viridis* can be classified as an emergent weed species in Finland due to the extension of distribution. It has often been found at the same sites as *E. crus-galli* but with less severe infestations. It is likely that *S. viridis* and *E. crus-galli* have the same immigration pathways, probably wildflower seed mixtures as well as cereal and concentrated animal feeds. *Amaranthus retroflexus* has not extended its distribution area or infestation level in crop species. In Finland, it occurs mainly in sugar beet (*Beta vulgaris* var. *altissima* Doell), whose cropping area in Finland is limited.

Two *Solanum* species, *Solanum nigrum* L. and *Solanum nitidibaccatum* Bitter (or *S. physalifolium* var. *nitidibaccatum* (Bitter) Edmonds) can be classified as emergent weed species due to their extension of distribution and abundance. They are annual broad-leaved weeds occurring mainly in carrot (*Daucus carota* L.) and potato fields (Table 1). *Solanum nigrum* is an archaeophyte species, which has extended its range during recent decades in Finland. *Solanum nitidibaccatum* is an alien species in Europe, which has been reported to be an increasing problem in field-grown vegetables in southern Sweden (Taab 2009) and recently also in southern Finland. In Finland, new observations of *S. nitidibaccatum* are regularly made in carrot fields, which may suggest that carrot seed provides an invasion pathway for the species. Both species can severely infest vegetable and potato fields, requiring control measures. *Solanum* weeds can act as alternative hosts for potato pathogens such as potato powdery scab (*Spongospora subterranea* (Wallr.) Lagerh f. sp. *subterranea* Tomlinson) (Hiltunen et al. 2024), which increase their severity as a harmful weed species.

In Finland, tillage practices have changed in Finland to favour no-tillage and reduced tillage (Salonen et al. 2023) due to environmental subsidies and other economic factors. In response to this change, an annual grass weed, *Poa annua* L., has increased its frequency of occurrence in spring cereal fields (Salonen et al. 2023). As an autumn-germinated weed species, it has benefitted from the reduced tillage that allows overwintering and better competitiveness against crops. Other typical autumn-germinated grass weeds such as *Alopecurus myosuroides* Huds. and *Lolium multiflorum* Lam. have not succeeded in Finland. *Alopecurus myosuroides* is an annual grass weed belonging to the group of the most severe weeds of winter cereals in Europe (Cook et al. 2023). Recently, it has been increasing in Sweden, Norway, and Denmark, primarily due to changes in cropping systems which favour its growth, i.e. no-tillage or reduced tillage with continuous growing of winter cereals in the same field (Lutman et al. 2013). Herbicide-resistant populations of *A. myosuroides* have been found in 15 countries worldwide (Heap 2024), which further emphasizes the harmfulness of the species (Cook et al. 2023). *Lolium multiflorum* is commonly grown as fodder grass and a cover crop, but it can become a problematic weed. Currently, it has been reported to be an increasing problem in Sweden and Denmark (Sønderskov et al. 2020). Also, herbicide tolerance in *L. multiflorum* is widespread worldwide (Heap 2024), including Denmark (Mathiassen 2014). The success of these weed species would require a large-scale shift from spring-sown cereals to winter cereals. Currently, winter cereals comprise only 3.5% of the Finnish cropping area, and the large-scale shift is predicted to take decades (Peltonen-Sainio et al. 2009).

Plant pathogens of arable crops

Cereals

The review of Jalli et al. (2011) suggested that changing climate may increase the significance of *Zymoseptoria tritici* (Roberge ex Desm.) Quaedvl. & Crous (2011) (a causal agent of septoria tritici blotch STB) in wheat and the impact of rusts (*Puccinia* spp.) across all cereals. A new pathogen, *Fusarium verticillioides* (Sacc.) Nirenberg (1976), was detected for the first time in winter wheat in 2019 (Gagkaeva and Yli-Mattila 2020). Although the pathogen has been identified in Finland, its overall impact on cereal cultivation is still unclear. Other changes since 2011 concern incidence and severity of already established pathogens.

Zymoseptoria tritici is established in Finnish winter wheat fields and often occurs as a mixed infection with *Parastagonospora nodorum* (E.Müll.) Hedjar. (1969) (causal agent of stagonospora blotch) and *Pyrenophora tritici-repentis* (Died.) Drechsler (1923) (causal agent of tan spot). In the surveys made in 2023 and 2024 in winter wheat in Jokioinen, the symptoms were visible in the spring when growth started. Both in 2023 and 2024, the beginning of the growing season was very dry, and the development of symptoms was slow. However, when the humidity increased in July, the symptoms developed, and the infection spread to the upper leaves before ripening. This was also verified by qPCR tests. As also shown by Prahl et al. (2023) in their long-term survey in northern Germany, the incidence of STB in wheat may even increase in Nordic conditions due to climate change, especially the temperature increase in spring.

Already in 1953, it was reported that local outbreaks of rusts were regularly found in Finland (Kivi 1953). At that time severe stem rust epidemics caused by *Puccinia graminis* Pers. (1794) originated in southern Scandinavia. The disease was less significant in Europe for more than 60 years, mainly due to the eradication of its alternate host, common barberry (*Berberis vulgaris* L.), and success in disease resistance breeding. However, since 2016 it has caused epidemics in several wheat-growing areas in Europe (Patpour et al. 2022). The same phenomenon has also been observed in Finland where, in addition to infecting wheat, stem rust has also infected oats (*Avena sativa* L.). However, the infection is still predominantly present towards the end of growing season, and the impact on crop yield has been limited.

There have been occasional years with high incidences of other rust diseases in cereals. In Finnish official variety trials in 2017–2024, the highest average severities of rusts in different cereals at milk ripening stage have been: leaf rust (*Puccinia recondite* Roberge ex Desm. (1857)) in rye (*Secale cereale* L.) in 2019 (30%), stripe rust (*Puccinia striiformis* Westend. (1854)) in triticale (× *Triticosecale* Wittmack) in 2021 (20%), leaf rust (*Puccinia triticina* Erikss. (1899)) in winter wheat in 2019 (7%), leaf rust in spring wheat in 2019 (4%), leaf rust (*Puccinia hordei* G.H. Otth (1871)) in barley (*Hordeum vulgare* L.) in 2024 (17%) (Natural Resources Institute Finland 2025d). In oats, high infection levels of crown rust (*Puccinia coronata* Corda (1837)) were observed across a wide range of growing areas in 2024.

Fusarium fungi and their toxins pose an increasing threat to Finnish cereal production. High levels of *Fusarium culmorum* (Wm.G.Sm.) Sacc. (1892) and *Fusarium graminearum* Schwabe (1839) have been noted in oats and barley, while winter cereals have had the lowest infection rates. *Fusarium graminearum* and *Fusarium langsethiae* Torp and Nirenberg (2004) have become more prevalent during the two last decades (Hietaniemi 2016), which is in accordance with other Nordic countries (Fredlund et al. 2013, Hofgaard et al. 2017) and *F. graminearum* has become the most important producer of deoxynivalenol (DON) mycotoxin. Oat production is most vulnerable to DON accumulation. According to the surveys made by the Finnish Cereal Committee, during the past decade Finland has had four severe mycotoxin years (2016, 2017, 2023, 2024) when DON contaminations frequently caused severe economic losses, especially for oat farmers. The variation between different cultivation areas is high and correlates positively with high precipitation (Kaukoranta et al. 2019).

The incidence and severity of septoria tritici blotch, rusts, and *Fusarium* head blight caused by *F. graminearum* and *F. langsethiae*, have increased in Finnish cereal fields since 2011, posing an established threat to cereal production. Efforts should be focused on disease monitoring, risk assessments, resistant cultivars, crop rotation, and European collaboration to address their growing significance on cereal yield quantity and quality.

Potato

The review of Hannukkala (2011) listed potato wart (*Synchytrium endobioticum* (Schilbersky) Percival (1909)), blackleg and soft rot (*Dickeya* and *Pectobacterium* spp.), Potato mop-top virus (PMTV) and its vector (*Spongospora subterranea* f. sp. *subterranea*) as economically important potato pathogens, and *Phytophthora infestans* and Potato virus Y (PVY) as potential future threats to Finnish potato production. Of these, blackleg and soft rot causing *Dickeya* and *Pectobacterium* bacteria, Potato mop-top virus (PMTV) and its vector have become emergent pests today.

Bacteria in the family Pectobacteriaceae and the genera *Dickeya* and *Pectobacterium* cause blackleg and soft rot on potato, which is currently regarded as one of the most complex and harmful diseases for Finnish potato production. The threat from these pathogens is continuously increasing because of rapid changes in bacterial populations and the emergence of new species (Degefu 2021, 2024). Climate change and global trade are believed to be driving forces behind changes in bacterial diversity and the spread of emerging species to new areas (Hannukkala 2011, Degefu 2024 and references therein).

Spongospora subterranea f. sp. *subterranea* causing potato powdery scab and Potato mop-top virus (PMTV), which it vectors, have spread to many potato production areas in Finland. According to the survey in 2013 (Tupala 2014), around 90% and 40% of the potato growing fields were infested with *S. subterranea* f. sp. *subterranea* and Potato mop-top virus (PMTV), respectively. While Potato mop-top virus (PMTV) has long been recognized as a cause of major quality problems for table and starch potato production (Kurppa 1989, Santala et al. 2010), the circumstantial evidence suggests that the impact of powdery scab is increasing, especially after wet growing seasons. Inspections for powdery scab tuber symptoms were included in the Finnish seed potato certification scheme in 2015, which indicates the increasing importance of the disease. Disease development by these pathogens is favoured by wet soil (Strydom et al. 2024 and references therein). Therefore, it is possible that problems caused by these pathogens will increase in the future with climate change, especially if heavy rainfall occurs during the growing season at the critical time for infection.

Unlike other pathogens listed by Hannukkala (2011), no new cases of *S. endobioticum* have been reported in professional farming since the 1990s and the pathogen is considered almost eradicated from Finland. However, *S. endobioticum* is a quarantine pathogen (Annex II of (EU) 2019/2072) that is becoming more widespread in Europe and new pathotypes have been reported (Pasanen 2025). There is a risk that the disease will spread as potato cultivars are not resistant to new pathotypes.

Hannukkala (2011) considered established pathogens *P. infestans* and Potato virus Y (PVY) as a threat to potato production due to the development of new aggressive strains. However, in recent years the occurrence of Potato virus Y (PVY) has notably reduced; for example, in seed potato production, both the proportion of Potato virus Y (PVY)-infected field plots and the level of Potato virus Y (PVY) infections in infected fields have decreased (Ranta 2024). *Phytophthora infestans* has caused significant damage if not controlled frequently with fungicides. Some emerging genotypes in Europe have increased resistance to fungicides from CAA and OSBPi groups (Abuley et al. 2023, EuroBlight 2024). The fungicide resistance status of the Finnish genotypes is unknown. According to the EuroBlight network, none of the common European *P. infestans* genotypes are found in Finland (https://agro.au.dk/forskning/internationale-platforme/euroblight/pathogen-monitoring/genotype-map). In the Finnish population, the sexual reproduction and cold tolerant oospores are more important for overwintering of the pathogen, and this is likely the reason that clonal lines have not been permanently established here (Lehtinen and Hannukkala 2004, Lehsten et al. 2017).

Arthropod and other invertebrate pests

Field crops

Five insect species or species groups were identified as emergent pests of field crops: *Athalia rosea* (Linnaeus 1758), *Autographa gamma* (Linnaeus 1758), three *Chaetocnema* sp., wireworms, and *Bruchus rufimanus* (Boheman 1833) (Table 2). *Athalia rosea* and *A. gamma* were present in Finland before 2011, but did not cause problems yet, whereas *B. rufimanus* and the three *Chaetocnema* species were not included in the primary list used as source data (Vänninen et al. 2011).

Wireworms, the soil-dwelling larvae of click beetles (Coleoptera: Elateridae) cause serious economic damage to many agricultural crops worldwide (Vernon and van Herk 2022). Evidence suggests that damage to potatoes has substantially increased in Europe in recent years (Vorss 2024) and, according to growers, is increasing in Finland. Several factors contribute to this increase, such as climate change, the loss of certain plant protection products, increased use of cover crops, and declining predator populations (Vorss 2024).

Autographa gamma is a migratory pest, the larvae of which have caused occasional severe damage to arable and horticultural crops, potato included, since the widespread destruction in 2018. Abundant migrations have been observed as early as 1947 (Kanervo 1947), but observations of the species in Finland have become more frequent since 2000 (Pakkanen and Wettenhovi 2014). No chemicals are registered for control of this species and can only be used on derogation basis, which is likely to contribute to problems as the pest reproduces here during summer. It does not overwinter at northern latitudes, but as droughts and high temperature events increase at the more southern latitudes, more frequent and abundant migration events are expected to reach Finland (Chapman et al. 2012, Torniainen and Mikonranta 2018).

In oilseed crops, the sawfly *A. rosae* has occurred in increasing abundance since the warm summer of 2018 (FinBIF) and is now considered to be a relatively harmful pest of oilseed crops, causing both quantitative and qualitative losses of autumn-sown oilseed rape (*Brassica napus* L. subsp. *oleifera*) crops particularly, but the pest occurs also in spring-sown oilseed crops. Recently, *A. rosae* was found to be an important and also numerous pollinators of caraway (Kilian et al. 2023). One possible factor behind the population growth of *A. rosae* could be the increased cultivation of caraway, which represents a food source for adults.

Damage caused by *Chaetocnema* spp. (*Chaetocnema hortensis* (Geoffroy 1785), *Chaetocnema mannerheimii* (Gyllenhal 1827), *Chaetocnema aridula* (Gyllenhal 1827)), whose larvae live in the stems of spring barley and spring wheat, has increased since 2021, together with warm and dry spring conditions, especially in southern Finland. They occur at the same time as barley flea beetles (*Phyllotreta vittula* (Redtenbacher 1849)).

Bruchus rufimanus was observed in Finland in 2021 and has damaged faba beans seeds every year since then (Huusela 2021). It uses the trading routes of faba bean seeds effectively, to spread from one country to another.

In 2011, *Ostrinia nubilalis* (Hübner 1796) was not considered to have established permanent populations in Finland. However, recent data from FinBIF indicate that it is now established, as it can tolerate subzero temperatures. It received a high risk index in the SOM analysis. Nevertheless, it has not yet caused damage to cultivated crops. Its primary host plant, maize, is not widely grown in Finland, and therefore it is not currently regarded as an emerging pest.

Several other alien, migratory Lepidopteran species—known pests of arable crops such as *Mythimna unipuncta* (Haworth 1809), *Mythimna loreyi* (Duponchel 1807), *Etiella zinckenella* (Treitschke 1832), and *Trichoplusia ni* (Hübner 1803) — or of horticultural crops, such as *Helicoverpa armigera* (Hübner 1808), also received medium to medium-high establishment risk indexes in 2011. Since then, all have been regularly reported in Finland via the FinBIF database. In the UK, these species were among the Lepidoptera observed more frequently as migrants between 1982 and 2005, with increased sightings linked to positive March – July temperature anomalies in south-western Europe — their region of origin (Sparks et al. 2007). None of these species are well adapted to overwinter in subzero temperatures. They remain rare in Finland and, aside from a few greenhouse outbreaks of *H. armigera*, no significant crop damage has been reported (MacLeod 2007). As such, they are not currently classified as emerging pests. However, continued monitoring is essential. *H. armigera* is of particular concern, as it may develop into a seasonal pest similar to *A. gamma*. This armyworm has expanded its range aggressively from the Mediterranean into Central Europe and is now considered an outdoor pest in regions where it was rare in the 1980s (Haris et al. 2025). Its increasing populations in southern Europe and their northward movements could lead to more frequent migrations and larger influxes of individuals reaching year-round greenhouse crops in Finland by autumn.

Table 1. Emergent weeds and plant pathogens

Species	Major crop	Comment
WEEDS		
Echinochloa crus-galli	spring crops	Invasive, severe infestations locally, especially in SE Finland. Warm early summers have favoured establishment.
Setaria viridis	spring crops	Found regularly in Finland. Severe infestations locally, occurs often in same fields as *E. crus-galli*. Warm early summers favour establishment.
Solanum nigrum	vegetables	More severe infestations in vegetable fields in 2000s.
Solanum nitidibaccatum /Solanum physalifolium var. *nitidibaccatum*	vegetables	More severe infestations in vegetable fields in 2010s. Immigrated to Finland in vegetable seeds.
PLANT PATHOGENS		
Dickeya spp., *Pectobacterium* spp.	potato	Economic losses have increased over the past two decades. Emergence of new pathogenic species.
Fusarium graminearum	oats, spring wheat, spring barley	Has spread across all cereal growing areas and is partly replacing *F. culmorum* and causes high infections in humid and warm conditions. Mycotoxins (DON) might cause high economic losses.
Fusarium langsethiae	oats, spring wheat, spring barley	Occurrence has increased in warm seasons, and T-2 / HT-2 toxins might cause high economic losses.
Potato mop-top virus (PMTV)	potato	Becoming more common in starch, table and processing potato production.
Puccinia coronata	oats	The timing of infection has become earlier, and severity has increased across all oat growing areas.
Puccinia hordei	barley	The timing of infection has become earlier, and severity has increased.
Puccinia recondite	rye	The timing of infection has become earlier, and severity has increased.
Puccinia striiformis	wheat and triticale	The timing of infection has become earlier, and severity has increased.
Puccinia triticina	spring and winter wheat	The timing of infection has become earlier, and severity has increased.
Spongospora subterranea f. sp. *subterranea*	potato	Increased occurrence and damage, especially after wet growing seasons.
Zymoseptoria tritici	winter wheat	Increased occurrence in winter wheat especially in warm and humid seasons at the same time as the area under winter wheat has increased.

Horticultural crops

According to the SOM (Vänninen et al. 2011), the likelihood of establishment was generally higher for horticultural pests than for pests of arable crops. In this review, ten invertebrate pest species or species groups were identified as emerging pests to horticultural crops—including greenhouse and open-field vegetables, ornamentals, berries, fruit crops, and hardy nursery plants. Three of the ten were among the alien species that received a risk index of 0.3 or higher in the SOM analysis: *Bemisia tabaci* (Gennadius 1889), *Otiorhynchus armadillo* (Rossi 1792), and *Otiorhynchus rugosostriatus* (Goeze 1777).

Bemisia tabaci was introduced regularly to Finland on ornamental seedlings and cuttings before 2011, but as a quarantine pest it was always eradicated. After a long tug-of-war between ornamental and vegetable growers, the protected zone status of Finland for this pest was abolished in 2018 (Maa- ja metsätalousministeriö 2018). The species has not been reported from vegetable greenhouses yet – although it is assumed to arrive regularly on ornamental plants for planting in greenhouses as before – but has potential to spread into them (Cuthbertson and Vänninen 2015). Such potential is increased by low or non-existent availability of effective chemicals against this pest in ornamental and vegetable crops, respectively, in Finland. *B. tabaci* can thus be considered as an emergent pest of greenhouse crops in both ornamentals and vegetables, particularly tomato and cucumber.

Otiorhynchus sulcatus (Fabricius 1775), a polyphagous pest of strawberries and ornamental plants, had established populations in Finland by 2011 (Tuovinen 2000). Since then, two additional species — *O. rugosostriatus* and *O. armadillo* — have been introduced into Finland through imports (FinBIF; Vänninen et al. 2011). The first confirmed population of *O. armadillo* in Finland was recorded in 2021, limited to conifer planting boxes (reported by the Puutarhan parhaaksi group, with identification verified by Coleoptera experts). Both species received a medium-high risk index in the SOM analysis (Vänninen et al. 2011). In Sweden, *O. rugosostriatus* has been observed as far north as the Uppsala region. *Otiorhynchus armadillo* was reported in Sweden as early as the 1990s (Borisch 1997) and is known to overwinter in Norway (Staverløkk 2010). All three alien *Otiorhynchus* species mentioned are parthenogenetic, which facilitates their establishment after introduction—typically as larvae hidden in the soil of potted plants. As a group, these three alien *Otiorhynchus* species are emerging pests of various berry plants and herbaceous and woody ornamentals in Finland. However, *O. rugosostriatus* may not yet have reached the establishment stage (see https://biolcoll.utu.fi/cole/colemaps.htm for records from 2000 onwards), and the *O. armadillo* population detected in 2021 was eradicated. The presence of two native species, *Otiorhynchus ovatus* (L. 1758) and *Otiorhynchus dubius* (H. Strøm 1765), makes species identification challenging and complicates the monitoring of *Otiorhynchus* population dynamics.

Some alien species not included in the database used for the SOM analysis, or which had a very low establishment risk index, have been introduced or arrived in Finland since 2011. Although there are some tools for predicting invasiveness of a species it still seems that opportunity allows entry of an invasive pest without notice. The introduced species include *Rhagoletis batava* (Hering 1958) (Stalažs and Balalaikins 2017), *Drosophila suzukii* (Matsumura 1931, Nissinen et al. 2023) and *Aculops lycopersici* (Tryon 1917, Vänninen 2008). *Drosophila suzukii* utilizes effectively global trade, but *R. batava* may have entered to Finland without any human action – Stalažs and Balalaikins (2017) suggested that the invasive population originates from Siberia. *Rhagoletis batava* is quite strictly limited to one host plant, whereas the great invasive success of *D. suzukii* is expected due to its wide host range and flexible adaptation to environmental conditions (Gutierrez et al. 2016, Little et al. 2020), *D. suzukii* has been observed in Finland as a transient species so far (Nissinen et al. 2023), and thus is not included in the list of emergent species as yet, but requires monitoring due to the plasticity of its biology, whereas *R. batava* is established and observations from new locations in the inner land are reported to Luke in every autumn.

Aculops lycopersici was found in two greenhouses in 2008 (Vänninen 2008, Vänninen et al. 2011), but until about 2015 no new occurrences were reported. Today, however, the mite occurs in several large year-round tomato greenhouses in different parts of the country and needs to be controlled. Its spread to Finland (route unknown, but possibly trade of seedlings or fruits of tomatoes) coincides with the species having become an emergent, serious pest in other European countries (Vervaet et al. 2021, Pfaff and Böckmann 2024). Year-round production favours its continuous reproduction and population development (Pfaff and Böckmann 2024), exactly as observed in Finland. The mite is of tropical origin and thus is not expected to survive winter temperatures of the boreal zone (Kim et al. 2002). Recently, it was found to be the vector of Tomato fruit blotch virus (ToFBV), which adds to its seriousness as a tomato pest (Bertin et al. 2025).

The whitefly *Aleyrodes lonicerae* (Walker 1852) occurs on many native plant species in Finland but has seldom been reported as a pest of cultivated plants in the temperate zone, where it is mostly known from ornamental *Lonicera* spp. (honeysuckle) and several wild plants (Evans 2007). An instance of it reproducing and overwintering in large numbers in a perennial, soil-bound strawberry tunnel crop in Finland was reported in 2018 by a grower, and the species' presence was verified by one of the authors of this paper. Thus, *A. lonicerae* has the potential of becoming a pest of strawberry, at least under some conditions. Furthermore, ongoing attempts to encourage cultivation of edible honeysuckle in Finland will contribute to the presence of previously scarce host plants. Interestingly, a reproducing population of *A. lonicerae* was observed in greenhouse-grown sweet pepper (*Capsicum annuum* L.) by a horticultural advisor in 2024, and the species identification was again verified by one of the authors of this paper. No instances of the species occurring on sweet pepper were found in the literature. Since the sweet pepper crop was annual and was removed in the autumn, we do not know how long the whitefly would have survived on the host. The whitefly had to be controlled, suggesting that sweet pepper served as a host for at least for 6–7 months continuously.

Some established pests of horticultural plants such as mites, thrips and aphids have increased in abundance, caused damage more often or entered new crop habitats. The cosmopolitan mite *Phytonemus pallidus* (Banks 1801) in strawberries has become increasingly troublesome due to warm and dry summers that promote its reproduction, lack or removal of semi-systemic rapid-action chemicals such as abamectin, and increasing cultivation of table-top strawberries in tunnels as an annual crop. High yield losses were reported by growers in tunnels in 2023 due to imported seedlings being infested by the mite (Vänninen 2024). Likewise, as reported by growers, difficulties in 2022 in purchasing chemicals for its control caused high yield losses in open field strawberry crops. Similarly, in greenhouse tomato crops, the two-spotted spider mite (the now cosmopolitan *Tetranychus urticae* (C.L. Koch 1836) has been causing increasing problems due to lack of synthetic chemicals that could earlier be used to support biocontrol of the pest.

Various thrips species, e.g. polyphagous *Thrips tabaci* (Lindeman 1889) and *Frankliniella intonsa* (Trybom 1895) increasingly infest strawberries in hot and dry summers, as reported in 2012 (Parikka and Tuovinen 2014), and have increased considerably in occurrence and as damaging agents since 2017–2019. A positive correlation has been established in Canada as well as in Finland between thrips presence in strawberry flowers and certain wild-flowers inhabiting the margins of strawberry fields (Tuovinen and Lindqvist 2014, Canovas et al. 2023).

Igutettix oculatus (Lindberg 1929) spread to Finland — likely on its own — across the eastern border in 1999 (Söderman 2005, Huusela-Veistola and Söderman 2010), having previously arrived in the European part of Russia from the Far East in 1984 (Gnezdilov 2014). In Finland, it has increasingly affected *Syringa* (lilac) plants since 2020, apparently benefiting from warmer summers. Data from FinBIF show a rising number of observations since 2020, and reports from the Puutarhan parhaaksi group indicate that the species has been noted as a pest of *Syringa* with increasing frequency since 2017.

As a group, aphids — many of which are multivoltine and reproduce parthenogenetically — benefit from the warming of growing seasons (Hullé et al. 2010). Rising temperatures also influence aphid biodiversity. Monitoring by the EXAMINE network has shown that aphid species richness can increase by between two and fifteen additional species for every 1°C rise in mean temperature, depending on the site (Hullé et al. 2010). These changes are occurring alongside the gradual withdrawal of chemical insecticides from the market. Aphids are emerging as pests particularly in greenhouse crops, but some species also in outdoor crops (Table 2).

Nasonovia ribisnigri (Mosley 1841) is an established pest in Finland, but according to grower reports it has become increasingly troublesome in lettuce (*Lactuca sativa* L.), both in the open field and in greenhouses, due to lack of systemic chemicals for its control. Biocontrol agents have difficulty accessing this species as it hides inside the lettuce crown. Reportings of *Brevicoryne brassicae* (Linnaeus 1758) have increased in numbers since 2019 (FinBIF), and its presence has been verified in ornamental cabbages (*Brassica oleracea* L.) and rucola (*Eruca sativa* Mill.) in greenhouses and late-maturing batches of *Brassica oleracea* L. var. *sabellica* in field crops. Exotic aphid species arrive regularly in Finland on ornamentals (observations by the virtual group Puutarhan parhaaksi) and also on seedlings of berry, fruit and vegetable crops. One example is *Neotoxoptera formosana* (Takahashi 1921) that lives on *Allium* spp. It was found infesting *Allium senescens* L. in Espoo in 2023 (Leena Luoto, personal communication). The sawfly species *Hoplocampa flava* (Linnaeus 1760), a pest of plums, is assumed to have spread naturally across the eastern border of Finland. The first report of its occurrence in Finland is from 2006 in the Mikkeli area (FinBIF, Paukkunen et al. 2009). Somewhat later, another *Hoplocampa* species, *Hoplocampa minuta* (Christ 1791), was reported as a new species in Finland (Paappanen et al. 2019). Home gardeners began reporting sawfly damage on plums in 2023–2024 in the virtual group Puutarhan parhaaksi. *H. flava*, often in combination with even more damaging *Grapholita funebrana* (*Treitschke* 1835) damages plums so severely that commercial production of plums in the Åland archipelago has been deemed impossible, unless more effective management methods become available (Gabrielsson 2021).

Table 2. Emergent arthropod and other invertebrate pests

Species	Major crop	Comment
FIELD CROPS		
Athalia rosae	oilseed crops	Since 2018, increasing damage compared with earlier abundant occurrences of the species decades ago.
Autographa gamma	faba bean, pea, oilseed crops, potato	Widespread damage in the hot and dry summer of 2018.
Bruchus rufimanus	faba bean	First observed in Finland in 2021 and damage to faba bean seeds observed every autumn subsequently.
Chaetocnema spp.(*Chaetocnema hortensis, Chaetocnema mannerheimii, Chaetocnema aridula*)	cereals	Since 2021 increasing damage in spring cereals (wheat and barley), especially in 2024.
Wireworms (Elateridae)	potato	Increasing as potato pests in Europe, and similar observations from Finnish potato growers.
HORTICULTURAL CROPS		
Aculops lycopersici	tomato	Severe infestations in several greenhouses, particularly in year-round tomato crops.
Aphids (various species infesting greenhouse crops, most significantly *Nasonovia ribisnigri*, *Aulacorthum solani* (Kaltenbach 1843), *Myzus persicae* (Sulzer 1776) and *Aphis fabae* (Scopoli 1763), and *Brevicoryne brassicae* (in outdoor *Brassica* crops)	greenhouse vegetables and ornamentals, field vegetables and berries	Warm summers favour multiple generations of multivoltine aphids outdoors. The lack of systemic chemicals makes it difficult to control aphids on lettuce in both greenhouse and outdoors, as the pests live in the heart of the plants.
Whiteflies: *Bemisia tabaci*, *Trialeurodes vaporariorum* (Westwood 1856), *Aleyrodes lonicerae* (Walker 1852)	tomato, cucumber, ornamentals	*B. tabaci* occurs in ornamental crops in greenhouses. No findings from vegetables to date. Lack of chemicals is becoming a problem. There are no synthetic chemicals available for *T. vaporariorum* in greenhouse vegetables crops anymore to support biocontrol. Damaging cases of *A. lonicerae* in sweet pepper (new host) and perennial strawberry in tunnels are known.
Grapholita funebrana	plums	So damaging to plums that their commercial production at larger scale is currently impossible in areas where plums would thrive.
Hoplocampa sawflies (*Hoplocampa flava, Hoplocampa minuta*)	plums	Damage reports of plums by citizens increasingly after 2020. Uncertain which one of the two species is more common.
Igutettix oculatus	syringa	Spread from Russia in the end of 1990s, increasing number of observations since 2020 due to warm summers (FinBIF, Puutarhan parhaaksi-group)
Otiorhynchus sulcatus, Otiorhynchus armadillo, Otiorhynchus rugosostriatus	strawberry, herbaceous and woody ornamentals	Arrive in soil of potted plants and seedlings, thus difficult to detect upon arrival, and increasing trade of plants contributes to their spread. Cars can contribute to their colonization stage (Westermarck 2007).
Phytonemus pallidus	strawberry	Dry hot summers contribute to reproduction and survival of this multivoltine pest. Introductions on strawberry seedlings used in tunnels has resulted in severe yield losses occasionally.
Rhagoletis batava	sea buckthorn	First observed in Finland on western coast in 2015. Thereafter gradually spreading to southern coastal areas and inland.
Tetranychus urticae	tomato	Removal of synthetic chemicals from the market has resulted in more severe infestations of the mite, since biocontrol is not always effective in tomato due to the plant's sticky trichomes.
Thrips (*Thrips tabaci* and *Frankliniella intonsa*)	strawberry	The importance of thrips as pests of strawberry in the open and in tunnels has increased during warm and dry summers.

Conclusions

This review assessed changes in the status of agricultural and horticultural pests that were identified in 2011 as emerging pests in the Finnish plant production and identified species that were not mentioned in the previous review but are considered emergent pests now. Of the ten weed species evaluated only *Echinochloa crus-galli* was confirmed as emergent pest. *Solanum nitidibaccatum* was not included in the 2011 list but is now considered as an emergent pest. Among pathogenic fungi affecting cereals, *Zymoseptoria tritici* considered as a potential threat in 2011 was classified as an emerging pest in this review. Additionally, several other cereal pathogens have now reached emergent status, including six *Puccinia* rust species, and two mycotoxin-producing *Fusarium* species. Notably, potatoes were the only arable crop for which a reduction in the occurrence and severity of some established pathogens has been observed since 2011, while *Dickeya* spp., *Pectobacterium* spp., Potato mop-top virus (PMTV), and *Spongospora subterranea* f. sp. *subterranean* require increased attention due to their increasing occurrence and severity.

Among emerging arthropod pests, most are alien species. Seven of these have successfully established and spread in Finland since 2011 to the extent that they are now considered emergent. Some established species—*Chaetocnema* spp., *Tetranychus urticae*, thrips such as *Frankliniella intonsa* (Trybom 1895) and *Thrips tabaci*, aphids such as *Brevicoryne brassicae* and *Nasonovia ribis-nigri* (Mosley 1841), and wireworms (in potato)—have also shown signs of emergence. The increase in emergent horticultural pests appears to be driven by a combination of factors: limited availability of selective pesticides compatible with biological control agents, climate change favoring multivoltine species such as aphids, thrips, whiteflies, and mites, year-round greenhouse production, and global trade, which facilitates the introduction of new pests. The growing challenge of plant protection is especially pronounced in sectors relying on imported seedlings. Some pests, however, are likely to arrive independently of human activities, with their establishment potentially supported by growing source populations in regions to the south or east of Finland.

The emergence of new arthropod pests also highlights that species not previously included in pest risk predictions can establish and become problematic. Pest risk analyses are never perfect, surprises happen. Regional, relatively unimportant pests can become seriously damaging pests when introduced to new areas, as happened with South American *Tuta absoluta* (Meyrick 1917, Campos et al. 2017) and East Asian *Halyomorpha halys* (Stål 1855, Lee 2015) after these species arrived to Europe. Among species identified as emergent pests in this review, *Chaetocnema* spp., *Rhagoletis batava, Bruchus rufimanus*, *Aculops lycopersici*, *Hoplocampa flava*, and *H. minuta* were not considered in the SOM-based analysis published in 2011, which aimed to predict likelihood of establishment. In the context of accelerating climate change and international trade, reviews like the current one should be repeated at least every five years. The development of new tools can significantly improve this process. For example, CABI (2025) and EFSA (2025) now offer ongoing horizon scanning services and regularly publish updated reports on both regulated and unregulated pests at the EU level, and the FinnPRIO ranking system (Heikkilä et al. 2016) is specifically designed to assess the risk that alien pests pose to plant health in Finland. These resources can inform more timely and targeted pest risk assessments and risk management for Finland, optimizing the use of limited resources.

Although it is difficult to prevent the arrival of pests not associated with human activity, improved horizon scanning may enhance preparedness and facilitate early management. These capabilities are especially important considering the increasing disparity between the rising complexity of plant health threats and the limited resources available to address them. This situation demands stricter prioritization, collaborative action, and the pursuit of synergies not previously recognized. Regular and structured interaction among stakeholders—enhanced by modern information technologies—will be essential. Citizen science initiatives, despite their occasional limitations in accuracy, are becoming increasingly valuable in early detection and national monitoring of new pests.

This study was conducted in a context where several of the new and previously known pests deemed emergent have already prompted plant protection actions in the form of projects to develop management methods and to better understand the biology and ecology of the pests. Information from the practice about the appearance of new pest species and their increasing damage capacity to crop plants is the final proof that a pest has become emergent. This underscores the importance of knowledge exchange between farmers, researchers, advisors and plant health authorities.

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Appendix 1

Primary list of pest species obtained from 2011 special issue https://journal.fi/afs/issue/view/932

WEEDS
Anagallis arvensis
Amaranthus retroflexus
Avena sterilis
Chrysanthemum segetum
Cynodon dactylon
Datura stramonium
Digitaria sanguinalis
Echinochloa crus-galli
Lolium temulentum
Papaver rhoeas
PATHOGENS CEREALS
Fusarium graminearum
Fusarium langsethiae
Puccinia coronata
Puccinia hordei
Puccinia recondite
Puccinia striiformis
Puccinia triticina
Zymoseptoria tritici
PATHOGENS POTATO
Dickeya spp.
Pectobacterium spp.
Phytophthora infestans
Potato mop-top virus (PMTV)
Spongospora subterranea f. sp. *subterranea*
Synchytrium endobioticum
INSECT PESTS OF ARABLE AND HORTICULTURAL CROPS Only alien species that had not been established by 2011 but received an establishment risk index of 0.3 or higher in the SOM analysis were included (55 species).
Acanthiophilus helianthi
Agromyza frontella
Amphimallon majalis
Antigastra catalaunalis
Aphis spiraecola
Bemisia tabaci
Bothynoderes punctiventris
Bruchophagus roddi
Cacoecimorpha pronubana
Cacopsylla pyricola
Cephus pygmeus
Ceresa alta
Chaetosiphon fragaefolii
Cnephasia longana
Curculio elephas

Diabrotica virgifera virgifera
Diaspidiotus perniciosus
Diuraphis noxia
Dyspessa ulula
Epidiaspis leperii
Eriosoma lanigerum
Etiella zinckenella
Euproctis chrysorrhoea
Grapholita molesta
Helicoverpa armigera
Hippotion celerio
Hyphantria cunea
Ips cembrae
Lampides boeticus
Leptinotarsa decemlineata
Liriomyza huidobrensis
Liriomyza trifolii
Lobesia botrana
Locusta migratoria
Mythimna loreyi
Mythimna unipuncta
Nipaecoccus nipae
Orthezia insignis
Ostrinia nubilalis
Otiorhynchus armadillo
Otiorhynchus rugosostriatus
Parthenolecanium persicae
Phyllotreta cruciferae
Pseudaulacaspis pentagona
Saturnia pyri
Schizaphis graminum
Scrobipalpa ocellatella
Siphoninus phillyreae
Sitophilus zeamais
Sphaerolecanium prunastri
Thaumetopoea pityocampa
Thrips simplex
Trichoplusia ni
Viteus vitifoliae
Zeuzera pyrina