VKM Report 2024:05

Risks to Norwegian plant health posed by import of plants with soil or other growing media from Europe

Paal Krokene, Beatrix Alsanius, Jorunn Børve, Daniel Flø, Bjørn Arild Hatteland, Erik Joner, Lawrence Kirkendall, Christer Magnusson, Mogens Nicolaisen, Line Nybakken, Johan Stenberg, Selamawit Tekle, Kristine B. Westergaard, Sandra A. I. Wright

Scientific Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment

VKM has assessed the risks to Norwegian plant health posed by the import of plants with soil or other growing media from Europe. The import of soil and other growing media into Norway poses significant risks to plant health due to the potential introduction of pests. Potential pests, including fungi, bacteria, nematodes, and arthropods, may harm agriculture.

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Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (*Vitenskapskomiteen for mat og miljø, VKM*) appointed a project group to draft the opinion. The project group comprised 10 VKM members, two VKM staff members, and two external experts. Two referees commented on and reviewed the draft opinion. VKM, by the Panel on Plant Health and an interdisciplinary VKM approval group, explicitly appointed for the assignment, assessed, and approved the final opinion.

Authors of the opinion

The authors have contributed to the opinion in a way that fulfils VKM's authorship principles (VKM, 2019). The principles reflect the collaborative nature of the work, and the authors have contributed as members of the project group or the VKM Panel on Plant Health, with supplementation from the VKM Panel on Biodiversity appointed specifically for the assignment.

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Acknowledgment

VKM would like to thank the two referees, Jane Debode and Walter Wohanka, for their valuable review of the assessment. In accordance with VKM's routines for approving a risk assessment, VKM emphasizes that the referees are not responsible for the content of the final assessment (VKM, 2019). VKM received their reviews before they were evaluated and approved by the VKM Panel on Plant Health and Panel on Biodiversity, and before the assessment was finalized for publication.

Competence of VKM experts

Individuals working for VKM, either as designated members of the committee or as external experts, are chosen based on their scientific expertise and not as representatives of their employers or any other third-party interests. The Civil Services Act guidelines on legal competence apply to all work prepared by VKM.

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Summary

Background: The Norwegian Environment Agency (*Miljødirektoratet*) and the Norwegian Food Safety Authority (*Mattilsynet*) tasked the Norwegian Scientific Committee for Food and Environment (*Vitenskapskomiteen for mat og miljø*, VKM) to provide a scientific opinion identifying which growing media associated with import of live plants pose the greatest risk of introducing non-native species to Norway. VKM was also asked to assess how effective various risk-reducing measures are to prevent such introductions. In this report, we focus on the introduction of plant pests.

Trade in plants for planting is a large and complex international business where live plants are grown in some areas and shipped to other areas where they are intended to be planted or replanted. Traded plants are usually shipped with associated growing media. Long-lived plants, like trees and bushes, may be imported to the EU (e.g., from Asia) and traded through different countries for several years of on-growth before being shipped to Norway. Long production cycles, partly in outdoor nurseries, suggest that the import of live plants with soil or other growing media into Norway comes with a high probability of introducing plant pests. Such pests could cause severe harm to Norwegian plant health and impact both agriculture and natural ecosystems. In this scientific opinion, we describe the most used growing media and assess the risks associated with these. We further evaluate what types of plants and which exporting countries are considered to pose the highest risks for introducing plant pests. Finally, we describe different risk reduction options and assess the effectiveness of current Norwegian regulations as a tool to reduce risks. Altogether, this assessment provides a comprehensive overview of the potential risks involved in importing soil and other growing media associated with plants for planting and of possible strategies for mitigating these risks.

Key findings: *Growing media constituents*: The most used organic growing media constituents are peat, wood fiber, and compost, but a great array of other constituents is also used. In this report, we have focused on organic constituents, as these are frequently colonized by living organisms when sourced and may support pest species by acting as a food source or as a sheltering environment that provides water, oxygen, and other crucial factors for pest survival.

Growing media as a plant pest carrier: Even though most growing media constituents initially are sterile or free from any plant pests, the processes of mixing, potting, plant cultivation, transport, and storage can easily allow contamination by and propagation of pests underway from a primary source to a customer in Norway. Many organisms can colonize and survive in growing media under conditions primarily designed to keep plants alive. Growing media thus poses a risk of introducing plant pests to Norway when such media are imported together with live plants.

Identified pest species: Organisms that can arrive with the import of live plants and associated growing media will include organisms that are not plant pests, known plant pests, regulated pests, and species that may be problematic even though they are not currently listed as quarantine pests. By screening two international databases (CABI, 2022; EPPO, 2024b) and performing a structured literature search, we identified a total of 651 pest species, most of which are not present in Norway, that may be associated with plants imported from Europe with soil or other growing media (154 species from CABI, 87 from EPPO, and 410 from the literature search). Due to time limitations, only 89 species were assessed for their association with soil and growing media. This evaluation included 20 species from CABI, 24 from EPPO, and 45 from the literature search, as detailed in Appendix 5. Climate suitability analyses were carried out for seven selected species to determine the likelihood

that these species could establish populations and spread in Norway. We prepared Köppen–Geiger climate classification maps for these seven species in individual express pest risk assessments and did Maxent species distribution modelling for selected insect species. Because both these methods for assessing climatic suitability carry considerable uncertainty, the results should only be considered indicative. Further analysis for those plant pests, where climate suitability analyses indicated a likelihood of establishment in Norway, should be considered.

High-risk plants and cultivation methods: The plants and plant categories that are most likely to promote entry of plant pests to Norway are trees and bushes grown under outdoor conditions in plant nurseries and imported with large clumps of growing medium. For such long-lived plants, the production and post-production cycle may span several years, increasing colonization probabilities. Plants grown in natural soil or in contact with soil also have a higher probability of bringing new plant pests to Norway. This is true even if the roots are washed, and the plants are re-potted in a new pest-free growing medium because it is unlikely to achieve complete soil removal from large root systems. Other growing media that can be associated with high risk under certain circumstances are compost and tree bark. Most other growing media are considered to carry a low risk of introducing associated pests.

Probability of pest association: Considering the high volumes of live plants and associated growing media that are imported, Norway is facing a high propagule pressure of plant-associated organisms. This is well documented by the monitoring of plant imports that the Norwegian Institute for Nature Research (NINA) has carried out for 10 years. The high propagule pressure highlights the urgency of addressing pest risks associated with plant imports. The probability that pests will be associated with imported plants at the origin can be considered from two perspectives: (1) by considering the country's total export volumes of live plants to Norway, or (2) by considering the propagule pressure of plant pests in different countries. When it comes to total trade volumes, the Netherlands, Germany, Denmark, and Sweden collectively account for 90% of total Norwegian imports. The Netherlands alone accounts for nearly half the total import volume. Because of their dominance in terms of trade volumes, these four countries probably generate the greatest number of instances of importing plant pests to Norway. When it comes to propagule pressure, Italy, France, Spain, and the UK are the European countries with the highest probability of exporting new plant pests to Norway, as these countries harbor the highest numbers of known plant pests that are not yet present in Norway. This is true both for plant pests in general and for plant pests that are associated with soil and other growing media.

Efficiency of risk reduction options: The Norwegian Scientific Committee for food and Environment provides independent scientific risk assessments on matters that are important for food safety and the environment. The Norwegian Scientific Committee for Food and Environment does not give advice or take a position on how risks should be handled but can investigate the consequences of various action options. It is up to the Norwegian Food Safety Authority to decide on the risk-reducing measures that VKM has identified and assessed. The most efficient risk reduction options are to prohibit the import of plants with soil and growing media from areas with high pest risk or to set special import requirements from high-risk areas. A combination of different risk reduction options will be most efficient, as no single risk reduction option is effective against all pests in all types of growing media. Potentially efficient risk reduction options could be drawn from the options set in EU regulations. These include using (i) only virgin growing media (i.e., media that have not previously been used to grow plants), (ii) soilless growing media that are free from natural soil and high-risk organic matter, (iii) growing media made entirely of peat or fiber from coconut husks, and (iv) growing media that have been fumigated or heat-treated according to international guidelines.

Measures to keep growing media pest-free during plant production include (i) physically isolating plants and associated growing media from natural soils and other pest sources, (ii) minimizing the exposure time of plants to pest sources, (iii) using pest-free irrigation water, and (iv) applying good sanitation/hygiene routines in plant nurseries and throughout trade pathways. For plants that are re-potted or transferred from the field to pots before export, growing media could be removed by washing the plant roots, and plants could be replanted in virgin growing media before shipping.

Efficiency of risk reduction options in current Norwegian regulation: Import of live plants with soil or other growing media poses a high risk to plant health in Norway and this risk can be reduced by imposing stricter import requirements. Current risk reduction options available in Norwegian plant health regulations are insufficient to prevent the introduction of plant pests with the import of plants and associated soil and other growing media from Europe. The current plant health regulations does not set special requirements for the import of soil and other growing media that accompany live plants from Europe (except for plants for planting with roots, grown in open air). Norway does not have mandatory official border control of imported plants. Importers are responsible for carrying out reception control of the consignments while the Norwegian Food Safety Authority carries out official risk-based random checks of consignments at the time of import and supervises the importers' reception control. Reception controls rely heavily on visual observations and are often limited in scope, reducing the likelihood that plant pests associated with soil and other growing media to be detected at arrival. This increases the probability of the introduction of both regulated and unregulated pests with soil and other growing media into Norway.

Conclusions: The import of soil and other growing media associated with live plants to Norway comes with a significant risk of pest introduction for all assessed organism groups. To illustrate the risks involved, we conducted express pest risk analyses for a few selected pest species. These species were selected for their potential to survive the importation process and possibly find suitable environments for establishment in Norway. However, it should be noted that the examples make up a small fraction of all possible pests that might be introduced by the import of plants and associated growing media. High import volumes of live plants with soil and other growing media increase the likelihood of introducing soil-borne pests that, if they become established, could negatively affect Norwegian agriculture and natural ecosystems. Potential impacts include reduced crop and timber yield, increased control costs for farmers, increased use of pesticides, and loss of plant biodiversity.

This assessment indicates that although current Norwegian legislation provides a foundation for managing risks of pest introduction, preventive measures could be strengthened by adopting additional risk reduction strategies. Today, preventive measures depend heavily on inspection and visual detection of soil-bound pests. However, visual detection is often very challenging due to the cryptic nature of many pest species. Inspection of root systems is particularly challenging, and asymptomatic infections are easily overlooked. Preventive measures should focus on the physical separation of traded plants and pest organisms. This can be done by producing plants in pest-free areas and by producing plants indoors in secured greenhouse facilities.

Keywords: VKM, pest risk assessment, Norwegian Scientific Committee for Food and Environment, Norwegian Food Safety Authority, Norwegian Environment Agency, growing media, plant pests, soil import, non-native species, risk reduction measures

Sammendrag

Bakgrunn: Miljødirektoratet og Mattilsynet har gitt Vitenskapskomiteen for mat og miljø (VKM) i oppdrag å gjøre en vitenskapelig vurdering av de vekstmediene som følger med import av levende planter til Norge som utgjør størst risiko for innførsel av fremmede arter. VKM ble også bedt om å vurdere hvor effektive ulike risikoreduserende tiltak er for å forhindre slik innførsel. I denne rapporten fokuserer vi på risiko forbundet med import av planteskadegjørere.

Handel med såkalte planter for planting er en stor og kompleks internasjonal virksomhet hvor planter dyrkes i noen områder og sendes til andre områder for å plantes eller omplantes. Planter for planting sendes vanligvis med tilhørende vekstmedium. Langlivede planter som trær og busker kan bli importert til EU som unge planter (for eksempel fra Asia) og deretter handles videre til forskjellige land for ytterligere vekst i flere år før plantene til slutt ender opp i Norge. Lange produksjonsperioder, som helt eller delvis foregår utendørs i planteskoler, tilsier at import til Norge av levende planter med jord eller andre vekstmedier har en høy sannsynlighet for å introdusere planteskadegjørere. Slike skadegjørere kan gjøre alvorlig skade på norsk plantehelse og påvirke både landbruket og naturlige økosystemer. I denne vitenskapelige vurderingen beskriver vi de vanligste vekstmediene som importeres sammen med levende planter, og vurderer risikoen forbundet med disse. Vi vurderer videre hvilke plantetyper og eksportland som utgjør den største risikoen for å introdusere planteskadegjørere. Til slutt beskriver vi ulike risikoreduserende tiltak, og vurderer hvor effektivt gjeldende norsk regelverk er som et virkemiddel for å redusere risiko. Samlet gir denne vurderingen en oversikt over mulig risiko ved import av jord og andre vekstmedier sammen med planter for planting, samt mulige strategier for å redusere risikoen.

Viktige funn: *Ingredienser brukt i vekstmedier*: De vanligste organiske ingrediensene i vekstmedier er torv, trekull og kompost, men svært mange andre ingredienser brukes også. I denne rapporten har vi fokusert på organiske ingredienser fordi disse oftest koloniseres av levende organismer og kan fungere som matkilde og/eller et beskyttende miljø som forsyner disse organismene med vann, oksygen og andre livsviktige faktorer.

Vekstmedier som bærere av planteskadegjørere: Selv om de fleste ingrediensene som brukes i vekstmedier opprinnelig er sterile eller fri for planteskadegjørere, medfører prosesser som blanding, potting, plantedyrking, transport og lagring fare for kolonisering og spredning av skadegjørere fra planteprodusenter i eksportlandet til kunder i Norge. Mange forskjellige organismer kan kolonisere og overleve i vekstmedier under forhold som primært har som formål å holde planter i live. Vekstmedier utgjør dermed en risiko for å introdusere planteskadegjørere til Norge når slike medier importeres sammen med levende planter.

Identifiserte skadegjørere: Organismer som kan komme til Norge med planter og tilhørende vekstmedier inkluderer arter som ikke er planteskadegjørere, kjente planteskadegjørere, regulerte planteskadegjørere og arter som kan bli problematiske i fremtiden selv om de ikke er regulert som karanteneskadegjørere i nåværende regelverk. Ved å gå gjennom to internasjonale databaser (CABI, EPPO) samt gjøre et litteratursøk, identifiserte vi 651 arter av planteskadegjørere som kan komme med planter med jord og andre vekstmedier importert fra Europa (154 arter fra CABI, 87 fra EPPO og 410 fra litteratursøket). På grunn av tidsbegrensninger, vurderte vi sannsynlighet for etablering og spredning i Norge for kun 154 arter. Vurderingen omfattet 20 arter fra CABI, 28 fra EPPO og 106 fra litteratursøket. Vi gjorde enkle klimatilpasningsanalyser for sju utvalgte arter for å vurdere sannsynligheten for etablering og spredning i Norge. Vi laget såkalte Köppen–Geiger klimaklassifikasjonskart for disse sju artene og gjorde Maxent utbredelsesmodellering for to utvalgte insektarter. Fordi begge disse metodene for vurdering av klimatilpasning er beheftet med betydelig

usikkerhet bør resultatene våre kun anses som preliminære. For planteskadegjørere som våre analyser indikerer at vil kunne etablere seg i norsk klima, anbefaler vi at det blir gjort mer omfattende risikovurderinger.

Planter og dyrkningsmetoder med høy risiko: Planter og plantekategorier med størst sannsynlighet for å introdusere planteskadegjørere til Norge er trær og busker som har vært dyrket utendørs i planteskoler og som importeres med store klumper av jord og andre vekstmedium. For slike langlivede planter kan hele produksjons- og etterproduksjonsperioden ta flere år, og dette øker sannsynligheten for at planter og jord koloniseres av planteskadegjørere. Planter som er dyrket direkte i jord eller i andre vekstmedier i kontakt med jord har også en høyere sannsynlighet for å introdusere nye planteskadegjørere til Norge. Dette gjelder selv om røttene vaskes og plantene ompottes i nytt vekstmedium som er fritt for skadegjørere, fordi det nesten er umulig å fjerne all jord fra store rotsystemer. Andre vekstmedier som kan innebære høy risiko under visse omstendigheter er kompost og trebark. De fleste andre vekstmedier anses å ha lav risiko for å introdusere planteskadegjørere til Norge.

Sannsynlighet for at skadegjørere vil følge med importerte planter: Med tanke på de store mengdene levende planter med tilhørende vekstmedier som importeres til Norge har vi trolig en høy og jevn tilførsel av planteskadegjørere. Dette er godt dokumentert gjennom importovervåkingen som i 10 år har vært utført av Norsk institutt for naturforskning (NINA). Den høye tilførselen understreker nødvendigheten av å håndtere risiko for introduksjon av planteskadegjørere med planteimport. Sannsynligheten for at skadegjørere vil følge med importerte planter fra opprinnelsesstedet kan vurderes på to måter: (1) ut fra de ulike landenes totale eksportvolum til Norge, eller (2) ut fra smittetrykket i de ulike landene. Når det gjelder totalt eksportvolum til Norge står Nederland, Tyskland, Danmark og Sverige for til sammen 90 % av totalimporten. Nederland alene står for nesten halvparten av importen. Import fra disse fire landene kan derfor sies å innebære størst sannsynlighet for introduksjon av planteskadegjørere til Norge. Når det gjelder smittetrykk er Italia, Frankrike, Spania og Storbritannia de europeiske landene som har størst sannsynlighet for å eksportere planteskadegjørere til Norge, siden disse landene har det høyeste antallet kjente skadegjørere som ennå ikke finnes i Norge. Dette gjelder både for planteskadegjørere generelt og for planteskadegjørere som er assosiert med jord og andre vekstmedier.

Effekt av risikoreduserende tiltak: Vitenskapskomiteen for mat og miljø leverer uavhengige vitenskapelige vurderinger av forhold som har betydning for helsemessig trygg mat og for miljøet. VKM gir ikke råd eller tar stilling til hvordan risiko skal håndteres, men kan utrede konsekvenser av ulike handlingsalternativer. Det er opp til Mattilsynet å ta stilling til de risikoreduserende tiltakene som VKM har identifisert og vurdert. De mest effektive tiltakene for å redusere risiko for import av planteskadegjørere er å forby import av planter med jord og vekstmedier fra områder med høy plantehelserisiko eller å sette spesielle importkrav fra høyrisikoområder. Fordi ingen enkelttiltak er effektive mot alle skadegjørere i alle typer vekstmedier, vil en kombinasjon av forskjellige risikoreduserende tiltak være mest effektivt. Risikoreduserende tiltak som kan ha god effekt er fastsatt i EU sitt regelverk. Disse tiltakene inkluderer å bruke (i) kun vekstmedier som ikke tidligere har vært brukt til å dyrke planter, (ii) vekstmedier uten naturlig jord eller annet organisk materiale med høy risiko for å inneholde planteskadegjørere, (iii) vekstmedier som kun består av torv eller fiber fra kokosnøttskall, og (iv) vekstmedier som har vært gasset eller varmebehandlet i henhold til internasjonale retningslinjer. Tiltak for å holde vekstmedier frie for planteskadegjørere under planteproduksjon inkluderer (i) fysisk isolering av planter og tilhørende vekstmedier fra naturlig jord og andre smittekilder, (ii) bruk av vanningsvann som er fritt for planteskadegjørere, (iii) begrensning av tiden plantene er eksponert for mulige planteskadegjørere, og (iv) gode rutiner for hygiene i planteskoler og langs handelsruter. For planter som pottes om eller overføres fra friland til potter før eksport kan gammelt vekstmedium fjernes ved å vaske røttene og plantene pottes om i ubrukt vekstmedium.

Effekt av risikoreduserende tiltak angitt i dagens norske regelverk: Import av planter for planting med jord og andre vekstmedier utgjør en høy risiko for norsk plantehelse og risikoen kan reduseres ved å stille strengere importkrav. Risikoreduserende tiltak i gjeldende norsk plantehelseregelverk er utilstrekkelige for å forebygge introduksjon av planteskadegjørere knyttet til jord og andre vekstmedier som følger med importerte planter fra Europa. Norge stiller ikke spesielle importkrav til jord og vekstmedier som følger med slik import (unntatt for planter og formeringsmaterialer, med røtter, dyrket på friland). Norge har ikke obligatorisk offisiell grensekontroll av importerte planter. Importørene selv har ansvar for å utføre mottakskontroll av sendingene, mens Mattilsynet gjennomfører offisiell risikobasert stikkprøvekontroll av sendinger og fører tilsyn med importørenes mottakskontroll. Mottakskontrollene baserer seg i stor grad på visuell observasjon og er ofte begrenset i omfang. Dette øker sannsynligheten for innføring av både regulerte og ikke-regulerte skadegjørere med jord og andre vekstmedier til Norge.

Konklusjoner: Norsk import av jord og andre vekstmedier som følger med planter for planting utgjør en betydelig risiko for introduksjon av planteskadegjørere. Dette gjelder for alle organismegruppene vi har vurdert. For å illustrere risikoen har vi gjort såkalte ekspress-risikovurderinger for noen utvalgte arter av planteskadegjørere som er tilknyttet jord. Disse eksempelartene er valgt ut fordi de har potensiale til å overleve importprosessen og trolig kan finne egnede miljøer for å etablere seg i Norge. Det bør imidlertid fremheves at disse artene kun utgjør en brøkdel av alle mulige skadegjørere som kan bli introdusert med import av planter og tilhørende vekstmedier. Store importvolumer av planter med jord og andre vekstmedier øker sannsynligheten for å introdusere jordbundne skadegjørere som, og vil hvis de etablerer seg, kunne ha negative konsekvenser for norsk landbrukg økosystemer. Mulige konsekvenser inkluderer reduserte avlinger og tømmerutbytte, økte kontrollkostnader for bønder, økt bruk av pesticider, og tap av plantebiodiversitet.

Vår vitenskapelige vurdering tilsier at selv om gjeldende norsk regelverk gir et grunnlag for å håndtere risiko forbundet med import av planter med jord og vekstmedier, kan forebyggende tiltak styrkes ved å iverksette ytterligere risikoreduserende tiltak. I dag innebærer forebyggende tiltak hovedsakelig visuell kontroll av planteimport. Påvisning ved visuell kontroll er ofte vanskelig siden mange aktuelle planteskadegjørere ikke er synlige for det blotte øye. Inspeksjon av rotsystemer er spesielt utfordrende, og planteskadegjørere som ikke er lett synlige blir fort oversett. Forebyggende tiltak kan fokusere på fysisk adskillelse av planter og planteskadegjørere. Dette kan gjøres ved å produsere planter i områder som er frie for skadegjørere og/eller innendørs i sikrede veksthus.

Definition of key terms in the phytosanitary and biodiversity field

Table 1. Key terms used in phytosanitary literature and biodiversity literature. Note that similar terms may have different meanings between fields, and other terms are sometimes used to describe the same thing. Definitions used in the biodiversity field are taken from the Convention on Biological Diversity (CBD, 2024) and phytosanitary definitions are taken from IPPC (ISPM no. 5: terms from International Plant Protection Convention, International Standards for Phytosanitary Measures, (FAO, 2023)).

Term	CBD	ISPM 5
Terms used to describe species		
Alien invasive species / Invasive alien species	An alien species whose introduction and/or spread threatens biological diversity	An alien species (by CBD definition) that by its establishment or spread has become injurious to plants or that by risk analysis is shown to be potentially injurious to plants
Alien species	A species, subspecies, or lower taxon introduced outside its natural past or present distribution. Includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (also referred to as a "non-native species")	Rather than "alien species", ISPM uses "exotic", "non-indigenous", or "non-native"
Non-quarantine pest	Pest that is not a quarantine pest for an area	See 'Regulated non-quarantine pest' below for a related ISPM term
Pest	CBD uses ISPM definition	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products
Quarantine pest (QP)	CBD uses ISPM definition	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled
Regulated non-quarantine pest (RNQP)	Not used by CBD	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party

Terms for biological processes and movement of species		
Entry (of a pest)	CBD uses ISPM definition	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled
Establishment	The process of an alien species in a new habitat successfully producing viable offspring with the likelihood of continued survival	Perpetuation, for the foreseeable future, of a pest within an area after entry
Establishment (of a biological control agent)	Perpetuation, for the foreseeable future, of a biological control agent within an area after entry	
Intentional introduction	The deliberate movement and/or release by humans of an alien species outside its natural range	See 'Release' for a related ISPM term
Introduction	The movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present). This movement can be either within a country or between countries or areas beyond national jurisdiction.	The entry of a pest resulting in its establishment
Occurrence (of a pest)	CBD uses ISPM definition	The presence in an area of a pest officially recognized to be indigenous or introduced and/or not officially reported to have been eradicated
Pathway	CBD uses ISPM definition	Any means that allows the entry or spread of a pest
Plants for planting		Plants intended to remain planted, to be planted or replanted
Release (into the environment)	See 'Intentional introduction' above for a related CBD term	Intentional liberation of an organism into the environment
Spread	CBD uses ISPM definition	Expansion of the geographical distribution of a pest within an area
Unintentional introduction	All other introductions which are not intentional	Not defined in ISPM 5
Management-related terms		
Area of low pest prevalence	Not used by CBD	An area, whether all of a country, part of a country, or all or parts of

		several countries, as identified by the competent authorities, in which a specific pest occurs at low levels, and which is subject to effective surveillance, control or eradication measures
Consignment	Not used by CBD	A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots)
Containment	CBD uses ISPM definition	Application of phytosanitary measures in and around an infested area to prevent spread of a pest
Contamination	CBD uses ISPM definition	Presence in a commodity, storage place, conveyance, or container, of pests or other regulated articles, not constituting an infestation
Control (of a pest)	CBD uses ISPM definition	Suppression, containment, or eradication of a pest population
Endangered area	CBD uses ISPM definition	An area where ecological factors favor the establishment of a pest whose presence in the area will result in economically important loss
Eradication	CBD uses ISPM definition	Application of phytosanitary measures to eliminate a pest from an area
Growing medium	Not used by CBD	Any material in which plant roots are growing or intended for that purpose
Monitoring	The continuous investigation of a given population or subpopulation, and its environment, to detect changes in the prevalence of a disease or characteristics of a pathogenic agent	An official ongoing process to verify phytosanitary situations.

Pest free area	In addition to their own definition, ISPM definition is one of several given by CBD	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained
Pest risk analysis	CBD uses ISPM definition	The process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it
Pest risk assessment (for quarantine pests)	CBD uses ISPM definition	Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences
Pest risk management (for quarantine pests)	CBD uses ISPM definition	Evaluation and selection of options to reduce the risk of introduction and spread of a pest
Phytosanitary measure	CBD uses ISPM definition	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests
Regulated article	CBD uses ISPM definition	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object, or material capable of harboring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved
Risk analysis	"(1) the assessment of the consequences of the introduction and of the likelihood of establishment of an alien species using science-based information (i.e., risk assessment), and (2) to the identification of measures that can be implemented to reduce or manage these risks (i.e., risk management), taking into account socio-economic and cultural	See definition for 'Pest risk analysis'

	considerations." (CBD cites several other definitions as well)	
Risk assessment	ISPM definition is one of several given by CBD	See definition for 'Pest risk assessment'
Risk management	ISPM definition is one of several given by CBD	See definition for 'Pest risk management'
Surveillance	ISPM definition is one of several given by CBD	An official process which collects and records data on pest occurrence or absence by survey, monitoring or other procedures

Background as provided by the Norwegian Food Safety Authority and the Norwegian Environment Agency

The introduction of plant pests through the import of soil and other growing media has been highlighted in several reports, also in Norway, and in 2015 the European Food Safety Authority (EFSA) published the report "Risks to plant health posed by EU imports of soil or growing media". The EFSA report reviews the risk of introducing plant pests through soil and other growing media into EU countries and assesses the effectiveness of the measures in the EU's plant health regulations to prevent introductions.

In Norway, the action plan "Bekjempelse av fremmede skadelige organismer 2020-2025" aims to reduce the negative impact of alien species, and states that there is a need for further efforts in the early phase where measures aimed at introduction and spread must be given the highest priority. Through the action plan, the Norwegian Environment Agency (*Miljødirektoratet*) and the Norwegian Food Safety Authority (*Mattilsynet*) have been given responsibility for identifying measures related to alien species that accompany the importation of plants, soil, and other growing media (Measure 20). Under Measure 20, a similar study to the EFSA report for Norway will be carried out, where the assessment of risk is based, among other things, on the information available from Norwegian surveys. The measure includes ordering a study from the Norwegian Scientific Committee for Food and Environment (VKM) on which growing media associated with plants for planting pose the greatest risk of the introduction of alien species into Norway, as well as how effective various risk-reducing measures are to prevent such introductions.

Measure 20 in the Action Plan is comprehensive. To narrow down the assessment, the Norwegian Environment Agency and the Norwegian Food Safety Authority have, after dialogue with VKM, decided to divide the assignment into several sub-orders. We have chosen to limit this first order to the Norwegian Food Safety Authority's need for scientific assessments regarding plant pests.

<u>Brief overview of current Norwegian legislation</u>:
Regulations related to plants and measures against pests: to prevent the introduction of plant pests, the regulation contains prohibitions and sets requirements for the import of plants and propagating material, soil, and other organic growing media. The import ban in appendix 3 no. 10, and special requirements in Appendix 4A no. 28, 29.1, 29.2, 31, and 36 are aimed at plant health risks when importing growing medium as a separate product and growing medium that comes with plants. Some of these rules and requirements only apply if the origin of the goods is from non-European countries. Furthermore, there is a requirement in §17 that used agricultural machinery must be cleaned and free of soil before import. The plant health regulations are currently under revision, and the Norwegian Food Safety Authority wants to use VKM's report to assess whether these import rules and regulations should be changed.

The Regulations relating to alien organisms §24 require the importer to take preventive measures to prevent the introduction and spread of alien organisms. Section 28, fourth paragraph of the Nature Diversity Act also gives authority to set more specific requirements for businesses that may entail a risk of the spread or accidental release of alien organisms.

Motivation for the commission: The Norwegian Food Safety Authority will use the assessment from VKM as a basis for future plant health-related risk management linked to the import of plants with soil and other organic growing media. The Norwegian Environment Agency will use the assessment as a knowledge base for environmental risk assessment related to the import of plants with growing medium and for work under the regulations related to alien organisms. The assessment will also be part of the basis for following up the new Nature Agreement to the Convention on Biological Diversity.

Terms of reference as provided by the Norwegian Food Safety Authority

The Norwegian Food Safety Authority and the Norwegian Environment Agency refer to their respective collaboration agreements with VKM and hereby ask VKM to assess the risk related to plant pests associated with soil and other growing mediums through the import of plants for planting to Norway.

We refer to the EFSA report on *Risks to plant health posed by EU import of soil or growing media* and ask VKM to assess the extent to which the findings in this report are relevant for answering the assignment. In assessing plant health risks, we ask VKM to also include results from the Norwegian surveys. We ask that VKM's assessments for Norway primarily include the groups of growing mediums that, according to the EFSA, report represent the highest plant health risk. Furthermore, we ask that VKM focus on the import of plants from European countries, as well as an assessment of the effect of current risk reduction measures.

Assignment questions and objectives:

1. Define and identify soil and other growing media from the literature.
2. Which plant pests associated with soil or other growing media that are used in plants for planting from European countries have the highest probability of establishment and spread in Norway?
3. Which plants, plant categories, or cultivation methods represent the highest probability of entry for species identified in question two through the imports of soil or other growing media?
4. Are there countries in Europe that have a higher probability of pests being associated with the pathway at the origin, when considering questions two and three?
5. Identify risk reduction options and evaluate their efficiency and applicability.
6. Are the risk reduction options deployed in the current Norwegian legislation sufficient in reducing the probability of entry of plant pests from Europe?

1. Introduction

1.1 Preamble - a brief guide to the reader

Project background and summary of results: These first parts present the project background and Terms of Reference as provided by the Norwegian Food Safety Authority and the Norwegian Environment Agency. There is also a summary of the assessment's main findings and conclusions, and a list of key terms used in the phytosanitary and biodiversity field.

Chapter 1 – International plant trade and risks: Here, we introduce international plant trade and the risks involved in importing live plants with growing media. We also describe national and international regulations and processes that have led to the preparation of this assessment, as well as results from a monitoring program of plant import to Norway.

Chapter 2 – Methods and data sources used in this assessment: This chapter details the methods and data sources used in the assessment, including descriptions of literature searches and criteria used for selecting pests for further analysis. This chapter emphasizes the systematic approach we have used to identify and analyze risks associated with import of live plants with soil or other growing media.

Chapter 3 – Soil and other growing media: In this chapter we provide an in-depth description of the most important types of soil and other growing media, detailing their characteristics and uses. The chapter presents the foundational knowledge necessary to understand the complexities of soil and other growing media as pathways for plant pests.

Chapter 4 – Pests associated with soil and other growing media: Here, we identify and discuss various plant pests that may be associated with soil and other growing media. For selected pest species, we provide details about their biology and ecology, as well as the risks they pose to Norwegian plant health. This information is structured and presented as individual express PRAs (Pest risk assessment) in Appendix 1.

Chapter 5 – Pest risk management: This chapter describes risk management strategies, including regulatory measures, pest exclusion practices, and pest management techniques. We provide an overview of current legislation and regulations related to plant health and the import of soil and other growing media in Norway and the EU, and evaluation of current risk reduction options described in Norwegian regulations.

Chapter 6 – Data gaps and uncertainties: Here, we identify key data gaps and uncertainties, emphasizing the challenges involved in comprehensively assessing risks to Norwegian plant health posed by importing plants with soil and other growing media.

Chapter 7 – Summary with answers to the terms of reference: In this final chapter, we summarize our main findings by briefly answering the Terms of Reference provided by the Norwegian Food Safety Authority and the Norwegian Environment Agency. Throughout, we refer to relevant parts of the main text for further details.

1.2 International plant trade and associated risks – a brief background

Global trade is a direct and indirect driver for the movement of plant pests worldwide. The rapidly increasing international trade volumes in recent decades are thus exponentially increasing the risk of introducing pests into new areas (Chapman et al., 2017; Hulme, 2021). Trade pathways and commodities with a particularly high risk for introducing plant pests are plants for planting, wood packing material, and transport vehicles. Wood packing materials are often used in international shipping and serve as spreading vectors for wood-boring insects, nematodes, and fungi (Lantschner et al., 2020). Transport vehicles, including ships, airplanes, and trucks, can inadvertently facilitate the spread of plant pests by carrying soil, seeds, insects, and other pests vectored by insects across borders. The most important pathway, however, is the import of plants for planting (i.e., plants intended to remain planted, to be planted or replanted; ISPM no. 5). Live plants can carry many pests and diseases, with roots, stems, and leaves serving as habitats for various species groups (MacLachlan et al., 2021). In addition, the growing media that accompany traded live plants can harbor several pests and diseases. Growing media used in plant nurseries and plant trade can carry nematodes, fungi, bacteria, viruses, and insects (see e.g., subchapter 1.3). Thus, among the many pathways that make up the global trade and transport system, soil and other growing media emerge as a critical, yet often overlooked, pathway for the movement of plant pests.

Trade in plants for planting is a large and complex international business where live plants are grown in some areas and shipped to other areas where they are intended to remain planted, to be planted, or replanted. This trade has increased much in the past decades (Liebhold et al., 2012). Plants for planting are usually shipped with an accompanying growing medium. These growing media are made from different organic and inorganic constituents (see Chapter 3 for details). Although manufacturers of growing media make efforts to keep the media pest-free during production, media may be colonized by pests during plant production or during transit, retail, and grow-on (i.e., post-production). Traded plants are grown indoors or outdoors in plant nurseries in the exporting country and shipped to customers in the importing country, often via intermediate brokers and handlers (Table 2). Depending on the type of plant, the production cycle in the exporting country can last from a few weeks to several years. Larger and older plants may also be shipped from production sites in one country to other countries for additional growth before they are shipped to customers. Thus, even if the growing media that are used are pest-free at the start of the production cycle, they will usually be colonized by different organisms over time. Such colonization can take place at different stages during plant production and transport. The colonization rate and species composition of any colonizing organisms will vary with geographical location, production methods, management practices, and other factors (see Chapter 4 for details).

To illustrate the complexity that may be involved in international plant trade, we here present an example of trade with large trees between the UK and the EU (EFSA Panel on Plant Health et al., 2023). Field maple (*Acer campestre*) trees that are up to 15 years old and 88 mm in stem diameter are exported from the UK to the EU. In the UK, plants are usually germinated from seeds and grown as young seedlings in greenhouses, before they are planted outdoors, either in the field or in pots. If field-grown plants are potted before export, the roots are washed to remove the field soil. Potted plants grow in peat or peat-free growing medium that has been heat-treated to eliminate pests and diseases. Maple trees are grown together with many other plant species in nurseries that may be quite large (up to 325 ha) and where maple typically occupies less than 3 % of the total nursery area. Maple trees produced for export are grown alongside trees intended for domestic markets, so there is no distancing in place. Maple species may also be found in the nursery surroundings, in some instances as close as 20 m away. Several plant sanitary measures are undertaken during nursery production and may include pesticide application, biological control, and cleaning of tools and other equipment between plant batches. Nursery hygiene is maintained throughout the production cycle by removing leaves, pruning residues, and weeds to reduce the availability of over-wintering sites for pests and diseases. Pest monitoring is carried out at least once a year by visual inspection. No special measures are taken against soil-born pests, but potted trees are grown in trays that are separated from the soil by plastic membranes or grown in a raised position separated from soil. Before export, plants are visually inspected for any plant health issues both by the producer and the UK National Plant Protection Organization. A final visual pre-export inspection is carried out less than two weeks before export, as part of the process of issuing a phytosanitary certificate. Any infected plants found are either treated or destroyed. Plants are transported by trucks, mostly to Northern Ireland or Ireland. Most plants are sold to professional operators for tree production and growing-on (for onward trading) or directly to final customers for use as ornamental plants.

Table 2. Outline of a simple and complex production and transport pathway for plants for planting imported to Norway. In the simple pathway, a plant commodity is sold directly from a producer in Europe to a customer in Norway. In the complex pathway, a tree or other plant commodity is produced in Europe (or elsewhere) and traded onward through various intermediaries before it ends up in Norway. The production and post-production stages can last from a few weeks to more than 15 years, depending on the plant commodity.

Stage	Description	Simple pathway	Complex pathway
Production - Propagation	Breeding, selection, and propagation of plants		EU/International
Production - Nursery/Gardener	Potting, growing, harvesting, processing, and finishing of plants	EU	EU
Post-production - Auction	Cooperative sales organization for plants, characterized by logistical services	↓	EU
Post-production - Trader/Exporter	Trade in plants (mainly international)	↓	EU
Post-production - Transporter	Transport of plants between pathway stages	EU/Norway	EU
Post-production - Large-scale retailer	Supermarkets, horticultural chains, and other international distribution centers	↓	EU
Post-production - Transporter	Transport of plants between pathway stages	↓	Norway
Post-production - Large-scale retailer/importer	Supermarkets, horticultural chains, and other centers for national distribution	↓	Norway
Post-production - Customer	Final purchaser of plants	Norway	Norway

1.3 Regulation of international movement of plants

Because international trade in plants and other commodities can contribute to the spread of plant pests, trade is regulated through international agreements and overseen by various institutions. The Norwegian Food Safety Authority (NFSA) and other national plant protection organizations (NPPOs) have an important role in countering the rising threat of plant pests. Global efforts to establish consensus regarding plant pests are coordinated by the Food and Agriculture Organization (FAO) of the United Nations. FAO is responsible for developing international standards through the International Plant Protection Convention (IPPC). These International Standards for Phytosanitary Measures (ISPMs) cover various measures and regulatory frameworks designed to prevent the spread of harmful pests associated with plants and plant products between countries and regions. Importantly, ISPMs hold legal weight through the World Trade Organization (WTO) via the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement).

International trade can only be prohibited or import requirements can be set only if there is scientific evidence of potential harm. At the regional level, FAO standards are implemented and followed up through 10 regional plant protection organizations (RPPOs), including the European and Mediterranean Plant Protection Organization (EPPO). These RPPOs collaborate with NPPOs, such as the Norwegian Food Safety Authority, and facilitate and enforce IPPC standards at regional and national levels. For EU countries, phytosanitary regulations are also addressed through the European Food Safety Authority (EFSA). Plant health regulations and Pest risk assessment (PRA) for different pests are key tools to prevent the introduction and spread of plant pests via plant import. Despite the existence of international, regional, and national organizations tasked to manage threats to plant health, the volumes and complexities of global trade often challenge the effectiveness of these systems. The high speed and large volumes of international trade may hamper the application of scientific principles and efforts of international consensus, making the control of plant pests and non-native species a difficult task.

The international movement of plants is regulated by both the phytosanitary agreements outlined above and by national and international regulations for environmental protection. Although related, the phytosanitary and biodiversity fields tend to operate in separation and often use different terms for similar concepts. To help bridge the phytosanitary-biodiversity gap, we have included a table with definitions of key concepts used in these two related fields (Table 1). This report will use the phytosanitary definitions taken from ISPM no. 5, as these are the standard definitions used by the VKM Panel on Plant Health.

1.4 National regulations to protect biodiversity

Norway's Nature Diversity Act (*Naturmangfoldloven)* came into force in 2009 (LOVDATA, 2009). It applies to all natural environments and all sectors that manage biodiversity or make decisions that impact biodiversity. The act supports Norway's international environmental obligations under the Convention on Biological Diversity (CBD) and the principles outlined in the environmental paragraph of the Norwegian constitution (§112). Norway's Nature Diversity Act establishes general rules for the sustainable use of nature as well as environmental legal principles that should support public decision-making (§§8-12). For example, the act mandates that public decisions affecting biodiversity should, as far as reasonable, be built on scientific knowledge about biodiversity and how it will be affected by different influences.

Norway's Regulation Relating to Alien Organisms (*Forskrift om fremmede organismer*) governs the introduction, trade, and release of alien species and their accidental spread in Norway (LOVDATA, 2015). The regulation defines an alien organism as one that does not belong to any species or population naturally occurring in the area in question (corresponding to 'non-native' organisms in the ISPM vocabulary; Table 1). The aim of the regulation is to prevent the introduction and spread of alien organisms that may have harmful effects on biodiversity. A primary rule is that permits are required if alien species are to be released into the environment. In addition, the regulation has five appendices listing species that are prohibited from being introduced and released, are allowed for introduction and release with labeling requirements, are banned from release, or can be freely released. These appendices should not be confused with the Alien Species List of The Norwegian Biodiversity Information Centre (*Fremmedartslista, Artsdatabanken*), which lists all alien species that have been recorded in Norway, as well as known "doorknockers" (alien species not currently reproducing in the wild in Norway, but that can be expected to do so within 50 years). The alien species list also provides ecological impact assessments of these species. Knowledge about impacts on biological diversity is used when applications for the release of alien organisms are processed by, among others, VKM. This knowledge is also used to assess species listed in the Regulation Relating to Alien Organisms.

In 2015, the Norwegian Ministry of Climate and Environment recognized that invasive species are a major threat to biodiversity both globally and within Norway. This led to the decision outlined in Meld. St. 14 (2015-2016) *"Natur for livet – Norsk handlingsplan for naturmangfold'* to develop a new action plan against harmful alien organisms. The resulting action plan, "*Bekjempelse av fremmede skadelige organismer 2020-2025,"* was adopted in the spring of 2020 and emphasized the need for cross-sectoral collaboration. The action plan sets goals and measures to reduce the risk of adverse effects from harmful alien organisms in Norway and includes 28 actions. Action no. 20 is to "investigate measures related to stowaways that accompany the import of plants, soil, and other growing media." As described in this report's terms of reference and motivation, the Norwegian Food Safety Authority and the Norwegian Environment Agency have commissioned VKM to assess risks associated with the import of live plants and associated growing media.

1.5 Monitoring imports of live plants with soil and other growing media to Norway

The unintentional introduction of species associated with live plants imported with soil and other growing media is a major pathway for several species' groups, including terrestrial invertebrates, fungi, and vascular plants (NOBANIS, 2015; Rabitsch, 2010; Roy et al., 2019; Sandvik et al., 2022; Saul et al., 2016). Tasked by the Norwegian Environment Agency, the Norwegian Institute for Nature Research (NINA) has developed a systematic monitoring program for this import pathway (Bruteig et al., 2017; E. et al., 2016; Endrestø et al., 2016; Westergaard et al., 2015) and implemented this program every year since 2014. The monitoring aims to (i) collect systematic and empirical data on the species diversity and composition of unintentionally introduced live invertebrate and vascular plants with imported plants from Europe; (ii) estimate the number of species introduced to Norway through this pathway; and (iii) assess the risk these species pose to Norway's biodiversity.

Non-native species can occur in the soil or growing medium, on the imported plants themselves, or elsewhere in the shipping containers used for transporting the goods to Norway. While NINA's monitoring program includes all unintentionally introduced species detected within the shipping containers, the following descriptions and results only include live invertebrate and vascular plant species identified in the soil or growing medium associated with the imported plants.

The plant commodities targeted in the monitoring program are assumed to have been grown outdoors in the exporting country and imported to Norway with a clod (a lump of soil or other growing medium). While all imported plants come with a phytosanitary certificate to verify compliance with phytosanitary import requirements, these certificates provide no information about any pre-export soil treatments meant to reduce the survival of contaminant species. Imported plants with clods fall into seven commodity codes within the Norwegian Customs Tariff (Tolletaten (2024); see subchapter 2.3.1 and Table 4 for details). The monitoring program has primarily focused on commodity code 06.02.9021 (woody ornamentals) because this code has the highest import volumes to Norway over time (see Figure 3). In addition, the program includes plants falling within code 06.02.9022 (herbaceous perennials), code 06.02.9043 (potted plants for planting), and, to a much lesser extent, code 06.02.2000 (trees and shrubs with edible fruits or nuts).

NINA's monitoring team has collaborated with large commercial plant importers and garden centers located in the area around Oslo fjord. These centers act as hubs for imported plants, and the NINA team was granted access to their warehouses. Immediately after the arrival of the shipping containers, sampling of the growing medium is done before plants are repacked for further distribution within Norway. Usually, 10 one-liter samples are collected within each container from up to 15 containers per year. The samples are collected in a non-destructive manner, each sample consisting of growing medium from one or more pots per imported plant, depending on the pot size. From 2014 to 2023, the monitoring program collected a total of 1323 samples (1631 liters) from 158 containers containing 246 different plant taxa. Samples were first placed in Berlese funnels to extract live invertebrates and then in a greenhouse for seed bank germination. Germination was followed by stratification to break dormancy and a second round of germination of any seeds requiring this pre-treatment. Detailed descriptions of the methods used can be found in Westergaard et al. (2020b), (Westergaard et al., 2020a), Westergaard et al. (2021) and (Davey et al., 2022).

Invertebrate taxa were identified based on morphology and DNA barcoding, focusing on springtails (Collembola), spiders (Araneae), true bugs (Hemiptera), butterflies (Lepidoptera), beetles (Coleoptera), and ants (Hymenoptera, Formicidae). Further identification has been limited by the difficulty of identifying juvenile specimens, lack of diagnostic morphological characters, lack of available taxonomic expertise and resources, and lack of species references in reference databases. All vascular plant seedlings were counted and identified to taxa (mostly to species). Species identification of import species is very labor-intensive, especially because the species detected in the soil of imported horticultural plants have been found to originate from all over the world (Westergaard et al. 2020b). Correct identification thus requires taxonomic expertise far beyond our own region.

The results from 10 years of monitoring clearly show that the import of plants with soil and other growing media is a major pathway for unintentional introduction of invertebrates and vascular plants to Norway. From 2014 to 2022 (2023 data are not yet finalized), the NINA team has extracted more than 1.5 million individuals of live invertebrates, of which almost 850.000 individuals have been identified to 534 different taxa (order, family, genus, or species). Of these invertebrate taxa, about half are native species to Norway (278 species), while the remaining are either known non-native species to Norway (33 species), potential new non-native species to Norway (70 species), or not possible to identify to species level (153 taxa). From 2014 to 2023, almost 42.000 vascular plant individuals germinated from seeds from the same samples and identified 452 different taxa. Of these, 205 species are native to Norway, while the remaining species are either known 'doorknockers' (8 species), non-native species to Norway (126 species), potential new non-native species to Norway (57 species), or impossible to identify (56 species). Although the monitoring program does not specifically target plant pests, a number of soil-associated invertebrate species found on a diverse range of imported host plant species have been identified as plant pests during the work with this VKM report.

Model calculations based on the number of live contaminant species detected in the samples suggest that the volume of imported horticultural plants to Norway from the two main export countries (the Netherlands and Germany) is so high that all species in the specific source species pools will likely be introduced to Norway in one year (Bruteig et al., 2017). Model calculations also show that many species have low detectability because they occur in low numbers and are only found in a few import containers. Also, after the first three years of monitoring, it was estimated that the samples collected thus far from 60 containers of imported plants represented only about 1 % of the focal plant commodity codes imported during this period (Bruteig et al., 2017). Thus, most imported plants were not sampled. Despite this relatively low sampling intensity, during over 10 years of systematic sampling the accumulated number of species detected has increased continuously.

Global trade provides introduction pathways for new source pools of species, and the number of introduced and emerging alien species is increasing worldwide (emerging alien species are species that never before have been encountered as aliens; Seebens et al. (2017), Roy et al. (2024)). Emerging alien species pose a major challenge for management, as they are difficult to identify and assess for invasion potential since they do not have a previous invasion history (Seebens et al., 2018). In addition to identifying live contaminant species with imported plants, the NINA monitoring program has also characterized potential source species pools by using eDNA (environmental DNA) metabarcoding on a subset of the samples. An analysis of fungal and vascular plant diversity in 80 pots of soil/growing medium from two containers identified more than 4600 fungal taxa and more than 100 vascular plant taxa (Davey et al., 2022; Farsund, 2022). Most of these taxa had not previously been identified in the monitoring program, and the eDNA data thus provides a first glimpse into the largely unknown source species pools of potential contaminant species that can reside in growing media associated with imported horticultural plants.

The NINA monitoring program shows that the propagule pressure of live invertebrates, vascular plants, and fungal species to Norway is high and continuous due to the extensive import of live plants (see subchapter 2.3.1). Many species have been identified as known non-native species to Norway, and these species are already assessed for ecological impacts and invasion potential through the work on the Norwegian alien species list (Artsdatabanken, 2023) by the expert committees of the Norwegian Biodiversity Information Centre (*Artsdatabanken*). However, two other categories of contaminant species stand out from the monitoring data: (i) the potential new non-native species to Norway, and (ii) the high number of species that are native to Norway. Many potential new non-native species to Norway are introduced from neighboring countries, where similar ecological and bioclimatic features may favor their establishment. In addition, almost half of all invertebrate and vascular plant contaminants that have been identified are indeed native to Norway but may represent cryptic invasions (unnoticed spread) of potentially non-native genotypes. The species in these two categories are typically not identified during expert- or literature-based horizon scans. They can only be identified through monitoring of their pathways, which in turn, enables the assessment of their impact and facilitates their management before they become established in Norwegian nature (Westergaard et al., 2021).

1.6 Risks posed by unregulated species

Unregulated plant pests may also pose a high risk. Several destructive pests were not regulated by national plant protection organizations when they first appeared as invasive pests (Ploetz et al., 2013). The challenge lies in the vast number of potential pest species that may be transported internationally with plants for planting. Species are often not recognized as threats until they have become established in a new country and caused significant economic or environmental damage. For example, the emerald ash borer (*Agrilus planipennis*) is now one of the most destructive invasive non-native plant pests in the world, killing millions of ash trees in the USA, Canada, and Europe. When it appeared as an introduced species in the USA about 25 years ago, it was little known and had been considered to be a harmless species. The *A. planipennis* example illustrates a broader pattern observed across all taxonomic groups, with a continuing influx of plant pests and other non-native species, and where many taxa even show an acceleration in the rate of new detections over time (Seebens et al., 2017).

Nematodes provide an illustrating example of an organism group with many potential harmful plant pests that currently are unregulated but may turn out to be harmful if they spread to new environments. On at least two occasions, plant-parasitic nematodes imported with ornamental plants for planting have caused significant problems in Norway. In both cases, the imported plants came from the Netherlands. Hybrid yew (*Taxus media* "Hillii") planted in Oslo was infested by *Trichodorus hellalae* and suffered extensive needle loss (Ben Hellal et. al. 2019, Decraemer et al. 2021). Similar problems were caused by *Paratrichodorus pachydermus* on English yew (*Taxus baccata*) in Bergen (Bergen Museum pers. com). Another example from Denmark involves the nematode *Rotylenchus buxophilus,* which caused severe damage on boxwood (*Buxus sempervirens*) in the baroque gardens of Frederiksborg Castle in Hillerød. This nematode species has also been detected on *B. sempervirens* plants for planting imported to Oslo (Magnusson, 2024; Talgø et al., 2014).

2 Methods and data sources used in this assessment

2.1 Geographic area of interest

The area of interest for this assessment is defined according to Annex 13 in Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests (LOVDATA, 2000): "European countries: countries and associated islands belonging to geographical Europe, including Svalbard, Jan Mayen, the Canary Islands, Madeira, the Azores, Cyprus, Malta, Russia west of 60 degrees east, but excluding Turkey, Azerbaijan, Kazakhstan, and Georgia". We understand "geographical Europe" to consist of countries that are located within the continental landmass of Europe and the British Isles (Figure 1). Within this large area, most Norwegian imports of live plants with growing media come from a few countries (the Netherlands, Germany, Denmark, and Sweden; see details below). Thus, in this assessment, we will mainly focus on imports from these and a few other EU member countries.

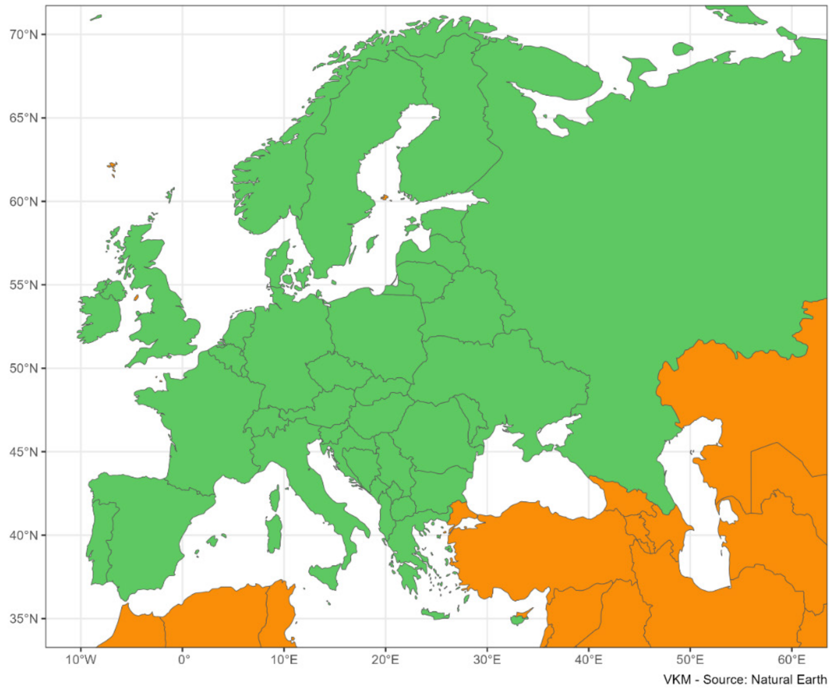

Figure 1. Map of Europe showing the area of interest for this assessment (in green). Russia is included to 60° eastern longitude.

2.2 Literature search and inclusion criteria

We conducted a systematic literature search for studies on soil or other growing media and plant pests. The search was conducted in two databases, CAB Abstracts (OVID) and Web of Science Core Collection (SCI-EXPANDED, SSCI, A&HCI, and ESCI), on November 20, 2023, by Astrid Merete Nøstberg, a specialist librarian at the Norwegian Institute of Public Health. The search strategy combined words and controlled subject headings for growing media, plants, and soil, and was based on the search strategy described in EFSA Supporting Publication (Bremmer et al., 2015). Additionally, for the search component on growing media, we used a comprehensive array of search terms, both as text words and controlled subject headings, sourced from an overview provided by VKM. The literature search was geographically limited to Europe, using a combination of text words, and controlled subject headings for relevant countries and areas, as formulated by Nøstberg (see Appendix 3 for the complete search strategy). The search was restricted to publications from January 2014 (i.e., after the publication of the 2014 EFSA report on the import of growing media to the EU) to November 2023, and the search strategy was tailored to each database's thesaurus and search interface. The search was peer-reviewed by specialist librarian Trude Anine Muggerud.

The search yielded a total of 4038 articles, 1790 found in Web of Science and 2248 in CAB Abstracts. After duplicates (870) were removed, 3168 articles were accepted for title and abstract screening in Rayyan (www.rayyan.ai). After this screening, 70% of the articles were excluded and 946 articles were selected for data extraction of soil or other growing media and plant pests. See Table 3 for detailed inclusion and exclusion criteria used when screening articles.

Table 3. Inclusion and exclusion criteria used in title and abstract screening of studies on soil or other growing media and plant pests published in the years 2014-2023.

Include study if:	Exclude study if:
The study describes organisms that are harmful to plants and are currently regulated in the EU (i.e., QP, RNQP, Priority pests) EPPO A1, EPPO A2, EPPO weeds	The study does not address any specific type of soil, growing medium, or pest.
The focus organism is a vector of relevant pest(s); such as aphids, thrips, and nematodes, carrying known virus.	The study does not focus on specific organisms in the following taxonomic groups: viruses, bacteria, phytoplasma, fungi, oomycetes, nematodes, or insects.
The study is written in English or Norwegian.	The document type is not eligible (non-peer reviewed letters, posters, comments, patents)

2.3 Data and information gathering

To quantify relevant trade pathways, we gathered data on volumes (in metric tons) of live plants imported to Norway with soil or other growing media. We also compiled lists of regulated plant pests from EPPO and other sources. This list was used when we screened for studies to include in the literature search. Below is a brief description of the results, as well as the data sources and procedures used.

2.3.1 Import statistics for live plants

Data on imports of live plants to Norway was downloaded from Statistics Norway (2024) for all commodity codes that include soil or other growing media (Table 4). Data were downloaded for the years 2014 to 2022 (the last year with complete import records). Statistics Norway table 08801 contains trade data classified according to the harmonized nomenclature (HS system). This system is a standard system used globally for classifying traded products and was developed by the World Customs Organization. The HS system is nested and provides more detailed information for each lower-level two-digit code. HS codes have up to eight digits, of which the first six are international. Section II of the HS system covers “vegetable products”, and Chapter 06 includes “live trees and other plants; bulbs, roots and similar, cut flowers and ornamental foliage.” Sub-category 0602 includes “other live plants (including roots), cuttings and scions; mycelium”. Within this sub-category, we summarized import volumes for seven commodity codes described in Table 4.

Norwegian import data shows that the Netherlands contributes nearly half the total import volume, followed by Germany, Denmark, and Sweden (Table 5, Figure 2, 4, 5). More than 90% of Norway's total imports of live plants come from these four countries, and the top eight exporting countries account for 99 % of total imports. The commodity with the highest import volume is ornamental trees and bushes imported with a clod or other growing medium (HS code 06029021, 'woody ornamentals'; Table 4, Figures 3 and 5).

Table 4. Classification and detailed description of the seven commodity codes used to calculate import volumes of live plants from Europe to Norway. Four-digit commodity codes are taken from Chapter 06 in the Harmonized System (HS) of the World Customs Organization. Classification codes are from Statistics Norway.

Chapter	Sub-category	Classifi-cation	English name	Norwegian name	Name used in this report
06	-	-	Plants and vegetables	Planter og grønnsaker	
06	02	-	Other live plants (including their roots), cuttings and slips; mushroom spawn	Andre levende planter (herunder røtter), stiklinger og podekvister; mycelium.	
06	02	2000*	Edible fruit or nut trees, shrubs and bushes, whether or not grafted	Trær og busker som skal bære spiselige frukter eller nøtter, også podede	Trees and shrubs with edible fruits or nuts
06	02	9021*	Live plants, including their roots, and mushroom spawn (excluding bulbs, tubers, tuberous roots, corms, crowns and rhizomes, including chicory plants	Buksbom, drake-, laurbærtre, kamelia, kransgran, kristtorn, magnolia, palmer, trollhassel, vinterpryd med jord/annet vekstmedium	Woody ornamentals
06	02	9022*	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants	Stauder, herunder urteaktige stauder, med klump av jord el annet vekstmedium	Herbaceous perennials
06	02	9092	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants	Frukt- eller grønnsakplanter, med klump av jord eller annet vekstmedium	Fruit and other vegetable plants
06	02	9098	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants	Levende planter, med klump av jord eller annet vekstmedium	Other live plants
06	02	9043*	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants	Potte-/utplantings-planter i blomst av typen blåkorg, margerit, isbegonia, krysantemum, ildtopp, lobelia, filoler mm (se tolltariffen), også i sammenplantinger	Potted plants for planting

06	02	9091*	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plant	Gress i ruller el. plater (plen)	Turfgrass

* Commodity codes that are included in NINA's monitoring program (see subchapter 1.5)

Table 5. Annual imports of live plants to Norway for the years 2014-2022 from eight European countries that constitute 99% of total Norwegian imports. Data shown are the total import volume in metric tons (Sum ton), the percentage contribution of each country to the total import volume (Percent), and the cumulative percentage of imports (Cumulative percent).

Country	Sum ton	Percent	Cumulative percent
Netherlands	204.058	48.3	48.3
Germany	99.284	23.5	71.7
Denmark	51.685	12.2	84.0
Sweden	25.778	6.1	90.1
Belgium	13.552	3.2	93.3
Italy	12.999	3.1	96.3
Poland	7.158	1.7	98.0
England	3.694	0.9	98.9

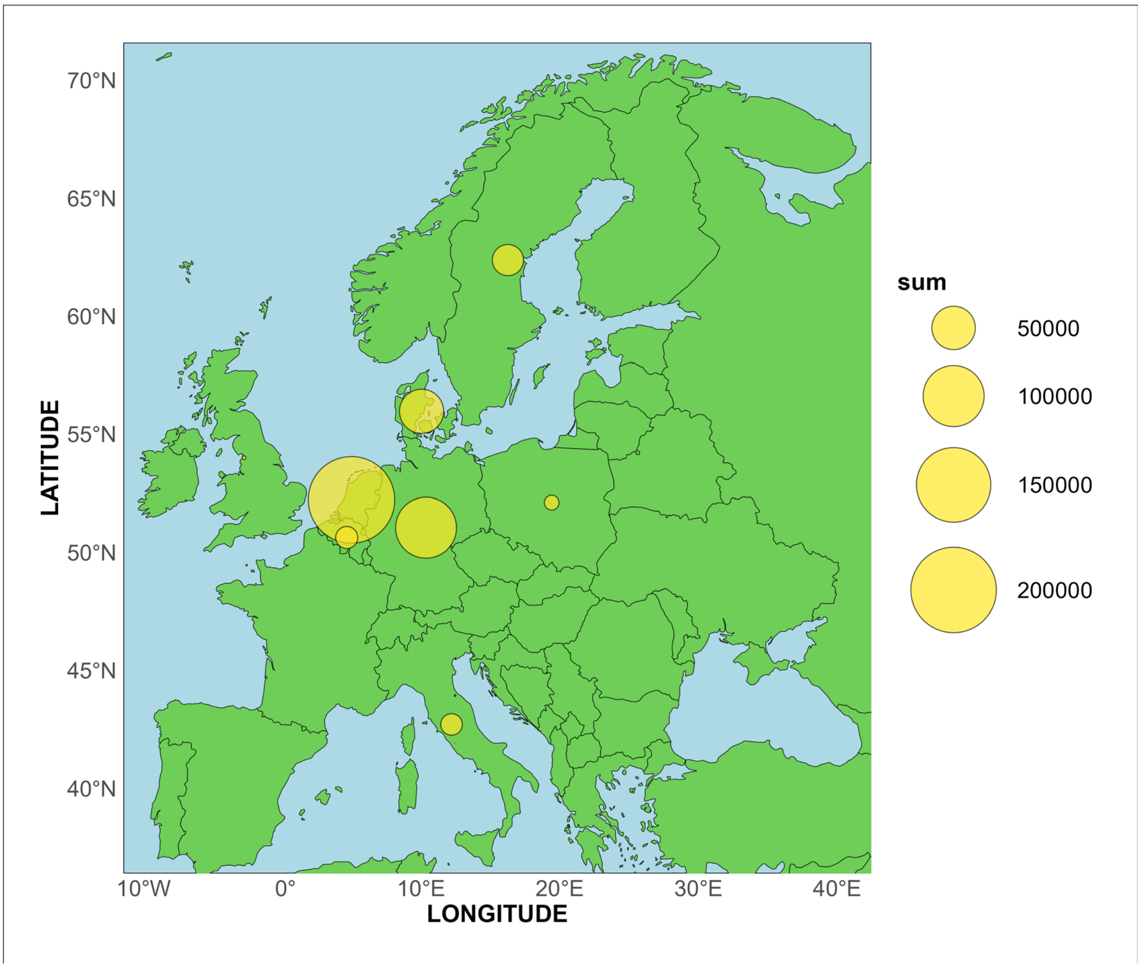

Figure 2. Map showing export volumes (in metric tons) of live plants to Norway for the years 2014-2022 from the seven main exporting countries (in descending order: the Netherlands, Germany, Denmark, Sweden, Belgium, Italy, and Poland). The circle on top of each exporting country is scaled to the country's total export volume. Data is sourced from Statistics Norway.

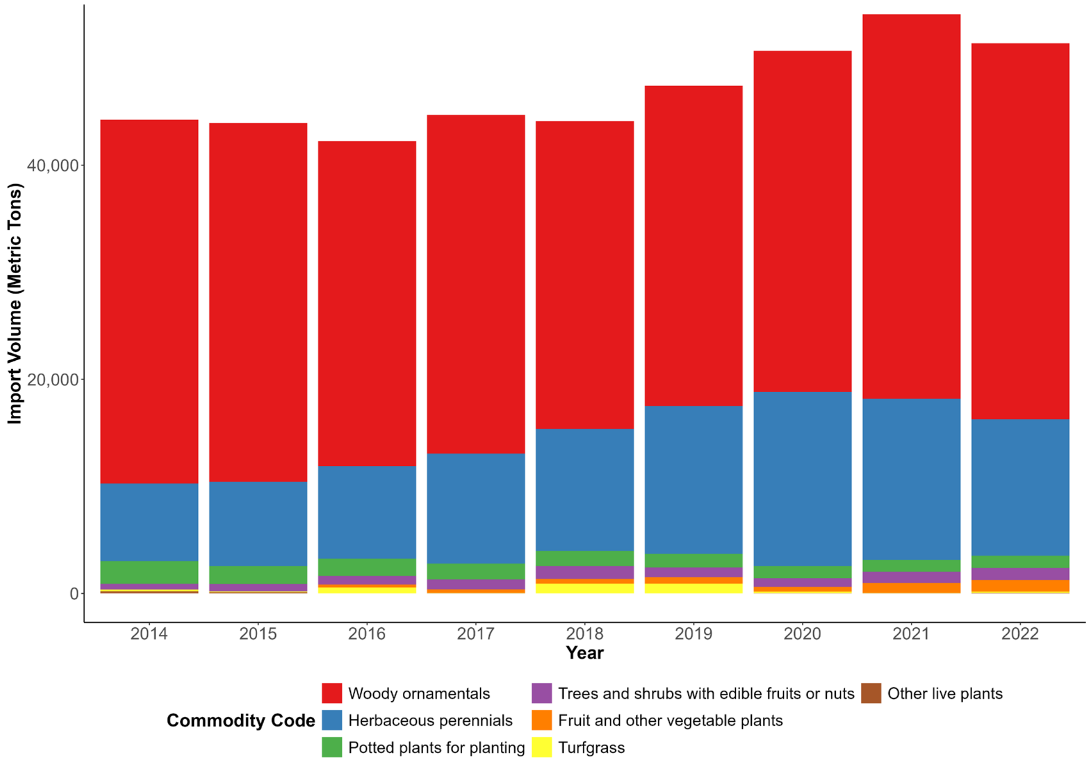

Figure 3. Annual import volumes (in metric tons) of live plants to Norway for the years 2014-2022. Total imports are broken down by commodity code for seven plant commodities imported with soil or other growing media (see Table 4 for a full description of these commodities). Data is sourced from Statistics Norway.

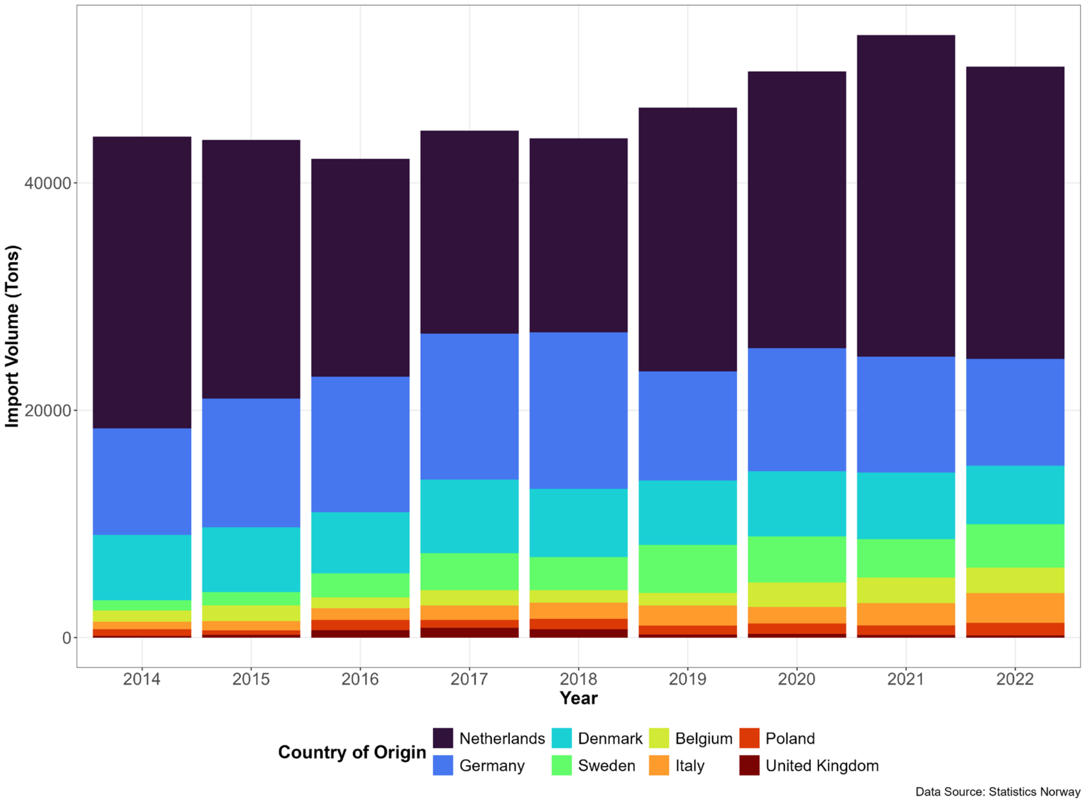

Figure 4. Annual import volumes (in metric tons) of live plants to Norway for the years 2014-2022 broken down by exporting country. The eight countries shown constitute 99% of Norwegian imports (Table 5). Data is sourced from Statistics Norway.

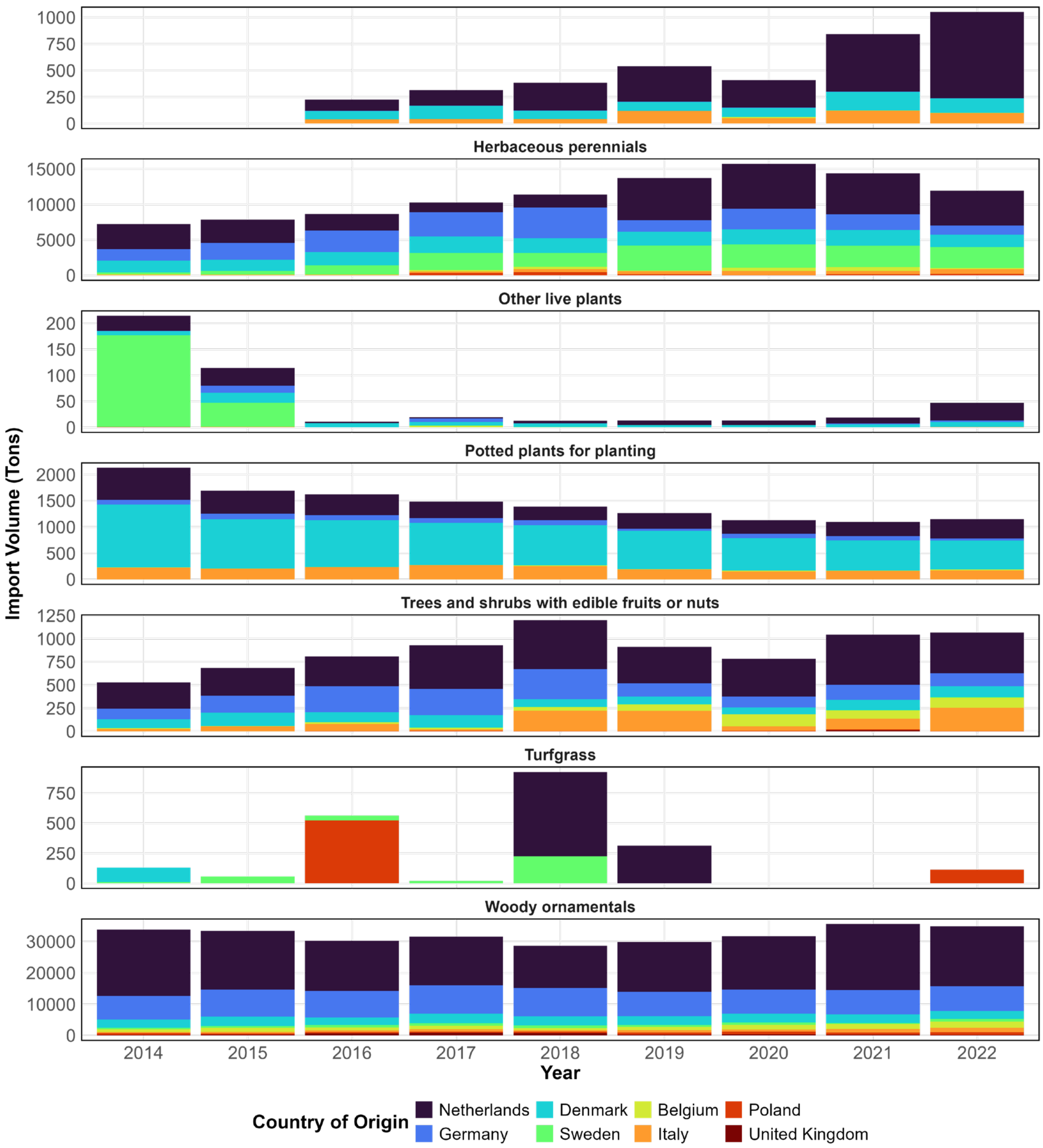

Figure 5. Annual import volumes (in metric tons) of live plants to Norway for 2014-2022. Import volumes are broken down by commodity code (for seven commodities imported with soil or other growing media; see Table 4 for details) and exporting country (eight countries constituting 99% of Norwegian imports; Table 5). Data is sourced from Statistics Norway.

2.3.2 Identifying plant pests from published literature and databases

In addition to our own literature search described in subchapter 2.2, we gathered information about plant pests associated with soil or other growing media from two international databases (CABI, 2022; EPPO, 2024b). Pest species included in the risk rankings described in subchapter 2.4, subchapter 4.4, and Appendix 1 had to (1) be known plant pests, (2) be present in Europe, (3) not be present in Norway [except for pests that are quarantine pests (QP) or regulated non-quarantine pests (RNQP)], and (4) have viable host plant(s) in Norway as of 2023.

Data on all pests, and whether they are associated with growing media or not, was summarized in spreadsheets listing the pest's scientific name, their soil or growing media association, and references to the literature sources used (Appendix 5). Species in Appendix 5 without an entry under associations may still be linked to soil, but we have not evaluated those relationships. Species names mentioned in literature sources were detected programmatically using R. This was done by breaking the publication text down to bigrams (sequences of adjacent word pairs) and matching these to databases for species identification. After identifying all plant pests mentioned in the literature, we merged synonyms by checking and standardizing all pest names according to the nomenclature used by Global Biodiversity Information Facility (GBIF, 2023). Higher-level taxonomical information was added using the GBIF Backbone. We also included the EPPO code for each pest species from the EPPO Global database (2024).

In addition to the list of plant pests identified by our literature search, we downloaded known plant pests from the EPPO Global Database (2024). This database contains information on species associated with "soil/growing medium" under the heading "Host commodities." We also downloaded plant pests associated with soil and other growing medium from the CABI pest compendium datasheet on soil, sand, and gravel (CABI, 2022).

2.4 Risk-ranking plant pests and their growing media associations

We developed a simple scoring system to assess risks associated with the plant pests identified as described in subchapter 2.3.2. This scoring system provides a structured approach to risk-ranking by assigning numerical scores to three important pest characteristics: geographical distribution, impact, and strength of growing media association. These three characteristics are defined below. The overall risk score for each pest was calculated by summing the score for each individual pest characteristic. The score can range from 3 to 9, with higher scores indicating higher relative risk:

Overall risk score [3-9] = Geographical distribution score [1-3] + Impact score [1-3] + Growing media association score [1-3]

2.4.1 Geographical distribution

Limited (Score 1): Species with a limited distribution are typically found in restricted habitats, climate types, or regions. Such species can, for example, be endemic to a particular area, occupy an unusual ecological niche, or be adapted to very specific conditions (e.g., a certain altitude, climate, or a particular type of forest). Species with a limited distribution can also be newly introduced species that have not yet expanded to their entire potential niche.

Moderate (Score 2): Species in this category are those found in several European countries or regions. They might occupy different habitats but still be limited by certain geographical or ecological factors. For instance, species that are present in a specific forest type such as the Nordic taiga, or in parts of Eastern Europe but not found in the Mediterranean or Arctic regions would be considered to have a moderate distribution.

Wide (Score 3): These species are found in many habitats across much of Europe. They are often generalists in their ecological needs and can be found in various environments and climate zones, from the Mediterranean area to the northern tundra, indicating high adaptability to different environmental conditions.

2.4.2 Pest impact

Low impact (Score 1): Pest species with a low impact cause minimal harm to agriculture or native ecosystems. They have limited effects on their surroundings and are usually not considered significant threats to agriculture. Low-impact pests typically do not require special management efforts. For low-impact species that have some adverse effects, these are generally limited and can be easily managed or tolerated.

Medium impact (Score 2): Pest species with a medium impact typically cause moderate harm to agriculture. While their effects are not as severe as those of high-impact pests, they can still result in noticeable losses, localized eruptions, or damage to specific crops or ecosystems. Medium-impact pests usually require some level of management intervention, such as measures to prevent further spread or otherwise minimize their negative consequences.

High impact (Score 3): Pest species with a high impact cause significant and severe damage to agriculture. They often lead to substantial losses and extensive damage. High-impact pests can spread rapidly, are challenging to control, and may pose severe threats to native ecosystems. Their presence will often lead to extensive economic costs and the need for intensive management efforts.

2.4.3 Association with growing media

Rarely associated (Score 1): Pests that rarely are associated with soil or other growing media have limited or casual interactions with such substrates throughout their life cycle. These pests are primarily associated with plants, and soil plays a minor or negligible role in their biology. They do not rely on soil for essential aspects of their survival or reproduction. These pests are found in soil infrequently and typically only under unusual circumstances or as a result of accidental encounters.

Sometimes associated (Score 2): Pests that sometimes are associated with soil or other growing media may utilize soil at some stages of their life cycle or under certain conditions but do not have any obligatory association with soil. These pests may alternate between the soil and the host plant. They may use soil for specific purposes, such as over-wintering or egg laying, but can also thrive in non-soil environments. Their association with soil can vary depending on the season, food availability, or environmental conditions.

Always associated (Score 3): Pests that always are associated with soil or other growing media have an obligatory dependency on soil during one or more stages of their life cycle and depend on soil as a habitat. These pests typically reside, reproduce or feed exclusively in soil. They rely on soil for essential aspects of their biology, such as nesting, pupation, or obtaining nutrients. Pests in this category are rarely found outside soil and are intimately tied to soil for survival and reproduction.

2.4.4 Uncertainty

We expected a high frequency of missing data for some pest characteristics and considered it important to account for such uncertainty (as defined in Table 6) when assessing pest risks. In case of missing data, we assigned a score of 1 (low) for geographical distribution and growing media association, assuming that this information would be known for species that are important pests (i.e., they would have a score of 2 or 3). The impact was also assigned a minimum score of 1, assuming all pests have some potential impact since all the identified species are known to plant pests. The score for individual pest characteristics was adjusted to factor in uncertainty by using a weighting factor of 0.5. This weighting factor reduces the contribution of any uncertain pest characteristics to the overall risk score, providing what we call an adjusted score. This adjusted score ensures that pests with missing or uncertain data do not get excessively high-risk scores. For example, if species A and B are given a similar pest impact score of 2 (medium) but with high uncertainty for species B, the adjusted pest impact score for species B will be 1.

Adjusted overall risk scores were plotted on a horizontal axis to visualize the overall risk assigned to each pest based on their distribution, economic impact, and growing media association (see Figures 12 to 15). In addition to adjusting the overall risk score for pests with missing data, we visualized uncertainty by adding error bars around the risk scores. Pests with larger error bars have greater uncertainty in their risk assessment, while those with smaller error bars have more reliable data. We graded the overall uncertainty for each species as low, moderate, or high and assigned numerical values of 0, 1, and 2, respectively (Table 6). All species with missing data were considered to have high uncertainty (2), to emphasize uncertainty in our evaluations. If species A and B have a similar adjusted overall risk score of 6, but the overall uncertainty is considered to be moderate (1) for species A and high (2) for species B, the error range will be 5 to 7 for species A and 4 to 8 for species B. Different error ranges due to different levels of uncertainty are illustrated by two assessed insect species. The Colorado potato beetle (*Leptinotarsa decemlineata*) has a high-risk score and relatively low uncertainty, whereas the walnut husk fly (*Rhagoletis complete*) has a moderate risk score but much higher uncertainty (Figure 12). The risk scores presented in Figures 12 to 15 served as the basis for selecting pests for further risk analysis by a simplified pest risk assessment (see Subchapter 2.4.4 and Appendix 1).

Table 6. Definition of uncertainty levels used to scale error bars around the overall risk scores assigned to plant pests associated with soil or other growing media.

Score	Uncertainty	Definition
0	Low	All data are from peer-reviewed sources or curated databases. No reliance on unpublished data or subjective judgment.
1	Moderate	The data includes some peer-reviewed sources but relies on reports and articles from web pages that may not have been peer-reviewed. Subjective judgments are occasionally necessary.
2	High	Lacks sufficient peer-reviewed data. Relies heavily on unverified web pages, anecdotal reports, or unpublished studies. Extensive subjective judgment is required due to contradictory evidence or the absence of consensus among experts.

2.4.5 Pest risk assessment and climate matching

Plant pests selected for assessment were subjected to a simplified pest risk assessment, following EPPO's "Decision-support scheme for an Express Pest Risk Analysis" (EPPO, 2012). In the express PRAs presented in Appendix 1, we use Köppen-Geiger climate classification maps to determine how likely it is that the assessed plant pests establish and spread in Norway, with potential negative impacts on agriculture or native ecosystems. Köppen-Geiger climate classification is based on annual and monthly averages of temperature and precipitation and divides climates into five main groups, which are further divided into types and subtypes (see https://www.britannica.com/science/Koppen-climate-classification for a complete list of definitions). The five main Köppen-Geiger climate groups are tropical climates (group A), dry climates (B), temperate climates (C), continental climates (D), and polar/alpine climates (E). Climate types found in Norway range from arctic (type E) at high altitudes and latitudes to continental (D) and various temperate (C) subtypes. This wide range of climate types reflects Norway's varied topography and latitudinal extent. The four most geographically widespread climate subtypes in lowland Norway are, in decreasing order, Dfc (humid continental), Dfb (warm summer continental), Cfb (temperate oceanic), and Cfc (sub-polar oceanic) (Figure 6). In addition, there are large areas of tundra climate (ET) at high elevations and very small areas of ice cap climate (EF) far north (Figure 6).

In the express PRAs, we present plots of the known distribution of the assessed pest species (based on GBIF occurrence data) and how the distribution overlays with different Köppen-Geiger climate types (see Appendix 1). Below each map we show the frequency distribution of pest occurrence points across different climate types, highlighting the four main climatic subtypes occurring in Norway. This allows for a coarse matching of the climates that occur in the known presence area of a pest with climates occurring in Norway.

We conducted Maxent species distribution models for insect pests with a high enough number of GBIF presence coordinates. This involved cleaning the presence coordinates from GBIF using the CoordinateCleaner library (Zizka et al., 2019) in R and downloading bioclimatic predictor variables from WorldClim using the geodata library (Hijmans et al., 2024). The occurrence data was then combined with these bioclimatic variables to build species distribution models using the SDMtune library (Vignali et al., 2020). The models underwent variable selection and hyperparameter tuning to enhance their predictive accuracy. Cross-validation was used to validate the models. The best models were then used to generate spatial predictions, which were visualized as maps showing potential pest distributions as predicted by the bioclimatic variables.

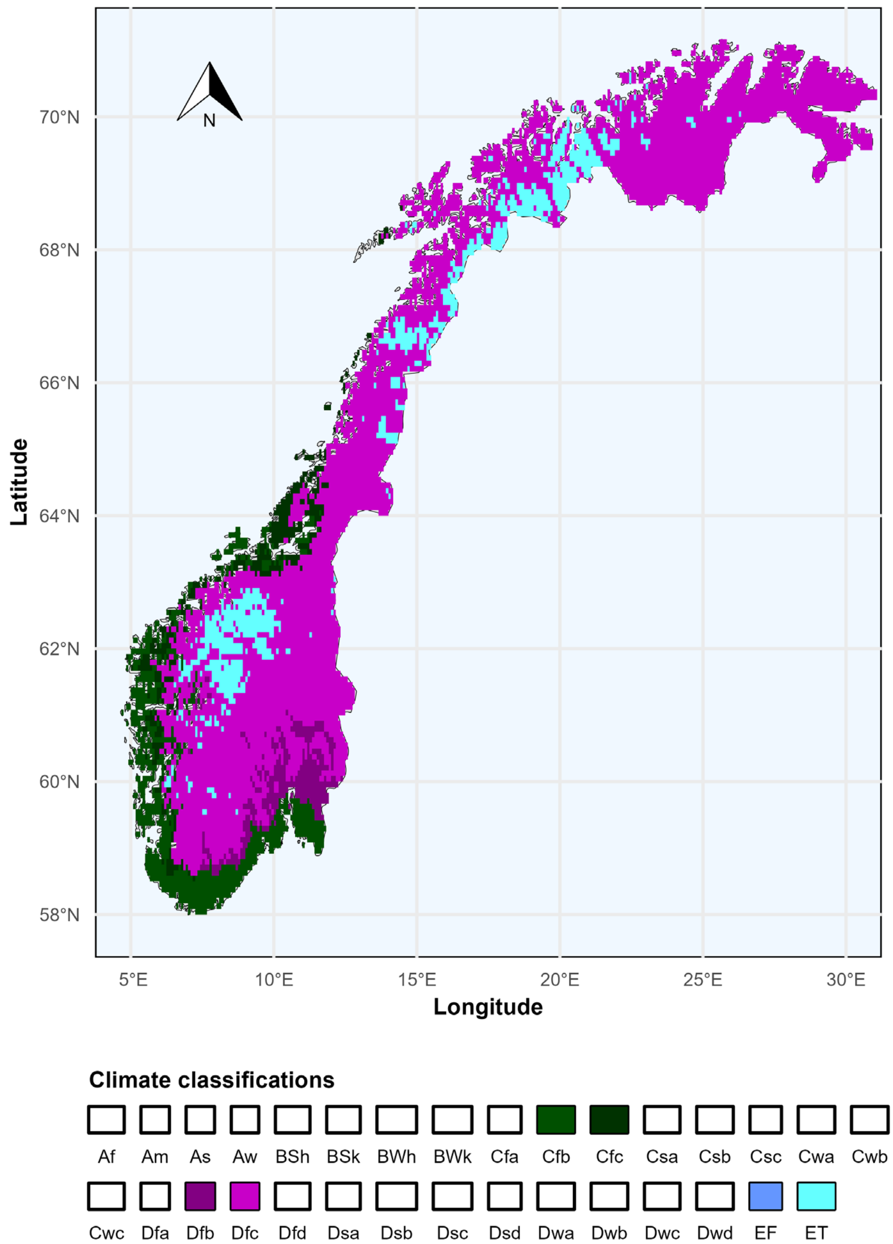

Figure 6. Köppen-Geiger climate classification map showing the six climatic sub-types that occur in Norway (Cfb: temperate oceanic; Cfc: subpolar oceanic; Dfb: warm summer continental; Dfc: humid continental; EF: ice cap; ET: tundra).

3 Soil and other growing media

3.1 Growing media in general

"Soil" is a colloquial term used for almost any solid substrate that can be used to grow plants. In strict terms, soil refers to the loose natural material constituting the upper layer of the Earth's crust, being modified by weathering and other natural chemical, physical, and biological processes. Mineral soil is a natural, layered medium formed over hundreds to thousands of years by weathering, leaching, and other natural processes, resulting in a matrix rich in living organisms (microorganisms, meso- and macrofauna) and humic substances (heavily degraded organic compounds formed during long-term decomposition and transformation of biomass). Natural organic soils (from peatlands) are also layered and contain humic substances but harbor far fewer living organisms.

Growing media used in commercial plant production do not contain soil in the strict sense, and natural soils connected to the subsoil are not normally used. Commercial plant production instead uses so-called soilless growing media, defined simply as "a material, other than natural mineral soil in the ground, in which plants are grown" (Caron & Zheng, 2021). Soilless production systems are used for horticultural plants grown in pots, containers, trays, or gutters. Since commercial growing media are not soil-bound, the plants are disconnected from the subsoil and its hydrological and nutritional continuum. There are some exceptions to this, such as turfgrass production, where the grass is grown on natural, mineral soil and where the top ~3 cm of soil follows the turfgrass product, and large trees that are grown in trenches dug into mineral soil and filled with growing media.

Soilless growing media may be composed of only a single constituent (e.g., pumice, Rockwool) or a mix of constituents supplemented with additives (e.g., commercial peat-based growing media). Many raw materials or constituents are used in commercial growing media (Figure 7), and the EFSA report on soil and other growing media identified more than 880 growing media constituents from the literature (EFSA 2015). Irrespective of the exact nature and number of individual constituents, the composition and structure of growing media tend to be optimized to fit the crops' demands, the cropping system, the management intensity, and the individual company's prerequisites. Materials used in growing media may have undergone different primary or secondary processes. Primary raw materials are used in their original state or after mechanical disintegration (e.g., chopping, splitting, grinding) or washing processes. Secondary raw materials have been subjected to a physical, chemical, or biological manufacturing process involving heating, spinning, molding, or composting (Figure 7). Raw materials used in growing media may also be re- or upcycled materials retrieved from societal side streams. Growing media are often supplemented with various additives to tweak physical, chemical, or biological properties. In this assessment we will concentrate on growing media that are based on organic resources, as these are most likely to harbor plant pests (EFSA, 2015).

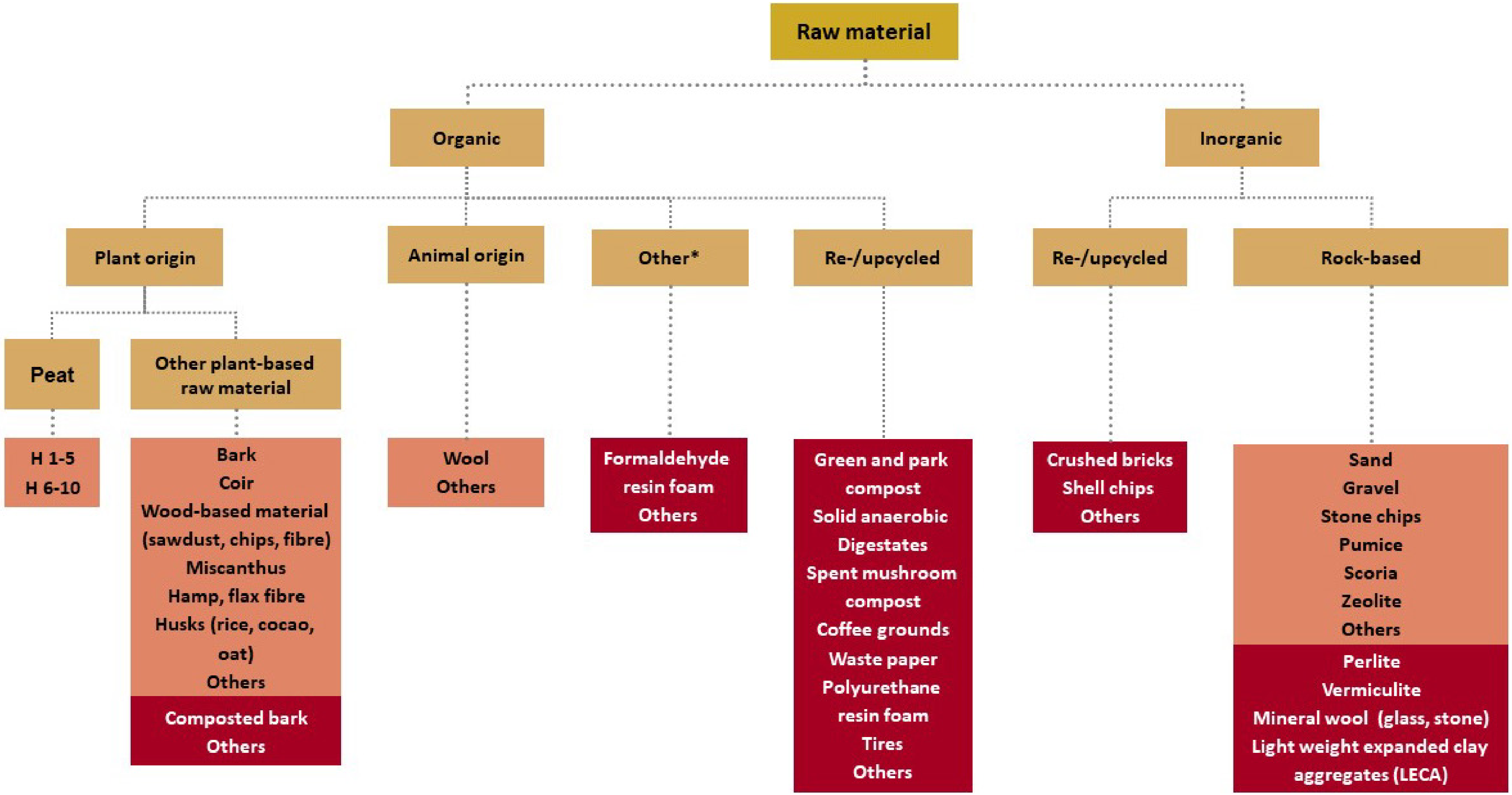

Figure 7. Raw materials used as main growing media constituents, grouped according to their origin (organic, inorganic). Examples of primary (light red boxes) and secondary (dark red boxes) constituents are listed. The asterisk (*) indicates various synthetically manufactured organic growing media constituents. For a definition of peat decomposition classes (H1-H10), see subchapter 3.5.1. Note: Organic materials are derived from living organisms (plants, animals), whereas inorganic materials are derived from non-living sources (minerals, rocks).

3.2 Growing media properties

Growing media are offered in different forms, such as commercial ready-made media for professional plant producers or the consumer market and bulk material or construction soils for urban plantations. Thus, there are many application-specific requirements for growing media. Similar to regular soil-bound cropping systems, the growing media used in soilless systems must support the plant, allow the root to anchor, and provide stability to the container or pot. Furthermore, all growing media should facilitate an optimal water, air, and nutrients supply to the plant roots. As plants grown in soilless systems usually have access to only a small volume of growing medium, the demands on the growing medium to provide its beneficial functions are high.

3.3 Processes involved in production of organic growing media

The processes involved in producing organic growing media are of particular interest, as these processes may be exploited to reduce or eliminate plant pests present in contaminated raw materials or, conversely, may serve to introduce pests inadvertently or by negligence. As described in subchapter 3.1, growing medium constituents may go through primary or secondary processes before they are integrated into the final growing medium blend. Primary processes include soaking, washing, or mechanical fragmentation by cutting, chopping, and grinding, whereas secondary processes include thermal or biological disintegration using heat or organic conversion (anaerobic digestion, composting). Table 7 lists the processing steps that are used for different organic constituents.

Organic waste should go through standardized hygienization process to minimize phytosanitary risk before it is used in growing media. This process can be part of composting or anaerobic digestion of organic waste. Brief process descriptions for composting and anaerobic digestion can be found in VKM et al. (2021). According to EPPO's standard for the treatment of biowaste of plant origin, the entire mass of a compost pile should be exposed to temperatures of 60 °C or higher for at least three days (EPPO, 2022). Alternatively, hygienization can be achieved through exposure to a temperature of at least 55 °C for a continuous duration of at least two weeks. During anaerobic digestion, the organic waste mass is exposed to 50–60 °C (thermophilic process) or 35–37 °C (mesophilic process). Processing time depends on system configuration, the composition of the organic waste, and its moisture content (EPPO, 2022). Anaerobic digestion should always be followed by a separate heat treatment to eliminate pests that tolerate temperatures <60 °C. Heat treatment of biowaste at 70 °C for one hour will eliminate most pests. For pests that tolerate this treatment, pest-specific, validated treatments should be applied (EPPO, 2022).

Some organic growing medium constituents are upcycled materials from side streams, such as wood processing (e.g., wood chips) or the food industry (e.g., coconut husks). Fragmentation of upcycled constituents may be done actively during growing medium production or passively during the primary production cycle. Soaking or washing is, for example, part of the process of conditioning coir, the fibrous material found between the hard coconut shell and the thin outer coat of a coconut.

Defibrillation of plant fibers and other growing medium constituents can be done using frictional pressure and wet steam at high temperatures (110-160 °C) (Table 7). These procedures can eliminate plant pests present in contaminated plant materials. 6Impregnation is a process used to prevent nitrogen immobilization in wood-derived materials with high C/N ratios. Nitrogen immobilization is the process in which nitrate and ammonium are taken up by soil organisms and, therefore, become unavailable to crops.

Aging is a process where organic materials are left in piles for months or years to allow the materials to be transformed. This transformation can include a reduction in the content of phytotoxic compounds as well as biological stabilization (Carlile et al., 2019).

Composting – described in detail in VKM et al. (2021) – is a process where organic materials are degraded (converted) under aerobic conditions. In an efficient composting process, temperatures should reach 55-70 °C, both to ensure a timely process, and to ensure hygienization that kills undesired plants and pests. This is facilitated by a succession of different trophic groups of microorganisms. Composting can occur in different settings, including open or enclosed (insulated) containers. The process can take place outdoors, under covered areas or indoors. The composting process generates heat, and to ensure an even distribution of heat throughout the entire compost it is crucial to select an appropriate location and ensure that composting containers are properly insulated.

Anaerobic digestion – also described in detail in VKM et al. (2021) – is the conversion of organic materials under anaerobic conditions. The process is usually designed to optimize energy extraction during biogas production and consists of two to three distinct steps with different temperature optima. These steps are (i) hydrolysis/acidogenesis (at 55–65 °C), mesophilic acetogenesis/methanogenesis (at 32–42 °C), and (iii) thermophilic acetogenesis/methanogenesis (at 50–57 °C). The last step is mainly intended to eliminate biological contaminants, and during biogas production this step often is not used. After dewatering, the solid digestate fraction is conditioned by anaerobic fermentation through composting and thermal drying before it is used as a growing medium constituent (Dubský et al., 2019).

Pyrolysis refers to a partial combustion of biomass under limited oxygen supply to produce charcoal (or biochar). The minimum temperature required for pyrolysis is 350–400 °C, but the most frequently used temperature range is 500–600 °C (Budai et al., 2016). These temperatures will efficiently kill pathogens and all other living organisms and result in a hygienized product that can be used as a growing medium constituent without risk of introducing unwanted organisms.

Table 7. Primary and secondary processes used to modify organic growing medium constituents. ● = Processes that are commonly used. ◐ = Processes that are occasionally used.

Constituent	Primary processes				Secondary processes								
	Chopping/cutting	Soaking/washing	Mechanical defibrillation	Screening/sieving	Thermal defibrillation	Impregnation	Anaerobic digestion	Composting	Ageing	Pyrolysis	Thermal drying	Molded (form pressed)	Heating
Peat	●			●								◐	
Bark:													
- Raw/fresh	●			●		◐			◐				
- Composted	●							●					
Wood-derived materials:													
- Sawdust	●												
- Wood chips	●		●		●	◐							
- Wood fibre	●		●		●	◐						◐	
Coir & other plant-derived materials:													
- Coir pith	●	●										◐	
- Coir chips	●	●		●									
- Coir dust	●												
- Plant fibre (flax, hemp)	●		●		●							◐	
Compost (green & park)								●	◐				
Solid anaerobic digestates							●	◐	◐		◐		
Spent mushroom compost								●					●
Biochar										●			

3.4 Reuse and recycling of organic growing media

An increasing focus on sustainability within the horticultural industry have led to an increased interest in reusing spent growing media, both from academia and practitioners. However, reuse of growing media increases disease risks unless the reused organic material is properly sanitized (FAO, 2021b). Various techniques can reduce phytosanitary risks, such as composting, irradiation, solarization, steaming and other thermal treatments. As an example, Vandecasteele et al. (2020) studied the impact of a 1–2 minutes steaming treatment of spent growing medium at 100 °C, followed by storage in heaps for one hour at a minimum of 70 °C. Microsclerotia of the pathogen *Verticillium dahliae*, larvae of vine weevils (*Otiorhynchus sulcatus*), as well as seeds of barnyard millet (*Echinochloa crus-galli*) and garden cress (*Lepidium sativum*) were used as process indicators. None of the indicator species survived the thermal treatment, in contrast to the untreated control treatment. It is important to note that the target temperatures for heat treatments are not always reached in the entire volume of treated materials. Therefore, heat treatments can reduce phytosanitary risks but not eliminate them. Further, heating may alter the physical properties of growing media by altering their structure, pore size distribution, and thus water-related parameters. This may in turn impact disease conduciveness in crops that are grown in heat-treated growing media. Furthermore, the high temperatures used for sanitation will also kill beneficial and neutral organisms, in addition to the targeted pathogens.

3.5 Growing medium constituents

Organic growing media constituents are usually mixed in various proportions and supplemented with inorganic additives (e.g., lime, clay, perlite, vermiculite, pumice, expanded clay) to obtain the desired physical, chemical, and biological properties for specific crops or uses.

For decades, peat has been the primary raw material in organic growing media, used either unmixed or as the main component. In recent years, peat use has come under increasing scrutiny because of the importance of peatlands as a carbon sink and the impact of peat extraction on greenhouse gas emissions. In addition, the trend towards more sustainable horticultural systems has changed the acceptance of peat as a growing medium constituent and challenged peat dominance. Much of the research on growing media is now directed toward testing alternative materials to reduce or replace peat. The level of transition to peat-free alternatives varies considerably between countries and market segments, such as growing media intended for professional growers versus hobby growers. For example, peat accounts for 43 % of the growing media produced for the German hobby market, as opposed to 77 % for the professional market. Likewise, green waste compost and bark compost contribute much higher shares (6- to 8-fold more) in growing media for hobby growers compared with professional growers (Table 8). For professional growers, peat-free alternatives accounted for less than 10 % of the total peat-free growing medium volume. Irrespective of the peat replacement discussion, it should be noted that the constituents used in growing media mixtures will vary substantially between different plant types, growing systems, and growers.

Table 8. Volumes (m^3) of dominant constituents used per year in horticultural growing media for the professional and hobby growers' market in Germany. Numbers are from the official statistics for 2023 published by Gütegemeinschaft Substrate.

Constituent	Professional		Hobby	
	Volume	%	Volume	%
White peat	892,000	39 %	740,000	18 %
Dark peat	871,000	38 %	1,000,000	25 %
Wood fiber	266,000	12 %	586,000	14 %
Green waste compost	80,000	4 %	1,300,000	31 %
Coir	32,000	1 %	80,000	2 %
Bark compost	20,000	1 %	243,000	6 %
Other organic constituents	22,000	1 %	50,000	1 %
Inorganic constituents	98,000	4 %	107,000	3 %

3.5.1 Peat

Peat can be defined as "a brown non-viable deposit resembling soil, formed from partial decomposition in the wet, acidic conditions of the above or upper layers of vegetation of bogs and ferns, and harvested mainly for fuel and horticultural purposes" (Caron & Zheng, 2021). Peatlands differ in hydrological and nutritional properties, and this leads to variations in vegetation and plant species composition. Thus, peat is not a homogenous material but varies depending on the plant community in the bog, the depth within the bog, and environmental conditions.

The most common source of peat used in horticultural contexts is so-called raised bog peat. Raised bog peat is found on bogs fed by rainwater (ombrotrophic bogs), where the precipitation is greater than the amount of water lost by evaporation. The nutrient-poor conditions on these bogs select for a flora dominated by various species of white moss (*Sphagnum magellanicum*; *S. fuscum* (Göttlich, 1990)). Low-humified peat suitable for horticultural use contains almost 100 % *Sphagnum* species and minute proportions of other plant species. Due to the low degree of humification that takes place in bogs, the various plant parts, such as leaves and stems, can usually still be macroscopically distinguished in the peat. The humification degree of peat is quantified on a scale from H1 to H10 (the von Post-scale), where H1-H3 denotes weakly decomposed "white" peat, H4-H6 medium decomposed "dark" peat, and H7-H10 strongly decomposed "black" peat (Carlile et al., 2019).

The physical properties of peat are affected by the level of humification, the plant fiber composition, particle size, and the extraction method used. Peat has a low bulk density that increases with increasing humification and decreasing particle size. Peat generally has many air-filled pores and high porosity, but this is influenced by extraction mode and downstream processing, as well as the proportion of *Sphagnum* in the peat. Decomposition also decreases pore size and affects pore size distribution by reducing the number of large pores. This increases water retention and reduces drainage.

The chemical properties of the extracted peat are influenced by the plant community on the peat bog and thus the fiber composition. Low-humified *Sphagnum* peat has a low pH of 3.5-4.1, while highly humified *Sphagnum* peat has a pH of 7.8 (Carlile et al., 2019). As a result of its unique physical and chemical properties, untreated peat is sparsely colonized by other organisms. Consequently, microbial degradation of peat is low, and peat is considered to be relatively stable. Peat that is used in horticultural growing media is usually pH-adjusted to pH 5.5-6 and fertilized. This, in combination with a growing plant crop, gradually changes the carbon dynamics in the peat and enhances microbial activity as well as microbial colonization and proliferation in the growing medium over time (Alsanius & Wohanka, 2019).

3.5.2 Bark and bark compost

Bark used in growing media is retrieved from the forest industry. The use of bark might increase in the future because the bark is often viewed as a peat replacer, particularly for nursery stock and other plants that have been grown for several years in large containers. Bark is rich in plant nutrients, and nutrient content varies among different tree species. Pine bark is generally high in potassium and phosphate, but only some of the phosphate is available to plants. The nutrients in the bark are locked into the bark tissue and only become available to plants when the tissues are broken down. Bark of various pine species meets the physical growing medium requirements well. Bark from deciduous trees is usually unsuitable as a growing medium constituent because it degrades very quickly.

Two obstacles when using fresh bark as a growing medium constituent are phytotoxicity caused by high levels of defense metabolites in the bark (such as phenols, tannic acids, tannins, and terpenes) and nitrogen immobilization caused by high C/N ratios. Phytotoxicity has been reported when fresh bark is used to grow certain tree species, such as Australian blackwood *Acacia melanoxylon* (Chemetova et al., 2019) and blue gum *Eucalyptus globulus* (Chemetova et al., 2021). This problem may be overcome by subjecting fresh bark to hydrothermal treatment (<150 °C), although this treatment may also cause nutrients to be leached (Chemetova et al., 2018). Composting also degrades phytotoxic compounds in the bark. The use of fresh bark in growing media can result in nitrogen immobilization, where nitrogen is taken up by soil organisms and, therefore, becomes unavailable to the plants. Nitrogen immobilization is a challenge with all growing media constituents that have a high C/N ratio, including fresh bark and wood fibers (but not biochar). To avoid nitrogen immobilization, bark may be supplemented or impregnated with nitrogen, aged for months or years, subjected to thermal treatment, or composted. Composting lowers the C/N ratio and stabilizes nitrogen dynamics.

Physical and chemical properties differ between bark materials that have been subjected to different processing steps. Composting of conifer bark increases dry bulk density, reduces air content and porosity, and increases water holding capacity. In general, bark products have a considerably higher dry bulk density than peat. Bark products are usually free-draining and have a lower water-holding capacity than peat, but the water held in bark pores is available and accessible to plants. Tree species also affect the physical and chemical properties of bark products. Pine bark is, for example, slightly acidic (pH 5.5-6), whereas Douglas fir bark is acidic (Buamscha et al., 2007). The pH usually decreases slightly as the bark ages, but this may not be true for all tree species.

Some studies have shown that composted bark can act antagonistic to plant pathogenic oomycetes, such as species of *Pythium* and *Phytophthora*. This effect might be attributed to increased microbial activity and microbial biomass in the composted bark (Chen et al., 1988). Also, the bark compost's decomposition level and maturity state might be involved (Boehm et al., 1993).

3.5.3 Wood fiber-based materials

Wood-based growing medium constituents may be divided into sawdust, wood chips, and wood fibers based on their level of disintegration. Sawdust is a residual material from wood processing and is mostly used as a growing medium constituent in areas with extensive forest industry, such as Canada and USA. Generally, sawdust is not much used in growing media due to its high C/N ratio and consequent risk of N immobilization.

Wood chips are small pieces of wood (3-6 mm) that are obtained by sieving pine sawdust and shavings. It is a relatively new constituent in the horticultural industry. Wood chips' coarse structure and slow degradation maintain structural stability and provide many air-filled pores. Growing media amended with wood chips is therefore well suited for potted plant cultures and container-grown seedlings. Given the broad C/N ratio of wood chips there is a risk for nitrogen immobilization. Because nitrogen turnover is difficult to control, wood chips should not exceed 20-30 % of the final growing medium mix. Chips made from other types of plant fibers are described below.

Wood fibers that are used in growing media are not an upcycled product but are made from clean wood. Different conifer species are used, such as Scots pine *Pinus sylvestris* and maritime pine *Pinus pinaster* in France (Lemaire et al., 1989), loblolly pine *Pinus taeda* in USA (Jackson & Wright, 2009), and Norway spruce *Picea abies* in Norway (Aurdal et al., 2023; Woznicki et al., 2023). During processing, the wood is either hammer-milled or undergo a process of mechanical disintegration and heat treatment at 80 to 160 °C (Carlile et al., 2019) before the material is presented as free fibers (defibration). Wood fibers are usually available in different fractions and are suitable for different applications. The fibers can be used either as a single constituent growing medium, e.g., in greenhouse vegetable production, or as a main component. Unlike peat, wood fibers do not react to dehydration and can be easily rewetted. Wood fibers are not uniform; raw material, processing, and particle size may differ for different products and companies.

Although growing media with wood fibers is intended to be an alternative to peat and peat mixtures, stand-alone wood fiber substrates cannot be compared to peat in terms of their chemical and physical properties. However, processing, particle size, and shape will affect the air- and water-holding properties of the resulting substrate. Water is very loosely bound in wood fiber-based materials. As the water holding capacity is below 50 % in many cases, cultures grown in wood fiber substrates must be watered more frequently.

Similar to bark-based growing media, wood fiber-based media have a high C/N ratio and contain much cellulose and hemicellulose that are readily available for microorganisms. This leads to nitrogen immobilization, especially in untreated wood fiber without additional nitrogen supply (Gumy, 2001). The level of nitrogen immobilization varies between different wood materials and studies. For example, nitrogen immobilization was more pronounced for wood fiber from *Pinus taeda* than for aged pine bark (Jackson & Wright, 2009). However, the bark had stronger nitrogen retention than various commercial wood fiber-based products based on *Pinus taeda* or *P. sylvestris* wood. One of the compared products (ForestGold) did not show any nitrogen immobilization at all (Dickson et al., 2022).

Organic fibers that are used as growing media constituents can be colonized by saprophytic fungi, such as *Pezzia* sp. and *Leucocoprinus birnbaumi* (Alsanius & Wohanka, 2019). These fungi may build up mycelial sheets that make the growing medium more hydrophobic and less wettable.

3.5.4 Coir

Upcycled fibers from coconut fruits and coir have received increased attention as constituents of growing medium mixes since the 1990s. Coir is incorporated into growing media and is used to grow a broad array of horticultural crops for different production purposes. While long coconut fibers tend to be used for other purposes than horticulture, three other fractions from coconut production are used in growing media: (i) a coarse fraction consisting of coir chips and shell fragments, (ii) a medium fraction consisting of short fibers, and (iii) a fine fraction consisting of coir pith. Coir chips (measuring 5-15 mm) are made from the outer husk of coconuts and improve the porosity of growing media intended for long-term nursery plant production. Fibers are extracted either by mechanical separation or retting (dissolving cellular tissues and pectins using microorganisms and moisture). During retting, husks are kept in seawater for several months and up to one year (Ross et al., 2010). To avoid detrimental effects on plants by high sodium chloride or potassium chloride content, coir fibers are usually washed with either water or calcium nitrate solution to produce so-called treated coir (Poulter, 2014). Short, medium fraction coir fibers are usually aged or composted before use. The fine coir fraction is a residual product from the shredding, milling, and screening of coconut husks or fibers and varies greatly in particle size (from less than 0.2 to 7 mm, according to Jana and Boxi (2020)).

Like peat, coir is superhydrophilic and can absorb 5-10 times its own weight in water (Carlile et al., 2019). Unlike peat, coir does not become hydrophobic upon drying and can easily be rewetted. Coir tends to have low dry bulk density and high total pore space, but these parameters vary greatly between batches from different production sites, as particle size varies and may be very heterogenous. This also leads to large variations in total air space between different batches and production sites. Coir is slightly acidic to neutral (pH 5.9-6.9; Konduru et al. (1999)) and is considered to be a stable product. From a plant pathological point of view, coir is viewed as being free from plant diseases.

3.5.5 Other plant fibers

Various other plant fibers have been tested and considered as growing media constituents and various pre-treatments have been investigated. Tested plant fibers come from perennial grasses such as *Miscanthus* (Altland & Locke, 2011; Kraska et al., 2018), switchgrass (*Panicum virgatum* L., Altland and Krause (2009)), and reed canary grass (*Phalaris arundinacea,* Kuisma et al. (2014)), as well as straw of rice (Feng et al., 2020), flax (*Linum usitatissimum*, Wohanka et al. (2008)), industrial hemp (*Cannabis sativa*), and fiber nettle (*Urtica dioica* convar. *fibra*). All these plant fibers are side-stream materials from other production lines. Given the competition for these fibers from other secondary uses, not all of them are yet studied in depth, but might receive more attention in the future under different market situations.

3.5.6 Husks

Husks are the protective outer covering of seeds, fruits, or vegetables. Different kinds of husks have been tested as growing medium constituents, including those from rice, rye, oat, and cacao. There are several publications on the use of rice husks as a growing medium constituent, but we could not identify any scientific literature on other kinds of husks using Web of Science, Scopus, or Google Scholar.

Rice husks, the outer layer of rice grains, are about 3-4 mm x 5-7 mm in size (Carlile et al., 2019). It is a recalcitrant material composed of lignin, cutin, and insoluble silica (Juliano et al., 1987). Rice husks used in growing media are usually an upcycled material from the processing of white rice and have thus previously undergone soaking, steaming, and drying. However, fresh, or aged/composted rice husks are also sometimes used. The use of fresh rice husks in growing media may give rise to weed problems (Evans & Gachukia, 2004). Rice husks are usually used as one of several constituents in multi-component growing media. It occurs in different formulations (ground, sieved) that affect its physical properties.

3.5.7 Green waste compost

The procedures involved in composting and green waste composting have been comprehensively presented in a previous VKM risk assessment, and readers are advised to consult this report for details (VKM et al., 2021). A brief overview of the processes involved in composting is given above (subchapter 3.3).

3.5.8 Spent mushroom compost

Spent mushroom compost is a residual material from commercial cultivation of edible mushrooms. The use of spent mushroom compost as a growing media constituent, especially for woody ornamentals (Chong & Rinker, 1994), has been considered for many years and has recently received increased scientific attention (Stoknes K et al., 2019). Before being used in mushroom production, raw compost constituents are run through a cascading pretreatment process that includes heating up to 80 °C under aeration. Spent mushroom compost is then heat-treated at 70 °C for 12 h before it is used as a growing medium constituent (Maher et al., 1993). The fraction of organic matter in spent mushroom compost is usually high (about 66% of the total volume) but may be as low as 407 g/kg (Jordan et al., 2008). Other physio-chemical properties of mushroom compost are extremely variable.

3.5.9 Digestates

Solid digestates, such as residues from biogas production, have recently been tested and partly introduced in growing medium mixtures. Plant health issues related to using anaerobic digestates, including a discussion of the feedstocks and processes used, have been comprehensively described in (VKM et al., 2021). In the context of the current report, it should be emphasized that materials used for biogas production are very variable, that the production process tends to be adapted to the primary goal of achieving maximum biogas yield, and that the solid digestate thus may not have been through a sanitizing thermophilic phase. Thus, to minimize risks for biological contamination digestates must be composted before they are used in growing media.

4 Plant pests associated with soil and other growing media

Associations between plant pests and soil and other growing media range from random occurrences to obligatory dependencies, where pests depend on a specific growing medium or plant species. Even though growing media typically are sanitized before use, ecological processes, such as decomposition, succession, and recolonization of growing media, may lead to the establishment of beneficial soil organisms and potential plant pests and other invasive species. During ecological succession, initial microbial colonizers modify the growing medium environment, making it more suitable for subsequent species. This succession and enrichment improves soil structure and fertility but may also pave the way for colonization by plant pests. Most of the colonizing species might be drawn to the plant crop, while fast-moving organisms such as ground beetles, ants, or spiders might appear incidentally. Contaminant species may also move from the plant to the growing medium. For example, if plants that are infested by root endoparasites are planted in pest-free medium the parasites might, over time, contaminate the medium.

4.1 Pests present in growing medium constituents

Growing media often contain different organic constituents; some can harbor pests. For most pests it is not known which growing media constituents they prefer or tolerate, but only that there is an association. However, some pests are specific to certain constituents, such as bark or wood from pine species growing in areas where the pine wood nematode (*Bursaphelenchus xylophilus*) occurs. EFSA (2015) lists several examples where there are indications that certain pests are associated with specific growing media constituents (Figure 8). Plant pests associated with compost include the beet necrotic yellow vine virus, cotton bollworm moth *Helicoverpa armigera* (NO: *pestfagerfly*), the water mold *Phytophthora kernoviae* (Appendix 1), tobacco cutworm moth *Spodoptera litura* (NO: *bomullsfly*), the fungal plant pathogen *Verticillium dahlia* (Appendix 1), and potato wart disease *Synchytrium endobioticum*. Furthermore, *P. kernoviae* is documented to be associated with peat while *Helicoverpa armigera* and the beta-proteobacterium *Xylophilus ampelinus* are associated with sphagnum. *Helicoverpa armigera,* chrysanthemum leaf miner *Liriomyza trifolii* (NO: *Florida minerflue),* chilli thrips *Scirtothrips dorsalis, Spodoptera litura*, and Mediterranean fruit fly *Ceratitis capitata* (NO: *appelsinflue*: see Appendix 1) are associated with various vermicompost products. Pests associated with various wood constituents include emerald ash borer *Agrilus planipennis* (NO: *asiatisk askepraktbille*)*, B. xylophilus, P. kernoviae,* planetree canker stain *Ceratocystis platani,* and flower blight fungus *Ciborinia camelliae.*

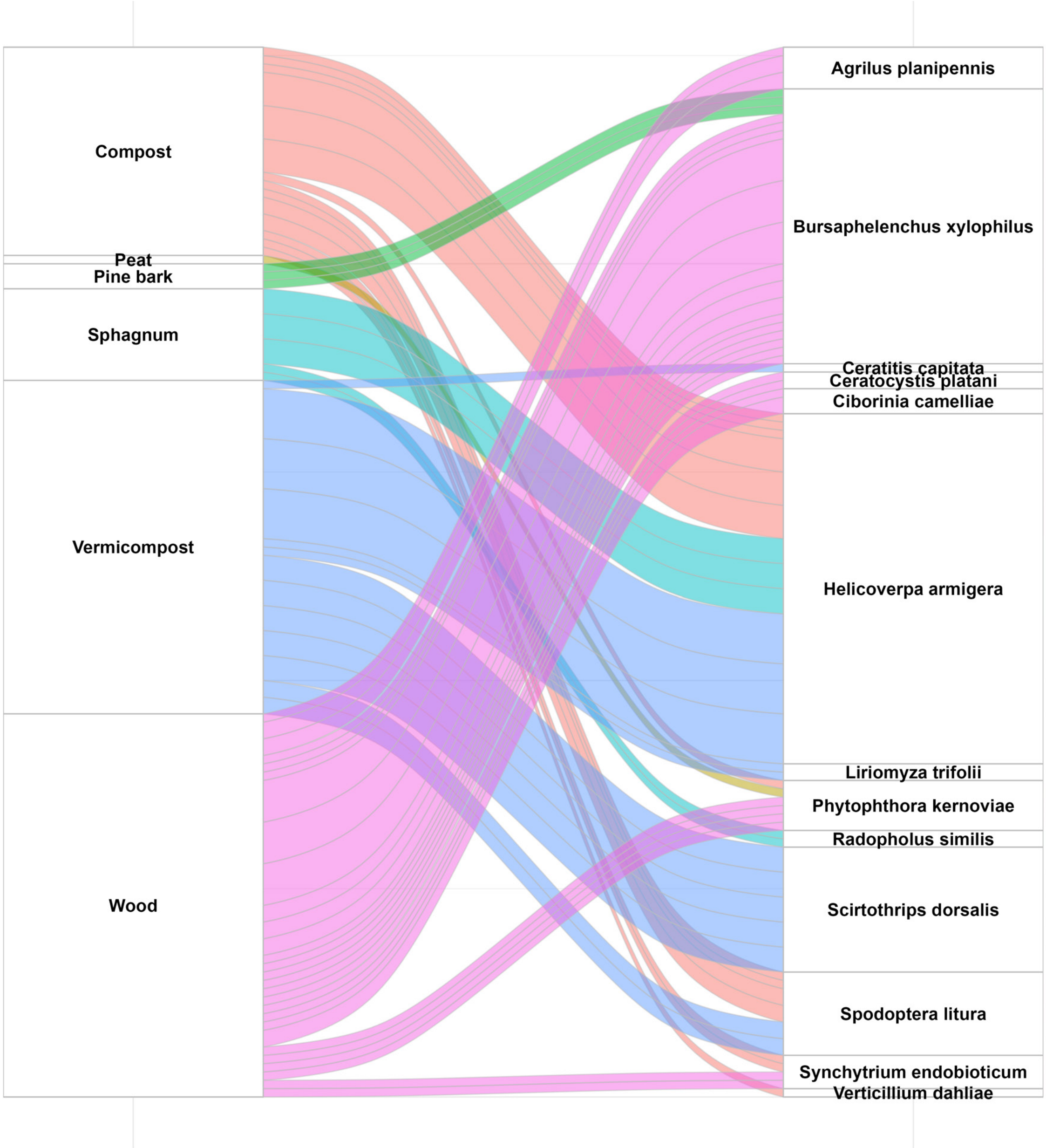

Figure 8. Alluvial flow diagram illustrating documented associations between growing media constituents (left-hand side) and selected plant pests (right-hand side). Colored bands show the links between growing media and pests, with the width of the bands corresponding to the number of documented associations, according to EPPO. Data from EFSA (2015)

For growing media containing fresh peat, there is a low risk of pest infestation, as peat is formed under waterlogged conditions and typically has a low PH. This creates an environment where only highly adapted oligotrophic organisms thrive. These organisms do not adapt well to the changes that occur when peat is processed by drying, aeration, liming, and nutrient enrichment. However, the oomycete *Phytophthora kernoviae* (Figure 8 and Appendix 1) is documented to be associated with peat (EFSA, 2015).

The pests that could be associated with compost depend on various factors, such as the material being composted. A sufficiently high composting temperature is also critical to hygienize the compost and kill any pests present. In this respect, it is important that the entire composted mass, including the outer zones that usually have lower temperatures, is hygienized sufficiently. Finally, it is crucial that the composting masses are managed effectively to avoid recontamination with pests. Due to uncertainties about these aspects, composting onion waste is not considered safe due to the risk of spreading the fungus *Sclerotium cepivorum*. VKM et al. (2021) concluded that several plant pests could spread from compost, including the nematodes *Globodera rostochiensis*, *G. pallida*, *Meloidogyne chitwoodi*, and *M. fallax* (Appendix 1), the potato wart disease *Synchytrium endobioticum*, and the protozoan *Plasmodiophora brassicae* causing clubroot disease.

Coir pith derived from coconut husks presents a low pest risk, which is primarily influenced by the level of processing and the geographic origin of the material. Coir is generally subjected to washing, drying, and compressing before it is used in growing media, and these treatments significantly mitigate pest risks. Since coir is usually obtained from tropical regions, it tends to harbor tropical species that are unlikely to establish in Norway.

Wood fiber is typically produced from timber industry by-products. The pest risk associated with wood fiber primarily depends on the raw materials used (type of wood and part of the tree), the processing method, and previous storage conditions. If the wood has not been adequately treated to remove or kill pests, it can introduce various plant pests into the growing media. Heat treatment and chemical treatment are common methods to render wood fiber pest-free, but the efficacy must be monitored to eradicate all potential pests.

Pine bark is often used in growing media due to its favorable properties for plant growth, such as drainage and aeration. However, if it is not properly processed pine bark can harbor specific pests such as bark beetles. The pest risks associated with pine bark can be high if the bark is sourced from areas with known pest infestations. Methods such as ageing, composting, and heat treatment are effective in reducing pest risks but must be carefully controlled to ensure that the whole bark material is treated.

4.2 Pests colonizing the growing medium after planting

Pests may also colonize growing media after planting. Such contaminating pests will often be less specific to the growing medium than pests that are present in growing medium constituents. The pest species composition will largely depend on the plant species and the source pool in the surrounding environment. Several factors influence the likelihood that pests will colonize the growing medium. These factors include the geographical location of the plant production site (e.g., whether a pest is present in or absent from the area), the nature of the surroundings (e.g., the abundance of host plants of potential pests), the degree of exposure to the environment (e.g., whether plants are grown inside greenhouses or outdoors), management practices (e.g., if insecticides or thermal treatments are used to eliminate pests), and soil volume (which is dependent on plant age and size). However, one overriding factor is exposure time. The longer the plants and their associated growing medium are exposed to the general environment, the more likely they are to be colonized. Pests that are endoparasites in plant roots can also colonize the growing medium during plant growth. This is true for endoparasitic nematodes in the genera *Pratylenchus, Radopholus, Meloidogyne* (e.g., *Meloidogyne fallax*, Appendix 1), *Heterodera*, and *Globodera*. The same applies to pests that live on above-ground plant parts and hibernate in the growing media as adults, larvae, or pupae.

4.2.1 Geographical location

The likelihood that a growing medium will be contaminated with pests depends on where the plants are imported from and the nature of the area where the plants were grown and traded. Countries that trade extensively with live plants and export large plant volumes to Norway have an especially high risk of introducing contaminated growing media to Norway (i.e., The Netherlands, Germany, Denmark, and Sweden). The risk that contamination will lead to the establishment and spread of pests is probably higher for imports from areas with similar environmental conditions as Norway (especially climatically) and that have the same or closely related plant species. The European countries with the greatest number of plant pests that are not found in Norway are Italy, Spain, Portugal, France, and the UK (Figure 9). The same countries predominate if we restrict the sample to plant pests that are associated with soil and other growing media (Figure 10). Figure 11 provides the country occurrences for selected, more widespread plant pests associated with soil and other growing media. Here we can see that, for example, The Netherlands and Germany, two countries that, taken together, account for more than 70% of Norway's imports of plants for planting, have relatively few plant pests associated with soil and other growing media compared to several other European countries.

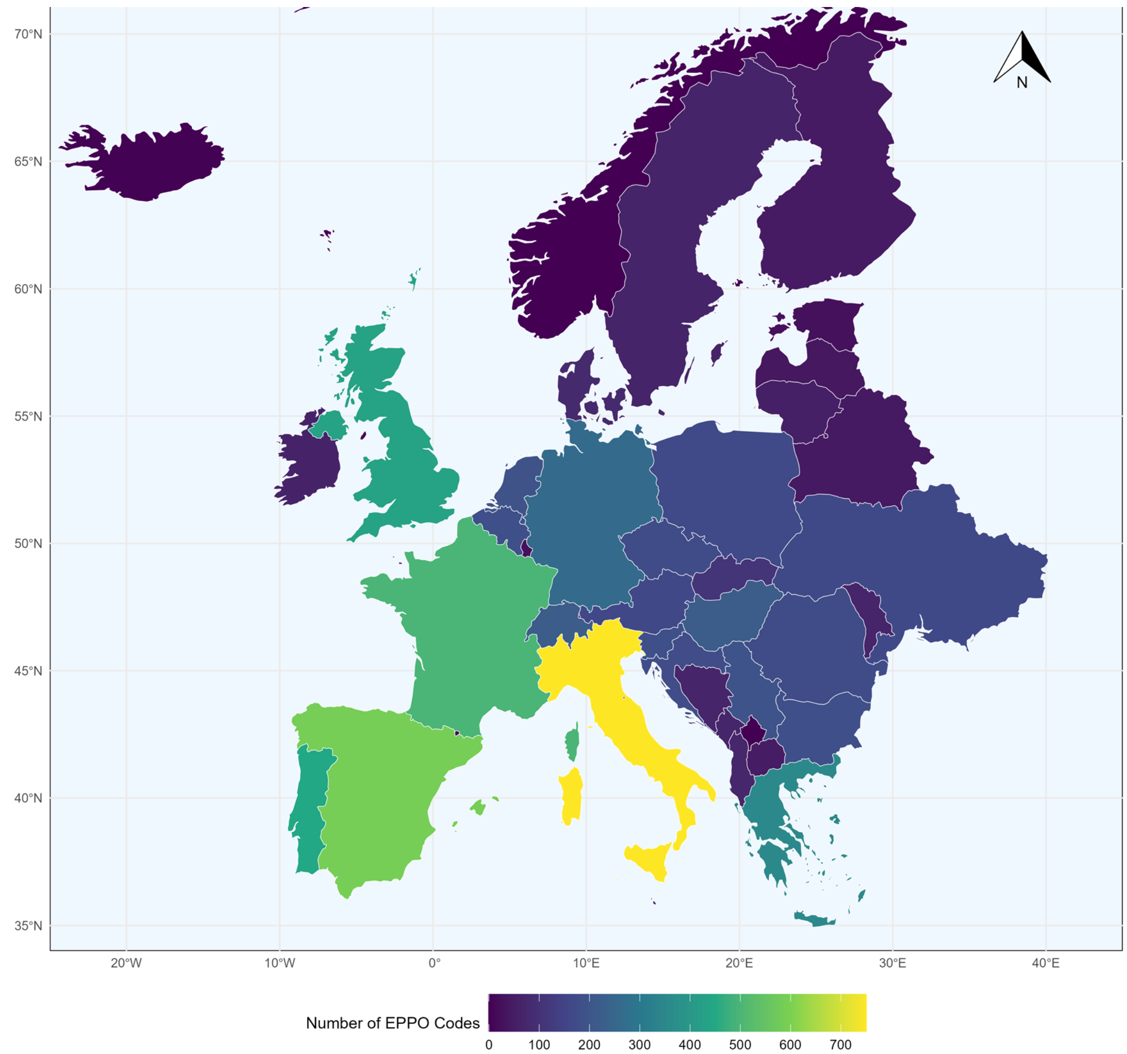

Figure 9. Number of plant pests occurring in different European countries but that are currently absent from Norway. Data is aggregated from the European and Mediterranean Plant Protection Organization global database of plant pests (EPPO, 2024a).

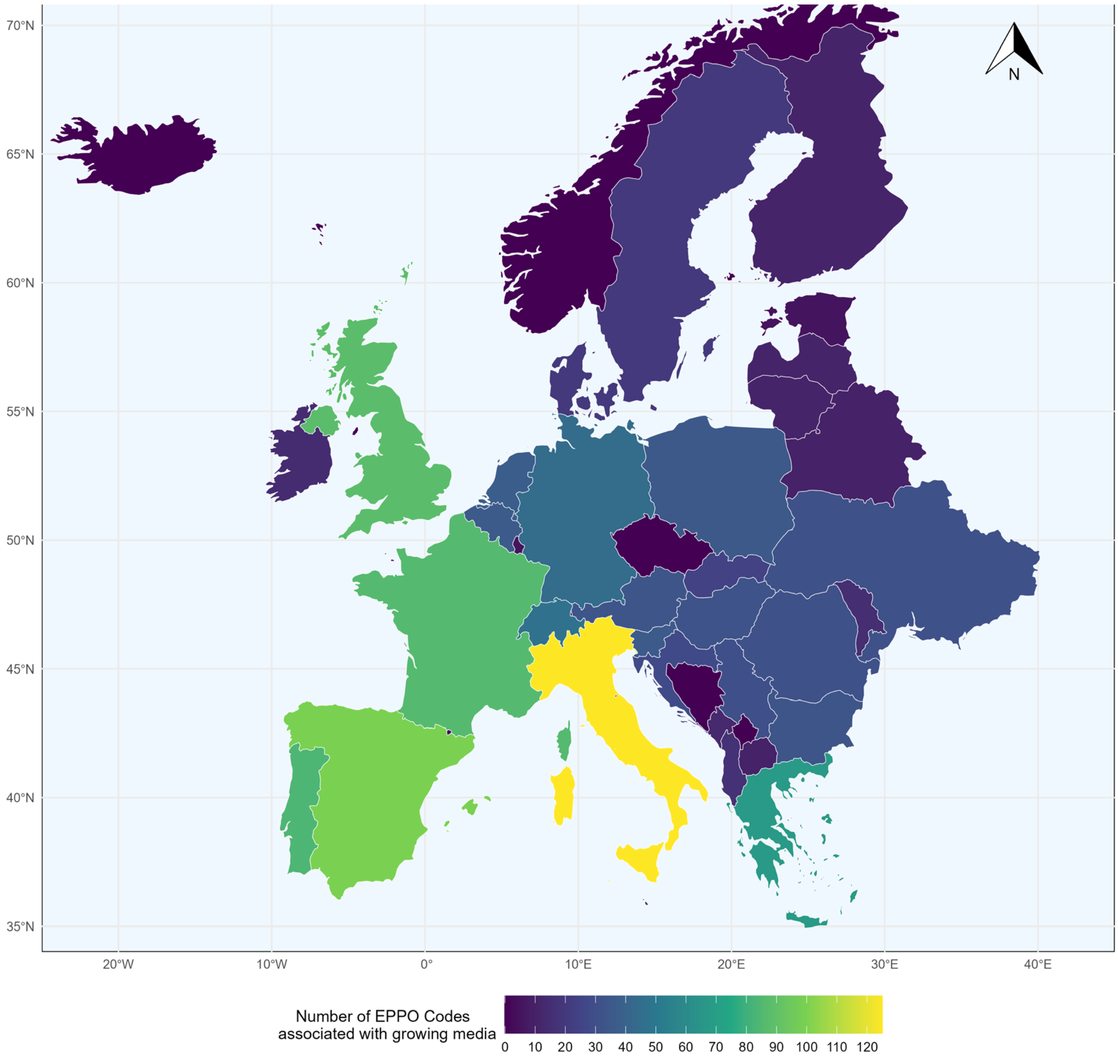

Figure 10. Number of plant pests associated with soil and other growing media that occur in different European countries but that are currently absent from Norway. Data is aggregated from the European and Mediterranean Plant Protection Organization global database of plant pests (EPPO, 2024a).

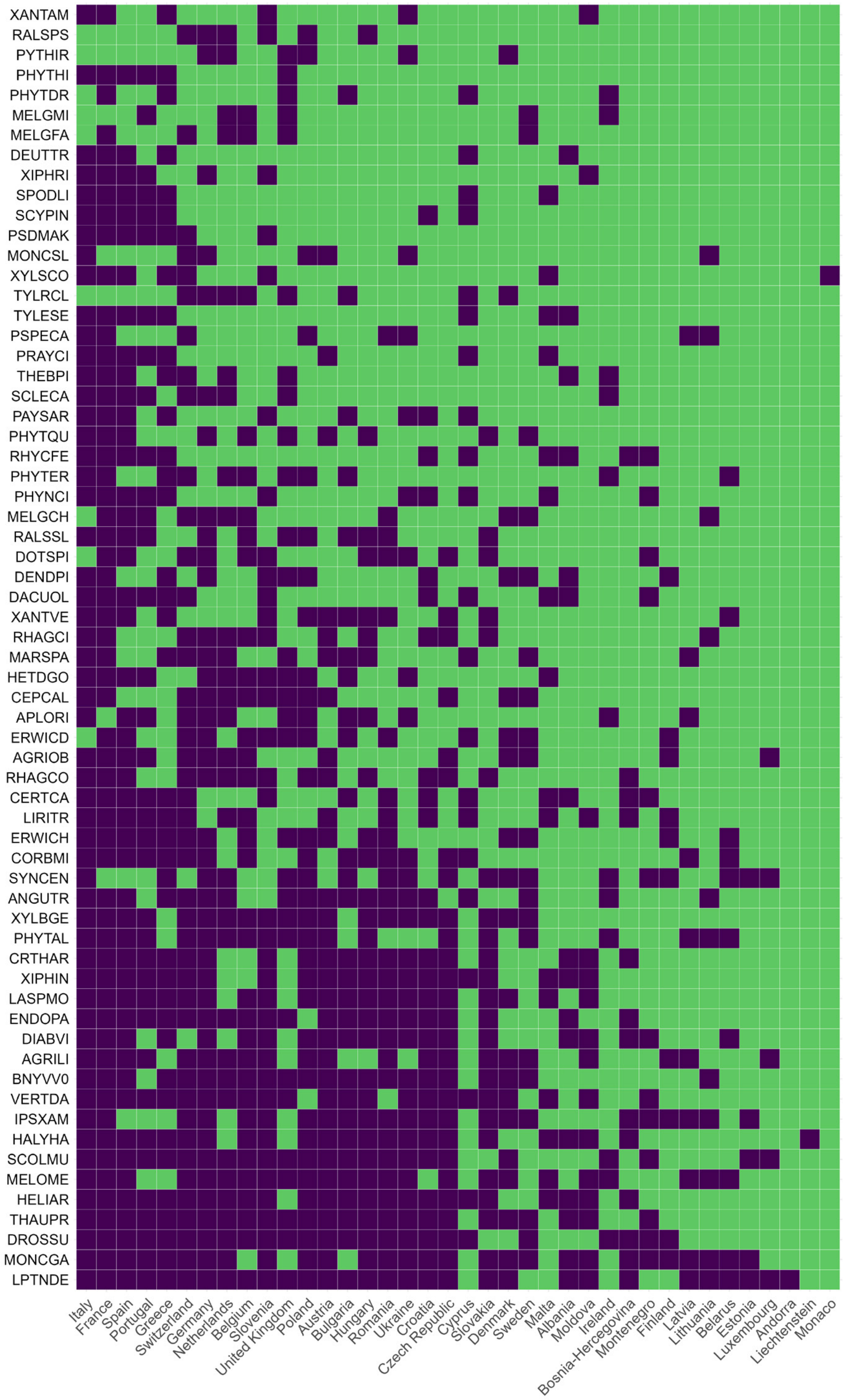

Figure 11. Presence of plant pests associated with growing media in different European countries. Only pests occurring in more than five countries and that are currently absent from Norway, according to EPPO (2024a), are included. Each tile shows the presence (purple) or absence (green) of a specific pest (shown by their EPPO code) within a country. Pests are ranked according to the number of countries in which they occur, from few (top) to many (bottom). Countries are listed after decreasing number of pests. See Appendix 2 for full species names.

4.2.2 Degree of exposure to the environment

The potential for contamination with plant pests is greater for plants grown and stored outdoors than for plants kept inside a greenhouse. However, plants may also be contaminated inside greenhouses since regular commercial greenhouses are not sterile environments sealed off from their surroundings. Plants and growing media can also be exposed to pests during storage and transportation. The contamination risk is probably higher if plants are stored outdoors before they arrive in Norway and if pots are placed directly on the ground instead of on benches or other barriers separating them from the ground. The longer plants and growing medium are exposed to the environment, the more likely it is that these substrates will be colonized by a pest. Long-lived plants, such as trees, have much longer production cycles than other plants, and thus longer exposure times. Larger plants traded in large quantities are more likely to be colonized by pests than small plants traded in low volumes. Large trees, for example, are usually transported with large root balls of soil.

4.2.3 Management practices in export and transit countries

The potential for pest contamination will be higher in countries that lack good preventive and curative pest control measures. Preventive measures include the use of resistant plants, uncontaminated irrigation water, and proper sanitation of equipment. Watering may be a source of plant pests. Pathogens may be present in the water source or enter the water along the path of distribution. If contaminated water is used, the consequence is repeated inoculation of plants with pathogens. Irrigation methods where water is in contact with soil or plant debris along the distribution path increase the contamination risk, as does the production of plants outdoors in containers where excess water is recycled. Pathogens can also be transported from infected plants elsewhere in the system. Plant pathogens that can be present in irrigation water include species of *Phytophthora* and *Pythium*, several genera of fungi, bacteria and viruses, and plant parasitic nematodes. There is substantial evidence that contaminated irrigation water is a primary source of Phytophthora diseases in numerous nursery, fruit, and vegetable crops (reviewed by Hong and Moorman (2005)).

Curative pest control, including the use of chemical and biological control agents, is important to reduce the likelihood of pest contamination. The absence of curative control measures (e.g., under organic production) typically leads to more contamination. On the other hand, excessive and habitual use of curative measures typically promotes pesticide-tolerant pests that may be very difficult to eradicate in importing countries.

4.3 Plant pest interceptions and host plants

We used data from EUROPHYT to obtain data on interceptions of plant pests with exported plants and associated growing media within Europe. EUROPHYT is a notification and rapid alert system dealing with pest interceptions in consignments of plants and plant products that are imported into the EU or traded within the Union. We used PDF reports with monthly overviews of interceptions of harmful organisms in imported plants and other objects made within the EU and Switzerland (European Commission, 2024). We searched the data for pests intercepted in shipments of plants with growing media between European countries (as defined in Figure 1). For the years 2011 to 2023, we found only three interceptions listed under the commodity type "soil". However, we found many interceptions of species associated with growing media, and most of these were intercepted with the commodity type "flowers, branches" (Table 9). The vast majority of these pest interceptions were insects that are relatively easy to detect during visual inspection due to their size or because they cause conspicuous damage. This suggests that visual inspection mainly helps to detect and intercept conspicuous pests, and that pests with cryptic habits (e.g., root and soil pathogens) rarely are discovered.

Table 9. Number of EUROPHYT interceptions of species associated with growing media and their exporting county in Europe. The most frequently intercepted species are conspicuous moths and other species causing symptoms that are easily detected during visual inspection.

Export country	Species	Total interceptions
Ukraine	*Helicoverpa armigera*	4934
Spain	*Thrips palmi*	1144
Ukraine	*Spodoptera litura*	924
Ukraine	*Liriomyza trifolii*	56
Spain	*Leucinodes orbonalis*	52
United Kingdom	*Globodera pallida*	40
Turkey	*Leucinodes orbonalis*	12
Turkey	*Liriomyza trifolii*	6
Ukraine	Potato spindle tuber viroid	4
Turkey	*Helicoverpa armigera*	2
Turkey	*Zeugodacus cucurbitae*	2
United Kingdom	*Helicoverpa zea*	2

During the 10 years of monitoring of plant imports carried out by NINA, many different plant species have been inspected (see subchapter 1.5 for details). We can get a tentative idea about the potential propagule pressure of some key pests identified in our report by summing up how many known hosts plant species of these pests that have been inspected in the NINA program. The results show that numerous host plants of potentially damaging plant pests are imported to Norway (Table 10).

Table 10. Potential propagule pressure of soil-associated insect and mite species that are plant pests. For each pest species we show the number of known host plant species that have been sampled during the monitoring of plant imports to Norway (see subchapter 1.5).

Pest species	No. hosts
Popillia japonica	14
Scirtothrips dorsalis	13
Ripersiella hibisci	11
Ceratitis capitata	10
Drosophila suzukii	9
Spodoptera frugiperda	9
Eotetranychus lewisi	8
Corythucha arcuata	5
Thaumatotibia leucotreta	5

Plants imported to Norway have been sampled and analyzed for nematodes on several occasions over the years. The results from 200 root balls of imported plants are presented in Table 11. Plant-parasitic nematodes were detected in 155 samples, corresponding to 78 % (Holgado et al., 2019, Mattilsynet, 2013). The plants analyzed were imported from Belgium, Denmark, Germany, Italy, The Netherlands, Poland, Portugal, and Sweden. This shows that plant parasitic nematodes are common on plants imported to Norway from Europe. The most frequently detected nematodes were stubby root nematodes in the genera *Trichodorus* and *Paratrichodorus* and spiral nematodes in the genera *Rotylenchus* and *Helicotylenchus* (Holgado et al., 2019). In 2013, four species of endoparasitic nematodes in the genus *Pratylenchus* were detected. Out of the 22 species of ectoparasitic nematodes, including four genera of virus vectors (*Trichodorus*, *Paratrichodorus*, *Longidorus* and *Xiphinema*), seven species were not native to Norway (Mattilsynet, 2013).

Table 11. Genera of plant-parasitic nematodes identified in root ball soil sampled from plants imported to Norway. More than one nematode genus was detected in 16 % of the samples. Data from Holgado et al. (2019).

Nematodes	No. hosts
Trichodorus spp.	39
Tylenchorhynchus spp.	33
Helicotylenchus spp.	31
Pratylenchus spp.	29
Tylenchus sensu lato	25
Rotylenchus spp.	17
Paratrichodorus spp.	16
Paratylenchus spp.	13
Hemicycliophora spp.	13
Criconemella spp.	8
Longidorus spp.	8
Heterodera spp. (including *H. avenae* complex)	5
Globodera spp. (not PCN)	3
Cactodera spp.	1
Meloidogyne naasi	1

4.4 Identifying and ranking significant pest species

Given the vast number of possible plant pests, we have narrowed our focus to the most studied species. Through a literature search (see subchapter 2.2) and screening of selected databases (subchapter 2.3.2), we identified numerous known plant pests (list given in Appendix 5). Based on this list we used a risk-ranking system to select a subset of plant pests associated with soil or other growing media for express PRAs (Figures 12-16). Our choice of species to include in the express PRAs (Appendix 1) was not necessarily reflect the highest-ranked species but rather was based on the most studied plant pests to reduce the uncertainty of our assessments. This approach allows us to generalize the conclusions from these express

PRAs to include most, if not all, plant pests. Our example species are then used to identify strengths and weaknesses in current plant health regulations related to growing media. The express PRAs consolidate our knowledge of growing media and plant pests associated with growing media and highlight and suggest additional risk reduction options.

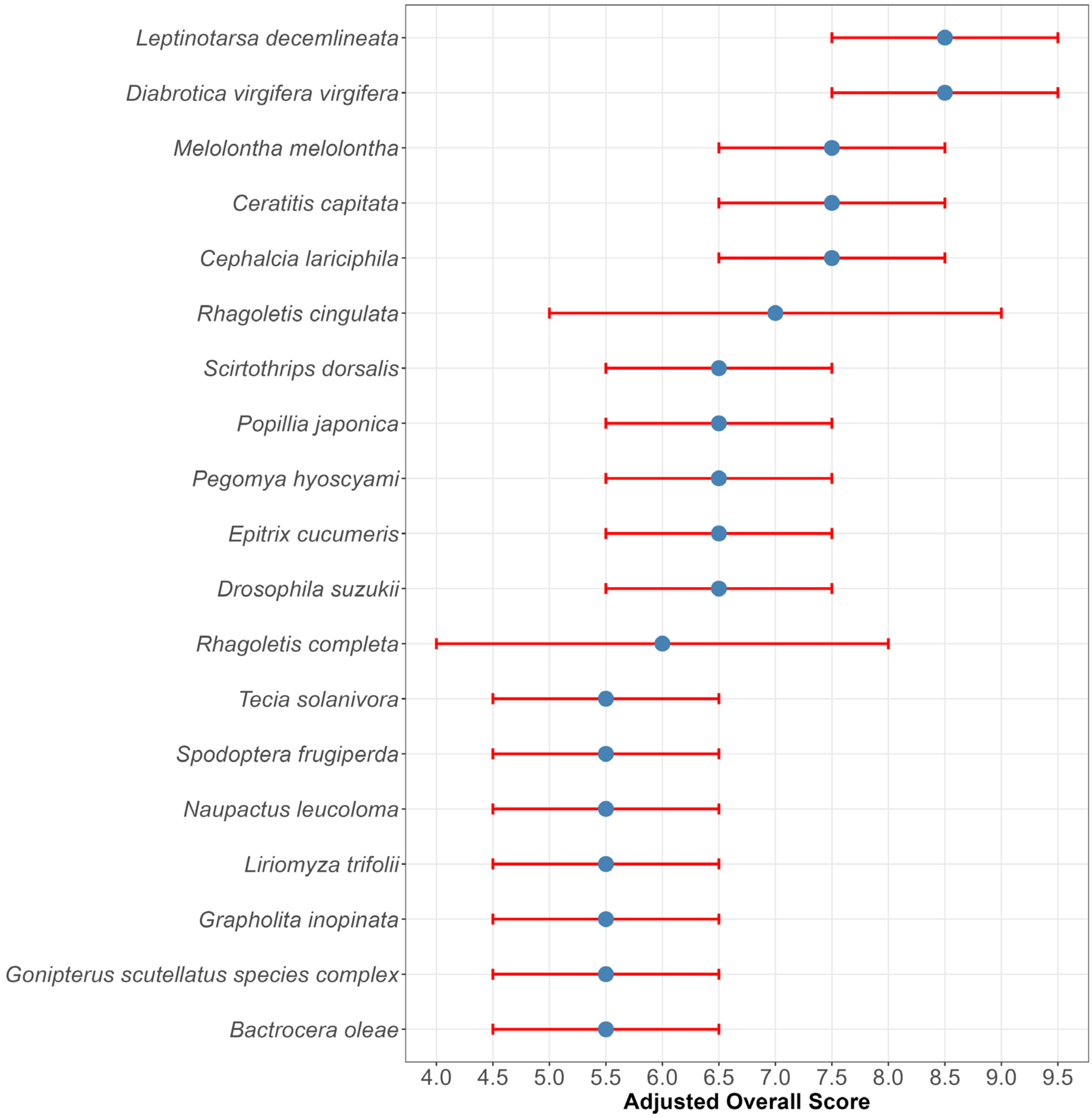

Figure 12. Adjusted pest risk scores for all Arthropoda (insects and mites) with a risk score above five. Higher scores suggest a higher risk. Blue dots indicate the pest score for each species and horizontal red lines show the uncertainty range. See subchapter 2.4 for a definition of pest risk score.

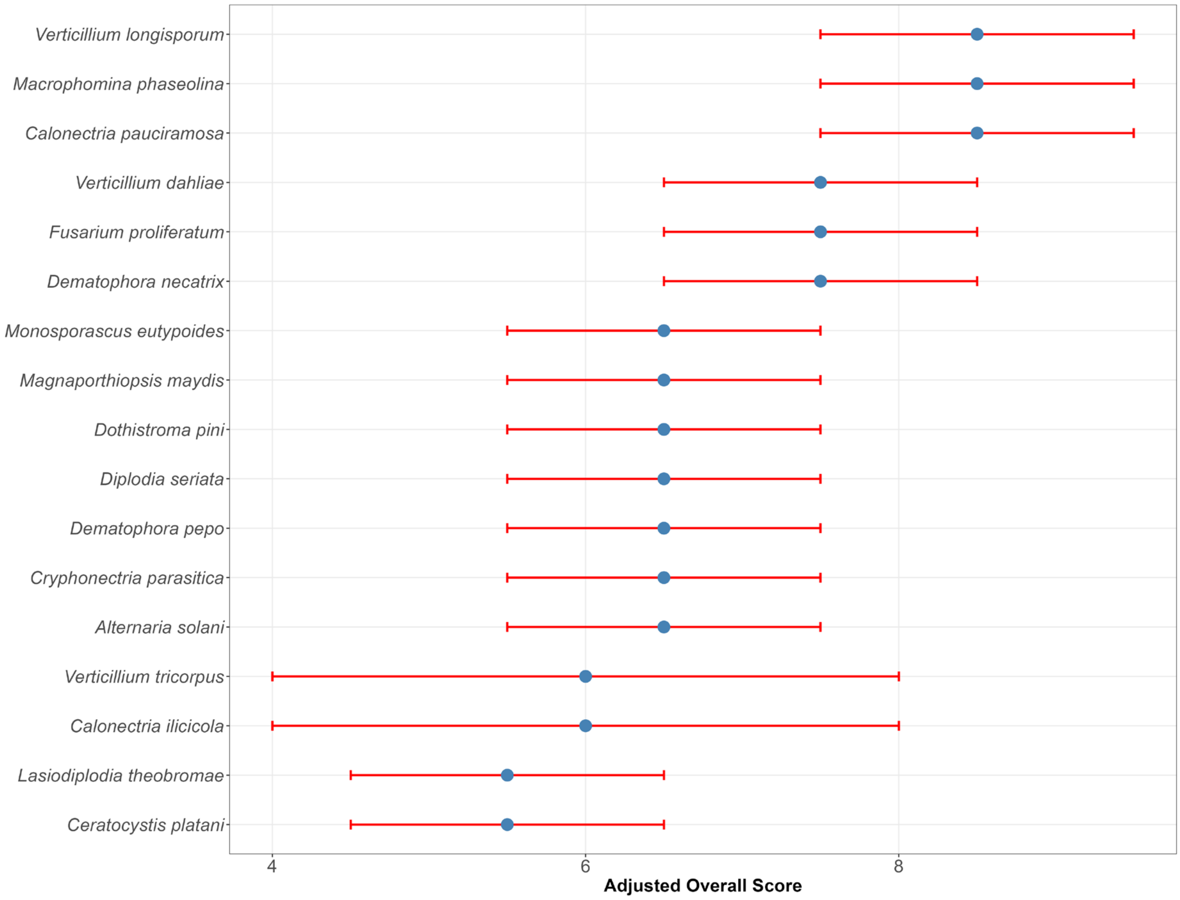

Figure 13. Adjusted pest risk scores for all Ascomycota (sac fungi or ascomycetes) with a risk score above four. Higher scores suggest a higher risk. Blue dots indicate the pest score for each species and horizontal red lines show the uncertainty range. See subchapter 2.4 for a definition of pest risk score.

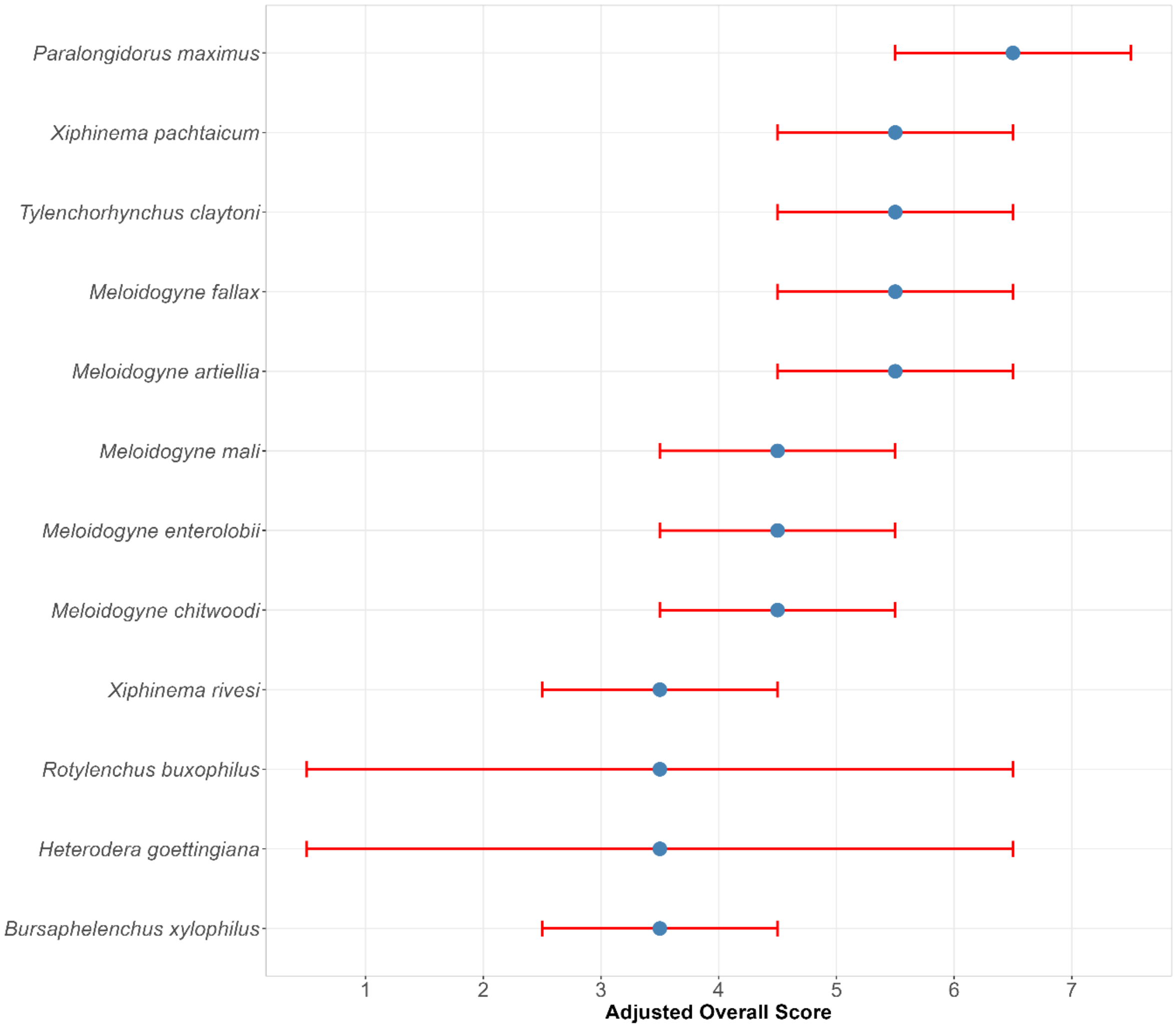

Figure 14. Adjusted pest risk scores for all Nematoda (nematodes) with a risk score above three. Higher scores suggest a higher risk. Blue dots indicate the pest score for each species and horizontal red lines show the uncertainty range. See subchapter 2.4 for a definition of pest risk score.

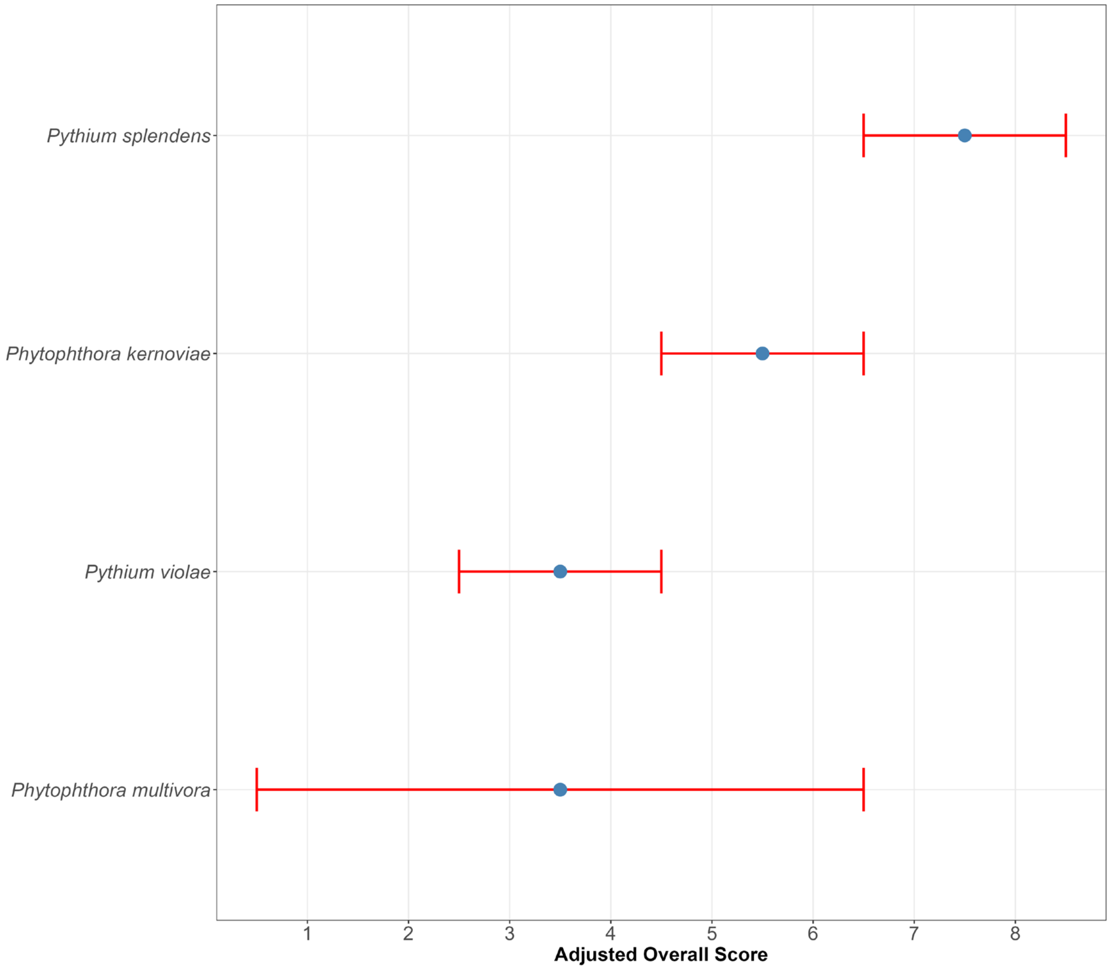

Figure 15. Adjusted pest risk scores for all Oomycota (water moulds) with a risk score above two. Higher scores suggest a higher risk. Blue dots indicate the pest score for each species and horizontal red lines show the uncertainty range. See subchapter 2.4 for a definition of pest risk score.

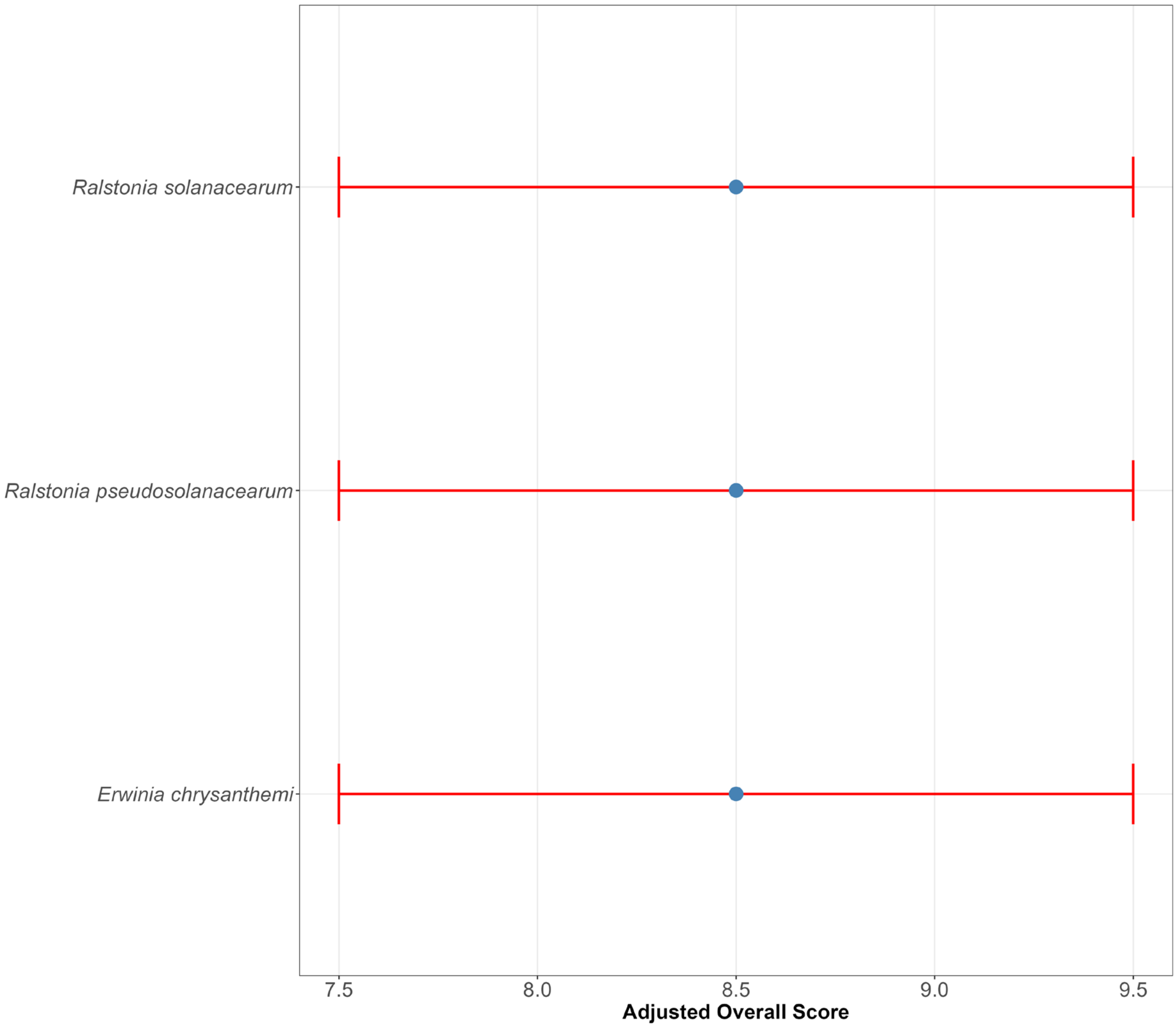

Figure 16. Adjusted pest risk scores for all Proteobacteria (a major phylum of Gram-negative bacteria) with a risk score above eight. Higher scores suggest a higher risk. Blue dots indicate the pest score for each species and horizontal red lines show the uncertainty range. See subchapter 2.4 for a definition of pest risk score.

4.5 Express pest risk assessment

As outlined in Chapters 1 and 3, a great diversity of plant species and growing media constituents are used in international plant trade. As a result of this diversity, many pest species may potentially be imported to Norway with this commodity. This is illustrated by the results of the Norwegian monitoring program described in subchapter 1.3. Given the many possible combinations of plants, growing media, and pest species, it is not feasible to describe all combinations in this assessment. Instead, we have done an express pest risk assessment of selected pests to illustrate the potential risks associated with the import of soil and growing media together with plants for planting. These express PRAs are presented in Appendix 1. The PRA scheme allows us to synthesize information about growing media and associated pests and identify useful risk-reduction options. The PRA results suggest that current plant health measures are insufficient to prevent the introduction of plant pests through the import of live plants with soil or other growing media. It should be emphasized that the species we have selected for express PRAs are just a few examples from a vast number of soil-bound species that could potentially enter Norway through the import of plants and associated growing media.

The main reasons why many of the pest species we have identified have not entered Norway is likely a combination of restrictive climate and the fact that Norway primarily imports plants from northern European countries with similar species assemblages (Figures 2, 3, 9, 10). If Norway increases its imports from high-risk EU countries, such as Italy, the problems with imported plant pests will probably be much larger. Risks posed by soil-living pests can only be managed by a thorough understanding of the complexities of the soil environment. This environment harbors a complex and largely invisible community of beneficial and potentially harmful organisms that are difficult to detect during inspections without destructive sampling.

4.6 The Norwegian Biodiversity Information Centre

Twenty-seven pest species identified in this assessment overlap with species assessed by the Norwegian Biodiversity Information Centre (*Artsdatabanken*). The 27 species are categorized into five distinct risk levels based on their potential impact on Norwegian biodiversity: no known impact (NK) (1 species), low impact (LO) (13 species), potentially high impact (PH) (3 species), high impact (HI) (6 species), and severe impact (SE) (4 species). Specific examples include the Asian ash borer (*Agrilus planipennis*), beech bleeding canker (*Phytophthora kernoviae)*, and the nematode *Bursaphelenchus xylophilus*. The overlap in identified species between our assessment and the work by the Norwegian Biodiversity Information Centre demonstrates a broad consensus on high-risk species. The Norwegian Biodiversity Information Centre has also assessed several soil-associated species that we could not assess further due to time constraints.

5 Risk reduction options

The Norwegian Scientific Committee for Food and Environment provides independent scientific risk assessments on matters that are important for food safety and the environment. The Norwegian Scientific Committee for Food and Environment does not give advice or take a position on how risks should be handled but can investigate the consequences of various action options. It is up to the Norwegian Food Safety Authority to decide on the risk-reducing measures that VKM has identified and assessed.

Risk reduction options (RROs) aim to diminish the potential adverse effects of identified plant pest risks by either decreasing the likelihood that the plant pest will occur or reducing the potential impact if the pest already occurs. No single risk reduction measure is effective in reducing pest risk across all types of soil and other growing media. Overall effectiveness depends on the combination of measures used, the type of soil and other growing medium used, and the pest itself. Combinations of RROs, tailored to specific pests and contexts, can provide a robust and effective defense against specific plant pests (EFSA Panel on Plant Health, 2012). This is called ‘a systems approach’ to pest management (ISPM no. 14) and involves integrating multiple strategies and measures across the entire production and supply chain to manage risks effectively. By addressing various points along the pathway from plant production to post-entry, the systems approach aims to create a more comprehensive defense against plant pests, reducing the reliance on any single measure and enhancing overall efficacy.

Risk reduction options can be deployed during plant production, packaging, shipment, and after consignments' arrival. The most important stages for deploying RROs are before consignments enter the importing country. The costs of eradication and management of invasive non-native plant pests after establishment are often much higher than the costs associated with preventing introduction. Therefore, early detection and rapid response are crucial when measures to prevent introduction fail (Noar et al., 2021).

In this chapter, we describe and evaluate the efficacy and applicability of various RROs relevant to pests associated with soil and other growing media. These descriptions are adopted from van Klinken et al. (2022), ISPM no. 36 (FAO, 2021a), and ISPM no. 40 (FAO, 2021b). We categorize RROs into two groups: production measures and phytosanitary measures. Further, we outline the RROs deployed in current EU and Norwegian legislations. Finally, we evaluate whether the phytosanitary measures deployed in the current Norwegian regulation are sufficient to prevent the introduction and spread of pests associated with soil and other growing media.

5.1 Production measures

Risk reduction options categorized as production measures are practices that already are standard production routines or measures that can be applied to reduce pest risk in a commodity. These measures are deployed by producers but may not necessarily be mandated by plant health authorities. A few examples are given in the introduction (subchapter 1.2).

Heat treatments: Sanitation of growing media can be achieved by various heat treatments, such as solarization, steaming, and composting of soil and growing media and production fields. Solarization by covering the soil with plastic film is a low-cost and low-environmental impact practice to reduce harmful organisms, including weeds, nematodes, and soilborne pathogens. Steaming of spent growing media has also been proven to eliminate pests and, therefore, enable the reuse and recycling of growing media with low phytosanitary concerns (see subchapter 3.4). However, steaming can be costly due to the high energy demand. Composted organic materials can reach 55-70 °C, which is warm enough to kill some pests, but rarely all. Pest risks associated with composting have been comprehensively reviewed by VKM et al. (2021).

Chemical treatments: Soil fumigants and pesticides can be used to control soilborne pests. Chemical treatments tend to be non-selective and affect not only harmful organisms. Therefore, the application of chemical treatments is strictly regulated and utilized as part of an integrated pest management (IPM) regime (*Forskrift om plantevernmidler*, *vedlegg* 2 and Barzman et al. (2015)).

Biological treatments: Biological control agents, such as beneficial nematodes, fungi, and bacteria, are used to manage soilborne pests. These agents can be antagonists, parasites, or competitors of plant pests. They can also indirectly affect plant health by inducing the plants' own defense mechanisms. The effectiveness of biocontrol agents is highly variable, often species-specific, and depends on various environmental factors. The number of suitable commercially available biocontrol agents is also limited.

Other production practices: The growing media and the procedures used during production are important for whether plant-associated growing media becomes contaminated. The nature of the growing media constituents, the degree of processing of these constituents, and the treatments applied during their production determine whether the growing media is pest-free or not to start with (see subchapters 3.3 and 3.5). Recycled growing media, for example, will have a higher pest risk compared to virgin growing media. Measures to avoid contamination or infestation during production, storage, and transport may include the use of uncontaminated starter plant stock, pest-free (treated) irrigation water, physical barriers separating plants from natural soils and the wider environment, and good hygiene and sanitation routines. Several water treatment options can be used, such as filtration, UV sterilization, and chlorination. Producing plants in greenhouses or polytunnels and growing plants on benches or plastic sheets reduces the risk of pest contamination from the surrounding environment or underlying soil. Proper sanitation routines and general hygiene measures also reduce overall pest risk, including removing weeds and volunteer plants, burning or deep burying infested material and plant waste, and disinfection of tools and equipment.

5.2 Phytosanitary measures

Risk reduction options categorized as phytosanitary measures include legislative and regulatory measures or official procedures with the aim of preventing the introduction and spread of regulated pests (ISPM no. 5). Here we briefly describe these measures, starting with the prohibition of import and proceeding to measures that can be used when import is permitted.

Import bans: Banning the import of high-risk commodities is an effective way to prevent the introduction of pests. For example, Norway prohibits importing all soil and organic growing media, except those composed entirely of peat, from non-European countries. Banning the import of certain commodities based on their place of origin can also be used when there is a high pest risk in a certain region. An import ban is a strict measure and is applied when other RROs are deemed insufficient and infeasible.

Special import requirements: These are specific phytosanitary measures that consignments must meet to be allowed to enter the importing country. The importing country sets these requirements to reduce the risk of introducing pests. Some examples are mandatory cleaning and disinfection of used agricultural and forest machinery, the requirement that root vegetables and plant propagating materials contain a maximum of 1 % soil or other growing media, testing of plants or soil and growing media, requirements for irrigation water, requirements for a pest-free area, etc.

Phytosanitary certification: This is the use of official procedures such as inspections, treatments, and surveillance to be carried out by the NPPO of the exporting country to verify whether import requirements set by the importing country are fulfilled. Phytosanitary certificates are issued close to the date of export and not more than two weeks before dispatch. The certificate documents that the consignment is free from regulated pests and meets the importing country's phytosanitary requirements.

Official inspections and reception controls: Official inspections of consignments are carried out by inspectors from the NPPO of the importing country. The purpose is to verify whether consignments are free from regulated pests and fulfill the phytosanitary requirements of the importing country. The Norwegian plant health regulation requires that importers control each consignment and its accompanying phytosanitary certificate. This control, called reception control, must be carried out before the importer can sell or use the plants.

Post-entry quarantine: The importing country can deploy quarantine to prevent the introduction and spread of plant pests through import. During quarantine, consignments are withheld and subjected to observation, inspection, testing and treatment for a certain period.

Surveillance: This is an official procedure for collecting and recording data on pest status through surveys, monitoring, or other procedures (FAO, 2023). The collected data will inform decision-making processes and enable timely and targeted interventions. Continuous surveillance and monitoring systems are essential for early detection of pests. These systems combine field inspections, trapping, and remote sensing technologies to monitor pest populations and their spread.

5.3 Overview of current European and Norwegian regulations on soil and other growing media

5.3.1 European Union and United Kingdom

The EU regulation (EU) 2016/2031 on protective measures against pests of plants prohibits import or sets general conditions for the import of plants, plant parts, and other products into Union territory (articles 40, 41, and 42). This regulation is implemented by regulation (EU) 2019/2072, detailing the specifics of the prohibitions and the requirements that must be met for the import of plants, plant products, and other products.

Importing soil and growing media, consisting of whole or in part solid organic substances, into the EU is forbidden from all third countries other than Switzerland. United Kingdom has an equivalent import ban on soil and growing media from all third countries other than EU member states, Switzerland, and Liechtenstein. Growing media composed entirely of peat or fiber of *Cocos nucifera* and that have not previously been used for growing plants or any agricultural purposes are exempt from this import ban (2019/2072 Annex VI nr. 19 and 20).

Used forest and agricultural machinery are required to be accompanied by phytosanitary certificates documenting that the machinery is completely free from soil and plant debris (2019/2072 annex VII nr. 2). Consignments of root and tubercle vegetables and tubers of potato (*Solanum tuberosum*) should contain no more than 1 % (by net weight) of soil and growing media. The same requirement applies to bulbs, corms, rhizomes, and tubers intended for planting (2019/2072 Annex VII, nr. 12, 13, and 14). The UK has similar requirements for used agricultural and forest machinery as well as root and tubercle vegetables, potato tubers, bulbs, corms, rhizomes, and tubers intended for planting.

Growing media attached to or associated with plants originating from all third countries other than Switzerland must fulfill certain requirements both at the time of planting and following planting. When planting, growing media should be free from soil and organic matter or composed entirely of peat or fiber of *Cocos nucifera*. The growing media should not previously have been used for growing plants or for any other agricultural purposes. If the growing medium does not fulfill these requirements, it must either be subjected to effective treatment (fumigation or heat) or other methods to ensure freedom from pests. Following planting, the growing media must either be kept free from EU quarantine pests or should be completely removed from the plants by washing no more than two weeks prior to dispatch (2019/2072 annex VII nr. 1). Note that the Norwegian plant health regulation sets equivalent requirements for plants and associated growing media originating in non-European countries.

Plants for planting with roots, grown in open air, originating from all third countries, can be imported into the EU if the places of production are free from *Clavibacter sependonicus* and *Synchytrium endobioticum.* In addition, the plants must originate from fields known to be free from the nematodes *Globodera pallida* and *G. rostochiensis* (2019/2072, annex VII nr. 3). The United Kingdom has similar requirements. These requirements apply to all third countries other than EU member states, Liechtenstein, and Switzerland.

5.3.2 Norway

Regulations relating to plants and measures against pests (FOR-2000-12-01-1333) set requirements for importing soil and growing media into Norway as a separate commodity and as attached to plants.

According to the regulation, it is forbidden to import soil and organic growing media as such, except growing media composed entirely of peat, originating from non-European countries (annex 3 nr. 10). All consignments of growing media made completely or partly of soil, plant parts, bark, peat, compost, and organic fertilizers must be accompanied by phytosanitary certificates (annex 5A nr. 9). Growing media composed entirely of peat originating in European countries is exempt from phytosanitary certification. Import of growing media composed entirely of peat from non-European countries is allowed, provided the consignment is followed by a phytosanitary certificate (annex 3 nr. 10 and Annex 5A nr. 9).

Private persons can import up to five household pot plants from European countries as part of their hand luggage or moving load without a phytosanitary certificate (§19 and annex 9). Note that EU regulation forbids such imports from all third countries.

Used agricultural and forestry machines can be imported to Norway only if thoroughly cleaned and completely free from soil, plant remains, and pests. The consignments must be accompanied by phytosanitary certificates or other official documents confirming thorough cleaning and, where applicable, disinfestation (§17). This is similar to the requirements set by EU.

For plants for planting with roots, grown in open air, the places of production are required to be free from specific pests: *C. michiganensis* ssp. *sepedonicus*, *G. pallida*, *G. rostochiensis*, *Ralstonia solanacearum*, and *S. endobioticum* (Annex 4A, nr. 28). Similar requirements apply to places of production of soil and other organic growing media (Annex 4A, nr. 36). It's important to note that while the EU regulation restricts the requirement for absence of *G. pallida* and *G. rostochiensis* to each specific production field, the Norwegian requirements apply to the whole place of production. Additionally, the EU regulation does not require places of production to be free *from R. solanacearum*, highlighting the specific nature of the Norwegian regulations.

Norwegian regulation sets measures to hinder the introduction of the New Zealand flat worm (*Arthurdendyus triangulatus*) from countries where the flat worm is known to occur. Places of production for potted plants must either be free from *Arthurdendyus triangulatus*, or the plants should be grown on raised benches, or the consignment should be subjected to disinfestation treatment prior to dispatch (Annex 4A, nr. 29.2).

5.4 Evaluation of current risk reduction options deployed in Norwegian regulation

Risk reduction options deployed in the current Norwegian regulation are insufficient to prevent the introduction of pests with the import of soil and other growing media attached to plants for planting from Europe. Norway allows the import of soil and other growing media attached to plants originating in European countries without any special import requirements. The only special import requirement in Norway for plants for planting with roots grown in open air is that the places of production must be known to be free from certain plant pests (listed in subchapter 5.2.2). The EU, in contrast, sets several requirements for growing media attached to plants originating from all third countries, including Norway. These requirements are set to keep the growing media free from EU quarantine pests during storage, at the time of planting, and following planting.

Norway does not impose mandatory official control of plant import by plant health inspectors at the borders. Instead, the plant importers themselves are responsible for controlling consignments for the presence of regulated and other plant pests on arrival, which is called reception control. During reception control, importers are expected to check whether the consignment is accompanied by a phytosanitary certificate with the required additional declarations, that the content of the consignment agrees with what is stated on the certificate, that the consignment is free from regulated pests, and that it has good quality. Reception controls are usually carried out quickly and rely heavily on visual observations. In practice, only a small sample of a consignment is controlled during reception controls (Brasier, 2008). Pests associated with underground plant parts, or the growing medium are usually difficult to detect by visual control. The effectiveness of reception controls also depends on the controllers' knowledge about regulated pests, access to and use of rapid tests, and the control methodology (sample size, sampling method, visual aid used, etc.). These factors reduce the likelihood that plant pests associated with soil and other growing media will be detected at arrival and effectively stopped from being introduced to Norway.

Phytosanitary certification systems are designed to ensure phytosanitary compliance through traceability and standard operating procedures. The effectiveness of these systems depends on the availability of sensitive and specific detection methods for target organisms. Additionally, the diversity of soil and growing media used in commercial plant production and the distribution of organisms within these substrates make it difficult to obtain representative samples. Phytosanitary certification in exporting countries, in addition, focuses on pests that are regulated by the importing country. However, as discussed in this assessment, pests that are currently unregulated may also present considerable risks to plant health in Norway. In conclusion, the import of live plants with soil or other growing media poses a high risk to plant health in Norway, and this risk can be reduced by imposing stricter import requirements.

6 Data gaps and uncertainty

Some plants imported to Norway may originally have been propagated and grown outside Europe. These plants may have been grown for several years in a non-European country, often outside greenhouse facilities. This increases the risk that the plants and associated growing media may unintentionally bring non-native species to Norway.

Various organisms may colonize sterile growing media at the start of the production cycle as the plant grows (sometimes) for several years before it is transported to Norway and planted out by a customer. The rate and degree by which different growing media are colonized by pests in different environments is largely unknown, as is the effect of different management options on reducing pest colonization.

The high volumes of live plants and associated growing media imported into Norway increase the risk of pest introduction. However, data on the actual propagule pressure—how many pests are present per unit of imported material—is not well documented, making it difficult to quantify the risk accurately.

Current phytosanitary measures focus on regulated pests. The extent of the threat from non-regulated plant pests and their potential impact on Norwegian plant health is not fully understood.

7 Summary with answers to ToR

In this section we briefly summarize the answers to the terms of reference provided by the commissioning agencies and refer to the respective parts of this report for further details.

7.1 Define and identify soil and other growing media from the literature

Soil and other growing media are defined in Chapter 3 of this assessment, where properties of a wide range of common constituents used in growing media are described. The relative importance of different growing media constituents with respect to volumes and areas of use is outlined, as are the processes involved in the production and sanitation of growing media. The constituents that are used in the largest quantities are peat, wood fiber, and compost. Our assessment focuses on organic growing media constituents, as they are frequently colonized by living organisms when sourced and may support plant pests by acting as a food source and a sheltering environment providing water, oxygen, and other crucial factors. Even though growing media components may initially be sterile or at least free from any plant pathogens, the processes of mixing, potting, plant cultivation, transport, and storage can easily allow contamination and even propagation of pests underway from a primary source to a Norwegian consumer. A wide range of organisms can colonize and survive in growing media under conditions that are primarily tuned to keep plants alive. Growing media thus poses a risk of introducing plant pests to Norway when such media are imported together with living plants.

7.2 Which plant pests associated with soil or other growing media that are used in plants for planting from European countries have the highest probability of establishment and spread in Norway?

Due to the great diversity of plants for planting and associated growing media that is imported to Norway, many species can be unintentionally introduced by this pathway. Arriving organisms will include organisms that are not plant pests, known plant pests, and species that may turn out to be problematic even though they are not currently listed as quarantine pests. By screening two international databases and doing a literature search (see subchapter 2.3.2), we identified 651 pest species that may be associated with plants imported from Europe with soil or other growing media. Climate suitability analysis was done for seven selected species to determine the likelihood that they will establish in Norway (see subchapter 2.4.5). Köppen–Geiger classification maps were produced for most species, in addition, we ran Maxent analysis for two selected insect species (Appendix 1). Both these methods to assess climatic suitability carry considerable uncertainty and should only be viewed as indicative. For plant pests that appear to be adapted to the climate in Norway based on these analyses, full risk assessments should be carried out to determine the probability of establishment and spread in Norway.

7.3 Which plants, plant categories, or cultivation methods represent the highest probability of entry for species identified in question 2, through the imports of soil or other growing media?

The plants and plant categories with the highest probability of leading to entry of plant pests to Norway are woody plants grown outside in plant nurseries and imported with large clumps of growing medium. For such long-lived plants the whole production and post-production cycle may span several years, and this increases colonization probabilities. Plants grown in natural soil or in contact with soil also have a high probability of carrying new plant pests to Norway. Even if the roots are washed and the plants are re-potted in new pest-free growing media, complete soil removal from large root systems is difficult to achieve.

7.4 Are there countries in Europe that have a higher probability of the pests being associated with the pathway at the origin, when considering questions 2 and 3?

The probability of pests being associated with the pathway plants for planting at the origin (i.e., in the exporting country) can be considered with respect to either total export volume to Norway from different countries or the propagule pressure in individual countries. The main exporters of live plants to Norway are the Netherlands, Germany, Denmark, and Sweden, which collectively accounts for 90 % of total imports (subchapter 2.3.1). The Netherlands alone accounts for nearly half of the total import volume. Because of their dominance in terms of trade volumes, these four countries can be considered to represent the highest propagule pressure of plant pests. The European countries with the highest probability of new plant pests being associated with the pathway at the origin are Italy, France, Spain, and the UK, because these countries harbor the highest numbers of known plant pests that are not yet present in Norway. This is the case both for plant pests in general (Figure 9) and for plant pests that are associated with soil and other growing media (Figure 10) (subchapter 4.2).

7.5 Identify risk reduction options and evaluate their efficiency and applicability

The Norwegian Scientific Committee for food and Environment provides independent scientific risk assessments on matters that are important for food safety and the environment. The Norwegian Scientific Committee for Food and Environment does not give advice or take a position on how risks should be handled but can investigate the consequences of various action options. It is up to the Norwegian Food Safety Authority to decide on the risk-reducing measures that VKM has identified and assessed.

The most efficient risk reduction options are to prohibit import of plants from areas with high pest risk or to set special import requirements from high-risk areas (see Chapter 5). The most effective risk reduction strategy in exporting countries is to cultivate plants for planting outside the distribution areas of specific pests or ensure physical separation of potential host plants from pests, either temporally or spatially. Potentially effective risk reduction options could be drawn from the options set in the EU regulation. These include using (i) only virgin growing media (i.e., media that have not previously been used to grow plants), (ii) soilless growing media that are free from soil and organic matter, (iii) growing media made entirely of peat or fiber of *Cocos nucifera* (coconut husks), and (iv) growing media that have been properly fumigated or heat-treated according to EPPO guidelines. Measures to keep growing media pest-free following planting include (i) physically isolating plants and associated growing media from natural soils and other sources of pest species, (ii) using pest-free irrigation water, and (iii) applying good sanitation/hygiene routines in plant nurseries and throughout trade pathways. For plants that are re-potted or transferred from the field to pots before export, growing media could be removed by washing the plant roots, and plants could be replanted in virgin growing media before shipping. However, washing roots cannot remove plant-parasitic nematodes and other endoparasites. The same is true for free-living pests on large specimen trees due to the difficulty of successfully removing adhering soil and pests from very voluminous root systems. A combination of different risk reduction options will be most efficient, as no single risk reduction option is effective against all pests in all types of growing media.

7.6 Are the risk reduction options deployed in the current Norwegian legislation sufficient in reducing the probability of entry of plant pests from Europe?

Current risk reduction options available in Norwegian regulation are insufficient to prevent the introduction of plant pests associated with import of soil and other growing media attached to plants from Europe (see subchapter 5.4). Unlike the EU, which imposes strict requirements on growing media from third countries, Norway allows soil and growing media attached to plants from European countries without special import requirements (except for plants for planting, with roots, grown in open air). Importers are responsible for carrying out reception control of the consignments while the Norwegian Food Safety Authority carries out official risk-based random checks of consignments and supervises the importers' reception control. Reception controls rely heavily on visual observations and are often limited in scope, reducing the likelihood that plant pests associated with soil and growing media will be detected at arrival. This increases the probability of introduction of both regulated and unregulated pests with soil and other growing media into Norway. In conclusion, import of live plants with soil or other growing media poses a high risk to plant health in Norway and this risk can be reduced by imposing stricter import requirements.

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9 Appendices

9.1 Appendix 1 - Express pest risk assessment

9.1.1 Arthropods

9.1.1.1 Express pest risk assessment of *Popillia japonica*

1. Taxonomy

Class: Insecta, Order: Coleoptera, Family: Scarabaeidae, Subfamily: Rutelinae, Genus: *Popillia*, Species: *Popillia japonica*
Common name: Japanese beetle, Japanbille
EPPO code: POPIJA

2. Conclusion and summary

Current Norwegian plant health regulations for *P. japonica* are likely insufficient to prevent its introduction with soil and growing media. This beetle is an invasive pest that causes damage in agriculture and horticulture by feeding on plant roots s. The beetle's biology, particularly its soil-dependent larval stage, is crucial in facilitating its spread. *Popillia japonica* is native to Japan and the Russian Far East and has spread to North America and parts of the EPPO region. It is a priority plant pest in the EU and is currently present in Italy, Portugal (Azores), and Switzerland (see EPPO Datasheet for more information).

3. Is the pest a vector?

No, *P. japonica* is not a vector.

4. Is a vector needed for pest entry or spread?

No, *P. japonica* does not require a vector.

5. Regulatory status of the pest

Norway: Quarantine pest
EU: A2 Quarantine pest (Annex II B)

6. Distribution in Europe

Portugal, Italy, and Switzerland

7. Host plants in Norway

Popillia japonica is polyphagous and feeds on over 300 plant species, many of which are found in Norway. These include *Acer* spp. (maple, sycamore), *Betula* spp. (birch), *Fagus sylvatica* (European beech), *Prunus* spp. (cherry, plum), *Tilia* spp. (linden or lime trees), *Quercus* spp. (oak), *Rubus idaeus* (raspberry), *Malus domestica* (apple), *Rosa* spp. (Rose), and *Rhododendron* spp.

8. Growing media for entry

Rating of likelihood of entry: Likely
Rating of uncertainty: Medium

Female *P. japonica* beetles lay eggs in the soil during summer. When the eggs hatch the larvae live in the soil and feed on the roots of different plants. The larvae prefer moist, well-maintained lawns, gardens, and agricultural fields, where they consume grass and crop roots. The species has been shown to prefer less acidic soils, especially with sandy-skeletal particles and medium content of soil organic carbon (Simonetto et al. 2022).

9. Likelihood of establishment outdoors in Norway

Probability of establishment outdoors: As likely as not
Rating of uncertainty: Medium
Köppen-Geiger mapping (Figure 1) shows areas with favorable conditions for the establishment of *P. japonica* in Norway (i.e., the climate zones CfB: marine west coast climate; DfC: continental subarctic climate, and Dfb: humid continental climate). Norway's climate varies from mild coastal areas influenced by the Gulf Stream to interior areas with a continental climate and cold winters. *Popillia japonica* thrives in regions where the mean temperature in the soil, where the larvae overwinter, is between 17.5 and 27.5 °C during summer and above -9.4 °C in winter (CABI pest compendium). Adequate precipitation that is uniformly distributed throughout the year is also essential. Given Norway's cooler climate, particularly in the interior, it is not an ideal environment for the beetle to complete its lifecycle, especially not the overwintering larvae stage. However, microclimates in urban and protected areas, especially those influenced by human activity, could potentially support establishment. Thus, although Norway's general climate might not be suitable for *P. japonica*, especially in terms of overwintering, the potential for establishment in protected conditions, such as greenhouses, cannot be ruled out.

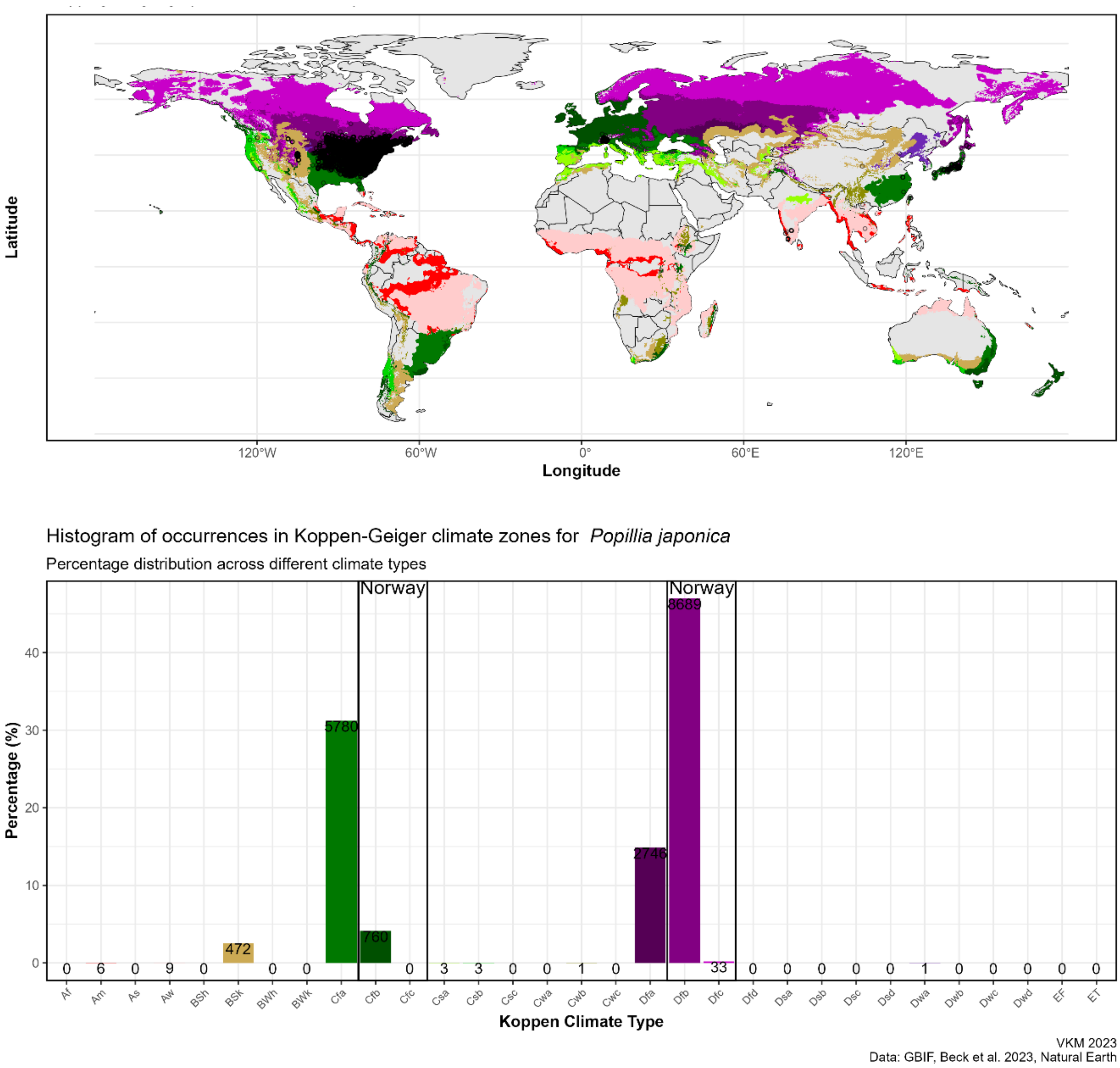

Figure 1. Recorded occurrences of *Popillia japonica* (black circles) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *P. japonica* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. *Popillia japonica* has a high population (or reporting rate) in a climate type that occurs in SE Norway (Dfb; 45 % of all occurrence points).

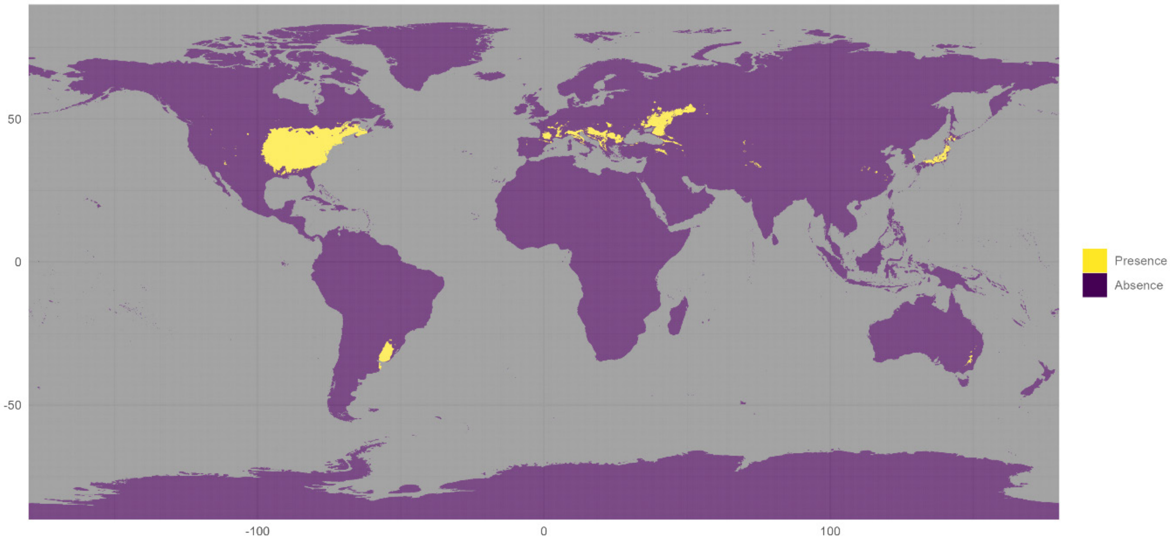

Figure 2. *Popillia japonica* presence and absence according to a Maxent model predicting areas with abiotic conditions that are suitable (yellow) or less suitable (purple) for the species.

A Maxent model for *P. japonica* predicts zero probability for establishment in Norway. The factors 'Precipitation seasonality' (bio15) and 'Precipitation of the wettest month' (bio13) account for almost 70% of the *P. japonica* maxent model variation. *Popillia japonica* had a low variation of 'Precipitation seasonality' (bio15), suggesting that precipitation should be evenly distributed throughout the year, with less pronounced wet and dry seasons. This corresponds with Fleming (1972), who notes that precipitation influences soil moisture and should be fairly uniform during the year but at least 250 mm during the summer. Also, *P. japonica* had a narrow response to 'Precipitation of the wettest month' (bio 13), showing particular precipitation needs. The west coast of Norway, which would have sufficiently warm soil temperatures, may be too wet for establishment.

10. Likelihood of establishment in protected conditions Norway

Probability of establishment in protected condition: Likely
Rating of uncertainty: Medium
The likelihood that *P. japonica* may be established under protected conditions in Norway is Likely. Greenhouses for growing vegetables, flowers, and plants are common along the coast and might offer suitable conditions for establishment, despite the limiting outdoor climatic conditions.

11. Spread in Norway

Probability of spread: Likely
Rating of uncertainty: Medium
Both natural spread (adult flight) and human-assisted spread (movement of plants and growing media) are likely.

Popillia japonica can spread over relatively large areas through both natural means and human activities. While the beetles can fly up to 8 km, they rarely do and are not attracted to traps more than 50–100 m away (CABI pest compendium). *Popillia japonica* spread over long distances through human-mediated activities such as the trade and transport of nursery stock, soil, and other plant materials. The larvae can survive in soil around plant roots, which means they can be unintentionally transported over long distances.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: Likely
Rating of uncertainty: Low
The beetle can cause significant damage and feed on over 300 plant species, affecting both ecological and agricultural systems.

13. Potential impact in Norway

Popillia japonica is known to feed on the leaves and fruits of many plants, potentially reducing yields. Apples could suffer from direct feeding damage. The beetle could also feed on various ornamental plants common in gardens and parks, including roses, rhododendrons, and lindens. Lawns and parks could be damaged by larval feeding on roots, leading to brown patches and increased vulnerability to weed invasion and erosion. Moreover, birch is the most widespread tree species in Norway and may become an abundant food source.

14. Phytosanitary measures

The most effective measure is to ban the import of plants with soil from areas where *P. japonica* is known to occur. Removal of soil and other growing media that could harbor pre-imaginal stages of *P. japonica*, plant production under the complete physical barrier, and covering the surface of containers/pots with anti-insect netting. Production on concrete floors, mulching fabric, plastic, or benches to avoid contact with underlying soil and use of insecticides can be integrated as part of a pest management regime. Cultural methods such as mechanical cultivation to reduce larval populations and avoiding irrigation during peak beetle emergence and flight times can be employed. Hand-picking of adults can be encouraged for small infestations. Restricting the movement of plants, soil, and other growing media from areas where the pest is known to occur could be used to prevent further spread. Surveillance and detection surveys could be carried out to monitor pest status at and around high-risk sites. Visual inspection is insufficient and should be combined with trapping of adult beetles using sex pheromones and floral attractants. Trapping can be used to suppress populations and monitor their spread. Raising the awareness of importers, growers, and the public might aid early detection and increase the probability of success of eradication efforts.

15. References

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9.1.1.2 Express pest risk assessment of *Ceratitis capitata*

1. Taxonomy

Class: Insecta, Order: Diptera, Family: Tephritidae, Genus: *Ceratitis*, Species: *Ceratitis capitata*

Common name: Mediterranean fruit fly, *appelsinflue*

EPPO code: CERTCA

2. Conclusion and summary

Current Norwegian plant health regulations are likely insufficient to prevent introduction of *C. capitata* in Norway through import of soil and growing media.

Ceratitis capitata is considered one of the world's most destructive agricultural pests due to its highly invasive nature, extensive host range, and ability to adapt to various climates. However, the probability that it will establish outdoors in Norway is low. Establishment probability and damage potential are much higher under protected environments. The pest has substantial economic impacts by limiting market access, increasing pest management costs, and necessitating extensive monitoring programs to prevent spread.

3. Is the pest a vector?

No, *C. capitata* is not known to be a vector for plant diseases.

4. Is a vector needed for pest entry or spread?

No, *C. capitata* does not require a vector.

5. Regulatory status of the pest

Norway: Not regulated

EU: Not regulated

EPPO: A2 List of pests recommended for regulation as quarantine pests

6. Distribution in Europe

Ceratitis capitata is present in various parts of Europe, including but not limited to Albania, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Malta, Montenegro, Portugal, Spain, and Switzerland. It is considered transient or under eradication in Germany and Ukraine. Within this distribution area the pest's presence ranges from widespread to localized.

7. Host plants in Norway

Ceratitis capitata has an extensive host range and affects a wide variety of cultivated and wild plants. Important hosts include various species in the genus *Capsicum, Citrus, Malus, Morus, Olea, Prunus, Pyrus, Rubus, Solanum,* and *Vitis.*

8. Growing media for entry

Rating of the likelihood of entry: Likely

Rating of uncertainty: Low

The likelihood of *C. capitata* entering Norway with the import of plants and associated growing media is considered likely, with low uncertainty. The pest's primary entry mode into new areas is usually through infested fruits rather than with growing media. However, the fly can also spread with imported plants because it pupates in the soil beneath host plants. The species is associated with clay, sand, and vermiculite (EFSA 2015).

9. Likelihood of establishment outdoors in Norway

Probability of establishment outdoors: Unlikely

Rating of uncertainty: High

Ceratitis capitata occurs frequently in climates classified as Csa and Csb (Mediterranean climates) and some tropical climates according to the Köppen-Geiger climate classification. However, Norway primarily has a Dfc climate classification (boreal climate with cool, short summers and long, cold winters), which is not optimal for *C. capitata* but does occur at low frequency. This mismatch suggests that the probability of *C. capitata* establishing a sustainable outdoor population in Norway might be unlikely compared to the Mediterranean areas. Norway’s cooler temperatures may not allow larval survival and will reduce the development rate of pupae and adults. Warmer periods during the year could allow for the temporary establishment or survival of *C. capitata* under favorable conditions. If the species is introduced during a warm summer, it might be able to complete a life cycle. However, the cold winters are still likely to hinder its long-term establishment. The high uncertainty rating reflects the potential for microclimates that could enable pest survival in greenhouses. Climate change could also alter the establishment in new regions.

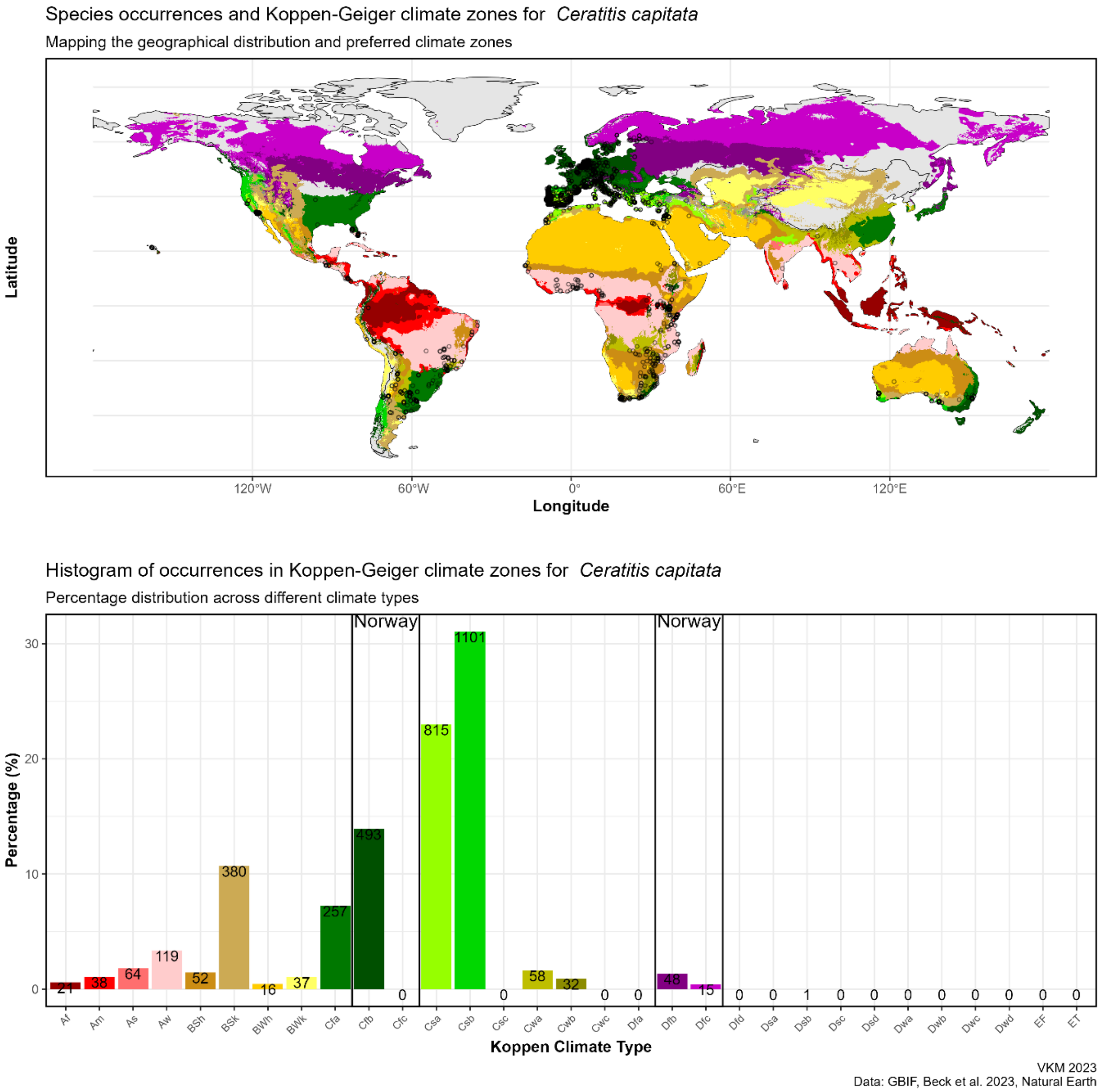

Figure 1. Recorded occurrences of *Ceratitis capitata* (black circles) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *C. capitata* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. *Ceratitis capitata* has a moderate population (or reporting rate) in a climate type that occurs in coastal areas of southern Norway (Cfb; 14 % of all occurrence points).

10. Likelihood of establishment in protected conditions in Norway

Probability of establishment in protected condition: As likely as not

Rating of uncertainty: High

Under greenhouse conditions, the likelihood of *C. capitata* establishing in Norway significantly increases.

Maxent (figure x) shows a very low probability of occurrence for *C. capitata* in Norway, indicating that the current climatic conditions are unfavorable to the pest's establishment in most parts, except for a narrow area along the southern coast. However, maxent does not consider microclimates. Greenhouse conditions are most likely favorable.

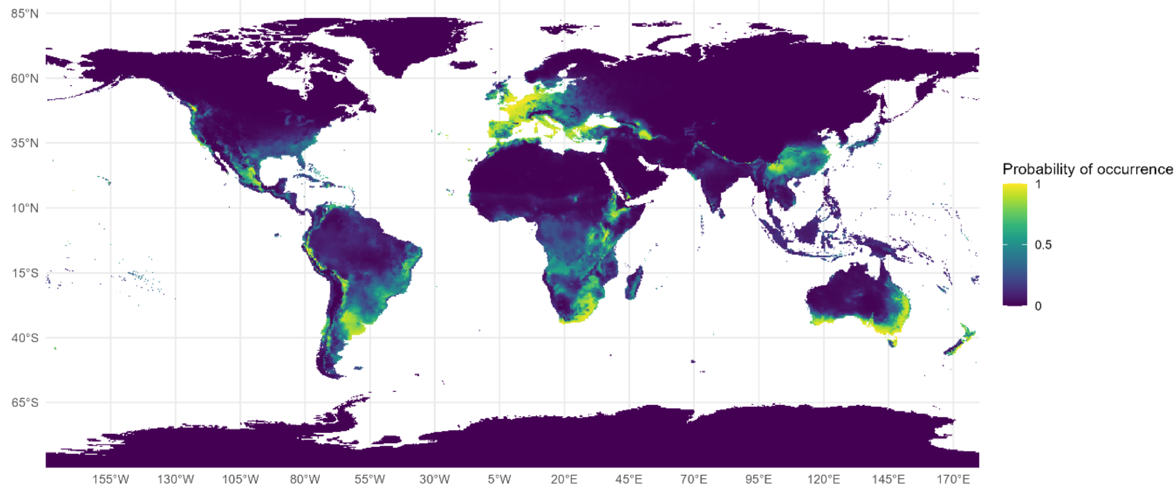

Figure 2. *Ceratitis capitata* presence and absence according to a Maxent model predicting areas with abiotic conditions that are suitable (yellow) or less suitable (purple) for the species.

11. Spread in Norway

Probability of spread: Likely

Rating of uncertainty: Low

The spread of *C. capitata* within Norway is considered likely, with a low level of uncertainty. This assessment is informed by the pest's known behavior and biology. *C. capitata* has strong flying capabilities and a high reproductive rate, which can facilitate its spread over large areas.

The movement of infested fruits and plants has quickly led to the introduction and subsequent spread of the Mediterranean fruit fly across regions that provide suitable climatic conditions and host plants. While Norway's climate is generally unsuitable for establishing *C. capitata* outdoors, the country would still need to consider the potential for the pest's spread, particularly to greenhouses.

12. Impact in the current area of distribution

Rating of the magnitude of impact in the current area of distribution: Likely

Rating of uncertainty: Low

The impact of *C. capitata* in areas where it is currently distributed has been significant, affecting both agricultural production and international trade. The Mediterranean fruit fly is considered one of the world's most destructive agricultural pests due to its wide host range and ability to adapt to various climates (Huang et al. 2009). In regions where *C. capitata* has become established, it has been shown to cause significant economic damage due to yield losses and the costs associated with control measures.

13. Potential impact in Norway

The pest attacks a wide range of soft-skinned fruit crops, leading to direct damage from larval feeding and secondary infections that can render fruits unmarketable. This could lead to increased production costs, market access limitations due to quarantine restrictions, and potential trade disruptions. The costs associated with monitoring and controlling the spread of *C. capitata* can also be significant.

14. Phytosanitary measures

Removal or treatment of soil and other growing media from plants for planting with roots from areas where *C. capitata* is known to occur. Physical barriers such as wrapping fruit with newspapers, paper bags, or polythene sleeves prevent oviposition. Proper sanitation including removal, burial and destruction of fallen and leftover fruits can be deployed to reduce reproduction sites for the pest. Pesticides can also be integrated as part of management of this pest. Fly-proof packaging of commodities could also be deployed.

15. References

Ceratitis capitata (Mediterranean fruit fly) | CABI Compendium (cabidigitallibrary.org)

Huang, C. G., Hsu, J. C., Haymer, D. S., Lin, G. C., & Wu, W. J. (2009). Rapid identification of the Mediterranean fruit fly (Diptera: Tephritidae) by loop-mediated isothermal amplification. *Journal of economic entomology*, *102*(3), 1239–1246. https://doi.org/10.1603/029.102.0350

9.1.2 Oomycota

9.1.2.1 Express pest risk assessment of *Phytophthora kernoviae*

1. Taxonomy

Kingdom: Chromista, Phylum: Oomycota, Class: Oomycetes, Order: Peronosporales, Family: Peronosporaceae, Genus: *Phytophthora*, Species: *Phytophthora kernoviae*

Common names: Beech bleeding canker, Rhododendron dieback

EPPO Code: PHYTKE

2. Conclusion and summary

The current Norwegian plant health regulations are likely insufficient to prevent introduction of *P. kernoviae* to Norway trough soil and growing media.

Phytophthora kernoviae presents a significant risk to a wide range of woody plants. It is known for causing bleeding cankers and leaf necrosis across various genus, including *Rhododendron, Quercus, Fagus, Magnolia,* and *Vaccinium*. Its impacts are documented extensively in the United Kingdom, Ireland, New Zealand, Argentina, and Chile. With a very high-risk classification due to its substantial invasion potential and medium ecological effects, *P. kernoviae* could lead to widespread infection and significant ecological disruption if introduced into Norway. The Norwegian Species Observation Service's Alien Species List 2023 concluded that "*Phytophthora kernoviae* is assessed as Very High Risk (SE). The potential for invasion is considered significant and the ecological effect of the species is medium."

3. Is the pest a vector?

No, *P. kernoviae* is not a vector.

4. Is a vector needed for pest entry or spread?

No, *P. kernoviae* does not require a vector.

5. Regulatory status of the pest

Norway: not regulated

EU: not regulated

UK: Quarantine pest (A2-list)

EPPO A2 List of pests recommended for regulation as quarantine pests.

6. Distribution in Europe

United Kingdom (England, Scotland, Wales).

7. Host plants in Norway

Rhododendron spp. (including *Rhododendron ponticum*), *Fagus sylvatica* (European Beech), *Vaccinium myrtillus* (Bilberry), *Magnolia* spp., *Aesculus hippocastanum* (Horse Chestnut), and *Quercus robur* (English Oak).

8. Growing media for entry

Rating of the likelihood of entry: Likely

Rating of uncertainty: Low

Soil and growing media represent significant pathways for the entry and spread of *P. kernoviae* into Norway. This pathogen can survive in soil and plant debris, making it capable of being transported through contaminated soil or growing media associated with plant material. EFSA (2015) recognized sand, compost, and peat as pathways. In addition, oospores survive on soil and plant debris. These oospores can remain viable for extended periods under suitable conditions, posing a risk when soil or debris is moved from one location to another. Nurseries and gardens are common environments where *P. kernoviae* may be present, especially in areas where infected plants have been grown or treated. The pathogen can be transferred through the movement of contaminated soil and growing media. Commercial potting mixes and other growing media can become contaminated if they are stored near infected plants or if they incorporate materials (such as compost or bark) that have been in contact with the pathogen. The distribution of any of these products can lead to the spread of *P. kernoviae*.

9. Likelihood of establishment outdoors in Norway

Probability of establishment outdoors: Likely

Rating of uncertainty: Medium

Phytophthora kernoviae grows best at around 18°C and has an upper limit for growth at approximately 26°C (CABI pest compendium). Southern Norway, with its milder and more temperate climate, could offer suitable conditions during the warmer months. High humidity and wet conditions favor the spread and establishment of most *Phytophthora* species. Norway's high rainfall, especially along the west coast, could facilitate the pathogen's dispersal and infection cycles, particularly in densely planted areas or regions with a history of *P. ramorum* outbreaks.

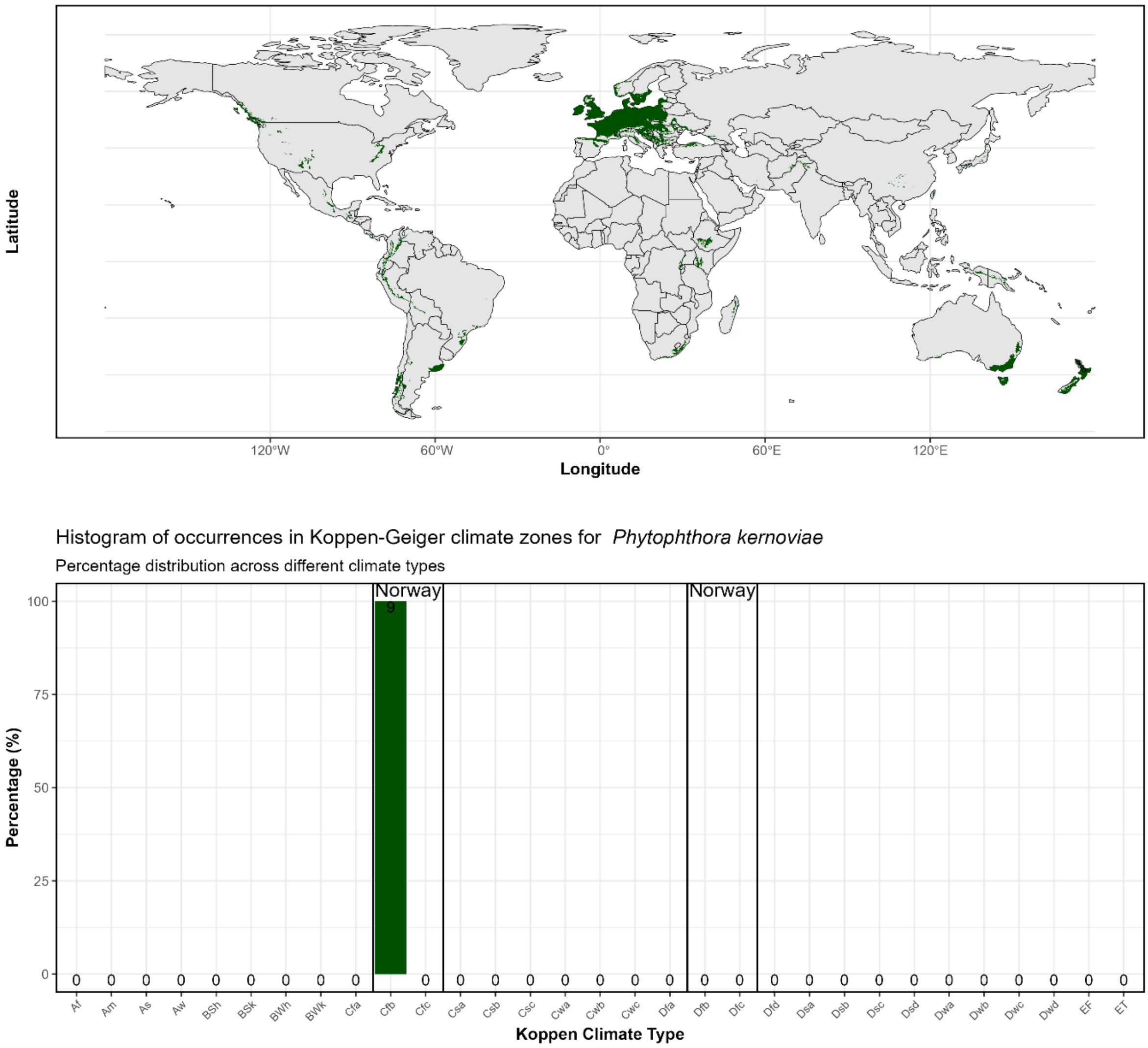

Figure 1. Recorded occurrences of *Phytophthora kernoviae* (black circles) overlaid on a world map showing the Köppen-Geiger climate types where the species has been recorded in. The histogram shows the frequency distribution of *P. kernoviae* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. *Phytophthora kernoviae* has a high population (or reporting rate) in a climate type that occurs in coastal areas in S Norway (Cfb; 100 % of all occurrence points).

10. Likelihood of establishment in protected conditions Norway

Probability of establishment in protected condition: Likely

Rating of uncertainty: High

The likelihood of the establishment of *P. kernoviae* under greenhouse conditions in Norway is generally higher compared to outdoor environments.

11. Spread in the Norway

Probability of spread: Unlikely

Rating of uncertainty: High

The primary mechanism for long-distance spread of *P. kernoviae* is through the trade of infected plants and associated growing media. Once established, local spread occurs through spores in soil, water, and air. Spread is facilitated by rain splash, wind-driven rain, and human activities such as plant transport (VKM, 2023). The expected spread rate of *P. kernoviae* in Norway is between 160 and 499 meters per year (Pettersson 2023).

12. Impact in the current area of distribution

Rating of the magnitude of impact in the current area of distribution: As likely as not

Rating of uncertainty: Medium

In the UK, the pathogen has had an impact on native woodlands and ornamental gardens. It causes bleeding cankers and leaf necrosis in a variety of hosts, including beech trees (*Fagus sylvatica*), rhododendrons (*Rhododendron* spp.), and bilberries (*Vaccinium myrtillus*), leading to declines in these species and alterations in forest structure and biodiversity (CABI compendium)

13. Potential impact in Norway

According to Pettersson (2023), *P. kernoviae* is classified as having a "very high risk" due to its substantial invasion potential, which could lead to widespread infection and a significant negative ecological impact. Similarly, to *P. ramorum, P. kernoviae* can sporulate on asymptomatic plant tissue (Denman et al. 2009). Given the pathogen's broad host range, including species within the genera *Rhododendron, Quercus, Fagus, Magnolia,* and *Vaccinium*, its introduction to Norway could have negative consequences for biodiversity, forests, parks, and natural landscapes.

14. Phytosanitary measures

Plants should originate from areas known to be free from the pathogen, or from places of production where symptoms of the disease are not observed during official inspections. Plants must be propagated from healthy stock. Regular testing of irrigation water and SGM by baiting with rhododendron leaves could be integrated into the routine of nurseries. Strict sanitation and hygiene measures such as removal and proper disposal of infected plants and associated soil and growing media within a given radius, cleaning machinery and footwear etc. used in contaminated areas are crucial to contain infection and restrict spread of the pathogen. Public awareness about the pathogen could also aid in early detection and eradication efforts.

15. References

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Report of a Pest risk management for *P. kernoviae* and *P. ramorum*. EPPO (13-18715)

VKM, Iben Margrete Thomsen, Beatrix Alsanius, Daniel Flø, Paal Krokene, Micael Wendell, Sandra A. I. Wright, Christer Magnusson, Johan Stenberg, Jorunn Børve, Line Nybakken, Mogens Nicolaisen, May-Guri Sæthre (2023). Updated pest risk assessment of Phytophthora ramorum in Norway. Scientific Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment. VKM Report 2023:XX, ISBN: 978- 82-8259-430-1, ISSN: 2535-419. Norwegian Scientific Committee for Food and Environment (VKM), Oslo, Norway.

9.1.3 Fungi

9.1.3.1 Express pest risk assessment of *Verticillium dahliae*

1. Taxonomy

Kingdom: Fungi, Phylum: Ascomycota, Subphylum: Pezizomycotina, Class: Sordariomycetes, Subclass: Hypocreomycetidae, Family: Plectosphaerellaceae, Genus: *Verticillium,* Species: *Verticillium dahliae*

Common Names: Verticillium wilt

EPPO Code: VERTDA

2. Conclusion and summary

The current plant health regulations may be insufficient to prevent the introduction and spread of *V. dahliae* in Norway.

Verticillium dahliae is a significant fungal pathogen affecting many economically important crops and ornamental plants. This disease leads to wilting, stunting, and death of infected plants. The pathogen has a broad host range, affecting plants in over 14 different families, and is known for its high genetic variability, complicating management efforts. Given its wide distribution and ability to be seed-borne, the risk of introduction and establishment in Norway, particularly through the trade of infected plant material with growing media containing compost, is likely.

3. Is the pest a vector?

No, *V. dahliae* is not a vector.

4. Is a vector needed for pest entry or spread?

No, *V. dahliae* does not require a vector for entry or spread.

5. Regulatory status of the pest

EU and United Kingdom RNQP (Annex IV)

6. Distribution in Europe

Verticillium dahliae has a widespread distribution in Europe.

7. Host plants in Norway

Main horticultural hosts include lettuce, tomato, potato.

Other significant hosts are various woody and herbaceous ornamental species including *Fraxinus excelsior*, *F. pennsylvanica*, *Acer palmatum*, *A. platanoides*, *A. saccharinum*, *Rosa* spp.

8. Growing media for entry

Rating of the Likelihood of Entry: Likely

Rating of Uncertainty: Low

Compost plant debris is probably a significant pathway for the entry and spread of *V. dahliae*. The pathogen produces microsclerotia that can survive in soil and on plant debris for extended periods, posing a risk through the movement of contaminated soil, plant material, compost, and growing media.

9. Likelihood of establishment outdoors in Norway

Probability of Establishment Outdoors: Likely

Rating of Uncertainty: Low

Norway's climate and agricultural practices will likely provide suitable conditions for the establishment and spread of *V. dahliae*, especially along the coastal areas where susceptible crops are grown.

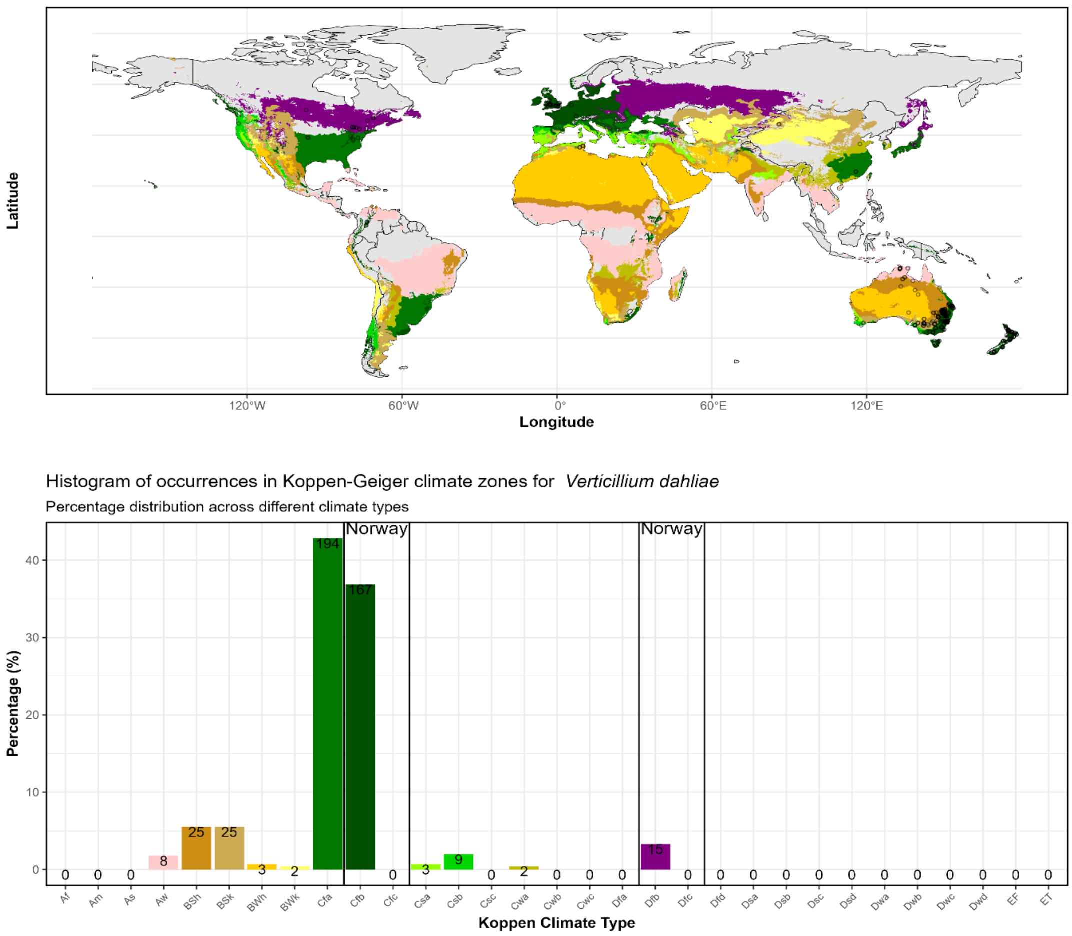


Figure 1. Recorded occurrences of *Verticillium dahliae* (black circles) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *V. dahliae* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. *Verticillium dahliae* has a high population (or reporting rate) in a climate type that occurs in coastal areas of S Norway (Cfb; 37 % of all occurrence points).

10. Likelihood of establishment in protected conditions in Norway

Probability of Establishment in Protected Condition: Likely

Rating of Uncertainty: Low

The pathogen can be established in greenhouse conditions, where it can infect susceptible plants year-round.

11. Spread in Norway

Probability of Spread: Likely

Rating of Uncertainty: Low

Verticillium dahliae may spread through the movement of infected plants, compost, and soil, as well as through wind and water. Its broad host range and persistence in soil make it a challenging pathogen to manage.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: Likely

Rating of Uncertainty: Low

Verticillium dahliae has caused significant agricultural losses in regions where it is established, impacting yields and quality of various crops.

13. Potential impact in Norway

The introduction of *V. dahliae* to Norway could significantly impact agriculture. Due to its wide host range and the difficulty of managing the disease, the economic and ecological effects could be substantial.

14. Phytosanitary measures

Integrated measures combining site selection, healthy planting material, crop rotation, use of resistant cultivars, and soil solarization reduce incidences of the disease. Site selection and cropping history are key as the pathogen has a high survival rate in the soil and has a wide host range. Import requirements such as propagation from pathogen-free mother plants and inspection at appropriate times for symptoms of *V. dahliae* before dispatch could be included. In addition, the import of *V. dahliae* host plants could be restricted to production sites with a known cropping history and no record of *V. dahliae* incidence.

15. References

CABI Compendium

EPPO Global database

EFSA PLH Panel (EFSA Panel on Plant Health), 2014. Scientific Opinion on the pest categorisation of *Verticillium dahliae* Kleb. *EFSA Journal* 2014; 12(12):3928, 54 pp. doi:10.2903/j.efsa.2014.3928

9.1.4 Nematoda

9.1.4.1 Express pest risk assessment of *Meloidogyne fallax*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Meloidogynidae, Genus: *Meloidogyne*, Species: *Meloidogyne fallax*

Common Names: false Columbia root-knot nematode

EPPO Code: MELGFA

2. Conclusion and summary

Meloidogyne fallax poses a significant risk to a wide range of agricultural and horticultural crops, including but not limited to potatoes, carrots, and strawberries. Its ability to affect a diverse range of host plants and its presence in neighboring regions (Sweden, EPPO 2020) necessitates rigorous measures to prevent introduction and spread. The economic and ecological impacts in currently infested regions underscore the potential threat it could pose if introduced and established in new areas, including Norway.

3. Is the pest a vector?

No, *M. fallax* does not act as a vector for other diseases.

4. Is a vector needed for pest entry or spread?

No, *M. fallax* does not require a vector.

5. Regulatory status of the pest

Meloidogyne fallax is a quarantine pest in Norway.

EU A2 quarantine pest (Annex II B)

EPPO A2

6. Distribution in Europe

Initially detected in the Netherlands in 1992, *M. fallax* has been found locally in Belgium, France, Germany, Sweden, Switzerland, and the United Kingdom (specifically in England) within the EPPO region. Outside of Europe, *M. fallax* has been reported in countries across several continents, including Australia, Chile, New Zealand, and South Africa, and New Zealand.

7. Host plants in Norway

Given its wide host range, many crops and ornamental plants grown in Norway could be potential hosts. These include potatoes (*Solanum tuberosum*), carrots (*Daucus carota*), and tomatoes (*Solanum lycopersicum*). Its impact on ornamentals and weeds suggests a potential risk to similar plant species grown in Norway. Sports turf or turf grass is a special concern for the pest.

8. Growing media for entry

Rating of the Likelihood of Entry: Likely

Rating of Uncertainty: Medium

Meloidogyne fallax can enter through the movement of infested plants (including turf), soil, and growing media.

9. Likelihood of establishment outdoors in Norway

Probability of Establishment Outdoors: As likely as not

Rating of Uncertainty: Medium

The pest's broad host range and adaptability to different climates suggest a potential for establishment if introduced.

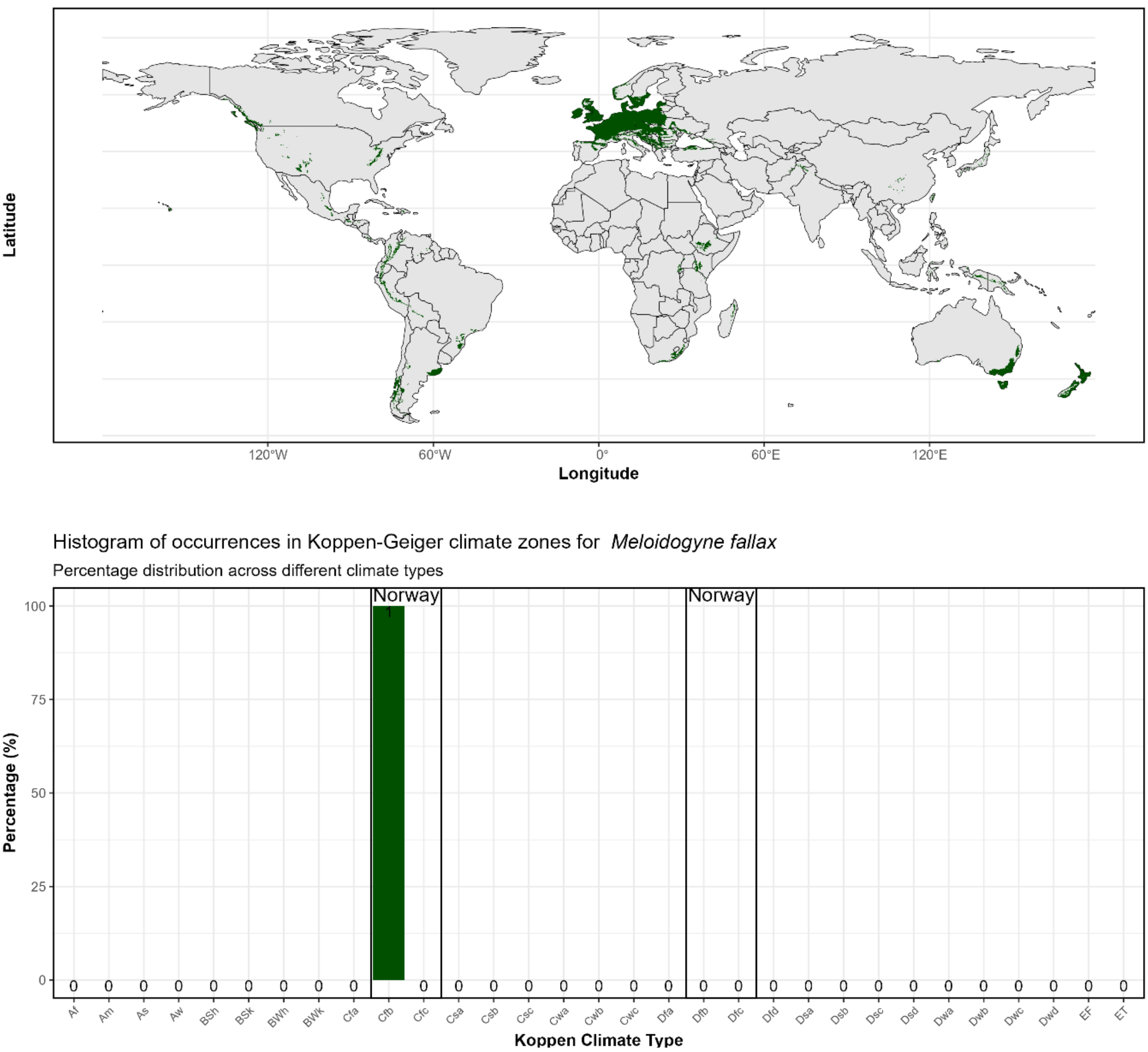


Figure 1. Recorded occurrences of *Meloidogyne fallax* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *M. fallax* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. The single occurrence point of *M. fallax* is in a climate type that occurs in coastal areas of S Norway (Cfb).

10. Likelihood of establishment in protected conditions in Norway

Probability of Establishment in Protected Condition: As likely as not with

Rating of Uncertainty: Medium

The controlled environments of greenhouses could offer suitable conditions for *M. fallax*, irrespective of outdoor climate conditions. The low degree to which root systems of plants for planting are inspected and the difficulty in detecting early asymptomatic infections would open the establishment of glasshouse crops.

11. Spread in Norway

Probability of Spread: As likely as not

Rating of Uncertainty: Medium

Meloidogyne fallax has a high potential for invasion (Magnusson et al. 2023). Once established, *M. fallax* could spread through contaminated soil and plant material movement within Norway.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: Likely
Rating of uncertainty: Low

Meloidogyne fallax has demonstrated a significant impact on various host crops in its current distribution areas, leading to economic and qualitative losses. The nematode primarily affects potatoes, carrots, and black salsify, causing external galling and, in potatoes, internal necrosis just below the skin, which can lead to the rejection of these crops if infection levels are high (MacLeod et al. 2012). In potato tuber, galling results from the invasion of the second generation of infective juveniles. This is expected in Rogaland, Oslo, Akershus, and Østfold (Magnusson pers. comm.).

13. Potential impact in Norway

The introduction of *M. fallax* into Norway could reduce crop yields and increase management costs, affecting agricultural productivity and biodiversity. In the UK, the pest damage sports turf (EPPO 2015, DEFRA 2017).

14. Phytosanitary measures

Plants and growing media should originate from pest-free areas or pest-free sites of production. Soil and growing media should be treated by heat and protected from contamination before being used in production. Potted plants should be physically isolated from soil by concrete floors, membranes, or benches. The use of clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems. Symptomatic plants should be destroyed. Root washing will not remove sedentary endoparasitic nematodes like *M. fallax.*

15. References

CABI Compendium.

DEFRA (Department for Environment Food and Rural Affairs), 2017. The nematode Meloidogyne fallax in sports turf: symptoms, biosecurity, guidance, and control. Plant Pest Factsheet, 5 pp. Available online: https://planthealthportal.defra.gov.uk/assets/factsheets/Meloidogyne-fallax-turf-biosecurity-guide-revision-date.pdf

EPPO (European and Mediterranean Plant Protection Organization), 2015. Meloidogyne fallax was detected on sports turf in the United Kingdom. EPPO Reporting Service No. 10-2015. Available online: https://gd.eppo.int/reporting/article-5137 [Accessed: 20 February 2023].

EPPO-Reporting-Service (2020). Update on the situation of Meloidogyne fallax in Sweden. https://gd.eppo.int/reporting/article-6850

MacLeod A, Anderson H, Follak S, van der Gaag DJ, Potting R, Pruvost O, Smith J, Steffek R, Vloutoglou I, Holt J, Karadjova O, Kehlenbeck H, Labonne G, Reynaud P, Viaene N, Anthoine G, Holeva M, Hostachy B, Ilieva Z, Karssen G, Krumov V, Limon P, Meffert J, Niere B, Petrova E, Peyre J, Pfeilstetter E, Roelofs W, Rothlisberger F, Sauvion N, Schenck N, Schrader G, Schroeder T, Steinmöller S, Tjou-Tam-Sin L, Ventsislavov V, Verhoeven K, and Wesemael W, 2012. Pest risk assessment for the European Community plant health: a comparative approach with case studies. Cases: Meloidogyne chitwoodi and M. fallax. Supporting publications 2012:EN-319. 1053 pp. Available online: www.efsa.europa.eu/publications

Magnusson C, Hamnes I, Karlsbakk E & Tangvik MP (2023). Rundormer: Vurdering av *Meloidogyne fallax* for Fastlands-Norge med havområder. Fremmedartslista 2023. Artsdatabanken. http://www.artsdatabanken.no/lister/fremmedartslista/2023/1704

9.1.4.2 Express pest risk assessment of *Meloidogyne enterolobii*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Meloidogynidae, Subfamily: Meloidogyninae, Genus: *Meloidogyne,* Species: *Meloidogyne enterolobii*

EPPO Code: MELGMY

Common name: *Guava root-knot nematode*

2. Conclusion and summary

Meloidogyne enterolobii is a quarantine pest in EU and EPPO. *M. enterolobii* is not regulated in Norway. This nematode is one of the most important root-knot nematodes (Moens et al. 2009). Due to parthenogenetic reproduction, only one infective juvenile can start a new population. In Norway, the pest is expected to be established mainly in protected production.

3. Is the pest a vector?

No, *M. enterolobii* is not a vector.

4. Is a vector needed for pest?

No, *M. enterolobii* does not need a vector.

5. Regulatory status

EU quarantine pest. EPPO A2. Not regulated in Norway.

6. Distribution in Europe

Switzerland and Portugal were eradicated in France (EPPO GD). No surveys for *M. enterolobii* have been conducted in Europe, so the pest distribution may be more comprehensive than currently known.

7. Host plants in Norway

Meloidogyne enterolobii is a tropical and subtropical nematode, so under Nordic conditions it is expected to damage plants like tomatoes, cucumbers, roses, cactus, and *Ficus* under protected conditions (EPPO 2021).

8. Growing media for entry

Rating of likelihood of entry: Unlikely
Rating of uncertainty: Medium

Meloidogyne enterolobii was intercepted in the Netherlands and Belgium on plants for planting (EPPO GD). Hence, the main pathways are plants for planting and soil attached to roots, tubers, bulbs, and rhizomes. In the case of infections by this pest, the damage is so dramatic that infested plants would be destroyed.

9. Likelihood for establishment outdoors in Norway

Probability of establishment outdoors: Unlikely
Rating of uncertainty: Low
Meloidogyne enterolobii is a tropical and subtropical pest in field crops, so outdoor conditions in Norway will not allow its reproduction.

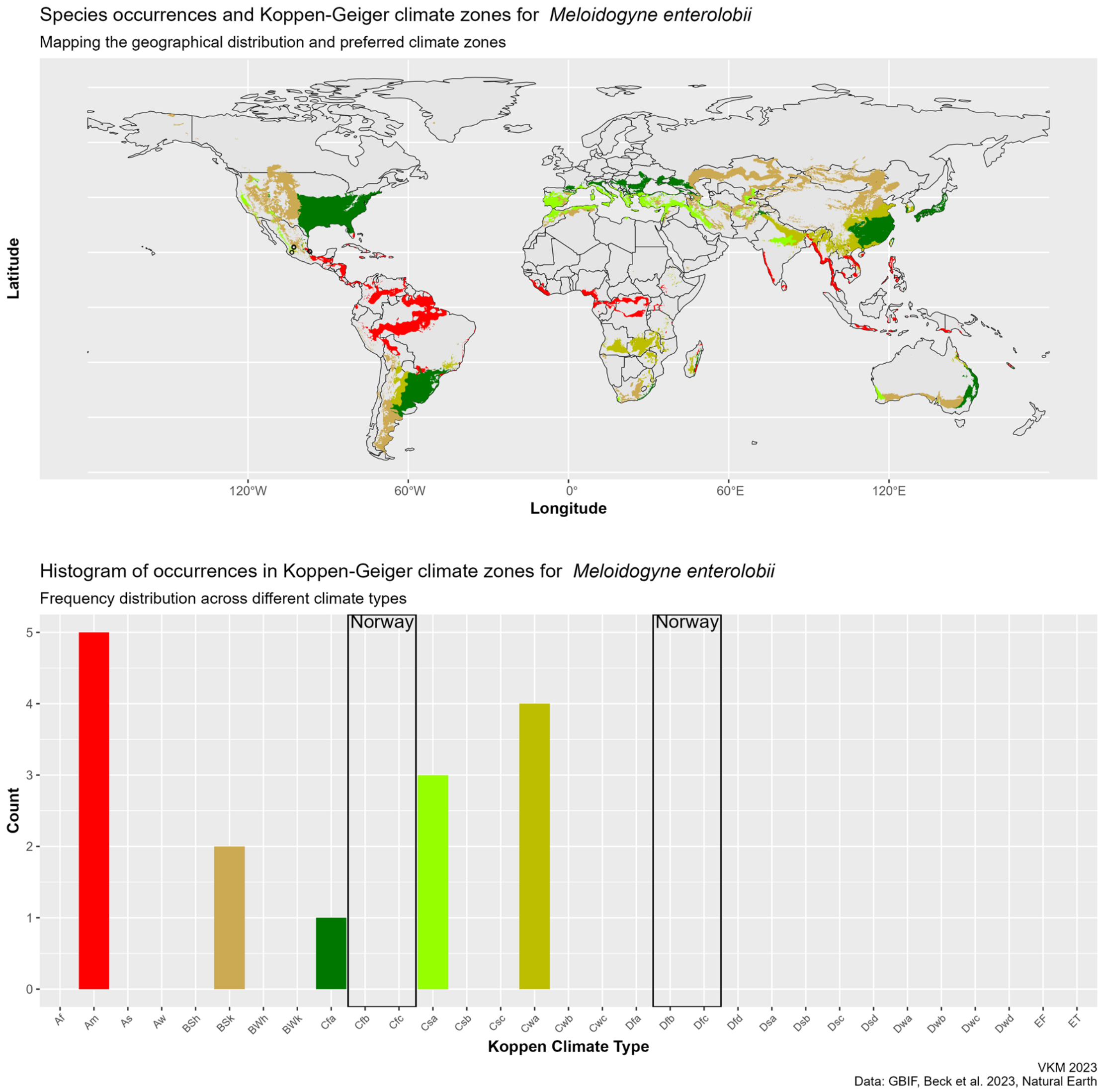


Figure 1. Recorded occurrences of *Meloidogyne enterolobii* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *M. enterolobii* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes.

10. Likelihood for establishment under protected conditions

Probability of establishment in protected condition: As likely as not
Rating of uncertainty: Medium
In Europe, the nematode is known as a pest of glasshouse crops. With medium uncertainty, the probability of the pest establishing in Norwegian protected production is as likely as not.

11. Spread in Norway

Probability of spread: Unlikely
Rating of uncertainty: Medium
The pest can spread only with human assistance, such as moving infested plants, soil, or other equipment. However, the damage is so dramatic that material in infested glasshouses is most likely to be destroyed. Hence, the spread in Norway is unlikely, with a medium uncertainty.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: Likely
Rating of uncertainty: Low

Meloidogyne enterolobii is currently regarded as one of the most important root-knot nematodes due to its broad global distribution, wide host range and its ability to break the resistance conferred by the Mi-1 gene in resistant plants like tomato (Moens et al. 2009). Also, unlike other tropical root-knot nematode species, *M. enterolobii* is considered highly virulent and damaging. This may be related to the induction of bigger galls, which may contribute to the higher reduction of crop yields (EPPO 2021). In greenhouses in Switzerland, a 50 % yield loss occurred in tomatoes and cucumbers.

13. Phytosanitary measures

Plants and growing media should come from pest-free areas or from a pest-free production site. Soil and growing media should be treated by heat and protected from contamination before production. Potted plants should be grown physically isolated from soil by concrete floors, membranes, or benches. Clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems. Symptomatic plants should be destroyed. Root washing will not remove sedentary endoparasitic nematodes like *M. enterolobii*.

14. References

Moens M, Perry R M & Starr J L. 2009. Meloidogyne Species – a Diverse Group of Novel and Important Plant Parasites Chapter 1. In: Root-knot Nematodes. R N Perry, M. Moens & Starr J L (eds). CABI. MPG Books Group, UK: 1-17.

EPPO 2021. Pest Risk Analyses for *Meloidogyne enterolobii*. 46 pp. https://pra.eppo.int/pra/b3f5ee8e-0551-4c8f-84fc-2fb729bb3dd8

9.1.4.3 **Express pest risk assessment** of ***Meloidogyne mali***

1. Taxonomy:

Kingdom: Metazoa, Phylum: Nematoda, Family: Meloidogynidae, Subfamily: Meloidogyninae, Genus: *Meloidogyne,* Species: *Meloidogyne mali*

EPPO Code: MELGMA

Common name: Apple root-knot nematode

2. Conclusion and summary

Meloidogyne mali is not known to be present in Norway. The pest is not regulated in Norway or the EU. In EPPO it is listed on the A2 list. *Meloidogyne mali* is a tree pest causing *Ulmus* trees to get up-rooted in urban environments, i.e.*,* Den Haag in the Netherlands. There is a concern that the nematode could spread to tree nurseries, facilitating further spread. Certain weed plants like *Taraxacum officinale*, *Dryopteris filix-mas,* and others would support the establishment of the pest. *Meloidogyne mali* is considered to represent a very high risk. It has a high potential for invasion with a moderate ecological effect. The pest's broad host spectrum may threaten red-listed species in *Geranium*, *Rubus,* and *Malus*. After entry into Norway, the pest is likely to be established in coastal areas of southern Norway up to Oslo and Akershus and in Telemark (Magnusson et al. 2023).

3. Is the pest a vector?

No, *M. mali* is not a vector.

4. Is a vector needed for pest?

No, *M. mali* does not need a vector.

5. Regulatory status

Not regulated in Norway and EU. The pest is listed on the A2 list of EPPO.

6. Distribution in Europe

Belgium, England, Italy, the Netherlands, and France (under eradication)

7. Host plants in Norway

Apium graveolens, Brassica oleracea var. capitata, Dryopteris filix-mas, Fagus sylvatica, Geranium robertianum, Malus domestica, Morus spp.*, Quercus robur, Rosa* spp*, Rubus fruticosus, Rubus idaeus, Solanum lycopersicum, Sorbus aucuparia, Taraxacum officinale, Taxus baccata, Trifolium repens, Ulmus glabra* and *Utrica dioica*.

8. Growing media for entry

Rating of likelihood of entry: Likely
Rating of uncertainty: Medium

M. mali has spread with trees (*Ulmus* spp) imported to Europe. All growing media associated with infected trees will harbor high levels of nematodes. The latent period is about 30 years (EPPO 2018), so the pest may enter via plants without symptoms, which have nematodes in the roots and the associated growing medium.

9. Likelihood for establishment outdoors in Norway

Probability of establishment outdoors: As likely as not
Rating of uncertainty: Medium

The pest is a parasite frequently associated with trees. Many common forest trees in Norway are hosts of the pest. The climatic conditions of southern Norway are conducive to establishment (Magnusson et al. 2023). The probability of establishment is as likely as not with medium uncertainty.

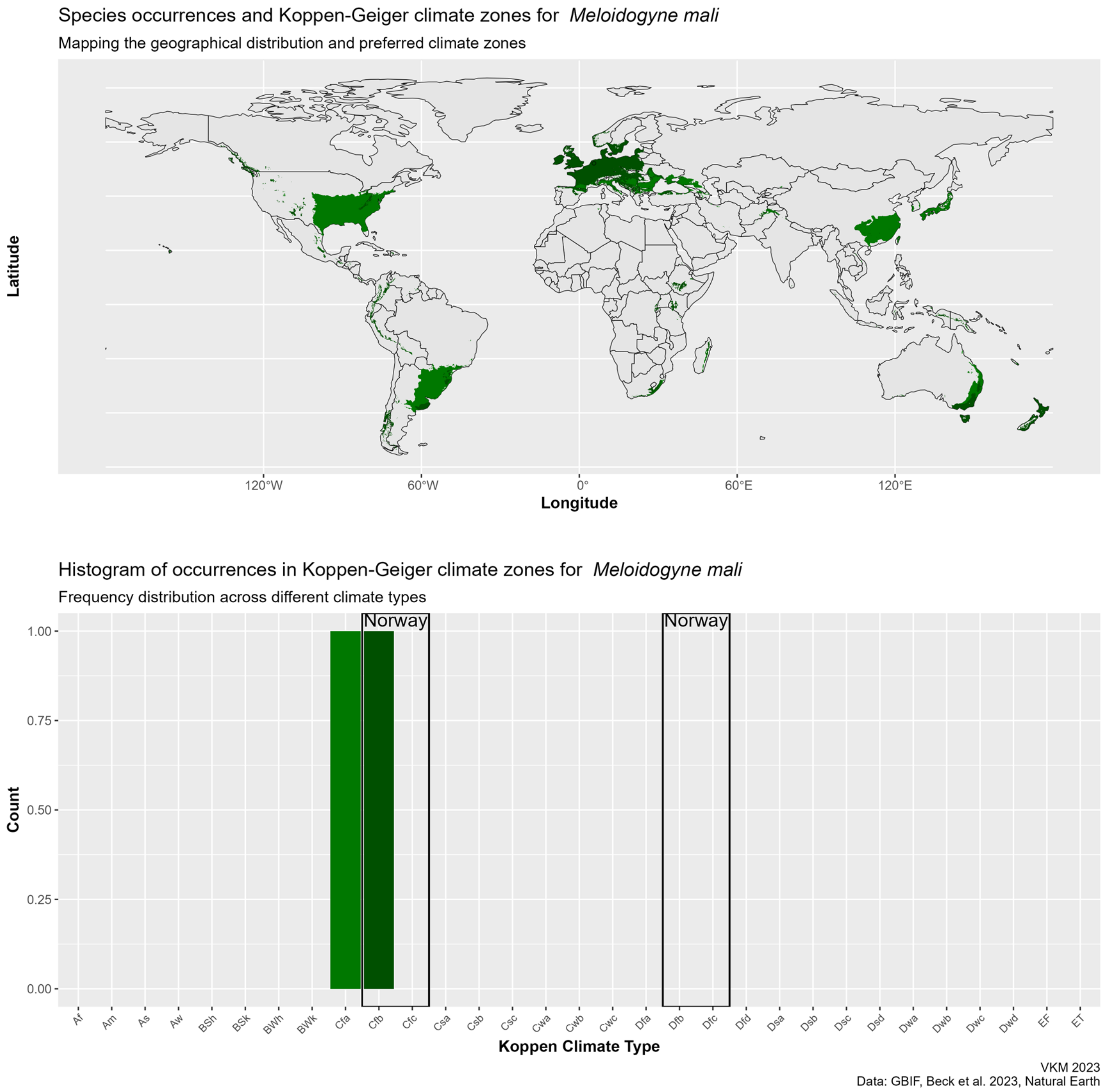


Figure 1. Recorded occurrences of *Meloidogyne mali* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *M. mali* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes.

10. Likelihood for establishment under protected conditions

Probability of establishment in protected condition: Unlikely
Rating of uncertainty: Low
The pest in the Netherlands has been recorded on tomatoes under glasshouse conditions (EPPO 2018). However, forest soil is not commonly used in protected production systems.

11. Likelihood for spread in Norway

Probability of spread: As likely as not
Rating of uncertainty: Medium

Like all nematodes, the pest can spread only with human assistance in moving infested plants, soil, or equipment.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: As likely as not
Rating of uncertainty: Medium
The pest causes dramatic root-galling and is associated with increased sensitivity and lower stability of the trees due to root rot caused by secondary pathogens through openings developing in older galls, leading to windfalls as reported for urban trees in the Netherlands (EPPO PRA 2018). For this to happen it may take 30 years after infection (Karssen pers comm. 2018). In Japan, *M. mali* is regarded as one of the most important nematodes that damage apple trees. In 36–50-year-old trees the pest has caused reductions in plant growth and fruit yields (EPPO PRA 2018). From other countries in Europe, little information is available on damage.

13. Potential impact in Norway

The pest may damage landscape plantings by destabilizing trees. If it spreads to agricultural and horticultural areas, it may damage crops like raspberries and apples.

14. Phytosanitary measures

Plants and growing media should originate from pest-free areas or pest-free production sites. Soil and growing media should be treated by heat and protected from contamination before production. Potted plants should be physically isolated from soil by concrete floors, membranes, or benches. Clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems. Symptomatic plants should be destroyed. Root washing will not remove sedentary endoparasitic nematodes like *M. mali.*

15. References

EPPO (European and Mediterranean Plant Protection Organization) (2018). Pest Risk Analysis for *Meloidogyne mali*, apple root-knot nematode. http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm and https://gd.eppo.int/taxon/MELGMA

Magnusson C, Hamnes I, Karlsbakk E og Tangvik MP (2023). Rundormer: Vurdering av *Meloidogyne mali* for Fastlands-Norge med havområder. Fremmedartslista 2023. Artsdatabanken. http://www.artsdatabanken.no/lister/fremmedartslista/2023/4844

9.1.4.4 Express pest risk assessment of *Pratylenchus vulnus*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Pratylenchidae, Subfamily: Pratylenchinae, Genus: *Pratylenchus,* Species: *Pratylenchus vulnus*

EPPO Code: PRATVU

Common name: Root lesion nematode

2. Conclusion and summary

Pratylenchus vulnus needs high temperatures (25–32 °C) for reproduction. In Norway, it has not been recorded in field soils but was reported on roses in protected production (Castillo & Vovlas, 2007) and routine samples to the NIBIO Plant clinic.

3. Is the pest a vector?

No, *P. vulnus* is not a vector.

4. Is a vector needed for pest?

No, *P. vulnus* does not need a vector.

5. Regulatory status

In the EU, *P. vulnus* is a regulated non-quarantine pest (RNQP) with a 0 % tolerance on *Fragaria, Malus, Prunus* spp., and other plants (Annex IV). There is no regulation in EPPO. In Norway, the pest is not regulated.

6. Distribution in Europe:

Belgium, Denmark, England, Finland and Norway. The pest is frequently associated with trees in several southern European countries (EPPO GD, Castillo & Vovlas 2007).

7. Host plants in Norway

Rose and other ornamental plants are under protected cultivation.

8. Growing media for entry

Rating of likelihood of entry: Likely
Rating of uncertainty: Medium
In Norway, the pest has been detected on several occasions in relation to protected production. The source of infection has been growing media and plants for planting.

9. Likelihood for establishment outdoors in PRA

Probability of establishment outdoors: Unlikely
Rating of uncertainty: Low

In the field, the pest is present in tropical and subtropical areas. In northern Europe, it is mainly known as a pest of glasshouse crops.

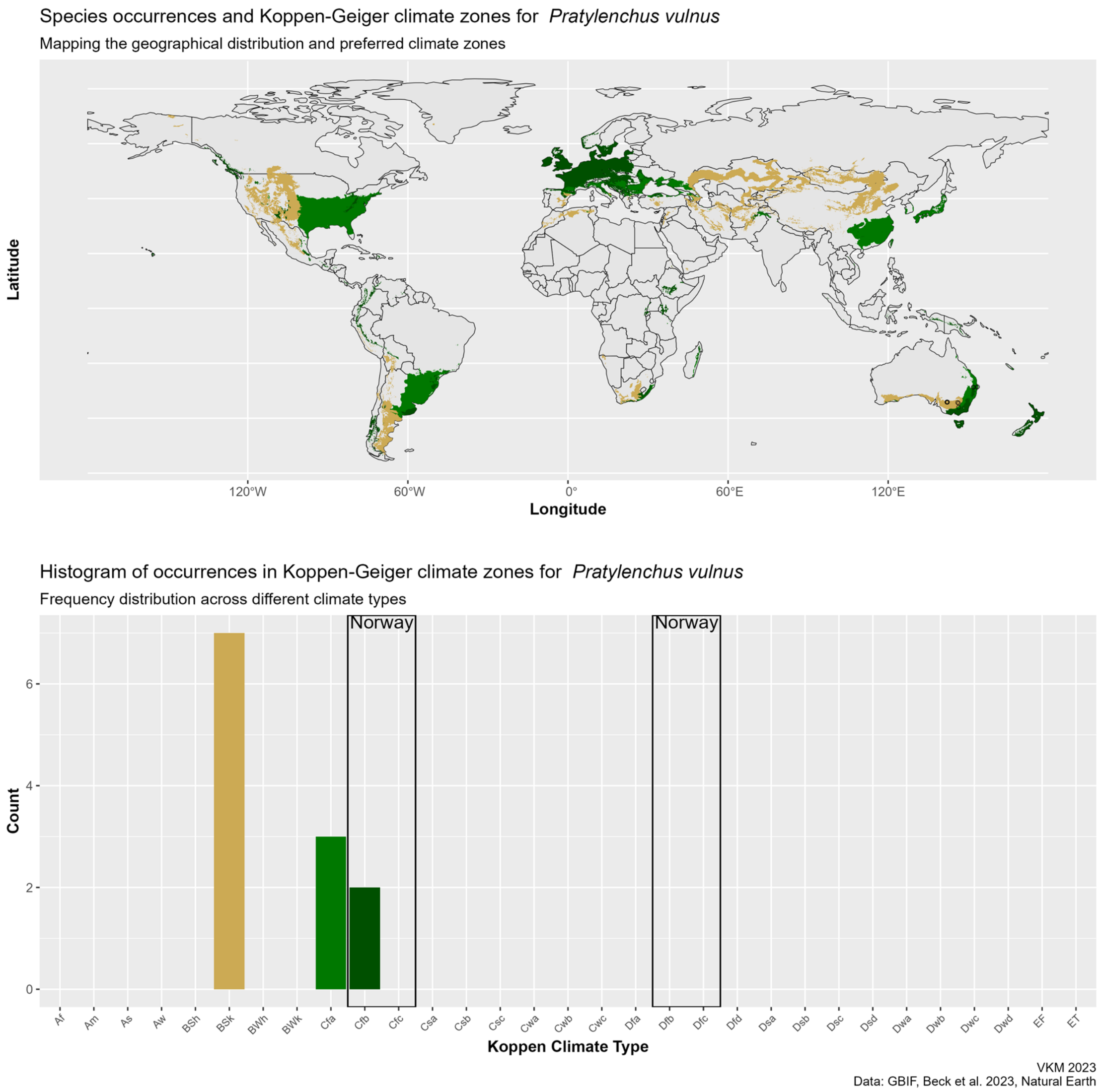


Figure 1. Recorded occurrences of *Pratylenchus vulnus* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *P. vulnus* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. The two occurrences point of *P. vulnus* is in a climate type that occurs in coastal areas of S Norway (Cfb).

10. Likelihood for establishment under protected conditions

Probability of establishment in protected condition: Likely
Rating of uncertainty: Low
P. vulnus has been detected in Norwegian glasshouse production, which confirms its capability for establishment in protected production systems in Norway.

11. Likelihood for spread in Norway

Probability of spread: Unlikely
Rating of uncertainty: Low
The pest can spread only with human assistance in moving infested soil or other equipment. The damage is dramatic; the material in infested glasshouses is most likely destroyed.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: As likely as not
Rating of uncertainty: Low
Damage has been recorded for ornamentals under protected conditions. In southern Europe, damage has been reported on roses, peaches, and olives (Corbett, 1974).

13. Potential impact in Norway

In northern Europe, *P. vulnus* is a pest of plants grown under protected production (Corbett, 1974). This was reported for roses in glasshouse production in Norway (Castillo & Vovlas, 2007).

14. Phytosanitary measures

Plants and growing media should originate from pest-free areas or pest-free production sites. Soil and growing media should be treated by heat and protected from contamination before production. Potted plants should be physically isolated from soil by concrete floors, membranes, or benches. Clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems regarding necrotic wounds. Symptomatic plants should be destroyed. Root washing will not remove migratory endoparasitic nematodes like *P. vulnus*.

15. References

Castillo P & Vovlas N (2007). Pratylenchus (Nematoda: Pratylenchidae): Diagnosis, Biology, Pathogenicity and Management. Nematology Monographs and Perspectives 6: 529 pp.
Corbett D C M (1974). *Pratylenchus vulnus*. C.I.H. Descriptions of Plant-parasitic Nematodes. Set 3, No. 37: 4 pp.

9.1.4.5 Express pest risk assessment of *Paralongidorus maximus*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Longidoridae, Subfamily: Longidorinae. Genus: *Paralongidorus,* Species: *Paralongidorus maximus*.

EPPO Code: LONGMX

Common name: Needle nematode

2. Conclusion and summary

This species is not regulated in the EU or Norway. It occurs in central Europe and the British Isles. The pest is polyphagous, attacking many cultivated plants, except for grasses. It can transmit the Raspberry Ring Spot virus. Long, warm, humid summers are optimal for its development (Heyns, 1975). The pest is generally strongly associated with diseased plants (Heyns, 1975). It has a high invasive potential, according to Magnusson et al. (2023). After entry, the pest is expected to be established in Southern Norway in the coastal regions from Hordaland to Østfold (Magnusson et al. 2023). The pathway is plants for planting and associated soil and growing media.

3. Is the pest a vector?

Yes, for Raspberry ring spot virus (RRSV) (Taylor & Brown, 1997).

4. Is a vector needed for pest entry or spread?

No, a vector is not needed.

5. Regulatory status of the pest

Not regulated.

6. Distribution in Europe

Reported in Austria, France, Hungary, Germany, Poland, Portugal, England, and Scotland (Heyns, 1975; Magnusson et al. 2023).

7. Host plants in Norway

Paralongidorus maximus is highly pathogenic, causing severe root deformation and dysfunction in various cultivated and forest tree species. Affected plants include carrot, lettuce, celery, cucumber, leek, onion, cauliflower, bean, asparagus, garden beet, potato, strawberry, parsley, *Rosa* spp., Tagetes, and genera such as *Abies, Alnus, Acer, Pinus, Larix, Quercus, Corylus, Picea,* and *Thuja.*

8. Growing media for entry

Rating of the likelihood of entry: Likely
Rating of uncertainty: Medium
Paralongidorus maximus can be introduced to new areas through plants for planting and via infested soil or growing media. This is of particular concern for plantations and forestry, where

plants from nurseries with soil adhering to their roots are planted out in new locations (Magnusson et al. 2023).

9. Likelihood of establishment outdoors in Norway

Probability of establishment outdoors: As likely as not
Rating of uncertainty: Medium
Paralongidorus maximus is found in France, Hungary, Germany, Poland, Portugal, England, and Scotland, which in some areas have climates also represented in Norway, suggesting it might be adapted to conditions similar to those in parts of Norway. The climate in Norway, especially in the southern coastal regions, may provide a suitable environment for the nematode to survive, reproduce, and establish populations. However, this is highly uncertain due to lack of data. Trade with ornamental plants from Europe would be an efficient pathway for entry.

10. Likelihood of establishment in protected conditions in Norway

Rating of the Likelihood of Entry: Likely as not

Rating of Uncertainty: Medium

Greenhouses or nurseries where external factors, including temperature, humidity, and soil conditions, are effectively managed increase the risk of establishment for pests like *P. maximus*.

11. Spread in Norway

Probability of Spread: As likely as not

Rating of Uncertainty: Medium

Like other nematodes *P. maximus* needs human assistance by moving of infested soil and plants.

12. Impact in the current area of distribution

Rating of the Magnitude of Impact in the Current Area of Distribution: Likely as not

Rating of Uncertainty: Medium

P. maximus is highly polyphagous and infests trees in the genera *Abies, Alnus, Acer, Pinus, Larix, Carpinus, Robinia, Quercus, Corylus*, and *Picea*. *Thuja* and raspberry can also be parasitized. Several vegetables have been affected, including carrots, onions, and potatoes. Symptoms include severe damage and reduced root systems, which can lead to stunted growth, dwarfism, and plant death (Heyns 1975).

13. Potential impact in Norway

The introduction of *P. maximus* into Norway could reduce crop yields and increase management costs, affecting agricultural and forestry productivity, landscape plantings, and biodiversity.

14. Phytosanitary measures

Plants and growing media should originate from pest-free areas or pest-free production sites. Soil and growing media should be treated by heat and protected from contamination before being used in production. Potted plants should be grown physically isolated from soil by concrete floors, membranes, or benches. The use of clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems. Symptomatic plants should be destroyed. High-pressure root washing will remove ectoparasites like *P. maximus*.

15. References

Heyns, J. (1975). *Paralongidorus maximus*. C.I.H. Description of Plant-parasitic Nematodes. Set 5 No 75. 4 pp.

Magnusson C, Hamnes I, Karlsbakk E & Tangvik MP (2023). Rundormer: Vurdering av *Paralongidorus maximus* for Fastlands-Norge med havområder. Fremmedartslista 2023. Artsdatabanken. http://www.artsdatabanken.no/lister/fremmedartslista/2023/4848

Sturhan, D. Nematode Vectors of Plant Viruses. 1997. C.A. Taylor and D.J.F. Brown. Integrated Pest Management Reviews 4, 270–271 (1999). https://doi.org/10.1023/A:1009677725038

9.1.4.6 Express pest risk assessment of *Radopholus similis*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Pratylenchidae, Subfamily: Radopholinae, Genus: *Radopholus,* Species: *Radopholus similis.*

EPPO Code: RADOSI

Common name: Burrowing nematode

2. Conclusion and summary

Radopholus similis need warm (24–32 °C) and humid conditions for its development but has adapted also to temperatures of 15°C. In Norway, it is not recorded in field soils but is more of a pest in protected production, where attacks from this pest can result in severe damage (Fig. 2). (EFSA 2014) It was found in produce from Norwegian retailers (Magnusson pers. comm).

3. Is the pest a vector?

No, *Radopholus similisis is* not a vector.

4. Is a vector needed for pest?

No, a vector is not needed.

5. Regulatory status

Radopholus similis is not regulated within the EU but is listed on the EPPO A2 list. In Norway, it is classified as a quarantine pest, with specific regulations applied to plants and growing media of several families, including Araceae, Marantaceae, and Musaceae.

6. Distribution in Europe

France, Italy, and the Netherlands with a restricted distribution

7. Host plants in Norway:

Under protected cultivation, it affects ornamental plants such as *Citrus, Musa*, *Anthurium, Philodendron, Maranta* and *Calathea*.

8. Growing media for entry & likelihood

Rating of the Likelihood of Entry: Likely as not

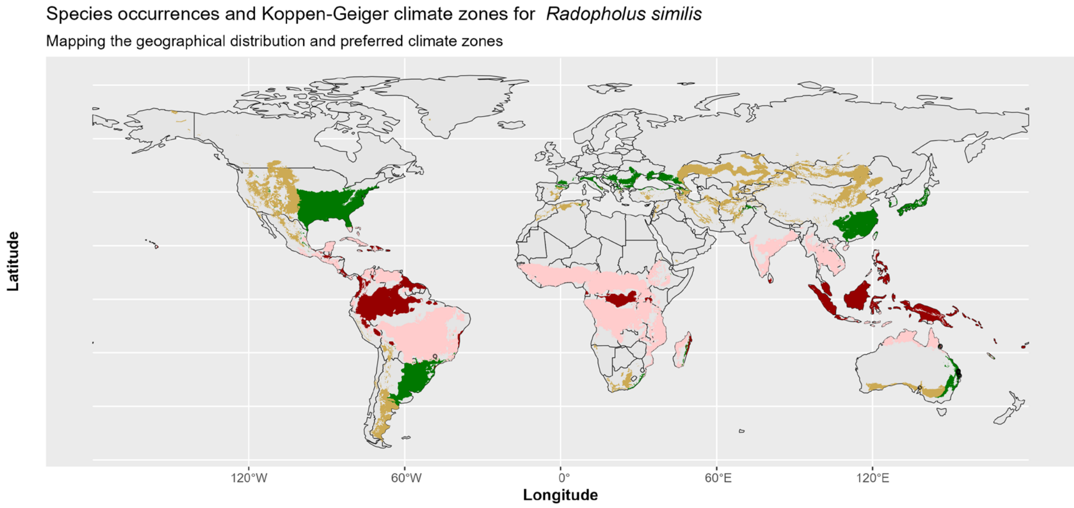
Rating of Uncertainty: Medium

Radopholus similis can be introduced to new areas through plants for planting, and via infested soil or growing media. This is documented for Norway both for producers and retailers.

9. Likelihood for establishment outdoors in Norway

Probability of establishment outdoors: Unlikely
Rating of uncertainty: Low

The pest thrives in warm and humid conditions so the establishment outdoors in Norway in not expected.



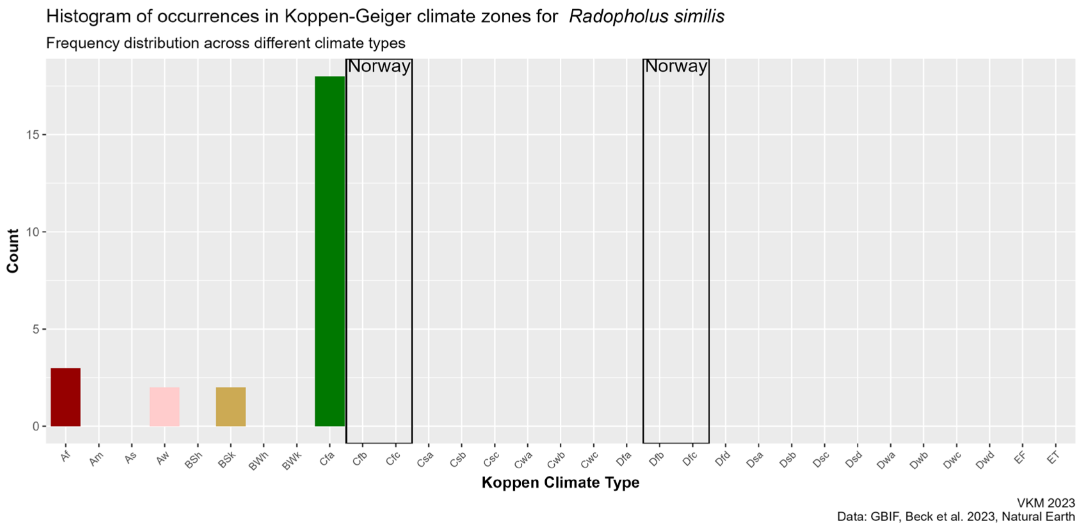


Figure 1. Recorded occurrences of *Radopholus similis* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *R. similis* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes.

10. Likelihood for establishment under protected conditions

Rating of the Likelihood of Entry: As likely as not

Rating of Uncertainty: Medium

In Norway, *R. similis* was recorded in protected cultivation only with producers and retailers. Hence, this pest is not uncommon here. It prefers warm and humid conditions typical of greenhouses. The probability of establishment in indoor production is as likely as not with a medium uncertainty.

Figure2. *Anthurium* sp. damaged by *Radopholus similis* under protected cultivation in Norway April 2022. (Photo: Birgit Schaller, NIBIO).

11. Likelihood for spread in Norway

Probability of Spread: As likely as not

Rating of Uncertainty: Medium

The spread in Norway relies on human assistance in moving infested plants and soil. Early infections may be difficult to detect, but later symptoms are dramatic (See pictures below). The probability of spread is as likely as not with medium uncertainty.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: Likely
Rating of uncertainty: Medium
Significant damage has been documented for ornamentals under protected conditions, although it is not considered a pest of field crops in the EU (EFSA 2014).

14. Phytosanitary measures

To mitigate the risk, plants and growing media should originate from areas certified as pest-free or from production sites known to be free of the pest. Heat treatment of soil and growing media and rigorous hygiene practices during production are recommended. Inspections should focus on root systems, and plants displaying root necrosis should be destroyed to prevent spread.

15. References

EFSA 2014. Scientific Opinion on the pest categorisation of *Radopholus similis* (Cobb) Thorne and *Radopholus citrophilus* Huettel, Dickson and Kaplan. EFSA Journal 2014;12(10): 3852, 36 pp. doi:10.2903/j.efsa.2014.3852

9.1.4.7 Express pest risk assessment of *Longidorus macrosoma*

1. Taxonomy

Kingdom: Metazoa, Phylum: Nematoda, Family: Longidoridae, Subfamily: Longidorinae, Genus: *Longidorus,* Species: *Longidorus macrosoma*

EPPO Code: LONGMA

Common name: Needle nematode

2. Conclusion and summary

Longidorus macrosoma is reported from temperate areas of Europe. It is a damaging root feeder that causes hook formation of the root tips and reduces the vigor of attacked plants. This species is not regulated. It is a vector of several viruses. It is expected to be able to establish in southern Norway. *L.ongidoru macrosoma* has many potential hosts and was noted to damage roses under glass (Brown & Boag 1975).

3. Is the pest a vector?

Yes, the pest is a vector. Raspberry Ringspot Virus English strain (RRV-E) (CABI1975), Brome Grass Mosaic Virus (BGMV), Carnation Ring Spot Virus (CRSV), and Prunus Necrotic Ring Spot Virus (PNRSV). Association in the field with Cherry Leaf Roll Virus is reported (CABI 1975). For Norway, this nematode was categorized as representing a high risk due to high invasive potential but with a small ecological effect (Magnusson et al. 2023).

4. Is a vector needed for pest?

No, *L. macrosoma* does not need a vector.

5. Regulatory status

Norway: Not regulated

EU: RNQP

UK: RNQP

6. Distribution in Europe

Belgium, France, Germany, Italy, the Netherlands, and UK.

7. Host plants in Norway

Sambucus, *Rubus fruticosus*, *R. idaeus*, *Rosa*, *Ribes nigrum*, *Prunus*, *Amaranthus caudatus, Petunia hybrida*, *Dactylis glomerata*, *Lolium perenne*, *Mentha rotundifolia* (CABI 1975, Cotten 1976).

8. Growing media for entry & likelihood

Rating of likelihood of entry: As likely as not
Rating of uncertainty: Medium

Longidorus macrosoma can be introduced to new areas through plants for planting, and via infested soil or growing media. This is of particular concern for plantations and forestry, where plants from nurseries with soil adhering to their roots are planted out in new locations (Magnusson et al. 2023).

9. Likelihood for establishment outdoors in Norway

Probability of establishment outdoors: Likely
Rating of uncertainty: Medium
This pest occurs naturally in countries of continental Europe. Hence, the climate in Norway, especially in the southern coastal regions, is expected to provide suitable conditions for the nematode to survive, reproduce, and establish populations (Magnusson et al. 2023).

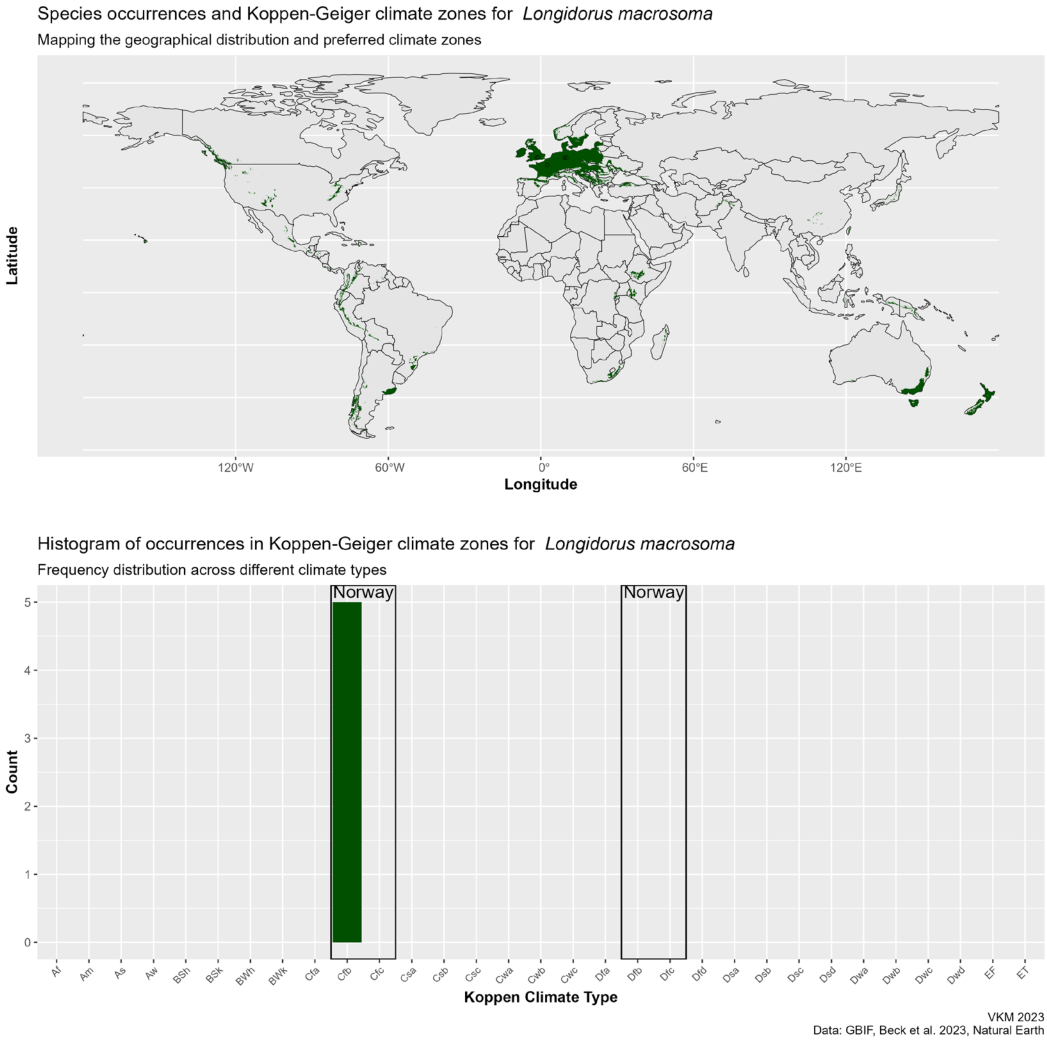


Figure 1. Recorded occurrences of *Longidorus macrosoma* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *L. macrosoma* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes.

10. Likelihood for establishment under protected conditions

Greenhouses or nurseries where external factors, including temperature, humidity, and soil conditions, are effectively managed increase the risk of establishment for pests like *L. macrosoma*. The probability for this is as likely as not with medium uncertainty.

11. Likelihood for spread in Norway

Like other nematodes, *L. macrosoma* needs human assistance by movement of infested soil and plants. The probability of the pest spreading in Norway is as likely as not with medium uncertainty.

12. Impact in the current area of distribution

Rating of the probability of impact in the current area of distribution: As likely as not with medium uncertainty.

Impact includes damage to the root systems of roses and raspberries. In addition, the pest may transmit several viruses (Brown & Boag 1975, Magnusson et al. 2023).

14. Phytosanitary measures

Plants and growing media should originate from pest-free sites of production. Soil and growing media should be treated by heat and protected from contamination before being used in production. Potted plants should be grown physically isolated from soil by concrete floors, membranes, or benches. The use of clean irrigation water and a high level of hygiene should be implemented during production. Inspections during production and before export should include the root systems. Symptomatic plants should be destroyed. High-pressure root washing will remove ectoparasites like *L. macrosoma*.

15. References

Brown D.J.F. & Boag B. (1975). *Longidorus macrosoma*. C.I.H. Description of Plant-parasitic Nematodes. Set 5 No. 67: 4 pp.

Cottten J (1976). Observations of life-cycle, population development and vertical distribution of *Longidorus macrosoma* on raspberry and other crops. Ann. appl. Biol. 83: 407-412.

Magnusson C, Hamnes I, Karlsbakk E og Tangvik MP (2023). Rundormer: Vurdering av *Longidorus macrosoma* for Fastlands-Norge med havområder. Fremmedartslista 2023. Artsdatabanken. http://www.artsdatabanken.no/lister/fremmedartslista/2023/4841

9.1.5 Bacteria

9.1.5.1 Express pest risk assessment of *Dickeya dianthicola*

1. Taxonomy

Kingdom: Bacteria, Phylum: Proteobacteria, Class: Gammaproteobacteria, Order: Enterobacterales, Family: Pectobacteriaceae, Genus: *Dickeya,* Species: *Dickeya dianthicola*

Common Names: Bacterial wilt of carnation, blackleg of potato

EPPO Code: ERWICD

2. Conclusion and summary

Dickeya dianthicola represents a significant threat to many host plants, including potatoes, tomatoes, carnations, and other ornamental and crop plants. Initially identified in carnation, its ability to cause blackleg in potatoes and other diseases highlights its adaptability and potential impact. **3. Is the pest a vector?**

No, *D. dianthicola* is not a vector.

4. Is a vector needed for pest entry or spread?

No, *D. dianthicola* does not require a vector for entry or spread.

5. Regulatory status of the pest

Norway QP, EPPO A2, EU RNQP

6. Distribution in Europe

Dickeya dianthicola is present in several European countries, including Belgium, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Israel, Morocco, Poland, Romania, Russia (Central Russia, Eastern Siberia), Serbia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom. The bacteria has also been detected in Norway.

7. Host plants in Norway

Hosts include potato (*Solanum tuberosum*), carnation (*Dianthus caryophyllus*), dahlia (*Dahlia* spp.), carrot (*Daucus carota*) and tomato (*Solanum lycopersicum*).

8. Growing media for entry

Rating of the Likelihood of Entry: Very Likely

Rating of Uncertainty: Low

The bacterium may spread in soil and other growing media, water, green manure, cover crops, and plant mulch, in addition to the trade plants for planting.

9. Likelihood of establishment outdoors in Norway

Probability of Establishment Outdoors: High

Rating of Uncertainty: High

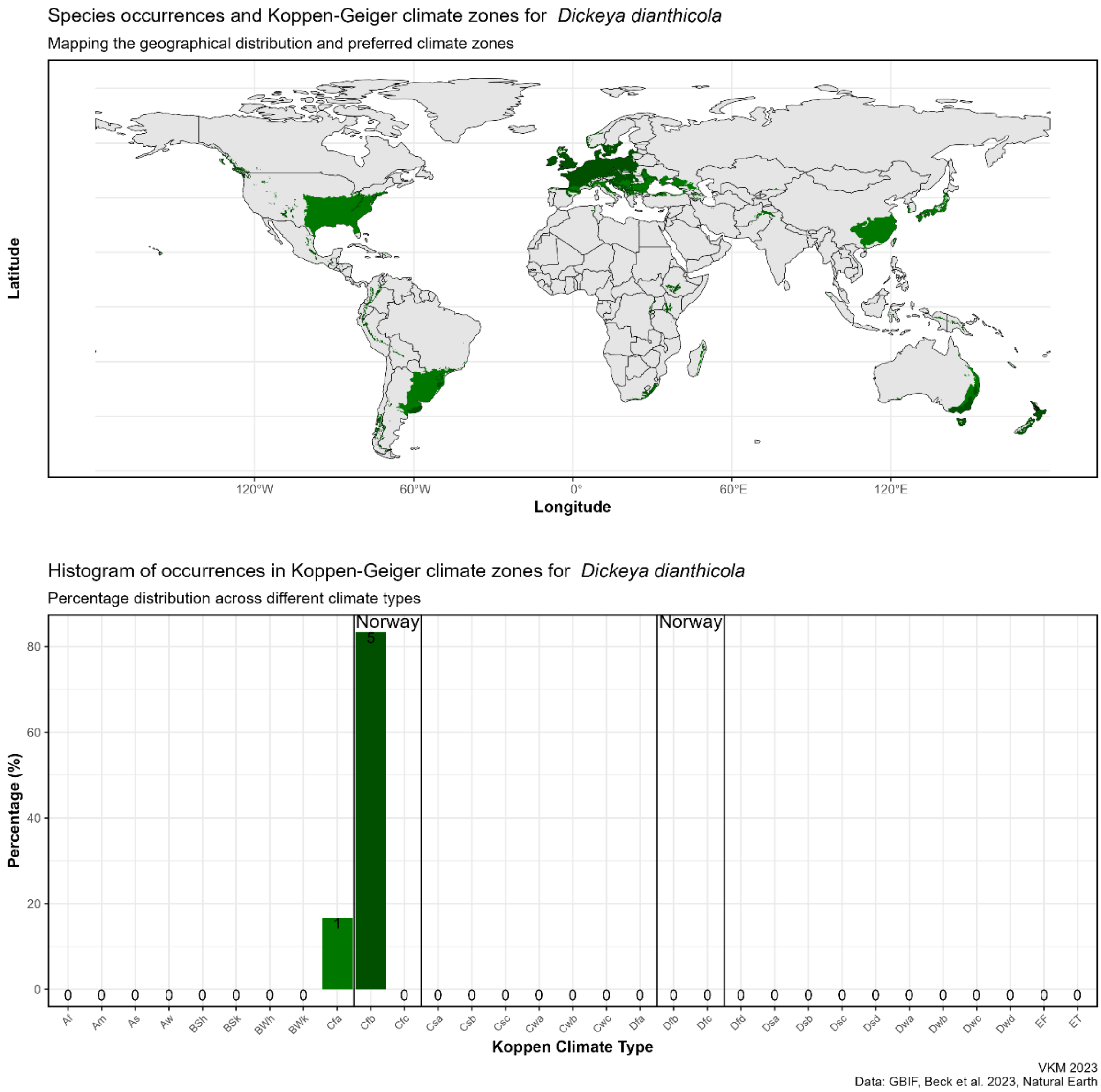


Figure 1. Recorded occurrences of *Dickeya dianthicola* (black circle) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *D. dianthicola* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. The single occurrence point of *D. dianthicola* is in a climate type that occurs in coastal areas of S Norway (Cfb).

10. Likelihood of establishment in protected conditions in Norway

Probability of Establishment in Protected Condition: High

Rating of Uncertainty: Low

The potential for *D. dianthicola* to be established in protected conditions, such as greenhouses, is high. This is primarily due to the bacterium's ability to infect a wide range of host plants under various conditions, making it a particularly adaptable and persistent threat.

11. Spread in Norway

Probability of Spread: High

Rating of Uncertainty: Low

12. Impact in the current area of distribution

Rating of the Magnitude of Impact in the Current Area of Distribution: High

Rating of Uncertainty: Low

Dickeya dianthicola has caused significant economic losses in the regions where it has been introduced, affecting a wide range of agricultural and ornamental plants.

13. Potential impact in Norway

The introduction of *D. dianthicola* to Norway could severely impact susceptible crops, particularly the potato and ornamental industries.

14. Phytosanitary measures

The use of disease-free (certified) propagation material is a key measure. Good hygiene routines, including pathogen-free irrigation water, disinfection of tools and equipment, and limiting access to production areas, are important to prevent introduction and spread. Growing plants under physical exclusion or temporal separation can also be deployed (EFSA 2013).

15. References

EPPO Global Database

EFSA Panel on Plant Health (PLH); Scientific Opinion on the risk of *Dickeya dianthicola* for the EU territory with identification and evaluation of risk reduction options. EFSA Journal 2013; 11(1):3072. [115 pp.] doi:10.2903/j.efsa.2013.3072.

9.1.6 Mollusca

9.1.6.1 Express pest risk assessment of Krynickillus melanocephalus

1. Taxonomy

Domain: Eukaryota, Kingdom: Metazoa, Phylum: Mollusca, Class: Gastropoda, Subclass: Pulmonata, Order: Stylommatophora, Suborder: Sigmurethra, Superfamily: Limacoidea, Family: Agriolimacidae, Genus: *Krynickillus*, Species: *Krynickillus melanocephalus*

Eppo Code: NA

2. Conclusion and summary

Krynickillus melanocephalus represents a potential high-risk species for Norway, with a significant invasion potential. Its ability to spread rapidly in similar climates and habitats increases the probability of introduction and establishment in Norway. The Norwegian Biodiversity Information Centre also evaluates this species as potentially high risk due to its significant invasion potential and yet unknown ecological effect in Norway (Hatteland et al. 2023). It has shown a rapid spread in Sweden, indicating a strong potential for establishment, and spread in Norway, especially in southern parts of the country.

3. Is the pest a vector?

No*, Krynickillus melanocephalus* is not a vector.

4. Is a vector needed for pest entry or spread?

No, a vector is not needed for the entry or spread of *Krynickillus melanocephalus.*

5. Regulatory status of the pest

Not regulated

6. Distribution in Europe

Krynickillus melanocephalus is native to the Caucasus region, eastern Turkey, and northern Iran. Over the past decade, it has spread to central and eastern parts of Europe and is notably present in Sweden, Germany, Latvia, Russia, and Ukraine. Since 2019, it has also spread to southern and central parts of Sweden, often in mass occurrences.

7. Host plants in Norway

Strawberries, lettuce, cabbage, and other leafy greens that are common in agriculture. In addition, ornamental plants may also act as potential hosts.

8. Growing media for entry

Rating of the Likelihood of Entry: Very Likely

Rating of Uncertainty: Low

The primary pathway of spread for *K. melanocephalus* is the movement of soil and plant material. This species is known to spread as a stowaway with garden plants and soil through various forms of transport. Transported soil can contain eggs or juvenile slugs, facilitating their introduction into new areas.

9. Likelihood of establishment outdoors in Norway

Probability of Establishment Outdoors: High

Rating of Uncertainty: High

Based on observations in similar environments, the likelihood of *K. melanocephalus* establishing outdoors in Norway is potentially high. The slug's recent spread in Sweden, including areas with climate and environmental conditions similar to Norway, indicates a high invasion potential (von Proschwitz 2020). It has been found in over 400 locations in Sweden, from southern regions up to the middle and along the coast northward from Stockholm (*Artsdatabanken*), suggesting that it could successfully establish and spread in southern parts of Norway.

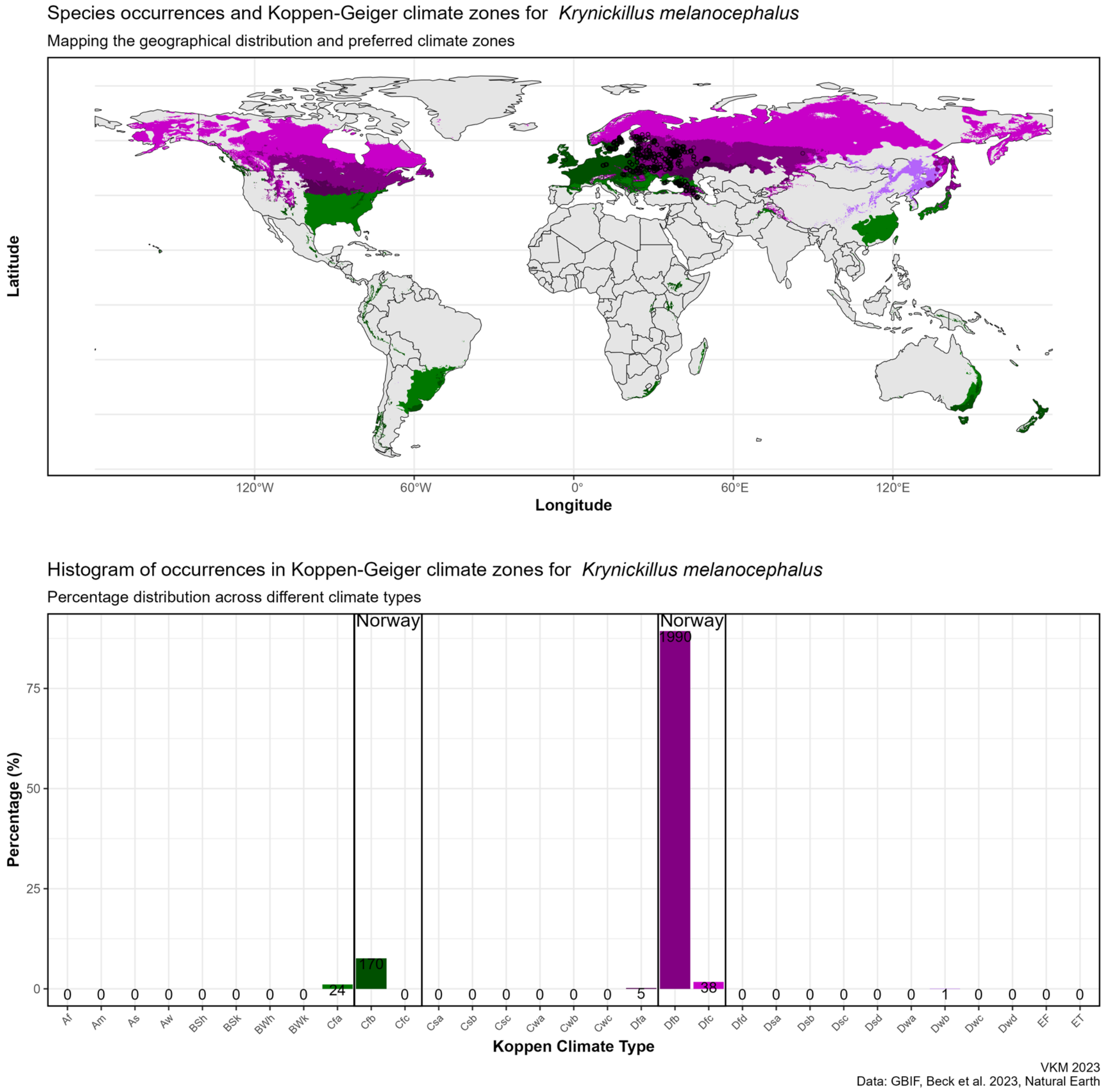


Figure 1. Recorded occurrences of *Krynickillus melanocephalus* (black circles) overlaid on a world map showing the Köppen-Geiger climate types this species has been recorded in. The histogram shows the frequency distribution of *K. melanocephalus* occurrence points across Köppen-Geiger climate types. Climate types that occur in Norway are shown inside boxes. *Krynickillus melanocephalus* has a high population (or reporting rate) in a climate type that occurs in SE Norway (Dfb; 45 % of all occurrence points).

10. Likelihood of establishment in protected conditions in Norway

Probability of Establishment in Protected Condition: High

Rating of Uncertainty: Low

The likelihood of its establishment in greenhouses or indoor environments in Norway can also be considered potentially high.

11. Spread in Norway

Probability of Spread: High

Rating of Uncertainty: Low

The potential for the spread of *K. melanocephalus* within Norway, should it be introduced, is considered high. *Krynickillus melanocephalus* can spread over land by natural movement, increasing its potential to colonize new areas from initial introduction points. However, human activity is the most significant factor in its spread, mainly through the movement of soil, plant materials, and garden waste, which can contain slugs or their eggs.

12. Impact in the current area of distribution

Rating of the Magnitude of Impact in the Current Area of Distribution: High

Rating of Uncertainty: Low

The impact of *K. melanocephalus* within its current area of distribution, which includes parts of Asia and Europe, especially following its spread to central and eastern European regions, has been noted mainly in terms of its invasive potential and the ecological concerns it raises. However, detailed assessments of its specific impacts are somewhat limited and generally focus on potential threats rather than documented ones. While direct reports are limited, *K. melanocephalus*, like many terrestrial slugs, is known to feed on a wide range of plants. This feeding behavior suggests it could pose a risk to agriculture, horticulture, and gardens by damaging vegetables and ornamental plants and possibly affecting native plant species. Its presence in gardens and agricultural settings in invaded areas implies potential economic impacts due to crop loss and control costs.

13. Potential impact in Norway

Based on its feeding habits observed in other regions, *K. melanocephalus* could threaten various crops, garden plants, and possibly native vegetation. This could result in economic losses for commercial agriculture and home gardening, necessitating increased use of slug control measures.

14. Phytosanitary measures

Hand picking and killing, physical barriers, weed control.

15. References

CABI Compendium on *Krynickillus melanocephalus*.

Hatteland BA, Endrestøl A, Gammelmo Ø, Laugsand AE, Olberg S, Slagsvold PK, Staverløkk A og Åström S (2023). Bløtdyr: Vurdering av *Krynickillus melanocephalus* for Fastlands-Norge med havområder. Fremmedartslista 2023. Artsdatabanken. http://www.artsdatabanken.no/lister/fremmedartslista/2023/3504

von Proschwitz T (2020). Rapid invasion of the slug *Krynickillus melanocephalus* Kaleniczenko, 1851 in Sweden and some notes on the biology and anthropochorous spread of the species in Europe (Gastropoda: Eupulmonata: Agriolimacidae). Folia Malacologica 28: 227-234.

9.2 Appendix 2 – EPPO codes and species names for Figure 11

EEPO code	Species name
ACHAFU	*Lissachatina fulica*
AGRILI	*Agriotes lineatus*
AGRIOB	*Agriotes obscurus*
AGRLPL	*Agrilus planipennis*
AMAZMA	*Nemorimyza maculosa*
ANGUTR	*Anguina tritici*
ANOLGL	*Anoplophora glabripennis*
APLOBE	*Aphelenchoides besseyi*
APLORI	*Aphelenchoides ritzemabosi*
ATHEOR	*Atherigona orientalis*
BNYVV0	*Beet necrotic yellow vein virus*
BURSXY	*Bursaphelenchus xylophilus*
CEPCAL	*Cephalcia lariciphila*
CERAFP	*Ceratocystis platani*
CERTCA	*Ceratitis capitata*
CHILSU	*Chilo suppressalis*
CORBFL	*Curtobacterium flaccumfaciens pv. flaccumfaciens*
CORBMI	*Clavibacter michiganensis*
CRTHAR	*Corythucha arcuata*
CYDIIN	*Grapholita inopinata*
DACUOL	*Bactrocera oleae*
DENDPI	*Dendrolimus pini*
DEUTTR	*Plenodomus tracheiphilus*
DIABVI	*Diabrotica virgifera virgifera*
DIAPVA	*Diaporthe vaccinii*
DOTSPI	*Dothistroma pini*
DROSSU	*Drosophila suzukii*
ENDOPA	*Cryphonectria parasitica*
EOTELE	*Eotetranychus lewisi*
EPIXCU	*Epitrix cucumeris*
ERWIAN	*Pantoea ananatis*
ERWICD	*Dickeya dianthicola*
ERWICH	*Erwinia chrysanthemi*
GIBBCI	*Fusarium circinatum*
GLOMGO	*Colletotrichum gossypii*
GONPSC	*Gonipterus scutellatus species complex*
GRAGLE	*Naupactus leucoloma*
HALYHA	*Halyomorpha halys*
HELIAR	*Helicoverpa armigera*

HETDGL	*Heterodera glycines*
HETDGO	*Heterodera goettingiana*
HETDZE	*Heterodera zeae*
IPSXAM	*Ips amitinus*
LAPHFR	*Spodoptera frugiperda*
LASPMO	*Grapholita molesta*
LIRISA	*Liriomyza sativae*
LIRITR	*Liriomyza trifolii*
LISSOR	*Lissorhoptrus oryzophilus*
LPTNDE	*Leptinotarsa decemlineata*
MARSPA	*Microdochium panattonianum*
MELGCH	*Meloidogyne chitwoodi*
MELGFA	*Meloidogyne fallax*
MELGGC	*Meloidogyne graminicola*
MELGMA	*Meloidogyne mali*
MELGMI	*Meloidogyne minor*
MELGMY	*Meloidogyne enterolobii*
MELOME	*Melolontha melolontha*
MNLCIN	*Monilochaetes infuscans*
MONCGA	*Monochamus galloprovincialis*
MONCSL	*Monochamus saltuarius*
PAYSAR	*Paysandisia archon*
PHENSO	*Phenacoccus solenopsis*
PHYNCI	*Phyllocnistis citrella*
PHYTAL	*Phytophthora alni subsp. alni*
PHYTAU	*Phytophthora austrocedri*
PHYTBM	*Phytophthora boehmeriae*
PHYTCP	*Phytophthora capsici*
PHYTDR	*Phytophthora drechsleri*
PHYTER	*Phytophthora erythroseptica*
PHYTHI	*Phytophthora hibernalis*
PHYTKE	*Phytophthora kernoviae*
PHYTLA	*Phytophthora lateralis*
PHYTQU	*Phytophthora quercina*
POPIJA	*Popillia japonica*
PRATCO	*Pratylenchus coffeae*
PRAYCI	*Prays citri*
PSDMAK	*Pseudomonas syringae pv. actinidiae*
PSDMAV	*Acidovorax avenae*
PSPECA	*Pseudoperonospora cannabina*
PYTHIR	*Pythium irregulare*

PYTHMY	*Pythium myriotylum*
RADOSI	*Radopholus similis*
RALSPS	*Ralstonia pseudosolanacearum*
RALSSL	*Ralstonia solanacearum*
RHAGCI	*Rhagoletis cingulata*
RHAGCO	*Rhagoletis completa*
RHAGSU	*Rhagoletis suavis*
RHIOHI	*Ripersiella hibisci*
RHYCFE	*Rhynchophorus ferrugineus*
ROTYPA	*Rotylenchulus parvus*
ROTYRE	*Rotylenchulus reniformis*
SAPECN	*Saperda candida*
SCITDO	*Scirtothrips dorsalis*
SCLECA	*Ciborinia camelliae*
SCOLMU	*Scolytus multistriatus*
SCYPIN	*Scyphophorus acupunctatus*
SOLEIN	*Solenopsis invicta*
SPODLI	*Spodoptera littoralis*
SPONSU	*Spongospora subterranea*
SYNCEN	*Synchytrium endobioticum*
TBSV00	*Tombusvirus lycopersici*
TECASO	*Tecia solanivora*
THAUPR	*Thaumetopoea processionea*
THEBPI	*Theba pisana*
TYLESE	*Tylenchulus semipenetrans*
TYLRCL	*Tylenchorhynchus claytoni*
VERTDA	*Verticillium dahliae*
XANTAM	*Xylophilus ampelinus*
XANTPF	*Xanthomonas euvesicatoria pv. perforans*
XANTVE	*Xanthomonas vesicatoria*
XIPHIN	*Xiphinema index*
XIPHRI	*Xiphinema rivesi*
XYLBGE	*Xylosandrus germanus*
XYLBPE	*Xyleborus perforans*
XYLEFA	*Xylella fastidiosa*
XYLSCO	*Xylosandrus compactus*
XYLSMU	*Cnestus mutilatus*

9.3 Appendix 3 – Litterature searches

Database: **CAB Abstracts <1973 to 2023 Week 46>**

Date: 20.11.2023

No. of results: 2239

#	Search Query	Results
1	((adher* or attach*) adj4 soil?).ti,ab,id.	1069
2	(((growing or rooting or potting) adj2 "med* mix*") or (growing adj2 (mix or mixes or mixture?)) or (pot adj2 mix*)).ti,ab,id.	765
3	((pot or potted or potting) adj3 "soil mix*").ti,ab,id.	66
4	(potting adj2 (material* or mix* or different or various or compost?)).ti,ab,id.	1894
5	(("pot soil?" or "potted soil?" or potting or "growing media" or "growing medium?" or "growing substrat*") adj10 (component? or composed or composing or composition? or contained or containing or manufactur* or process*)).ti,ab,id.	1266
6	or/2-5	3592
7	vegetative propagation/ or grafting/ or budding/ or inarching/ or layering/ or air layering/ or natural layering/ or micropropagation/ or bud culture/ or stooling/ or topworking/	58709
8	bulbs/ or bulb scales/	10112
9	ornamental crops/ or carnations/ or chrysanthemums/ or hyacinths/ or jasmine/ or lilac/ or lilies/ or poinsettias/ or poppies/ or roses/ or sweet peas/ or tulips/	26309
10	ornamental plants/ or ornamental aquatic plants/ or ornamental bromeliads/ or ornamental bulbs/ or ornamental foliage plants/ or ornamental ferns/ or ornamental herbaceous plants/ or ornamental orchids/ or ornamental palms/ or ornamental succulent plants/ or ornamental woody plants/ or bonsai/ or ornamental conifers/ or pot plants/	90952
11	planting stock/ or balled stock/ or bare rooted stock/ or cut sets/ or sets/ or transplants/ or wildings/ or seedlings/ or exp nurseries/	148898
12	seed tubers/ or seed potatoes/	4378
13	rootstocks/ or rhizomes/ or scions/ or budwood/ or stolons/	41623
14	(container* adj3 (crop? or cultivat* or culture? or plant?)).ti,ab,id.	3426
15	(pot adj3 (culture? or cultivat* or (grow? adj1 plant?))).ti,ab,id.	5865
16	("pot plant?" or "plant? in pot?" or "house plant?" or "plant? for planting").ti,ab,id.	4696

17	((potted or potting or ornamental) adj3 plant?).ti,ab,id.	20073
18	((graft or grafting or bud) adj wood?).ti,ab,id.	97
19	(ornamental adj2 (crop? or bromeliad? or orchid? or palm? or shrub? or tree?)).ti,ab,id.	6145
20	(stock? adj2 (balled or root* or planting or type?)).ti,ab,id.	4551
21	("vegetative propagation" or "vegetative reproduction" or "bud stick?" or "seed tuber?" or "seed potato*" or "planting material?" or "cut set?" or "cut sett?").ti,ab,id.	29382
22	(potplant? or houseplant? or bulb? or budwood? or graftwood? or graftings or cuttings or ornamentals or budstick? or budling? or seedling? or stocktype? or rootstock? or rhizome? or scion? or stolon* or transplant* or nurser* or wilding?).ti,ab,id.	544957
23	((carnation? or chrysanthemum? or hyacinth? or jasmine? or lily or lilies or poinsettia? or poppy or poppies or rose? or "sweet pea?" or tulip?) adj3 crop?).ti,ab,id.	1033
24	(grafting or budding or inarching or layering or marcotting or micropropagation or "micro propagation" or "bud culture" or stooling or topworking or "top working").ti,ab,id.	39490
25	or/7-24	633689
26	agricultural wastes/ or banana waste/ or cotton waste/ or dairy wastes/ or feedlot wastes/ or potato waste/ or tomato waste/	14228
27	organic amendments/ or manures/ or animal manures/ or cattle manure/ or fish manure/ or horse manure/ or night soil/ or pig manure/ or poultry manure/ or sheep manure/ or composts/ or bark compost/ or leaf mould/ or mushroom compost/ or refuse compost/ or vermicompost/ or farmyard manure/ or green manures/ or guano/ or "hoof and horn meal"/ or liquid manures/	115312
28	organic wastes/ or cellulosic wastes/ or lignocellulosic wastes/	9743
29	soilless culture/ or aeroponics/ or hydroponics/ or nutrient film techniques/	21168
30	mulches/ or live mulches/ or straw mulches/	16307
31	growing media/	12283
32	(compost* or manure* or residue*).ti,ab,id.	305214
33	(biowaste? or hydroponic* or aeroponics or mulch* or potsoil* or "soilless culture?" or substrat* or uncomposted or vermicompost* or "organic fertili#er?").ti,ab,id.	263169
34	(organic* adj1 amendment?).ti,ab,id.	6400
35	((growing or potting or rooting) adj (media or medium?)).ti,ab,id.	9954

36	(((pot or potted or potting) adj soil?) or (soil adj (mix* or conditioner?))).ti,ab,id.	7234
37	("nutrient film" adj (technique* or culture*)).ti,ab,id.	1110
38	or/26-37	577755
39	25 and 38	57069
40	aquatic plants/ or aquatic weeds/ or marine plants/ or seagrasses/ or seaweeds/ or brown seaweeds/ or green seaweeds/ or red seaweeds/	112310
41	(((aquatic or marine) adj plant?) or ((aquatic or sea) adj weed?) or seagrass* or "sea grass*" or eelgrass* or "eel grass*" or seaweed? or kelp).ti,ab,id.	26719
42	exp algae/ or exp Azolla/ or exp Posidonia/ or exp Sargassum/ or Eichhornia crassipes/	75414
43	(alga? or Phycophyta or Azolla or "water fern" or "water velvet" or "fairy moss" or "mosquito fern" or Posidonia or Sargassum).ti,ab,id.	65852
44	((Eich?ornia adj (crassipes or speciosa or crassicaulis)) or Pontederia or Piaropus or (water adj (hyacinth* or lil*)) or waterhyacinth* or "Florida devil*" or "lilac devil*" or "German pana" or Heteranthera or "river raft").ti,ab,id.	6482
45	wood ash/ or wood dust/ or wood fibres/ or exp logs/ or wood chips/ or ((wood? adj3 (ash* or dust or fibre? or fine? or log? or pellet? or sawdust or straw? or drift* or chip?)) or driftwood* or "hog fuel").ti,ab,id.	24872
46	(bagasse adj3 (cassava* or manioc* or me#cal or maguey)).ti,ab,id.	186
47	exp bales/ or ((bale? or mat?) adj3 hay).ti,ab,id.	1857
48	pine bark/ or (bark adj3 (shred* or spruce*)).ti,ab,id.	2651
49	(bark adj4 (cassava or cedar* or Cedrus or conifer? or c#press* or "Douglas fir" or Pseudotsuga or Abies or Pinus or Eucalyptus or ferment* or "fruit tree*" or hardwood* or "hard wood*" or humus or Cryptomeria or Chamaecyparis or Retinospora or oak* or ornamental* or pine* or ((red or coral) adj wood*) or redwood* or sandalwood* or Adenanthera or circassian or bead* or "bean tree*" or Corallaria or wiliwili or legliz or "crab* eye*" or (peacock adj (flower* or tree*)) or "Polynesian peanut*" or Rhododendron* or Azalea*)).ti,ab,id.	6847
50	((bean? adj3 (cake? or husk?) adj3 castor) or (castor adj3 cake?) or (organic* adj3 bean? adj3 castor)).ti,ab,id.	584
51	(berry or berries).ti,ab,id.	30301
52	(((biodigest* or codigest* or digest* or anaerobic* or aerobic*) adj3 slurr*) or bioslurr* or "bio slurr*" or biomanure* or bioresidu*).ti,ab,id.	1646
53	((digest* or biodigest* or codigest*) adj4 ((maize* or corn* or oat?) adj3 silage*)).ti,ab,id.	659
54	((anaerobic* or aerobic*) adj3 digest* adj4 slurr*).ti,ab,id.	461

55	"energy plantation?".ti,ab,id.	383
56	((biomass* or "bio mass*") adj3 (Gliricidia or vegetable* or salad*)).ti,ab,id.	336
57	(potato* adj3 (bioproduct* or "bio product*")).ti,ab,id.	8
58	bran/ or maize bran/ or oat bran/ or rice bran/ or wheat bran/ or (bran adj3 (maize* or corn* or rice or wheat or oat* or mushroom* or coffee)).ti,ab,id.	21086
59	(brine adj3 olive?).ti,ab,id.	121
60	(bulb* adj4 (Cyperus or Chlorocyperus or Pycreus or "coco grass*" or "red grass*" or "nut grass*" or nutgrass or nutsedge)).ti,ab,id.	55
61	(empt* adj3 fruit* adj4 bunch*).ti,ab,id.	1562
62	((b#product* or "b# product*") adj5 ("Phoenix dactylifera*" or "date palm*")).ti,ab,id.	67
63	oilseed cakes/ or neem seed cake/ or olive cake/ or palm kernel cake/ or groundnut oilmeal/	6272
64	((Citrullus or colocyth* or coconut* or coco or cotton or gingelly or sesame or beniseed or simsim or groundnut* or "ground nut*" or peanut* or kapok or mustard or olive* or Pongamia or neem or Azadirac?ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) adj tree?) or soy?bean* or "soya bean*" or Jatropha or "Brassica napus" or Brassicanapus or "Brassica rapa" or "rape seed*" or rapeseed* or sunflower*) adj4 cake*).ti,ab,id.	8947
65	oilmeals/ or castor oilmeal/ or coconut oilmeal/ or copra meal/ or cottonseed oilmeal/ or groundnut oilmeal/ or kapok seed meal/ or linseed oilmeal/ or mustard oilmeal/ or rapeseed oilmeal/ or safflower oilmeal/ or sal seed meal/ or sesame oilmeal/ or soyabean oilmeal/ or sunflower oilmeal/	22825
66	(("Brassica napus" or Brassicanapus or "Brassica rapa" or rapeseed* or groundnut* or "ground nut*" or peanut* or seed or sesame or beniseed or simsim or soy?bean* or "soya bean*") adj3 (meal? or oilmeal*)).ti,ab,id.	35113
67	(Carbocalc* or "carbo calc*").ti,ab,id.	8
68	((catch or stubble?) adj crop? adj4 (oat? or serradella*)).ti,ab,id.	91
69	(chafe* adj4 (soy?bean* or "soya bean*")).ti,ab,id.	2
70	rice byproducts/ or (chaff* adj3 rice*).ti,ab,id.	433
71	(chip* adj3 residu*).ti,ab,id.	389
72	((chipp* adj5 oak*) or ((chipp* or branch*) adj3 oak*)).ti,ab,id.	192
73	((poplar* or bark or hemp or maravalha) adj3 chip*).ti,ab,id.	627
74	((chopp* or straw* or stem?) adj3 (Bhusa or Ilex)).ti,ab,id.	57

75	maize cobs/ or corn flour/ or (((maize* or corn*) adj3 (cob? or core? or flour)) or cornflour).ti,ab,id.	10798
76	coir/ or (coir or coirs or ((coconut* or coco) adj2 fibre?)).ti,ab,id.	4206
77	coarse woody debris/ or ((logging or log?) adj3 debris).ti,ab,id.	2121
78	crop residues/ or stubble/ or sorghum stubble/	25167
79	(defibre* or "de fibre*" or defiber* or "de fiber*").ti,ab,id.	84
80	coconut milk/ or coconut water/ or ((coconut? or coco) adj3 (dice* or milk or pith or water)).ti,ab,id.	3600
81	(Ipomoea adj3 fistulosa adj4 (leaf or leaves)).ti,ab,id.	19
82	(powder* adj3 (Eucalyptus or leek? or thyme or thymus or "Origanum webbianum" or Caragana* or ginger? or sugarcane* or "sugar cane*" or xaxim* or Dicksonia)).ti,ab,id.	795
83	(extract* adj3 (Azadirachtin or Eucalyptus or "Ligustrum nepalens*" or Sapium or Urtica or Lantana or Camara or ((red or white or wild or yellow) adj2 sage) or "cherry-pie?" or "Spanish flag?" or tickberr* or Chromol?ena or weed? or Siamweed? or kingsweed? or Christmas or bitterbush* or parrafinbush* or geritoo or hagonoy or Eupatorium or archangel* or thoroughwort or "Osmia odorata" or "hemp agrimony" or "jack-in-the-bush" or "mile-a-minute")).ti,ab,id.	3138
84	(((wastewater* or "waste water*") adj4 mushroom*) or ((wastewater* or "waste water*") adj3 farm?)).ti,ab,id.	566
85	(fibre? adj3 (cocoa or cacao or "Phoenix dactylifera*" or palm? or palmtree* or Poaceae* or Bambusaceae* or Festucaceae* or Gramin?ae* or Triticaceae* or vegetable*)).ti,ab,id.	1173
86	(("filter cake*" or "clarification mud*") adj3 (sugarcane* or "sugar cane*" or coffee)).ti,ab,id.	220
87	("press mud*" or pressmud*).ti,ab,id.	1469
88	((tea or chai) adj4 fluff*).ti,ab,id.	10
89	food wastes/ or plate waste/ or ((food or plate? or kitchen? or hotel* or salad? or catering? or herbal or soup*) adj3 (waste or wastes or garbage*)).ti,ab,id.	12672
90	((fruit? or cake* or presscake*) adj3 cranberr*).ti,ab,id.	347
91	maize gluten/ or maize gluten meal/ or ((gluten or "gluten meal?") adj3 (corn* or maize*)).ti,ab,id.	2849
92	(grain? adj2 (rice or wheat)).ti,ab,id.	29978
93	(("green leaves" or "green leaf") adj5 (Alnus or Artemisia or Cingulum or mugwort or "felon herb" or wormwood or "John* plant*" or Datura or Eupatorium or Schima)).ti,ab,id.	15

94	(coffee adj3 (ground? or parchment*)).ti,ab,id.	1777
95	(("Arachis pintoi" adj4 (cover* or ground?)) or ("ground cover*" adj4 Arachis)).ti,ab,id.	47
96	groundnut husks/ or cocoa husks/ or cottonseed husks/ or rice husks/ or sunflower husks/ or ((groundnut* or "ground nut*" or peanut* or corn* or maize* or pistachio* or cocoa or cacao or chickpea* or coffee or cotton or Eucalyptus or olive? or pine? or pinetree* or rice or Sorghum or sunflower* or tung? or wheat or coconut*) adj3 (hull? or husk? or shell?)).ti,ab,id.	17923
97	((hummock* or mound*) adj3 (moss or mosses or Bryopsida)).ti,ab,id.	43
98	((Industri* adj2 (b#product* or "b# product*") adj3 (organic* or plant? or farm? or farming or garden* or agro*)) or (Industri* adj2 (Aibes or fir or firs or Pinus or pine? or Picea or spruce* or Thuja? or sugarcane* or "sugar cane*" or Copernicia or prunifera or carnauba))).ti,ab,id.	1422
99	((integument* or tegument*) adj4 cashew*).ti,ab,id.	1
100	(juice* adj4 (waste or wastes or garbage*)).ti,ab,id.	376
101	pulp press water/	46
102	(kernel? adj2 (mango* or cake?)).ti,ab,id.	1096
103	((leaf or leaves) adj2 (dust or extract? or litter or mould? or powder?)).ti,ab,id.	51075
104	((leaf or leaves) adj3 (banana* or plantain* or kuppaimeni or Acalypha or nochi or "Vitex negundo" or teak* or vasambu or "Acorus calamus" or Acacia? or Senegalia? or wattle or neem or Azadirac?ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) adj tree?) or rye* or turnip* or neep* or Pueraria or Platanus or plane or sycamores or Fagus or beech or bhimal or Grewia or Copernicia or prunifera or carnauba or "cashew tree?" or cashewtree? or castor or Casuarina or Cordyla or "Phoenix dactylifera*" or "date palm*" or Faidherbia or Fleabane? or Gliricidia or jojoba or kharik or Celtis or Leucaena? or mango* or Murraya or curry or Quercus or oak* or Butea or Palas or pine* or Pongamia? or sugarbeet? or "sugar beet?" or tea or chai or Ficus or Covellia or timla or pellet?)).ti,ab,id.	24656
105	(lime adj3 (sugarbeet* or "sugar beet*")).ti,ab,id.	88
106	((litter or bedding) adj3 (Bactris or Guilielma or grassland* or "grass land*" or heath or heathland* or oak* or Quercus or Tusam?)).ti,ab,id.	774
107	(mill? adj3 (waste or wastes or wastewater* or garbage*) adj4 olive?).ti,ab,id.	2100
108	(mucilage* adj4 agave*).ti,ab,id.	5
109	mud/ or gyttja/ or gyttja*.ti,ab,id.	1555
110	conifer needles/ or pine needles/ or ((conifer? or pine? or pinetree*) adj3 needle?).ti,ab,id.	6100

111	(pine* adj3 (nugget* or litter)).ti,ab,id.	899
112	((neem or Azadirac?ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) adj tree?)) adj2 oil?).ti,ab,id.	3406
113	biogas slurry/ or ("biogas spent slurr*" or "bio gas spent slurr*").ti,ab,id.	1103
114	((biodegradable or "bio degradable" or pharmaceut* or monosodium or glutamate or sapropel* or sericulture* or silkworm* or "silk worm*" or starch) adj4 (waste or wastes or garbage*)).ti,ab,id.	1848
115	palm oil mill effluent/ or ((palm adj1 oil adj3 (effluent* or mill?)) or (pome adj3 palm?)).ti,ab,id.	1774
116	((pea or peas) adj1 grass*).ti,ab,id.	789
117	cassava peel/ or orange peel/ or (peel* adj3 (cassava* or orange* or banana? or plantain?)).ti,ab,id.	4906
118	lucerne pellets/ or ((Alfalfa or lucerne or "Brassica carinata") adj3 pellet?).ti,ab,id.	750
119	((Agrostis or bentgrass* or "bent grass*") adj4 cover*).ti,ab,id.	85
120	(ash* adj3 (pod? adj3 husk?)).ti,ab,id.	24
121	((kola or cola) adj3 (pod? or husk?)).ti,ab,id.	55
122	(pod? adj3 bean?).ti,ab,id.	1671
123	grape residues/ or grape marc/ or olive marc/ or ((pomace? or marc?) adj3 (olive? or grape?)).ti,ab,id.	3423
124	((priming or prime?) adj4 apple*).ti,ab,id.	36
125	((chlamydospori* or catenulata) adj5 remain*).ti,ab,id.	2
126	potato protein/ or (protein? adj3 potato*).ti,ab,id.	1904
127	((pruning or brashing or trimming or shearing) adj4 (lemontree* or "lemon tree*")).ti,ab,id.	6
128	coffee pulp/ or citrus pulp/ or orange pulp/ or potato pulp/ or wood pulp/ or ((cane? or coffee or orange? or potato* or wood?) adj3 pulp).ti,ab,id.	5755
129	((receptacle? or receptable?) adj3 (sunflower* or remain*)).ti,ab,id.	25
130	(removal? adj5 (appletree* or "apple tree*")).ti,ab,id.	17
131	((reuse* or reutil* or "re use*" or "re util*") adj4 (shell? or nutshell?)).ti,ab,id.	29
132	(extract* adj3 (root? or cassava or manioc or Manipueira)).ti,ab,id.	16749
133	((Asparagus or Protasparagus) adj4 (rootstock* or "root stock*")).ti,ab,id.	12

134	sawdust/ or ((sawdust or "saw dust") adj3 (coconut* or cedar* or Cedrus or coniferous or Gmelina or "white teak" or oak* or Quercus or Erythrobalanus or pine? or pinetree*)).ti,ab,id.	9400
135	(mushroom* adj4 scrap?).ti,ab,id.	7
136	((seed or seeds) adj3 (Acai or "Euterpe oleracea" or mahoni* or mango*)).ti,ab,id.	758
137	((seed or seeds) adj3 (meal or mix* or oil? or pomace* or powder* or waste or wastes or garbage*) adj3 (Brassica or cotton or palm? or castor or beaver* or neem or Azadirac?ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) adj tree?) or pa?paw* or papaya* or mustard*)).ti,ab,id.	3160
138	(seedling* adj4 "Pearl millet*").ti,ab,id.	167
139	((seed or seeds) adj3 (Terminalia or catappa or (almond adj1 (Indian or Malabar or tropical)) or Badamia or "Phytolacca javanica")).ti,ab,id.	140
140	(shell* adj3 (almond* or nut or nuts or Camellia or Thea or hazelnut* or cobnut* or filbert* or mango* or peanut* or groundnut* or pecan* or walnut*)).ti,ab,id.	4930
141	((flax or Linum) adj3 shive?).ti,ab,id.	90
142	((C#press* or castor* or Acacia? or Senegalia? or Eucalyptus or coconut*) adj4 shred*).ti,ab,id.	51
143	grass silage/ or maize silage/ or (silage* adj3 (maize* or corn* or grass*)).ti,ab,id.	26848
144	sewage sludge/ or water treatment sludge/ or (biosolid? or "bio solid?" or (sewage* adj3 sludge*) or (sludge* adj4 (bean? or wastewater* or "waste water*")) or ((wastewater* or "waste water*") adj3 (treatment* adj3 plant?))).ti,ab,id.	46976
145	(slurr* adj4 Myceli*).ti,ab,id.	35
146	(sod? adj3 (grass* or cou?ch or Elymus or repens or Agropyron or arundinaceum or vaillantian* or "Bromus villosus" or scutch or Cynodon or dact#lon or Digitaria or "Agrostis bermudiana" or do?b or "Fibichia umbellata")).ti,ab,id.	433
147	("spent wash*" adj4 sugar*).ti,ab,id.	27
148	((stalk or stalks) adj3 (corn* or maize* or grape or grapes)).ti,ab,id.	4281
149	maize starch/ or (starch adj3 (maize* or corn* or wheat)).ti,ab,id.	12434
150	((stem? or culm?) adj3 (Buriti or Mauritia or "moriche palm*")).ti,ab,id.	22
151	(vine adj3 stock*).ti,ab,id.	94
152	barley straw/ or maize straw/ or oat straw/ or rice straw/ or rye straw/ or sorghum stalks/ or soya straw/ or wheat straw/	27308
153	(straw? adj3 (barley or Brassica or rapeseed* or "rape seed*" or Caragana or carnauba or Copernicia or "Palma prunifera" or cassava or coconut* or coffee or	39123

	corn* or maize* or millet* or fingermillet* or ragimillet* or "Eleusine coracana" or flax or foragemillet* or Pennisetum or glauc* or bajra or Panicum or Chaetochloa or Setaria or "Cenchrus americanus" or oat or peanut* or groundnut* or "ground nut*" or pine? or pinetree* or rice or paddy or rye* or sesame* or beniseed* or simsim or Sorghum or soy?bean* or "soya bean*" or brizanth* or ((bread or panic or palisade or Lucia) adj grass*) or sugarcane* or "sugar cane*" or turnip* or neep* or vetch* or "wax palm*" or wheat)).ti,ab,id.	
154	(tassel* adj3 (maize* or corn*)).ti,ab,id.	565
155	biodegradable materials/	2281
156	((biodegradab* or "bio degradab*") adj4 textile*).ti,ab,id.	68
157	(thiol? adj5 powder*).ti,ab,id.	9
158	(Sesbania* adj4 top*).ti,ab,id.	12
159	cotton waste/ or ((trash or waste or wastes or garbage*) adj3 cotton*).ti,ab,id.	1102
160	((Euterpe or acai?) adj4 triturate*).ti,ab,id.	7
161	(tissue* adj4 trunk? adj4 palm?).ti,ab,id.	18
162	((Bahia or Paspalum) adj4 turf*).ti,ab,id.	108
163	(vinegar* adj4 "brown rice").ti,ab,id.	23
164	((waste or wastes or garbage*) adj4 (banana? or plantain? or Brassica* or cabbage? or carrot? or citrus or orange* or lemon? or lime? or grapefruit? or "grape fruit?" or clementin* or mandarin* or cork? or forestr* or agr#forest* or fruit? or garden? or green? or lignocellulos* or onion? or scallion? or "oyster mushroom*" or Pleurotus or palm* or pequi or Caryocar or souari or sugarcane* or "sugar cane*" or tea or chai or Thespesia or "Abelmoschus acuminatus" or Azanza or populne* or "Hibiscus blumei" or "portia tree?" or timber? or vegetable* or wood? or yard* or pellet? or powder* or Yuzu or hull?)).ti,ab,id.	17641
165	(wild adj4 sunflower*).ti,ab,id.	641
166	(yeast adj3 grape?).ti,ab,id.	284
167	or/40-166	623827
168	25 and 167	35646
169	1 or 6 or 39 or 168	84386
170	exp Europe/ or Greenland/ or Alps/ or Apennines/ or Carpathians/ or Pyrenees/ or Sierra de Guadarrama/ or exp European Union Countries/ or European Union/	1477867
171	(Europe* or Austria* or Burgenland or Salzburg or Steiermark or Styria or T#rol or Vienna or Vorarlberg or Belarus* or Belorussian* or Byelorussian* or Russia* or Czech* or Hungar* or Moldov* or Moldav* or Poland or Polish* or Slovak* or Slovenia* or Ukrain* or "Baltic States" or Estonia* or Latvia* or Lithuania* or "Nordic Countries" or Finland or Aland* or Aaland* or Iceland* or Scandinavia* or	2009134

	Denmark or Danish or Bornholm or Funen or Jutland or "Lolland Falster" or Norway or Norwegian* or "Jan Mayen" or Spitsbergen or Svalbard or Sweden or Swedish or Balkans or Albania* or Bosnia* or Bulgaria* or Croatia* or Greece or Greek? or Crete or Rhodes or Kosov* or Montenegr* or "Crna Gora" or Macedonia* or FYROM or R#mania* or Serbia* or Srbija* or Vojvodin* or Yugoslavia* or Jugoslavia* or Cyprus or Cypriot* or Gibraltar* or Italy or Italian* or Abruzzi or Apulia or Puglia or Basilicata or Calabria or Campania or "Emilia Romagna" or "Friuli-Venezia Giulia" or Latium or Lazio or Liguria* or Lombard* or Molise or Piedmont or Piemonte or Sardinia* or Sardegna or Sicily or Sicilia* or "Trentino-Alto Adige" or Tuscan* or Umbria* or "Valle d'Aosta" or Veneto or Venetian* or Malta or Maltese or Monaco or Monegasque* or Portugal or Portuguese or Azores or Madeira* or "San Marino" or Sammarinese or Spain or Spanish or Balearic or "Canary Islands" or Vatican or Andorra* or Benelux or Belgium or Antwerp* or Belgian* or Brabant or Flanders or Hainau?t or Liege or Limb?urg or Namur or Ireland or Irish or Eire or Connacht or Leinster or Munster or Ulster or "United Kingdom" or UK or Britain or British or "Channel Islands" or Guernsey or Jersey or England or Yorkshire or Lancashire or Scotland or Scottish or Wales or Welsh or "Isle of Man" or France or Alsace or Aquitaine or Auvergne or Brittany or Bretagne or Breton? or Burgund* or Ardennes or Corsica* or "Franche Comte" or "Languedoc Roussillon" or Limousin or Lorraine or "Nord Pas de Calais" or Normandy or Normandie or "Basse-Normande" or Loire or Picardy or Picardie or "Poitou Charentes" or "Cote d'Azur" or Rhone or Provence or German? or "Baden-Wurttemberg" or Bavaria* or Bayern or Berlin or Brandenburg or Bremen or Hesse? or Saxony or Saxon? or Mecklenburg or Rhine or Rhineland or Saarland or Schleswig or Holstein or Thuringia* or Liechtenstein or Luxembourg or Netherlands or Dutch or Holland or Drenthe or Flevoland or Friesland or Gelderland or Groningen or Overijssel or Utrecht or Zeeland or Switzerland or Swiss or Greenland or Alps or Alpes or Apennines or Carpathians or Pyrenees or "Sierra de Guadarrama" or "Common Market" or English or French).ti,ab,id,gl.	
172	170 or 171	2011047
173	169 and 172	11782
174	limit 173 to yr="2014 -Current"	2609
175	limit 174 to (english or norwegian)	2239

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Date: 20.11.2023

No. of results: 1799
Comments: «Exact search» was used

#	Search Query	Results
1	TS=((adher* or attach*) NEAR/3 soil$)	904
2	TS=(((growing or rooting or potting) NEAR/1 "med* mix*") or (growing NEAR/1 (mix or mixes or mixture$)) or (pot NEAR/1 mix*) or ((pot or potted or potting) NEAR/2 "soil mix*") or (potting NEAR/1 (material* or mix* or different or various or compost$)) or (("pot soil$" or "potted soil$" or potting or "growing media" or "growing medium$" or "growing substrat*") NEAR/9 (component$ or composed or composing or composition$ or contained or containing or manufactur* or process*)))	1815
3	TS=((container* NEAR/2 (crop$ or cultivat* or culture$ or plant$)) or (pot NEAR/2 (culture$ or cultivat* or (grow$ NEAR/1 plant$))) or "pot plant$" or "plant in pot$" or "plants in pot$" or "house plant$" or "plant$ for planting" or ((potted or potting or ornamental) NEAR/2 plant$) or ((graft or grafting or bud) NEAR/0 wood$) or (ornamental NEAR/1 (crop$ or bromeliad$ or orchid$ or palm$ or shrub$ or tree$)) or (stock$ NEAR/1 (balled or root* or planting or type$)) or "vegetative propagation" or "vegetative reproduction" or "bud stick$" or "seed tuber$" or "seed potato*" or "planting material$" or "cut set$" or "cut sett$" or ((carnation$ or chrysanthemum$ or hyacinth$ or jasmine$ or lily or lilies or poinsettia$ or poppy or poppies or rose$ or "sweet pea$" or tulip$) NEAR/2 crop$) or grafting or budding or inarching or layering or marcotting or micropropagation or "micro propagation" or "bud culture" or stooling or topworking or "top working")	185711
4	TS=(potplant$ or houseplant$ or bulb$ or budwood$ or graftwood$ or graftings or cuttings or ornamentals or budstick$ or budling$ or seedling$ or stocktype$ or rootstock$ or rhizome$ or scion$ or stolon* or transplant* or nurser* or wilding$)	975164
5	#4 OR #3	1140953
6	TS=((organic* NEAR/0 amendment$) or ((growing or potting or rooting) NEAR/0 (media or medium$)) or ((pot or potted or potting) NEAR/0 soil$) or (soil NEAR/0 (mix* or conditioner?)) or ("nutrient film" NEAR/0 (technique* or culture*)))	15145
7	TS=(compost* or manure* or residue*)	611965
8	TS=(biowaste$ or hydroponic* or aeroponics or mulch* or potsoil* or "soilless culture$" or substrat* or uncomposted or vermicompost* or "organic fertili?er$")	1203888

9	#8 OR #7 OR #6	1746451
10	#9 AND #5	37861
11	TS=(((aquatic or marine) NEAR/0 plant$) or ((aquatic or sea) NEAR/0 weed$) or seagrass* or "sea grass*" or eelgrass* or "eel grass*" or seaweed$ or kelp or alga$ or Phycophyta or Azolla or "water fern" or "water velvet" or "fairy moss" or "mosquito fern" or Posidonia or Sargassum or (Eich$ornia NEAR/0 (crassipes or speciosa or crassicaulis)) or Pontederia or Piaropus or (water NEAR/0 (hyacinth* or lil*)) or waterhyacinth* or "Florida devil*" or "lilac devil*" or "German pana" or Heteranthera or "river raft")	206270
12	TS=((wood$ NEAR/2 (ash* or dust or fibre$ or fine$ or log$ or pellet$ or sawdust or straw$ or drift* or chip$)) or driftwood* or "hog fuel" or (bagasse NEAR/2 (cassava* or manioc* or me?cal or maguey)) or ((bale$ or mat$) NEAR/2 hay) or ((bean$ NEAR/2 (cake$ or husk$)) NEAR/2 castor) or (castor NEAR/2 cake$) or ((organic* NEAR/2 bean$) NEAR/2 castor) or berry or berries or ((biodigest* or codigest* or digest* or anaerobic* or aerobic*) NEAR/2 slurr*) or bioslurr* or "bio slurr*" or biomanure* or bioresidu* or ((digest* or biodigest* or codigest*) NEAR/3 ((maize* or corn* or oat$) NEAR/2 silage*)) or ((anaerobic* or aerobic*) NEAR/2 digest* NEAR/3 slurr*) or "energy plantation$" or ((biomass* or "bio mass*") NEAR/2 (Gliricidia or vegetable* or salad*)) or (potato* NEAR/2 (bioproduct* or "bio product*")) or (bran NEAR/2 (maize* or corn* or rice or wheat or oat* or mushroom* or coffee)) or (brine NEAR/2 olive$) or (bulb* NEAR/3 (Cyperus or Chlorocyperus or Pycreus or "coco grass*" or "red grass*" or "nut grass*" or nutgrass or nutsedge)) or ((empt* NEAR/2 fruit*) NEAR/3 bunch*) or ((b?product* or "b? product*") NEAR/4 ("Phoenix dactylifera*" or "date palm*")))	67471
13	TS=((bark NEAR/2 (shred* or spruce*)) or (bark NEAR/3 (cassava or cedar* or Cedrus or conifer$ or c?press* or "Douglas fir" or Pseudotsuga or Abies or Pinus or Eucalyptus or ferment* or "fruit tree*" or hardwood* or "hard wood*" or humus or Cryptomeria or Chamaecyparis or Retinospora or oak* or ornamental* or pine* or ((red or coral) NEAR/0 wood*) or redwood* or sandalwood* or Adenanthera or circassian or bead* or "bean tree*" or Corallaria or wiliwili or legliz or "crab* eye*" or (peacock NEAR/0 (flower* or tree*)) or "Polynesian peanut*" or Rhododendron* or Azalea*)))	5498
14	TS=(((Citrullus or colocyth* or coconut* or coco or cotton or gingelly or sesame or beniseed or simsim or groundnut* or "ground nut*" or peanut* or kapok or mustard or olive* or Pongamia or neem or Azadirac$ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) NEAR/0 tree$) or soy$bean* or "soya bean*" or Jatropha or "Brassica napus" or Brassicanapus or "Brassica rapa" or "rape seed*" or rapeseed* or sunflower*) NEAR/3 cake*) or (("Brassica napus" or Brassicanapus or "Brassica rapa" or rapeseed* or groundnut* or "ground nut*" or peanut* or seed or sesame or beniseed or simsim or soy$bean* or "soya bean*") NEAR/2 (meal$ or oilmeal*)))	22801

15	TS=(Carbocalc* or "carbo calc*" or (((catch or stubble$) NEAR/0 crop$) NEAR/3 (oat$ or serradella*)) or (chafe* NEAR/3 (soy$bean* or "soya bean*")) or (chaff* NEAR/2 rice*) or (chipp* NEAR/4 oak*) or ((chipp* or branch*) NEAR/2 oak*) or ((poplar* or bark or hemp or maravalha or residu*) NEAR/2 chip*) or ((chopp* or straw* or stem$) NEAR/2 (Bhusa or Ilex)) or ((maize* or corn*) NEAR/2 (cob$ or core$ or flour)) or cornflour or coir or coirs or ((coconut* or coco) NEAR/1 fibre$) or ((logging or log$) NEAR/2 debris) or defibre* or "de fibre*" or defiber* or "de fiber*" or ((coconut$ or coco) NEAR/2 (dice* or milk or pith or water)) or ((Ipomoea NEAR/2 fistulosa) NEAR/3 (leaf or leaves)) or (powder* NEAR/2 (Eucalyptus or leek$ or thyme or thymus or "Origanum webbianum" or Caragana* or ginger$ or sugarcane* or "sugar cane*" or xaxim* or Dicksonia)))	11771
16	TS=(extract* NEAR/2 (Azadirachtin or Eucalyptus or "Ligustrum nepalens*" or Sapium or Urtica or Lantana or Camara or ((red or white or wild or yellow) NEAR/1 sage) or "cherry-pie$" or "Spanish flag$" or tickberr* or Chromol$ena or weed$ or Siamweed$ or kingsweed$ or Christmas or bitterbush* or parrafinbush* or geritoo or hagonoy or Eupatorium or archangel* or thoroughwort or "Osmia odorata" or "hemp agrimony" or "jack-in-the-bush" or "mile-a-minute" or root$ or cassava or manioc or Manipueira))	16028
17	TS=(((wastewater* or "waste water*") NEAR/3 mushroom*) or ((wastewater* or "waste water*") NEAR/2 farm$) or (fibre$ NEAR/2 (cocoa or cacao or "Phoenix dactylifera*" or palm$ or palmtree* or Poaceae* or Bambusaceae* or Festucaceae* or Gramin$ae* or Triticaceae* or vegetable*)) or (("filter cake*" or "clarification mud*") NEAR/2 (sugarcane* or "sugar cane*" or coffee)) or "press mud*" or pressmud* or ((tea or chai) NEAR/3 fluff*) or ((food or plate$ or kitchen$ or hotel* or salad$ or catering$ or herbal or soup*) NEAR/2 (waste or wastes or garbage*)) or ((fruit$ or cake* or presscake*) NEAR/2 cranberr*) or ((gluten or "gluten meal$") NEAR/2 (corn* or maize*)) or (grain$ NEAR/1 (rice or wheat)) or (("green leaves" or "green leaf") NEAR/4 (Alnus or Artemisia or Cingulum or mugwort or "felon herb" or wormwood or "John* plant*" or Datura or Eupatorium or Schima)) or (coffee NEAR/2 (ground$ or parchment*)) or ("Arachis pintoi" NEAR/3 (cover* or ground$)) or ("ground cover*" NEAR/3 Arachis) or ((groundnut* or "ground nut*" or peanut* or corn* or maize* or pistachio* or cocoa or cacao or chickpea* or coffee or cotton or Eucalyptus or olive$ or pine$ or pinetree* or rice or Sorghum or sunflower* or tung$ or wheat or coconut*) NEAR/2 (hull$ or husk$ or shell$)) or ((hummock* or mound*) NEAR/2 (moss or mosses or Bryopsida)))	65760
18	TS=(((leaf or leaves) NEAR/1 (dust or extract$ or litter or mould$ or powder$)) or ((leaf or leaves) NEAR/2 (banana* or plantain* or kuppaimeni or Acalypha or nochi or "Vitex negundo" or teak* or vasambu or "Acorus calamus" or Acacia$ or Senegalia$ or wattle or neem or Azadirac$ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) NEAR/0 tree$) or rye* or turnip* or neep* or Pueraria or Platanus or plane or sycamores or Fagus or beech or bhimal or Grewia or Copernicia or prunifera or carnauba or "cashew tree$" or cashewtree$ or castor or Casuarina or Cordyla or "Phoenix dactylifera*" or "date palm*" or Faidherbia or	62195

	Fleabane$ or Gliricidia or jojoba or kharik or Celtis or Leucaena$ or mango* or Murraya or curry or Quercus or oak* or Butea or Palas or pine* or Pongamia$ or sugarbeet$ or "sugar beet$" or tea or chai or Ficus or Covellia or timla or pellet$)))	
19	TS =(((Industri* NEAR/1 (b?product* or "b? product*")) NEAR/2 (organic* or plant$ or farm$ or farming or garden* or agro*)) or (Industri* NEAR/1 (Aibes or fir or firs or Pinus or pine$ or Picea or spruce* or Thuja$ or sugarcane* or "sugar cane*" or Copernicia or prunifera or carnauba)) or ((integument* or tegument*) NEAR/3 cashew*) or (juice* NEAR/3 (waste or wastes or garbage*)) or (kernel$ NEAR/1 (mango* or cake$)) or (lime NEAR/2 (sugarbeet* or "sugar beet*")) or ((litter or bedding) NEAR/2 (Bactris or Guilielma or grassland* or "grass land*" or heath or heathland* or oak* or Quercus or Tusam$)) or ((mill$ NEAR/2 (waste or wastes or wastewater* or garbage*)) NEAR/3 olive$) or (mucilage* NEAR/3 agave*) or gyttja* or ((conifer$ or pine$ or pinetree*) NEAR/2 needle$) or (pine* NEAR/2 (nugget* or litter)) or ((neem or Azadirac$ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) NEAR/0 tree$)) NEAR/1 oil$) or "biogas spent slurr*" or "bio gas spent slurr*" or ((biodegradable or "bio degradable" or pharmaceut* or monosodium or glutamate or sapropel* or sericulture* or silkworm* or "silk worm*" or starch) NEAR/3 (waste or wastes or garbage*)) or ((palm NEAR/0 oil) NEAR/2 (effluent* or mill$)) or (pome NEAR/2 palm$) or ((pea or peas) NEAR/0 grass*) or (peel* NEAR/2 (cassava* or orange* or banana$ or plantain$)) or ((Alfalfa or lucerne or "Brassica carinata") NEAR/2 pellet$) or ((Agrostis or bentgrass* or "bent grass*") NEAR/3 cover*) or (ash* NEAR/2 (pod$ NEAR/2 husk$)) or ((kola or cola) NEAR/2 (pod$ or husk$)) or (pod$ NEAR/2 bean$) or ((pomace$ or marc$) NEAR/2 (olive$ or grape$)) or ((priming or prime$) NEAR/3 apple*) or ((chlamydospori* or catenulata) NEAR/4 remain*) or (protein$ NEAR/2 potato*))	28328
20	TS=(((pruning or brashing or trimming or shearing) NEAR/3 (lemontree* or "lemon tree*")) or ((cane$ or coffee or orange$ or potato* or wood$) NEAR/2 pulp) or ((receptacle$ or receptable$) NEAR/2 (sunflower* or remain*)) or (removal$ NEAR/4 (appletree* or "apple tree*")) or ((reuse* or reutil* or "re use*" or "re util*") NEAR/3 (shell$ or nutshell$)) or ((Asparagus or Protasparagus) NEAR/3 (rootstock* or "root stock*")) or ((sawdust or "saw dust") NEAR/2 (coconut* or cedar* or Cedrus or coniferous or Gmelina or "white teak" or oak* or Quercus or Erythrobalanus or pine$ or pinetree*)) or (mushroom* NEAR/3 scrap$) or ((seed or seeds) NEAR/2 (Acai or "Euterpe oleracea" or mahoni* or mango*)) or (((seed or seeds) NEAR/2 (meal or mix* or oil$ or pomace* or powder* or waste or wastes or garbage*)) NEAR/2 (Brassica or cotton or palm$ or castor or beaver* or neem or Azadirac$ta or Antelaea or Azedarach or cornucopia or "Indian lilac*" or "Persian lilac*" or Melia or ((bastard or bead or margosa or paradise) NEAR/0 tree$) or pa$paw* or papaya* or mustard*)) or (seedling* NEAR/3 "Pearl millet*") or ((seed or seeds) NEAR/2 (Terminalia or catappa or (almond NEAR/0 (Indian or Malabar or tropical)) or Badamia or "Phytolacca javanica")) or (shell* NEAR/2 (almond* or nut or nuts or Camellia or Thea or hazelnut* or cobnut* or filbert* or mango* or peanut* or groundnut* or pecan* or walnut*)) or ((flax or Linum)	13972

	NEAR/2 shive$) or ((C?press* or castor* or Acacia$ or Senegalia$ or Eucalyptus or coconut*) NEAR/3 shred*))	
21	TS=((silage* NEAR/2 (maize* or corn* or grass*)) or biosolid? or "bio solid$" or (sewage* NEAR/2 sludge*) or (sludge* NEAR/3 (bean$ or wastewater* or "waste water*")) or ((wastewater* or "waste water*") NEAR/2 (treatment* NEAR/2 plant$)) or (slurr* NEAR/3 Myceli*) or (sod$ NEAR/2 (grass* or cou$ch or Elymus or repens or Agropyron or arundinaceum or vaillantian* or "Bromus villosus" or scutch or Cynodon or dact?lon or Digitaria or "Agrostis bermudiana" or do$b or "Fibichia umbellata")) or ("spent wash*" NEAR/3 sugar*) or ((stalk or stalks) NEAR/2 (corn* or maize* or grape or grapes)) or (starch NEAR/2 (maize* or corn* or wheat)) or ((stem$ or culm$) NEAR/2 (Buriti or Mauritia or "moriche palm*")) or (vine NEAR/2 stock*) or (tassel* NEAR/2 (maize* or corn*)) or ((biodegradab* or "bio degradab*") NEAR/3 textile*) or (thiol$ NEAR/4 powder*) or (Sesbania* NEAR/3 top*) or ((trash or waste or wastes or garbage*) NEAR/2 cotton*) or ((Euterpe or acai$) NEAR/3 triturate*) or ((tissue* NEAR/3 trunk$) NEAR/3 palm$) or ((Bahia or Paspalum) NEAR/3 turf*) or (vinegar* NEAR/3 "brown rice") or (wild NEAR/3 sunflower*) or (yeast NEAR/2 grape$))	94494
22	TS=(straw$ NEAR/2 (barley or Brassica or rapeseed* or "rape seed*" or Caragana or carnauba or Copernicia or "Palma prunifera" or cassava or coconut* or coffee or corn* or maize* or millet* or fingermillet* or ragimillet* or "Eleusine coracana" or flax or foragemillet* or Pennisetum or glauc* or bajra or Panicum or Chaetochloa or Setaria or "Cenchrus americanus" or oat or peanut* or groundnut* or "ground nut*" or pine$ or pinetree* or rice or paddy or rye* or sesame* or beniseed* or simsim or Sorghum or soy$bean* or "soya bean*" or brizanth* or ((bread or panic or palisade or Lucia) NEAR/0 grass*) or sugarcane* or "sugar cane*" or turnip* or neep* or vetch* or "wax palm*" or wheat))	32776
23	TS=((waste or wastes or garbage*) NEAR/3 (banana$ or plantain$ or Brassica* or cabbage$ or carrot$ or citrus or orange* or lemon$ or lime$ or grapefruit$ or "grape fruit$" or clementin* or mandarin* or cork$ or forestr* or agr?forest* or fruit$ or garden$ or green$ or lignocellulos* or onion$ or scallion$ or "oyster mushroom*" or Pleurotus or palm* or pequi or Caryocar or souari or sugarcane* or "sugar cane*" or tea or chai or Thespesia or "Abelmoschus acuminatus" or Azanza or populne* or "Hibiscus blumei" or "portia tree$" or timber$ or vegetable* or wood$ or yard* or pellet$ or powder* or Yuzu or hull$))	23914
24	#23 OR #22 OR #21 OR #20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 OR #13 OR #12 OR #11	601918
25	#24 AND #5	19194
26	#1 OR #2 OR #10 OR #25	55134
27	TS=(Europe* or Austria* or Burgenland or Salzburg or Steiermark or Styria or T?rol or Vienna or Vorarlberg or Belarus* or Belorussian* or Byelorussian* or Russia* or Czech* or Hungar* or Moldov* or Moldav* or Poland or Polish* or Slovak* or Slovenia* or Ukrain* or "Baltic States" or Estonia* or Latvia* or Lithuania* or	4681173

	"Nordic Countries" or Finland or Aland* or Aaland* or Iceland* or Scandinavia* or Denmark or Danish or Bornholm or Funen or Jutland or "Lolland Falster" or Norway or Norwegian* or "Jan Mayen" or Spitsbergen or Svalbard or Sweden or Swedish or Balkans or Albania* or Bosnia* or Bulgaria* or Croatia* or Greece or Greek$ or Crete or Rhodes or Kosov* or Montenegr* or "Crna Gora" or Macedonia* or FYROM or R?mania* or Serbia* or Srbija* or Vojvodin* or Yugoslavia* or Jugoslavia* or Cyprus or Cypriot* or Gibraltar* or Italy or Italian* or Abruzzi or Apulia or Puglia or Basilicata or Calabria or Campania or "Emilia Romagna" or "Friuli-Venezia Giulia" or Latium or Lazio or Liguria* or Lombard* or Molise or Piedmont or Piemonte or Sardinia* or Sardegna or Sicily or Sicilia* or "Trentino-Alto Adige" or Tuscan* or Umbria* or "Valle d'Aosta" or Veneto or Venetian* or Malta or Maltese or Monaco or Monegasque* or Portugal or Portuguese or Azores or Madeira* or "San Marino" or Sammarinese or Spain or Spanish or Balearic or "Canary Islands" or Vatican or Andorra* or Benelux or Belgium or Antwerp* or Belgian* or Brabant or Flanders or Hainau* or Liege or Limb$urg or Namur or Ireland or Irish or Eire or Connacht or Leinster or Munster or Ulster or "United Kingdom" or UK or Britain or British or "Channel Islands" or Guernsey or Jersey or England or Yorkshire or Lancashire or Scotland or Scottish or Wales or Welsh or "Isle of Man" or France or Alsace or Aquitaine or Auvergne or Brittany or Bretagne or Breton$ or Burgund* or Ardennes or Corsica* or "Franche Comte" or "Languedoc Roussillon" or Limousin or Lorraine or "Nord Pas de Calais" or Normandy or Normandie or "Basse-Normande" or Loire or Picardy or Picardie or "Poitou Charentes" or "Cote d'Azur" or Rhone or Provence or German$ or "Baden-Wurttemberg" or Bavaria* or Bayern or Berlin or Brandenburg or Bremen or Hesse$ or Saxony or Saxon$ or Mecklenburg or Rhine or Rhineland or Saarland or Schleswig or Holstein or Thuringia* or Liechtenstein or Luxembourg or Netherlands or Dutch or Holland or Drenthe or Flevoland or Friesland or Gelderland or Groningen or Overijssel or Utrecht or Zeeland or Switzerland or Swiss or Greenland or Alps or Alpes or Apennines or Carpathians or Pyrenees or "Sierra de Guadarrama" or "Common Market" or English or French)	
28	#27 AND #26	4228
29	#28 Timespan: 2014-01-01 to 2023-12-31	1841
30	#29 and Exclude Languages: Russian or German or Polish or Spanish or Croatian or Korean or Portuguese or Chinese or Czech or French or Italian or Slovak or Turkish	1799

9.4 Appendix 4 - Probability and uncertainty

Probability	Probability range (%)	Corresponding categories
Unlikely	0-33	Extremely unlikely, Very unlikely, part of Unlikely
As likely as not	34-66	As likely as not
Likely	67-100	Likely, Very likely, Extremely Likely

Uncertainty	Definition
Low	No or little information is missing. No or few data are missing, incomplete, inconsistent, or conflicting. No subjective judgment is introduced. No unpublished data are used.
Medium	Some information is missing. Some data are missing, incomplete, inconsistent, or conflicting. Subjective judgment is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing. Most data are missing, incomplete, inconsistent, or conflicting. Subjective judgment may be introduced without supporting evidence. Unpublished data are frequently used.

9.5 Appendix 5 – Comprehensive Species Inventory

EPPO code	**Scientific name**	**Association with soil and other growing media**	**Source**
ACHAFU	*Achatina fulica*	rarely	EPPO GDB
ANSTFR	*Anastrepha fratercula*		EPPO GDB
ANSTLU	*Anastrepha ludens*		EPPO GDB
ANSTOB	*Anastrepha obliqua*		EPPO GDB
ANSTSU	*Anastrepha suspensa*		EPPO GDB
	Anguispira alternata	rarely	EPPO GDB
DACUDO	*Bactrocera dorsalis*	always	EPPO GDB
DACUCT	*Bactrocera minax*		EPPO GDB
DACUTR	*Bactrocera tryoni*	always	EPPO GDB
DACUTS	*Bactrocera tsuneonis*		EPPO GDB
DACUZO	*Bactrocera zonata*	always	EPPO GDB
BNYVV0	*Beet necrotic yellow vein virus*	sometimes	EPPO GDB
	Camaena cicatricosa	rarely	EPPO GDB
HELXAP	*Cantareus apertus*	always	EPPO GDB
CARMV0	*Carnation mottle virus*	sometimes	EPPO GDB
CARSSA	*Carposina sasakii*	always	EPPO GDB
CERTCA	*Ceratitis capitata*	sometimes	EPPO GDB
CERTCO	*Ceratitis cosyra*	always	EPPO GDB
CERTQU	*Ceratitis quinaria*	unlikely	EPPO GDB
CERTRO	*Ceratitis rosa*	always	EPPO GDB
CONHNE	*Conotrachelus nenuphar*	always	EPPO GDB
CGMMV0	*Cucumber green mottle mosaic virus*	sometimes	EPPO GDB
DIABLO	*Diabrotica barberi*	always	EPPO GDB
DIABSC	*Diabrotica speciosa*	always	EPPO GDB
DIABUN	*Diabrotica undecimpunctata*	always	EPPO GDB
DIABUH	*Diabrotica undecimpunctata*	always	EPPO GDB
DIABVI	*Diabrotica virgifera*	always	EPPO GDB
EPIXCU	*Epitrix cucumeris*	always	EPPO GDB
EPIXTU	*Epitrix tuberis*	always	EPPO GDB
ANMLOR	*Exomala orientalis*		EPPO GDB
HETDPA	*Globodera pallida*		EPPO GDB
HETDRO	*Globodera rostochiensis*		EPPO GDB

GONPGI	*Gonipterus gibberus*	sometimes	EPPO GDB
GONPSC	*Gonipterus scutellatus*	sometimes	EPPO GDB
CYDIIN	*Grapholita inopinata*	sometimes	EPPO GDB
HALYHA	*Halyomorpha halys*		EPPO GDB
MYNDCR	*Haplaxius crudus*	always	EPPO GDB
	Hawaiia minuscula	rarely	EPPO GDB
HETDGL	*Heterodera glycines*	always	EPPO GDB
HETRAR	*Heteronychus arator*	always	EPPO GDB
HYGRCI	*Hygromia cinctella*	rarely	EPPO GDB
	Krynickillus melanocephalus	rarely	EPPO GDB
VAGILE	*Laevicaulis alte*	rarely	EPPO GDB
	Lucilla singleyana	rarely	EPPO GDB
MARGPR	*Margarodes prieskaensis*	always	EPPO GDB
MARGVI	*Margarodes vitis*	always	EPPO GDB
MARGVR	*Margarodes vredendalensis*	always	EPPO GDB
EOBAVE	*Massylaea vermiculata*	rarely	EPPO GDB
MELNCO	*Melanotus communis*	always	EPPO GDB
MELGCH	*Meloidogyne chitwoodi*	always	EPPO GDB
MELGMY	*Meloidogyne enterolobii*	always	EPPO GDB
MELGFA	*Meloidogyne fallax*	always	EPPO GDB
MELGMA	*Meloidogyne mali*	always	EPPO GDB
	Monacha cantiana	rarely	EPPO GDB
NACOBA	*Nacobbus aberrans*		EPPO GDB
GRAGLE	*Naupactus leucoloma*	sometimes	EPPO GDB
	Paralaoma servilis	rarely	EPPO GDB
LIMOCF	*Pheletes kiesenwetter*	always	EPPO GDB
PHMPOM	*Phymatotrichopsis omnivora*		EPPO GDB
PHYTLA	*Phytophthora lateralis*		EPPO GDB
PHYTRA	*Phytophthora ramorum*		EPPO GDB
POPIJA	*Popillia japonica newman*	always	EPPO GDB
RADOCI	*Radopholus similis*		EPPO GDB
RADOSI	*Radopholus similis*	always	EPPO GDB
RCNMV0	*Red clover necrotic mosaic virus*	sometimes	EPPO GDB
RHAGCI	*Rhagoletis cingulata*	always	EPPO GDB
RHAGCO	*Rhagoletis completa*	always	EPPO GDB
RHAGFA	*Rhagoletis fausta*	always	EPPO GDB

RHAGIN	*Rhagoletis indifferens*	always	EPPO GDB
RHAGME	*Rhagoletis mendax*	always	EPPO GDB
RHAGPO	*Rhagoletis pomonella*	always	EPPO GDB
RHAGSU	*Rhagoletis suavis*	always	EPPO GDB
SOMV00	*Sowbane mosaic virus*	sometimes	EPPO GDB
STRMVI	*Strobilomyia viarium*	always	EPPO GDB
SYNCEN	*Synchytrium endobioticum*		EPPO GDB
TECASO	*Tecia solanivora*	sometimes	EPPO GDB
THEBPI	*Theba pisana*	rarely	EPPO GDB
TMV000	*Tobacco mosaik virus*	sometimes	EPPO GDB
TNV000	*Tobacco necrosis virus*	sometimes	EPPO GDB
TRV000	*Tobacco rattle virus*	sometimes	EPPO GDB
TOBRFV	*Tomato brown rugose fruit virus*	sometimes	EPPO GDB
TBSV00	*Tomato bushy stunt virus*	sometimes	EPPO GDB
TOMV00	*Tomato mosaic virus*	sometimes	EPPO GDB
TRHIST	*Trochulus striolatus*	rarely	EPPO GDB
XIPHAA	*Xiphinema americanum*		EPPO GDB
XIPHCA	*Xiphinema cobb*		EPPO GDB
XIPHRI	*Xiphinema rivesi*	always	EPPO GDB
ACLYWI	*Achlysiella williamsi*		CABI
PSDMAV	*Acidovorax avenae*		CABI
PSDMAC	*Acidovorax citrulli*		CABI
ADORSI	*Adoretus sinicus*		CABI
AGROYP	*Agrotis ipsilon*		CABI
ANSTMA	*Anastrepha manihoti*		CABI
ANSTST	*Anastrepha striata*		CABI
ANGUAG	*Anguina agrostis*		CABI
ANGUTR	*Anguina tritici*		CABI
ANMLSU	*Anomala sulcatula*		CABI
ANOPLO	*Anoplolepis gracilipes*		CABI
APLOBE	*Aphelenchoides besseyi*		CABI
ARKONI	*Arkoola nigra*		CABI
ARDDTR	*Arthurdendyus triangulatus*		CABI
ATHEOR	*Atherigona orientalis*		CABI
ATHEOZ	*Atherigona oryzae*		CABI
BCTRCB	*Bactrocera carambolae*		CABI

DACUCM	*Bactrocera cucumis*		CABI
DACUCU	*Bactrocera cucurbitae*		CABI
BCTRFA	*Bactrocera facialis*		CABI
BCTRFR	*Bactrocera frauenfeldi*		CABI
BCTRJA	*Bactrocera jarvisi*		CABI
BCTRKI	*Bactrocera kirki*		CABI
DACULA	*Bactrocera latifrons*		CABI
BCTRME	*Bactrocera melanotus*		CABI
BCTRNE	*Bactrocera neohumeralis*		CABI
BCTROC	*Bactrocera occipitalis*		CABI
DACUOL	*Bactrocera oleae*		CABI
BCTRPA	*Bactrocera passiflorae*		CABI
DACUPS	*Bactrocera psidii*		CABI
BCTRTA	*Bactrocera tau*		CABI
BCTRUM	*Bactrocera umbrosa*		CABI
BCTRXA	*Bactrocera xanthodes*		CABI
BELOLO	*Belonolaimus longicaudatus*		CABI
BOTRCI	*Botrytis cinerea*		CABI
CADOLO	*Cadophora luteo-olivacea*		CABI
CRCNMA	*Carcinus maenas*		CABI
CERTPU	*Ceratitis punctata*		CABI
CERAFI	*Ceratocystis fimbriata*		CABI
CLABMI	*Clavibacter michiganensi*		CABI
DACHGY	*Coniothyrium glycines*		CABI
COPTGE	*Coptotermes gestroi*		CABI
COICFL	*Corbicula fluminea*		CABI
HELXAS	*Cornu aspersum*		CABI
CRAOVI	*Crassostrea virginica*		CABI
KREPFO	*Crepidula fornicata*		CABI
CRONRI	*Cronartium ribicola*		CABI
HYLEAN	*Delia antiqua*		CABI
HYLECO	*Delia coarctata*		CABI
HYLEFL	*Delia floralis*		CABI
HYLEPL	*Delia platura*		CABI
HYLERA	*Delia radicum*		CABI
ERWIZE	*Dickeya zeae*		CABI

DIPRSI	*Diprion similis*		CABI
GONIRO	*Discus rotundatus*		CABI
DITYAN	*Ditylenchus angustus*		CABI
FORFAU	*Forficula auricularia*		CABI
FUSAOX	*Fusarium oxysporum*		CABI
GECCCO	*Geococcus coffeae*		CABI
ERYSCI	*Golovinomyces cichoracearum*		CABI
ERYSPP	*Golovinomyces orontii*		CABI
HELYDH	*Helicotylenchus dihystera*		CABI
HELYOL	*Helicotylenchus oleae*		CABI
HELYPS	*Helicotylenchus pseudorobustus*		CABI
HEMRMA	*Hemicriconemoides mangiferae*		CABI
HEMCAR	*Hemicycliophora arenaria*		CABI
HETDCJ	*Heterodera cajani*		CABI
HETDCI	*Heterodera ciceri*		CABI
HETDGO	*Heterodera goettingiana*		CABI
HETDOR	*Heterodera oryzae*		CABI
HETDOC	*Heterodera oryzicola*		CABI
HETDSA	*Heterodera sacchari*		CABI
HETDZE	*Heterodera zeae*		CABI
HOLLIN	*Hoplolaimus indicus*		CABI
HOLLPA	*Hoplolaimus pararobustus*		CABI
HOLLSE	*Hoplolaimus seinhorsti*		CABI
LIMXMA	*Limax maximus*		CABI
LPRNFO	*Limnoperna fortunei*		CABI
IRIDHU	*Linepithema humile*		CABI
LUMBRU	*Lumbricus rubellus*		CABI
MELGAC	*Meloidogyne acronea*		CABI
MELGAR	*Meloidogyne arenaria*		CABI
MELGBR	*Meloidogyne brevicauda*		CABI
MELGCO	*Meloidogyne coffeicola*		CABI
MELGEX	*Meloidogyne exigua*		CABI
MELGGC	*Meloidogyne graminicola*		CABI
MELGIN	*Meloidogyne incognita*		CABI
MARSPA	*Microdochium panattonianum*		CABI
MNLCIN	*Monilochaetes infuscans*		CABI

CERSPD	*Mycosphaerella gibsonii*		CABI
NEODSE	*Neodiprion sertifer*		CABI
ORYCBO	*Oryctes boas*		CABI
PCHNIN	*Pachnoda interrupta*		CABI
PAADTU	*Paradiplosis tumifex*		CABI
TRIHPS	*Paratrichodorus porosus*		CABI
PECBCB	*Pectobacterium brasiliense*		CABI
PEGOHY	*Pegomya hyoscyami*		CABI
PRSCPH	*Peronosclerospora philippinensis*		CABI
TOGNMI	*Phaeoacremonium minimum*		CABI
PHMOCH	*Phaeomoniella chlamydospora*		CABI
PHEIME	*Pheidole megacephala*		CABI
PHYGSM	*Phyllophaga smithi*		CABI
PHYTAL	*Phytophthora alni*		CABI
PHYTBM	*Phytophthora boehmeriae*		CABI
PHYTCN	*Phytophthora cinnamomi*		CABI
PHYTOO	*Phytophthora colocasiae*		CABI
PHYTMC	*Phytophthora medicaginis*		CABI
PHYTPO	*Phytophthora porri*		CABI
PHYTVI	*Phytophthora vignae*		CABI
PITYCH	*Pityogenes chalcographus*		CABI
PLADBR	*Plasmodiophora brassicae*		CABI
PTYDMA	*Platydemus manokwari*		CABI
PLUTMA	*Plutella xylostella*		CABI
POMACA	*Pomacea canaliculata*		CABI
PRATBR	*Pratylenchus brachyurus*		CABI
PRATGO	*Pratylenchus goodeyi*		CABI
PRATLO	*Pratylenchus loosi*		CABI
PRATTH	*Pratylenchus thornei*		CABI
PRAYCI	*Prays citri*		CABI
PRISER	*Pristiphora erichsonii*		CABI
PSDMAG	*Pseudomonas agarici*		CABI
PSDMSX	*Pseudomonas syringae*		CABI
PSPECA	*Pseudoperonospora cannabina*		CABI
PSILRO	*Psila rosae*		CABI
PUCCAS	*Puccinia asparagi*		CABI

PUNCCH	*Punctodera chalcoensis*		CABI
HETDPU	*Punctodera punctata*		CABI
RADOCT	*Radopholus citri*		CABI
RHAGCE	*Rhagoletis cerasi*		CABI
RHAGRI	*Rhagoletis ribicola*		CABI
ROTYPA	*Rotylenchulus parvus*		CABI
RUSLSO	*Russelliana solanicola*		CABI
SCPHRZ	*Sclerophthora rayssiae*		CABI
SCLPGR	*Sclerospora graminicola*		CABI
SCUNCL	*Scutellonema clathricaudatum*		CABI
SOLERI	*Solenopsis richteri*		CABI
SPONSU	*Spongospora subterranea*		CABI
STREIP	*Streptomyces ipomoeae*		CABI
TANYDI	*Tanymecus dilaticollis*		CABI
THAUPR	*Thaumetopoea processionea*		CABI
THPHSO	*Thecaphora solani*		CABI
TIPUPA	*Tipula paludosa*		CABI
TRTYPI	*Trophotylenchulus piperis*		CABI
TYLRMA	*Tylenchorhynchus annulatus*		CABI
UROCAG	*Urocystis agropyri*		CABI
WASMAU	*Wasmannia auropunctata*		CABI
XANTRB	*Xanthomonas arboricola*		CABI
XANTXX	*Xanthomonas axonopodis*		CABI
XANTKM	*Xanthomonas campestris*		CABI
XANTHT	*Xanthomonas hortorum*		CABI
XANTTL	*Xanthomonas translucens*		CABI
XANTVE	*Xanthomonas vesicatoria*		CABI
XIPHIF	*Xiphinema ifacolum*		CABI
ZYGTGU	*Zygotylenchus guevarai*		CABI
AETNTU	*Aethina tumida*		from literature
AGRLPL	*Agrilus planipennis*	rarely	from literature
AGRILI	*Agriotes lineatus*		from literature
AGRIOB	*Agriotes obscurus*		from literature
AGRISU	*Agriotes sputator*		from literature
ALTEAL	*Alternaria alternata*		from literature
ALTEDA	*Alternaria dauci*		from literature

ALTERA	*Alternaria radicina*		from literature
ALTESO	*Alternaria solani*		from literature
AMANGE	*Amanita gemmata*		from literature
AMPNBY	*Amphinema byssoides*		from literature
ANSTLU	*Anastrepha ludens*		from literature
CRSPAN	*Anisogramma anomala*		from literature
ANOLGL	*Anoplophora glabripennis*		from literature
ANTHBI	*Anthonomus bisignifer*		from literature
ANTHEU	*Anthonomus eugenii*		from literature
APLOFR	*Aphelenchoides fragariae*		from literature
APLOFR	*Aphelenchoides fragariae*		from literature
APLORI	*Aphelenchoides ritzemabosi*		from literature
APLUAV	*Aphelenchus avenae*		from literature
APLUAV	*Aphelenchus avenae*		from literature
ARIORU	*Arion rufus*		from literature
ARMLCE	*Armillaria cepistipes*		from literature
ARMLBU	*Armillaria gallica*		from literature
ARMLLU	*Armillaria luteobubalina*		from literature
ARMLOS	*Armillaria ostoyae*		from literature
MCOCAG	*Arthrobacter agilis*		from literature
ARBAGL	*Arthrobacter globiformis*		from literature
ARTBOL	*Arthrobotrys oligosporus*		from literature
ATADAN	*Atalodera andina*		from literature
AUREPU	*Aureobasidium pullulans*		from literature
AZOSLI	*Azospirillum lipoferum*		from literature
AZOBCH	*Azotobacter chroococcum*		from literature
BEAUBA	*Beauveria bassiana*		from literature
BEAUBR	*Beauveria brongniartii*		from literature
ERYSGR	*Blumeria graminis*		from literature
BOTSDO	*Botryosphaeria dothidea*		from literature
BREMLA	*Bremia lactucae*		from literature
BREMLA	*Bremia lactucae*		from literature
CERAFA	*Bretziella fagacearum*		from literature
PSDMCE	*Burkholderia cepacia*		from literature
BURSTU	*Bursaphelenchus tusciae*		from literature
BURSXY	*Bursaphelenchus xylophilus*		from literature

CALOIL	*Calonectria ilicicola*		from literature
CYLDPA	*Calonectria pauciramosa*		from literature
CARSSA	*Carposina sasakii*		from literature
CENCGR	*Cenococcum graniforme*		from literature
CEPANE	*Cepaea nemoralis*		from literature
CEPCAL	*Cephalcia lariciphila*	always	from literature
CERTCA	*Ceratitis capitata*	always	from literature
CRTBCO	*Ceratobasidium cornigerum*		from literature
CCYSMI	*Ceratocystiopsis minuta*		from literature
CERAFP	*Ceratocystis platani*		from literature
CHOACU	*Choanephora cucurbitarum*		from literature
CHONFU	*Choristoneura fumiferana*		from literature
TORTLA	*Choristoneura lambertiana*		from literature
CHONRO	*Choristoneura rosaceana*		from literature
KHRBIN	*Chryseobacterium indologenes*		from literature
CHMYAR	*Chrysomyxa arctostaphyli*		from literature
CLADCL	*Cladosporium cladosporioides*		from literature
CORBSE	*Clavibacter sepedonicus*		from literature
XYLSMU	*Cnestus mutilatus*		from literature
COLSPH	*Coleosporium phellodendri*		from literature
COLSTU	*Coleosporium tussilaginis*		from literature
COLLFR	*Colletotrichum fragariae*		from literature
COLLKA	*Colletotrichum kahawae*		from literature
NECTFU	*Corinectria fuckeliana*		from literature
NECTFU	*Corinectria fuckeliana*		from literature
CRTHAR	*Corythucha arcuata*	rarely	from literature
ENDOPA	*Cryphonectria parasitica*		from literature
CARPPO	*Cydia pomonella*		from literature
CYTOPU	*Cytospora punicae*		from literature
DCLLOV	*Dactylella oviparasitica*		from literature
ILYOTO	*Dactylonectria torresensis*		from literature
ROSLBU	*Dematophora bunodes*		from literature
ROSLNE	*Dematophora necatrix*		from literature
ROSLPE	*Dematophora pepo*		from literature
DENCAD	*Dendroctonus adjunctus*		from literature
DENCBR	*Dendroctonus brevicomis*		from literature

DENCFR	*Dendroctonus frontalis*		from literature
DENCMS	*Dendroctonus mesoamericanus*		from literature
DENCPO	*Dendroctonus ponderosae*		from literature
DENCPS	*Dendroctonus pseudotsugae*		from literature
DENCVA	*Dendroctonus valens*		from literature
DENDPI	*Dendrolimus pini*		from literature
DENDSI	*Dendrolimus sibiricus*	sometimes	from literature
DEROLA	*Deroceras laeve*		from literature
DERORE	*Deroceras reticulatum*		from literature
ARMITA	*Desarmillaria tabescens*		from literature
DIAPTU	*Diaporthe tulliensis*		from literature
DIAPVA	*Diaporthe vaccinii*		from literature
DIPBBU	*Diplodia bulgarica*		from literature
DIPBBU	*Diplodia bulgarica*		from literature
DIPDML	*Diplodia malorum*		from literature
BOTSST	*Diplodia mutila*		from literature
DIPDPI	*Diplodia sapinea*		from literature
BOTSOB	*Diplodia seriata*		from literature
DITYDE	*Ditylenchus destructor*		from literature
DITYDE	*Ditylenchus destructor*		from literature
DITYDI	*Ditylenchus dipsaci*		from literature
DOTSPI	*Dothistroma pini*		from literature
DROSSU	*Drosophila suzukii*	sometimes	from literature
ELASLI	*Elasmopalpus lignosella*		from literature
ENTBAE	*Enterobacter aerogenes*		from literature
ENCCFA	*Enterococcus faecium*		from literature
EOTELE	*Eotetranychus lewisi*	rarely	from literature
ERWICH	*Erwinia chrysanthemi*		from literature
ERWITR	*Erwinia tracheiphila*		from literature
ANMLOR	*Exomala orientalis*		from literature
GIBBAV	*Fusarium avenaceum*		from literature
FUSABC	*Fusarium brachygibbosum*		from literature
FUSAFS	*Fusarium chlamydosporum*		from literature
GIBBCI	*Fusarium circinatum*		from literature
FUSACU	*Fusarium culmorum*		from literature
GIBBIN	*Fusarium equiseti*		from literature

FUSAPO	*Fusarium poae*		from literature
FUSAPF	*Fusarium proliferatum*		from literature
GIBBPU	*Fusarium sambucinum*		from literature
FUSAUD	*Fusarium udum*		from literature
GIGAMA	*Gigaspora margarita*		from literature
GILPPO	*Gilpinia hercyniae*		from literature
HETDPA	*Globodera pallida*		from literature
HETDPA	*Globodera pallida*		from literature
HETDRO	*Globodera rostochiensis*		from literature
GLMUMO	*Glomus mosseae*		from literature
GNAHSU	*Gnathotrichus sulcatus*		from literature
GONPST	*Gonipterus scutellatus*		from literature
GRCPAT	*Graphocephala atropunctata*		from literature
LASPMO	*Grapholita molesta*	rarely	from literature
GROSCL	*Grosmannia clavigera*		from literature
GROSCL	*Grosmannia clavigera*		from literature
HALYHA	*Halyomorpha halys*		from literature
MYNDCR	*Haplaxius crudus*		from literature
HECBPY	*Helicobacter pylori*		from literature
HELYMU	*Helicotylenchus multicinctus*		from literature
HELIZE	*Helicoverpa zea*		from literature
HETEPA	*Heterobasidion parviporum*		from literature
HETDMA	*Heterodera avenae*		from literature
HETDMA	*Heterodera avenae*		from literature
HETRAR	*Heteronychus arator*		from literature
HETOBA	*Heterorhabditis bacteriophora*		from literature
HETODO	*Heterorhabditis downesi*		from literature
HIRSBE	*Hirschmanniella behningi*		from literature
HIRSCA	*Hirschmanniella caudacrena*		from literature
HIRSCA	*Hirschmanniella caudacrena*		from literature
HIRSDI	*Hirschmanniella diversa*		from literature
HIRSGR	*Hirschmanniella gracilis*		from literature
HIRSHA	*Hirschmanniella halophila*		from literature
HIRSIM	*Hirschmanniella imamuri*		from literature
HIRSMI	*Hirschmanniella miticausa*		from literature
HIRSMU	*Hirschmanniella mucronata*		from literature

HIRSOR	*Hirschmanniella oryzae*		from literature
HIRSSH	*Hirschmanniella shamimi*		from literature
HIRSSC	*Hirschmanniella spinicaudata*		from literature
HIRSZO	*Hirschmanniella zostericola*		from literature
HOLLGA	*Hoplolaimus galeatus*		from literature
PEROPA	*Hyaloperonospora parasitica*		from literature
HYLOAB	*Hylobius abietis*		from literature
HMSCAL	*Hymenoscyphus albidus*		from literature
CHAAFR	*Hymenoscyphus fraxineus*		from literature
ILYOPA	*Ilyonectria palmarum*		from literature
IPSXAM	*Ips amitinus*	rarely	from literature
IPSXCA	*Ips calligraphus*		from literature
IPSXGR	*Ips grandicollis*		from literature
IPSXHA	*Ips hauseri*		from literature
IPSXLE	*Ips lecontei*		from literature
IPSXPI	*Ips pini*		from literature
IPSXPL	*Ips plastographus*		from literature
IPSXFA	*Ips subelongatus*	sometimes	from literature
IPSXTY	*Ips typographus*		from literature
GNORLY	*Keiferia lycopersicella*		from literature
KUEHUR	*Kuehneola uredinis*		from literature
LAESFU	*Laetisaria fuciformis*		from literature
LSDPPS	*Lasiodiplodia pseudotheobromae*		from literature
LSDPPS	*Lasiodiplodia pseudotheobromae*		from literature
PHYORH	*Lasiodiplodia theobromae*		from literature
PHYORH	*Lasiodiplodia theobromae*		from literature
LEHMVA	*Lehmannia valentiana*		from literature
LPTNDE	*Leptinotarsa decemlineata*	always	from literature
LEPGGU	*Leptographium guttulatum*		from literature
LEPGGU	*Leptographium guttulatum*		from literature
LEPGPR	*Leptographium procerum*		from literature
LEUIOR	*Leucinodes orbonalis*		from literature
LEUIPS	*Leucinodes pseudorbonalis*		from literature
LEUNME	*Leuconostoc mesenteroides*		from literature
LIRIBO	*Liriomyza bryoniae*		from literature
LIRISA	*Liriomyza sativae*	pupate in soil	from literature

LIRITR	*Liriomyza trifolii*	pupate in soil	from literature
HYROBO	*Listronotus bonariensis*		from literature
LONGAT	*Longidorus attenuatus*		from literature
LONGEL	*Longidorus elongatus*		from literature
LONGMA	*Longidorus macrosoma*		from literature
LOPHCO	*Lophodermium conigenum*		from literature
LUMBTE	*Lumbricus terrestris*		from literature
LYSOEN	*Lysobacter enzymogenes*		from literature
MCPHPH	*Macrophomina phaseolina*		from literature
CPHUMA	*Magnaporthiopsis maydis*		from literature
MELGAT	*Meloidogyne artiellia*		from literature
MELGCH	*Meloidogyne chitwoodi*		from literature
MELGET	*Meloidogyne ethiopica*		from literature
MELGFA	*Meloidogyne fallax*		from literature
MELGHA	*Meloidogyne hapla*		from literature
MELGJA	*Meloidogyne javanica*		from literature
MELGMA	*Meloidogyne mali*		from literature
MELGML	*Meloidogyne marylandi*		from literature
MELGMI	*Meloidogyne miror*		from literature
MELOME	*Melolontha melolontha*	always	from literature
CRINXP	*Mesocriconema xenoplax*		from literature
PCHOSU	*Metapochonia suchlasporia*		from literature
MTRHBR	*Metarhizium brunneum*		from literature
MONGNI	*Microdochium nivale*		from literature
MILXGA	*Milax gagates*		from literature
MONCAL	*Monochamus alternatus*		from literature
MONCCA	*Monochamus carolinensis*		from literature
MONCGA	*Monochamus galloprovincialis*		from literature
MONCMC	*Monochamus guérin*		from literature
MONCIM	*Monochamus impluviatus*		from literature
MONCMR	*Monochamus marmorator*		from literature
MONCNI	*Monochamus nitens*		from literature
MONCNO	*Monochamus notatus*		from literature
MONCOB	*Monochamus obtusus*		from literature
MONCSL	*Monochamus saltuarius*		from literature
MONCST	*Monochamus scutellatus*		from literature

MONCSU	*Monochamus sutor*		from literature
MONCTI	*Monochamus titillator*		from literature
MONCUR	*Monochamus urussovii*		from literature
MSPSEY	*Monosporascus eutypoides*		from literature
MORTEL	*Mortierella elongata*		from literature
MORTHY	*Mortierella hyalina*		from literature
MUCOHI	*Mucor hiemalis*		from literature
NACODO	*Nacobbus dorsalis*		from literature
MAGNSA	*Nakataea oryzae*		from literature
AMAZMA	*Nemorimyza maculosa*	sometimes	from literature
NFABPE	*Neofabraea perennans*		from literature
BOTSPA	*Neofusicoccum parvum*		from literature
NEOLEL	*Neoleucinodes elegantalis*		from literature
NECTMA	*Neonectria neomacrospora*		from literature
PESPCL	*Neopestalotiopsis clavispora*		from literature
HENLTO	*Neoscytalidium dimidiatum*		from literature
HENLTO	*Neoscytalidium dimidiatum*		from literature
OIDDTE	*Oidiodendron tenuissimum*		from literature
OLPIBO	*Olpidium bornovanus*		from literature
CHEIBR	*Operophtera brumata*		from literature
OPHSBI	*Ophiostoma bicolor*		from literature
OPHSMI	*Ophiostoma minus*		from literature
OPHSPE	*Ophiostoma penicillatum*		from literature
CERAPC	*Ophiostoma piceae*		from literature
OPHSQU	*Ophiostoma quercus*		from literature
OXYHCE	*Oxychilus cellarius*		from literature
PAECFA	*Paecilomyces farinosus*		from literature
BACILA	*Paenibacillus larvae*		from literature
BACIPL	*Paenibacillus polymyxa*		from literature
LONGMX	*Paralongidorus maximus*		from literature
TRIHTE	*Paratrichodorus*		from literature
TRIHPA	*Paratrichodorus pachydermus*		from literature
PARABU	*Paratylenchus bukowinensis*		from literature
PAYSAR	*Paysandisia archon*		from literature
PENICI	*Penicillium citrinum*		from literature
PEROAR	*Peronospora arborescens*		from literature

PESTLO	*Pestalotiopsis longisetula*		from literature
PHENSO	*Phenacoccus solenopsis*	sometimes	from literature
PHILSU	*Philaenus spumarius*		from literature
PHANGI	*Phlebiopsis gigantea*		from literature
PHLYCA	*Phlyctinus callosus*		from literature
PHYNCI	*Phyllocnistis citrella*		from literature
PHYSCP	*Phyllosticta capitalensis*		from literature
GUIGCI	*Phyllosticta citricarpa*		from literature
PHYSHM	*Phyllosticta hymenocallidicola*		from literature
PHYSPP	*Phyllosticta paracitricarpa*		from literature
PHYSVA	*Phyllosticta vaccinii*		from literature
PHMPOM	*Phymatotrichopsis omnivora*		from literature
PHRDMU	*Phyrdenus muriceus*		from literature
PHYOVA	*Physalospora vaccinii*		from literature
PHYOVA	*Physalospora vaccinii*		from literature
PHYOVA	*Physalospora vaccinii*		from literature
PHYTAG	*Phytophthora agathidicida*		from literature
PHYTAU	*Phytophthora austrocedri*		from literature
PHYTBI	*Phytophthora bilorbang*		from literature
PHYTCC	*Phytophthora cactorum*		from literature
PHYTCP	*Phytophthora capsici*		from literature
PHYTCN	*Phytophthora cinnamomi*		from literature
PHYTCI	*Phytophthora citricola*		from literature
PHYTCU	*Phytophthora crassamura*		from literature
PHYTCR	*Phytophthora cryptogea*		from literature
PHYTCR	*Phytophthora cryptogea*		from literature
PHYTDR	*Phytophthora drechsleri*		from literature
PHYTER	*Phytophthora erythroseptica*		from literature
PHYTGA	*Phytophthora gallica*		from literature
PHYTGO	*Phytophthora gonapodyides*		from literature
PHYTHI	*Phytophthora hibernalis*		from literature
PHYTKE	*Phytophthora kernoviae*		from literature
PHYTLA	*Phytophthora lateralis*		from literature
PHYTME	*Phytophthora megasperma*		from literature
PHYTMN	*Phytophthora mengei*		from literature
PHYTMU	*Phytophthora multivora*		from literature

PHYTNN	*Phytophthora nicotianae*		from literature
PHYTOL	*Phytophthora oleae*		from literature
PHYTPL	*Phytophthora palmivora*		from literature
PHYTPL	*Phytophthora palmivora*		from literature
PHYTPU	*Phytophthora plurivora*		from literature
PHYTPK	*Phytophthora pseudocryptogea*		from literature
PHYTQU	*Phytophthora quercina*		from literature
PHYTRA	*Phytophthora ramorum*		from literature
PPYTSI	*Phytopythium sindhum*		from literature
PYTHVE	*Phytopythium vexans*		from literature
PISOST	*Pissodes strobi*		from literature
PLADBR	*Plasmodiophora brassicae*		from literature
MONGCU	*Plectosphaerella cucumerina*		from literature
DEUTTR	*Plenodomus tracheiphilus*		from literature
POLGPR	*Polygraphus proximus*		from literature
POLMBE	*Polymyxa betae keskin*		from literature
PRATCO	*Pratylenchus coffeae*		from literature
PRATPE	*Pratylenchus penetrans*		from literature
PRATH	*Pratylenchus thornei*		from literature
PRATVU	*Pratylenchus vulnus*		from literature
PRATZE	*Pratylenchus zeae*		from literature
PRATZE	*Pratylenchus zeae*		from literature
PRAYEN	*Prays endocarpa*		from literature
PREMLA	*Premnotrypes latithorax*		from literature
PREMSO	*Premnotrypes solani*		from literature
PREMSU	*Premnotrypes suturzcallus*		from literature
PREMVO	*Premnotrypes vorax*		from literature
PROTVU	*Proteus vulgaris*		from literature
CERCAN	*Pseudocercospora angolensis*		from literature
PSDMTL	*Pseudomonas tolaasii*		from literature
PSDMUM	*Pseudomonas umsongensis*		from literature
PESPTH	*Pseudopestalotiopsis theae*		from literature
PSDPMI	*Pseudopityophthorus minutissimus*		from literature
PSDPPR	*Pseudopityophthorus pruinosus*		from literature
PUCCHD	*Puccinia hordei*		from literature
PUCCPT	*Puccinia pittieriana*		from literature

PYTHAP	*Pythium aphanidermatum*		from literature
PYTHDE	*Pythium debaryanum*		from literature
PYTHGR	*Pythium graminicola*		from literature
PYTHIR	*Pythium irregulare*		from literature
PYTHMY	*Pythium myriotylum*		from literature
PYTHOL	*Pythium oligandrum*		from literature
PYTHSL	*Pythium splendens*		from literature
PYTHTO	*Pythium torulosum*		from literature
PYTHUL	*Pythium ultimum trow*		from literature
PYTHVI	*Pythium violae*		from literature
RADOSI	*Radopholus similis*		from literature
RALSPS	*Ralstonia pseudosolanacearum*		from literature
RALSSL	*Ralstonia solanacearum*		from literature
RALSSY	*Ralstonia syzygii*		from literature
RESSCI	*Resseliella citrifugis*		from literature
RHIZBU	*Rhizoctonia butinii*		from literature
RHIZSO	*Rhizoctonia solani*		from literature
RHYCFE	*Rhynchophorus ferrugineus*		from literature
RHIOHI	*Ripersiella hibisci*	always	from literature
ROTYRE	*Rotylenchulus reniformis*		from literature
HELYBU	*Rotylenchus buxophilus*		from literature
ROTLRO	*Rotylenchus robustus*		from literature
SAPECN	*Saperda candida*		from literature
SAPETR	*Saperda tridentata*		from literature
SCYZCO	*Schizophyllum commune*		from literature
SCITDO	*Scirtothrips dorsalis*	always	from literature
SCOLMU	*Scolytus multistriatus*		from literature
SCPURI	*Scopuloides rimosa*		from literature
SCUNBR	*Scutellonema bradys*		from literature
SCYPIN	*Scyphophorus acupunctatus*		from literature
SCYTLI	*Scytalidium lignicola*		from literature
SRENIN	*Serendipita indica*		from literature
SOLEGE	*Solenopsis geminata*		from literature
SOLEIN	*Solenopsis invicta*		from literature
SOLESA	*Solenopsis saevissima*		from literature
PRODER	*Spodoptera eridania*		from literature

LAPHFR	*Spodoptera frugiperda*	sometimes	from literature
SPONSU	*Spongospora subterranea*		from literature
GNOMUL	*Stegophora ulmea*		from literature
NEAPGL	*Steinernema feltiae*		from literature
STNRGL	*Steinernema glaseri*		from literature
STREHY	*Streptomyces hygroscopicus*		from literature
STRESC	*Streptomyces scabiei*		from literature
SUBUOC	*Subulina octona*		from literature
SUILVA	*Suillus variegatus*		from literature
SYNPRA	*Syncephalastrum racemosum*		from literature
ARGPLE	*Thaumatotibia leucotreta*	sometimes	from literature
THEBPI	*Theba pisana*		from literature
THEOJA	*Thecodiplosis japonensis*		from literature
THELTE	*Thelephora terrestris*		from literature
THRIPL	*Thrips palmi*		from literature
TRCDHM	*Trichoderma hamatum*		from literature
TRCDHR	*Trichoderma harzianum*		from literature
TRCDKO	*Trichoderma koningii*		from literature
GLIOVI	*Trichoderma virens*		from literature
TRCDVI	*Trichoderma viride*		from literature
	Trichodorus hellalae		from literature
TRCHMA	*Tricholoma matsutake*		from literature
TUERAE	*Tuber aestivum*		from literature
TYLRCL	*Tylenchorhynchus claytoni*		from literature
TYLESE	*Tylenchulus semipenetrans*		from literature
TYPHIN	*Typhula incarnata*		from literature
TYPHIS	*Typhula ishikariensis*		from literature
UROCCE	*Urocystis magica*		from literature
USTIMA	*Ustilago maydis*		from literature
VERTDA	*Verticillium dahliae*		from literature
VERTLO	*Verticillium longisporum*		from literature
VERTTR	*Verticillium tricorpus*		from literature
XANTEV	*Xanthomonas euvesicatoria*		from literature
XIPHDI	*Xiphinema diversicaudatum*		from literature
XIPHIN	*Xiphinema index*		from literature
XIPHME	*Xiphinema pachtaicum*		from literature

XYLBFE	*Xyleborus ferrugineus*		from literature
XYLBGR	*Xyleborus glabratus*		from literature
XYLBPE	*Xyleborus perforans*		from literature
XYLBPE	*Xyleborus perforans*		from literature
XYLSCO	*Xylosandrus compactus*		from literature
XYLBGE	*Xylosandrus germanus*		from literature
SACMLL	*Yarrowia lipolytica*		from literature