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Economic and Environmental impacts of the introduction of Western flower thrips (*Frankliniella occidentalis*) and Potato late blight (*Phytopthora infestans*) to Norway

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Bioforsk Plant Health and Plant Protection Division

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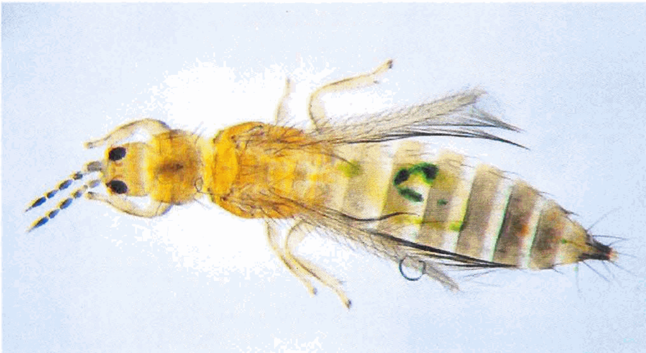

Report to

Directorate for Nature Management

(Direktoratet for naturforvaltning)

By

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Table of Contents

	Page No.
1. Executive Summary	
1.1 Western flower thrips, *Frankliniella occidentalis* (Pergande)	**1**
1.2 Potato late blight, *Phytopthora infestans*	**2**
2. Norsk sammendrag	
2.1 Amerikansk blomstertrips, *Frankliniella occidentalis* (Pergande)	**3**
2.2 Potettørråte, *Phytopthora infestans*	**4**
3. Western flower thrips, *Frankliniella occidentalis* (Pergande)	**5**
3.1 Introduction	**5**
3.2 Identity	**5**
3.3 Biology	**5**
3.4 Symptoms and damage	**6**
3.5 Methods for identification and detection	**8**
3.6 The history of *Frankliniella occidentalis* in Norway	**8**
3.7 Means of movement and dispersal	**9**
3.8 Control measures	**10**
3.9 Direct economic impact	**11**
3.10 Indirect economic impact	**12**
3.11 Environmental impact	**13**
3.12 Prospects for the future	**14**
4. Potato late blight, *Phytopthora infestans*	**15**
4.1. Introduction	**15**
4.2. Identity	**16**
4.3. Host range and distribution	**16**
4.4. Symptoms and methods for identification and detection	**16**
4.5. Biology and epidemiology	**19**
4.6. The history of late blight in Norway	**21**
4.7. Control measures	**22**
4.8. Economical impact	**25**
4.9. Environmental impact	**26**
4.10. Prospects for the future	**29**
5. Conclusions	**29**
5.1 Western flower thrips, *Frankliniella occidentalis* (Pergande)	**29**
5.2 Potato late blight, *Phytopthora infestans*	**30**
6. References	**31**

Annex 1: Host range for *Frankliniella occidentalis.*
Annex 2: EPPO Distribution map of *Frankliniella occidentalis.*
Annex 3: Import to Norway of saleable plants and plants for further cultivation from different countries in 2003 and the status of *Frankliniella occidentalis* in the respective countries.
Annex 4: Interceptions of Tomato spotted wilt virus (TSWV) to Norway 1996-2005.
Annex 5: Bekjempelses- og Rengjøringsprogram for Amerikansk blomstertrips (ABT). (Programs to combat/eradicate *Frankliniella occidentalis*)
Annex 6: Examples of financial compensation to growers during 1987-1991 from a fund managed by the Norwegian Horticultural Growers Association after attack of *Frankliniella occidentalis*.
Annex 7. Potential host plants for *Phytophthora infestans* in Norway

1. Executive Summary

1.1 Western flower thrips, *Frankliniella occidentalis* (Pergande)

The western flower thrips, *Frankliniella occidentalis* (Pergande), is a highly polyphagous species with a host range including over 250 species of herbaceous and woody plants belonging to 62 families. *F. occidentalis* originates in western USA but has spread, since 1970, into many countries in Asia, Africa, Central and South America, Europe and Oceania. In southern regions of Europe the pest is found outdoors attacking the flowers of a number of host plants. In northern European countries it is a pest mainly in protected crops (i.e. glasshouses) attacking a number of ornamentals and vegetables. *F. occidentalis* is a vector of Tomato spotted wilt virus (TSWV) and several other viruses. Both these organisms are regulated as quarantine pests in the EPPO region (European and Mediterranean Plant Protection Organization).

The first report of *F. occidentalis* in Norway was in 1986 and it spread very quickly within greenhouse environments. In 1987 the species was added to the A-list (quarantine pests with zero-tolerance on import to Norway) and a comprehensive spraying program to eradicate the introduced pest and stop further spread was developed. The thrips, however, continued to spread and in 1991 about 40% of all greenhouses in Norway were infested with *F. occidentalis.* A plan of action (Trips-aksjonen) to combat and eradicate *F. occidentalis* from Norway was executed in 1991. In spite of extensive efforts by growers and authorities they did not succeed in eradicating or stopping further spread of *F. occidentalis*. In 1997 the species was considered established in Norwegian greenhouses and it was therefore deleted from the Norwegian A-list. It is now under surveillance as a vector for TSWV (an A-list pest) and is treated as a quarantine pest if discovered in connection with TSWV.

The introduction and establishment of *F. occidentalis* in Norwegian greenhouses has been a burden to both growers and the society. Growers have suffered financial losses in terms of costs of carrying out comprehensive quarantine instructions (1986-1996) as well as through direct crop loss and costs of control measures (1986-2006). Indirect economic impacts of *F. occidentalis* include the implications for growers due to the quarantine instructions (1987-1996) such as increased labour to carry out the instructions; cost of pesticides; loss of production time during the quarantine and eradication period; loss of contracts when not able to deliver plants and seedlings on time; loss of reputation; and perhaps as a combination of the others also loss of future contracts. Growers have also suffered in terms of health risks as they have used pesticides more frequently and thereby been exposed to pesticides more often. Very rough estimates and assessments to predict potential crop loss caused by *F. occidentalis* suggests a worst case scenario (or 100% crop loss) to be about 1454.4 mill NOK per year (2003-numbers). Assuming that the proportion of infested greenhouses at any given time during the year is somewhere between 30-40%, then potential crop losses would be between 436-582 mill NOK per year. It should be underlined that these numbers are rough estimates only, not accurate measurements. Introduction/establishment of the species has resulted in an increased effort from extension service, phytosanitary authorities, and scientists, the costs involved are, however, difficult to assess.

F. occidentalis is regarded as a pest that has severely contributed to making biological control difficult to use in several greenhouse crops and even impossible to use in others. Introduction of non-indigenous species may severely distort already established integrated pest management (IPM)-programs and in particular those relying on biological control agents. The use of pesticides to eradicate and combat *F. occidentalis* has been quite extensive and still is.

The insecticides recommended for use in Norway all have adverse effects on human health and the environment, and pest resistance is an increasing problem.

Every effort should be made, and phytosanitary measures should be actively used, to avoid such introductions in the future. Unfortunately, the contrary might happen, as import of plants for indoor and outdoor use are steadily increasing, while the control and inspection of such goods at the entry sites are not. It is very likely that organisms that do not pose immediate threats to crops, or are very visible in other ways have already been introduced but never recorded. Such organisms may pose a severe threat to the biodiversity in the long term.

1.2 Potato late blight, *Phytophthora infestans* (Mont.) de Bary

Potato late blight, caused by *Phytophthora infestans,* is the most devastating disease in potatoes worldwide. The pathogen has been present in Norway since 1841. However in Troms county the disease did not cause significant problems until the 1950s. The introduction of *P. infestans* in Europe (the first migration) happened about 1840 with potatoes coming from Mexico, the place of origin of the pathogen. A new migration of the pathogen from Mexico happened in the 1980s. The presence of the new population, which consists of both mating types A1 and A2 of *P. infestans,* was documented in Norway in the 1990s. In Norway potato late blight currently causes problems in all the important potato growing areas.

The pathogen has a limited host range (mainly solanaceous hosts). In Norway the pathogen has only been reported on potato and tomato. Normally there are no late blight disease problems in commercial tomato production in greenhouses.

Control strategies for potato late blight include phytosanitary measures of primary inoculum, use of resistant cultivars and chemical treatments. Fungicides are very important in current late blight control, and decision support systems (DSS) are used for helping optimal use of these compounds.

The total annual cost in Norway caused by potato late blight is calculated to 55-65 million NOK. Behind these figures the following elements have been included. The average fungicide costs per year is 22,9 million NOK and the application costs is calculated to 25,6 million NOK. The actual yield loss (yield and quality) for the potato producers is estimated to be in the range from about 5 million NOK in 2005 (low risk year) to about 14 million NOK in a more severe late blight year. Cost for inspection, research and advisory service sum up to approximately 3,3 million NOK per year.

The pathogen has minor direct effects on the natural ecosystem. The indirect effects on the environment are related to possible effects of late blight fungicides. Data about the properties of the two main late blight fungicides and monitoring data from the JOVA program indicate that the fungicides only have minor and temporary effects on the natural ecosystem.

P. infestans has been a well established pathogen in Norway for about 150 years. We probably will have to deal with this pathogen as long as we are growing potatoes in Norway. Introduction of new genotypes of the pathogen during the last 15 years and global warming might cause increased problems with this pathogen during the coming years.

2. Norsk Sammendrag

2.1 Amerikansk blomstertrips, *Frankliniella occidentalis* (Pergande)

Amerikansk blomstertrips, *Frankliniella occidentalis* (Pergande) er en svært polyfag art med en vertplaneliste på over 250 arter av urteaktige og treaktige planter fra 62 familier. *F. occidentalis* har sin opprinnelse fra USA, men har siden 1970 spredd seg til mange land i Asia, Afrika, Sentral og Sør Amerika, Europa og Oceania. I sørlige deler av Europa finns denne skadegjøreren utendørs og angriper særlig blomstene hos et uttall vertplanter. I nordlige Europa er den hovedsakelig en skadegjører i veksthus der den angriper svært mange dekorasjonsplanter samt grønnsaker. *F. occidentalis* er vektor for tomatbronsetoppvirus (TSWV) og flere andre virus. Begge disse organismene reguleres som karanteneskadegjørere i EPPO regionen (European and Mediterranean Plant Protection Organization).

F. occidentalis ble første gang rapportert fra Norge i 1986 og spredde seg svært fort innen veksthusnæringen. I 1987 ble arten satt på A-lista (karanteneskadegjørere med null-toleranse ved import til Norge) samtidig som det ble utviklet et omfattende sprøyteprogram for å utrydde den introduserte skadegjøreren og stoppe videre spredning. Tripsen fortsatte likevel å spre seg, og i 1991 var cirka 40 % av alt veksthusareal i Norge infisert med *F. occidentalis*. En handlingsplan (Tripsaksjonen) for å bekjempe og utrydde *F. occidentalis* fra Norge ble gjennomført i 1991. Til tross for den store innsatsen fra dyrkere og myndigheter lykkes de ikke i å utrydde eller stoppe videre spredning av *F. occidentalis*. I 1997 ble arten vurdert som etablert i norske veksthus og ble derfor fjernet fra den norske A-lista. Den er nå under overvåkning som en vektor for TSWV (en A-liste skadegjører) og blir behandlet som en karanteneskadegjører dersom den blir oppdaget i forbindelse med TSWV.

Introduksjon og etablering av *F. occidentalis* i norske veksthus har vært en byrde både for dyrkere og for samfunnet. Dyrkere har lidd økonomiske tap både i form av kostnadene ved å utføre de omfattende karantene påleggene (1986-1996) så vel som direkte avlingstap og kostnadene ved kontrolltiltak (1986-2006). De direkte økonomiske konsekvenser for dyrkere relatert til karantene bestemmelsene for *F. occidentalis* inkluderer økt arbeidsinnsats for å utføre påleggene, pesticid kostnader, tap av produksjonstid i karantene- og utryddelsesperioden, tap av kontrakter ved forsinket levering av planter og småplanter, redusert renommé, og muligens som en kombinasjon av de andre også tap av framtidige kontrakter. Dyrkere har også utsatt seg for en økt helserisiko idet de har brukt pesticider oftere og dermed blitt eksponert for pesticider hyppigere. Svært grove estimater og vurderinger for å predikere et potensielt avlingstap av *F. occidentalis* gir et mulig avlingstap på opptil 100 % (et såkalt 'worst case scenario'), noe som tilsvarer 1454,4 mill NOK per år (tall fra 2003). Dersom en antar at andelen av infiserte veksthus til enhver tid i løpet av året ligger et sted mellom 30-40 %, vil det potensielle avlingstapet være mellom 436-582 mill NOK per år. Det må understrekes at disse tallene kun er grove estimat, og ikke eksakte tall. Introduksjon av denne arten har også medført økt innsats fra veiledningstjenesten, fytosanitære myndigheter, og det vitenskapelige miljø, men eksakte kostnader for disse tjenestene er vanskelige å anslå.

F. occidentalis regnes som en skadegjører som har vanskeliggjort biologisk kontroll i flere veksthus kulturer og umuliggjort det i andre. Introduksjon av fremmede arter kan medføre alvorlig problemer godt innarbeidede og etablerte integrert plantevern (IPM)-programmer og da spesielt for slike som baserer seg på biologisk kontroll agenter. Bruken av pesticider for å utrydde og bekjempe *F. occidentalis* har vært og er fortsatt nokså omfattende. Insekticider som er anbefalt brukt i Norge har alle uheldige side effekter på både human helse og på miljøet, samt at resistens hos skadegjøreren er et økende problem også her i landet.

Alle bestrebelser skulle gjøres og fytosanitære tiltak burde brukes aktivt for å unngå lignende introduksjoner i framtiden. Dessverre kan det motsatte skje siden import av planter til innendørs og utendørs bruk stadig øker, mens kontroll og inspeksjon av slike varer ved innførsel ikke økes. Det er svært sannsynlig at organismer som ikke umiddelbart utgjør en fare for produksjoner og avlinger, eller er svært synlig på andre måter, allerede har blitt introdusert men aldri registrert. Slike organismer kan være en trussel mot biodiversiteten på lang sikt.

2.2 Potettørråte, Phytophthora infestans

Potettørråte, forårsaket av eggsporesoppen *Phytophthora infestans*, er den mest ødeleggende sjukdommen i potet på verdensbasis. Sjukdomsorganismen har trolig vært i Norge siden 1841. I Troms ble ikke potettørråte problematisk før på 1950-tallet. Sjukdommen fører nå til skade i alle viktige potetdistrikt i Norge. *P. infestans* ble introdusert i Europa ca 1840 (første migrasjon) med potet som kom fra Mexico, som er patogenets opphavsted. En ny migrasjon av patogenet fra Mexico skjedde på 1980-tallet. Den nye populasjonen at tørråtesoppen, som består av både krysningstype A1 og A2, ble påvist i Norge på 1990-tallet.

Patogenet har begrenset med vertplanter, som i hovedsak tilhører søtvierfamilien. I Norge er *P. infestans* bare blitt funnet på potet og tomat. I kommersiell tomatproduksjon i veksthus er tørråte ikke noe problem blant annet på grunn av god klimastyring.

Bekjempelse av potettørråte omfatter både plantesanitære tiltak mot primære smittekilder, bruk av resistente sorter og kjemisk bekjempelse. Fungicider (soppmidler) er svært viktige i dagens tørråtebekjempelse. Beslutningsstøttesystemer som inkluderer varsling blir brukt for å sikre en optimal bruk av fungicider.

Den totale årlige kostnaden i Norge forårsaket av potettørråte er beregnet til 55-65 millioner NOK. Bak disse tallene er følgende elementer tatt med. Den gjennomsnittlige årlige fungicidkostnaden er 22,9 millioner NOK og kostnaden med sprøytearbeidet er beregnet til 25,6 millioner NOK. Det aktuelle avlingstapet (avling og kvalitet) for potetprodusentene er estimert til å variere mellom 5 millioner NOK i et år med lavt smittepress (eksempelvis 2005) til ca 14 mill NOK i et år med sterkt smittepress. Kostnadene til inspeksjoner, forskning og veiledningstjeneste er anslått samlet til å utgjøre 3,3 millioner NOK årlig.

Potettørråtesoppen har liten direkte effekt på det naturlige økosystemet. Den indirekte effekten på miljøet er relatert til mulige effekter av fungicidene som brukes. Data om egenskapene til de to viktigste fungicidene, mankozeb og fluazinam, og overvåkningsdata fra JOVA programmet indikerer at fungicidene bare har små og midlertidige effekter i det naturlige økosystemet.

P. infestans har vært etablert i Norge i ca 150 år. Vi må trolig leve med dette patogenet så lenge som vi dyrker poteter i landet. Introduksjon av nye genotyper av *P. infestans* i løpet av de siste 15 årene og et mildere klima kan føre til økende problemer med denne skadegjøreren i framtida.

3. Western flower thrips, *Frankliniella occidentalis* (Pergande)

3.1 Introduction

The western flower thrips, *Frankliniella occidentalis,* originates in western USA but has spread, since 1970, into many countries in Asia, Africa, Central and South America, Europe and Oceania (OEPP/EPPO, 2002) (Annex 2). *F. occidentalis* is a highly polyphagous species and its host range includes over 250 species of herbaceous and woody plants belonging to 62 families (see Annex 1). In the USA, the pest is found outdoors attacking the flowers of apricots, peaches and nectarines, plums, roses, carnations, sweet peas, *Gladiolus*, peas, tomatoes, *Capsicum*, Cucurbitaceae, strawberries and a number of others. In northern European countries it is a pest mainly in protected crops (i.e. glasshouses) on an ever-increasing range of host plants, but most commonly on chrysanthemums, *Gerbera*, roses and *Saintpaulia*. It may also attack vegetables such as tomato, capsicum, cucumber, aubergine and lettuce. In southern regions of Europe it is a pest on outdoor crops, found even on fruit trees (EPPO/CABI, 1997). In California *F. occidentalis* survives the winter outdoors, chiefly in the adult stage, although a few fully grown nymphs are occasionally found during the colder months in flower and leaf buds.

In addition to its status as a troublesome pest *F. occidentalis* is also a vector of Tomato spotted wilt virus (TSWV) and four other *Tospovirus* species (Whitfield et al. 2005), and of Tobacco streak ilarvirus (TSV) (EPPO/CABI, 1997). *F. occidentalis* and TSWV are both regulated as quarantine pests in the EPPO region (European and Mediterranean Plant Protection Organization), and are listed on the A2 list (no. 177 and 290, respectively) (EPPO A2 list, version 2005-09). The A2 list contains pests that are regulated by EPPO countries on EPPO's recommendation and which are locally present in the EPPO region. Of the different TSWV insect vectors cited, the most important is *F. occidentalis,* which transmits TSWV in a persistent propagative fashion (OEPP/EPPO, 2004). In the EPPO region TSWV was virtually absent for over 40 years after the Second World War. The recent and epidemic spread of TSWV in protected and outdoor crops in the EPPO region is closely associated with the establishment and spread of *F. occidentalis* (EPPO/CABI, 1997).

3.2 Identity

Name: *Frankliniella occidentalis* (Pergande)
Synonyms: *Frankliniella californica* (Moulton)
Frankliniella helianthi (Moulton)
Frankliniella moultoni Hood
Frankliniella trehernei Morgan
Taxonomic position: Insecta: Thysanoptera: Thripidae
Common names: Western flower thrips, alfalfa thrips (English)
Thrips californien, thrips des petits fruits (French)
Blütenthrips (German)
Amerikansk blomstertrips (shortform: ABT) (Norwegian)

3.3 Biology

Thysanoptera are small or minute, slender-bodied insects with short antennae and asymmetrical, rasping and sucking mouthparts. Thrips have very narrow and pointed wings with hair-like fringes and greatly reduced venation. The nymphs are similar in appearance to adults but are wingless (Alford, 1991). *F. occidentalis* reproduces throughout the year in glasshouse environments, producing several generations per year depending on temperature and host plant (Blystad & Johansen, 1996; EPPO/CABI, 1997). The full life cycle from egg to egg at 15, 20, 25 and 30ºC is 44.1, 22.4, 18.2 and 15 days, respectively (Figure 1). The number of eggs reported per female are 20-40, however, temperature and quality of the host plant influence both development time and fecundity and under favourable conditions more than 300 eggs per female has been reported (Blystad & Johansen, 1996).

The eggs are inserted in the parenchyma cells of leaves, flower parts and fruits, by the aid of a saw-like ovipositor. Eggs hatch in about 4 days at 27ºC. This period is lengthened to 13 days at 15ºC. The eggs are susceptible to desiccation, and high mortality at this stage is not uncommon. Adult thrips have been observed entering closed chrysanthemum buds, presumably to lay eggs, a behaviour pattern that makes control very difficult (Alford, 1991; EPPO/CABI, 1997).

There are four larval stages; the first two are active, feeding stages and the last two non-feeding, pre-pupal and pupal stages. The first-instar nymph emerges from the plant tissue head-first and feeding begins almost immediately. The first moult occurs within 1-3 days at 27ºC. Second-instar nymphs are very active and often seek enclosed sites for feeding. The second-instar nymph becomes progressively more sluggish, moults, and transforms into the early pseudopupae. The choice of pupation site varies; although usually in the soil it may also pupate in a flower. The late pseudopupa moves very little. In a 30-day life cycle, more than 10 days may be spent in this stage in the soil (EPPO/CABI, 1997).

The adult emerges after usually 2-9 days, depending on the temperature. The newly emerged adult female is relatively quiescent during the first 24 h, but becomes extremely active when mature. The female usually lives for about 40 days under laboratory conditions but can survive as long as 90 days. The male lives half as long as the female. Oviposition usually begins 72 h after emergence and continues intermittently throughout almost all adult life (EPPO/CABI, 1997). In a population there are usually four times as many females as males. Males derive from unfertilized eggs, which can be produced by unmated females. In addition to feeding on plant tissues, nymphs and adult females of *F. occidentalis* are known to be omnivorous and will feed on the eggs of mites when these are abundant on plants.

F. occidentalis is a vector of five *Tospovirus* species, namely Tomato spotted wilt virus (TSWV), Chrysanthemum stem necrosis virus, Groundnut ringspot virus, Impatiens necrotic spot virus and Tomato chlorotic spot virus (Whitfield et al. 2005). It is also a vector of Tobacco streak ilarvirus (TSV) (EPPO/CABI, 1997). Only the nymphs, and not the adults, can acquire the virus. The acquisition time is at least 30 min, and the insect becomes infective in 3-10 days (by which time it is usually adult). It then needs to feed for at least 15 minutes to transmit (Figure 1).

3.4 Symptoms and damage

The major symptoms of *F. occidentalis* infestation include discolouration of the upper leaf surface, and indentation where damage occurs. Silvering, deformity, growth malfunctioning and brown bumps may also be present on the foliage of ornamental plants. Thrips feeding causes a silvering and spotting tissue (‘Halo spotting’: small dark scars surrounded by whitish tissue), and also noticeable blanching, especially to petals. It also results in deformation of buds if the feeding occurs before they start opening. Significant damage is often caused by a relatively small number of individuals, infestation may also lead to noticeable distortion of host plants (Alford, 1991; EPPO/CABI, 1997).

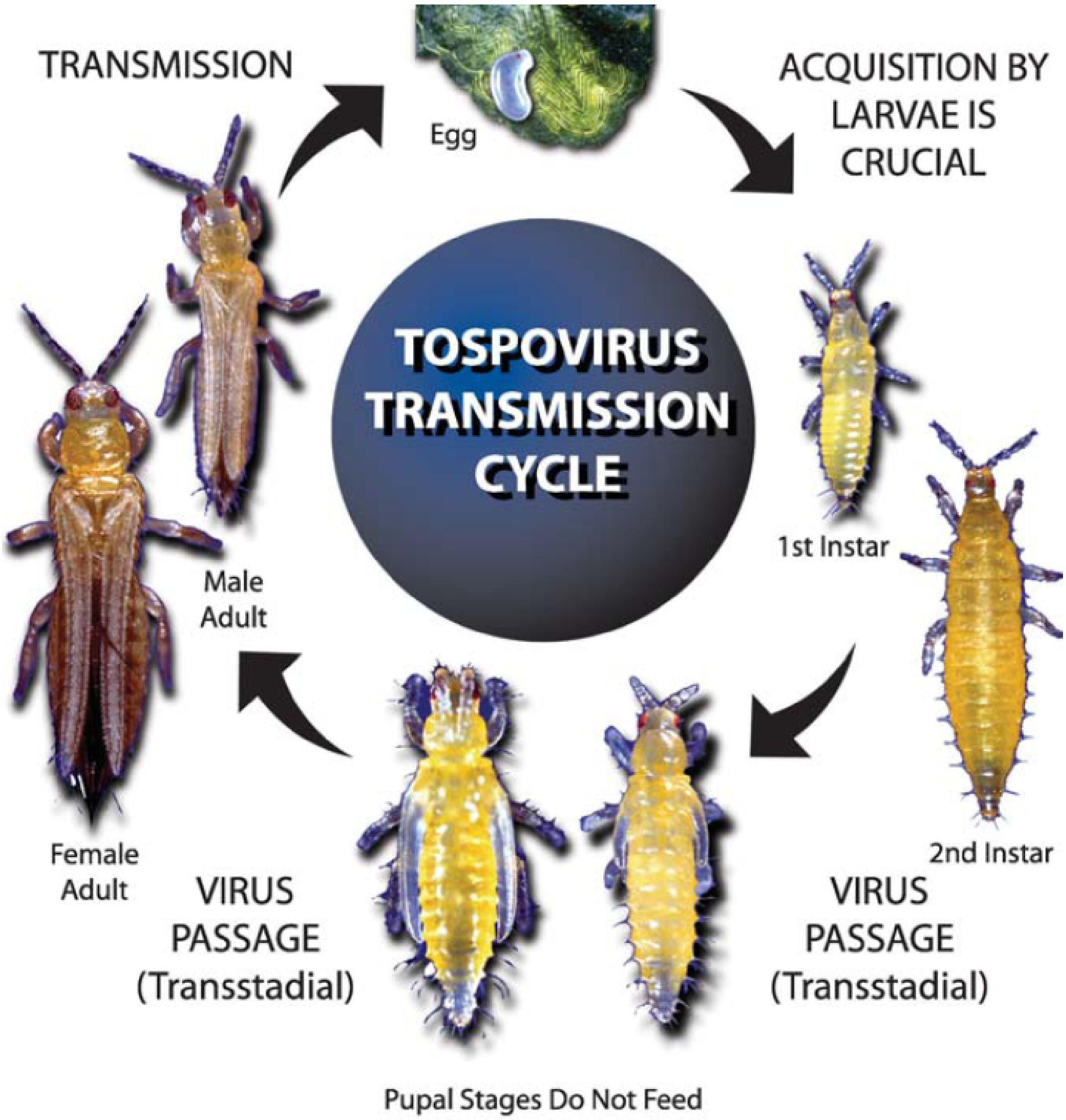

Figure 1: Graphic presentation of the thrips life cycle and the tospovirus transmission cycle. Thrips eggs are oviposited into plant tissue and within a few days the first instar larvae emerge. Virus acquisition occurs solely during the larval stages after which the virus is passed transstadially to the adult. The pupal stages are non-feeding and do not move, although they do maintain virus infection. In nature, *Frankliniella occidentalis* pupates in the soil. Adults emerge and have a tendency to disperse widely. Only adult thrips (male and female) that aquired the virus during their larval stages transmits tospoviruses. (Whitfield et al., 2005).

The effects of TSWV transmitted by thrips vectors to various host plants, are often severe. TSWV can induce a wide variety of symptoms including: necrotic or chlorotic local lesions, ring spots, ring spots in concentric rings, green island mosaic, stem discolouration, line patterns, wilting, stunting, mottling, bronzing, distortion, chlorosis, necrosis. Symptoms may vary on the same host species with the cultivar, age, and nutritional and environmental conditions of the plant, and differences between the different isolates of TSWV on the same host. On tomatoes bronzing, curling, necrotic streaks and spots on the leaves, small plants and stunted growth are observed. Fruit symptoms are usually either irregular yellow/orange flecks and occasionally rings on red fruits, or necrotic lesions or rings. Sometimes plants are killed by severe necrosis. On lettuce infestation starts on leaves on one side of the plant, which become chlorotic with brown patches. On chrysanthemums there is a wide variation among cultivars. Usually black stem streaks and wilt are observed. On *Sinningia* spp., infected leaves show yellow or brown spotting, or brown oak-leaf patterns (Alford, 1991; EPPO/CABI, 1997).

3.5 Methods for identification and detection

Symptoms as described above are clear indications of presence of *F. occidentalis*. Further investigations of the planting material may then reveal eggs, nymphs and/or adult stages of the pest. By shaking aerial parts of the plant over white paper sheets thrips and other small insects present on the plant surface fall onto the paper. For identification, microscopic slides of thrips should be prepared, a process that takes about one hour. For more detailed studies, the thrips may be mounted in Canada balsam (as described by Palmer et al., 1989), and identification should be performed under a light microscope. Identification of larvae is difficult, and the available key described in EPPO/CABI (1997) can only be used to distinguish larvae of *F. occidentalis* from other *Frankliniell*a species occurring in Europe. Secure identification can therefore only be done on adults, and should be carried out by an expert (entomologist) to avoid the many possibilities of misidentifications with similar genera and numerous similar species in the genus *Frankliniella* occurring worldwide.

3.6 The history of *Frankliniella occidentalis* in Norway

The first report of *F. occidentalis* in Norway was in 1986 and it spread very quickly within greenhouse environments (Johansen, 1997). A total number of 24 greenhouses were infested during 1987 (Stenseth, 1988a) and already in 1988 *F. occidentalis* was found in commercial greenhouses in most counties in Norway with the exception of Nordland, Troms, Finnmark, Hedmark and Oppland (Stenseth, 1988b). To avoid further introduction and spread of *F. occidentalis* phytosanitary measures were put in place almost immediately (SPV, 1988a). These measures included that the species was added to the A-list, a list of quarantine pests with zero-tolerance on import to Norway. In addition a comprehensive and systematic spraying program to combat/eradicate the pest if introduced/found was developed. In spite of these efforts, it was concluded later the same year that 35 commercial greenhouses in Norway were infested and it was also confirmed that the spread of *F. occidentalis* to these greenhouses was mainly caused by domestic production and distribution of seedlings and not through imported goods (SPV, 1988b).

F. occidentalis turned out to be a very difficult pest to control, and during the summer 1989 a rise in infestations were reported from the counties Aust- and Vest-Agder. As a response to the increased level of infestations, a plan of action (Trips-aksjonen) to combat and eradicate *F. occidentalis* was developed and organised as a collaborative effort between the Norwegian Horticultural Growers Association (Norsk Garnerforbund), the Norwegian Agricultural Inspection Service (now: The Norwegian Food Safety Authority/Mattilsynet) and Statens Plantevern (now: The Norwegian Institute of Agricultural and Environmental Research-Plant Health and Plant Protection Division/ Bioforsk-Plantehelse). During 1991 an extensive investigation was initiated in all counties of Norway, where sticky traps to capture thrips was sent to 369 commercial greenhouse producers (836.105 m^2 of greenhouses) and returned to Statens Plantevern following certain procedures. The investigation revealed that almost 40% of all commercial greenhouses in Norway were infested with *F. occidentalis* (Johansen, 1997). Comprehensive spraying programs in infested greenhouses were enforced to avoid further spread.

In 1996 an investigation aiming to detect the possible introduction and spread of another quarantine pest, the leafminer *Liriomyza huidobrensis*, in Norwegian greenhouses was initiated. In this study sticky traps were also used and gave the rather surprising result that about 28% of the greenhouses investigated was infested with *F. occidentalis* (Kobro et al., 2001). The result was surprising since *F. occidentalis* was a quarantine pest and it is regarded illegal to avoid reporting the presence of such pests to the respective authorities, namely the Norwegian Agricultural Inspection Service (now: Mattilsynet) or Statens Plantevern (now: Bioforsk-Plantehelse).

In spite of extensive efforts by both growers and authorities to control *F. occidentalis,* they did not succeed to maintain control over the spread of this pest in Norway. In 1997 it was announced that the species was considered established in Norwegian greenhouses (Johansen, 1997). It was therefore deleted from the A-list in Norway, but is under surveillance as a vector for TSWV (an A-list pest). As mentioned in the introduction, *F. occidentalis* and TSWV are both regulated as quarantine pests in the EPPO region and are listed on the A2 list as pests that are regulated by EPPO countries on EPPO's recommendation and which are locally present in the EPPO region (EPPO A2 list, version 2005-09).

More recent investigations indicate that *F. occidentalis* has become even more widespread in Norwegian greenhouses since 1996 (Kobro et al., 2001). An investigation in 33 commercial greenhouses in 2001 showed that 28 (about 85%) were infested with *F. occidentalis*. Some of these had population levels of *F. occidentalis* far above the economic threshold of about 20 individual thrips caught per trap per week (varying slightly among different crops). The conclusion that 85% of the greenhouses in Norway contains *F. occidentalis* should, however, not be directly drawn from this investigation, as the greenhouses examined were not a complete random sample, they all produced plants listed as host plants of *F. occidentalis*. On the other hand, 28 out of 33 producers were a potential risk for spreading TSWV **(**Annex 6 shows reported incidences of TSWV 1996-2005).

3.7 Means of movement and dispersal

Thrips are easily carried into glasshouses by wind, making re-infestation during the summer a constant problem. They are also easily carried on clothes and hair, and on equipment and containers that have not been properly cleaned.

Female thrips can be aggressive to one another. Perhaps because of this aggression, the generally cryptic living adults can be seen to run, jump and fly within a crop and this can result in even small populations becoming widespread within a glasshouse.

Internationally, *F. occidentalis* is liable to be carried on any plants for planting or on cut flowers (EPPO/CABI, 1997). About 80% of all trade with decoration plants, flowering pot plants as well as seedlings and plants for further cultivation to Norway are imported via the Netherlands, while the number of countries of origin of the same goods is more than 30 (Kobro et al., 2001). Detailed statistics over planting material, its origin and domestic routes in Norway is not available, but there is information that *F. occidentalis* has been discovered a number of times during routine controls at the border in both Norway and the Netherlands. Annex 3 shows a list of countries exporting planting materials to Norway in 2003, of which a majority is host plants of *F. occidentalis,* and it also shows the status of *F. occidentalis* in the respective countries.

3.8 Control measures

Phytosanitary regulations

F. occidentalis is no longer a quarantine pest to Norway, but is treated as one if discovered in connection with TSWV. As there is no direct means of controlling the virus, the method of control must either be aimed at the thrips vector or involve the application of sanitary measures.

Consignments are rejected at entry if infested. Inland infestations releases comprehensive quarantine and eradication programs of both TSWV and its vector based on a combination of insecticide applications, disinfection of greenhouses, restrictions on plant sales and distribution. Annex 5 gives a detailed description of the eradication program (in Norwegian). The process of eradication is the responsibility of the Norwegian Food Safety Authority (Mattilsynet).

Chemical control

Chemical control is particularly difficult because of the secretive habit of the species and because of the appearance of resistance (EPPO/CABI, 1997). Eggs inside leaves and pupae in soil are protected against insecticides, and adults hiding inside buds and petals may avoid being hit by the spray. Insecticides must be applied once or twice a week (depending on the pesticide used) for 5-6 weeks, and repeated if necessary. To avoid resistance it is recommended to alternate between at least three different pesticides with different mechanisms of controlling (killing) the thrips. Annex 5 gives a detailed description of the spraying program recommended by Bioforsk-Plantehelse for ornamentals and decoration plants (in Norwegian). In greenhouse vegetables it is illegal to use pesticides due to residues in the end product. Disinfection of empty greenhouses is recommended after termination of the cropping season (see Annex 5 for details).

Resistance to pesticides is a problem in many European countries (EPPO/CABI, 1997). Several Norwegian growers have reported that the effects of insecticide treatments are not satisfactory, indicating that resistance is becoming a problem also in Norway (Johansen, pers. comm.). The continued interceptions of new populations of *F. occidentalis* from different parts of the world are also an increased risk of importing new and resistant populations of western flower thrips.

Integrated Pest Management (IPM) and Biological control

The removal of *F. occidentalis* from the Norwegian list of quarantine pests (A-list) in 1997 gave growers the options of using IPM and biological control, in particular in greenhouse vegetables. Biological control of *F. occidentalis* is almost impossible in flowering plants because the economic threshold is very low in such crops (see section 3.4 and 3.9). Biological control agents such as the predators *Amblyseius barkeri* (Hughes), *A. cucumeris* (Oudemans), *A. degenerans* (Berlese), *Neoseiulus cucumeris* and others have been used. Several other natural enemies including predators, parasitoids and entomopathogens have been identified as possible biological control agents. Biological control of *F. occidentalis* in greenhouse vegetables is quite satisfactory, particularly if replanting and not inter-planting is done in year-round production (Folkedal, 1999). In Norway year-round production of greenhouse vegetables is not a common practice due to the high production costs in winter (heating and light).

The general advice to growers is to be careful with imported plants and plant parts, and not mix such newly imported goods with their already ongoing greenhouse production until they are sure the material is clean. The best option against *F. occidentalis* is not to introduce it to the greenhouse, however when the damage is done one should also be careful and not export it to other growers.

3.9 Direct economic impact

F. occidentalis is a very important pest of ornamental flowers as it takes only a few individuals to scarthe the marketable portion of the crop, the flower. When present, the flowers are the preferred sites for feeding. Petals may be scarred or discoloured. The thrips also feeds on the pollen and this may be dislodged to fall onto surrounding foliage. If this then becomes infected with sooty moulds, the general appearance of the plant is damaged. Therefore *F. occidentalis* is regarded as a direct pest of such crops, and control treatments must be applied immediately to avoid reduction of the aesthetic quality of the crop. Even by slight damage, the value of these plants is greatly reduced, and any infestation of *F. occidentalis* is liable to have an economic effect (EPPO/CABI, 1997).

F. occidentalis attacks vegetables under glass and may affect most fruiting vegetables. Problems are most severe on cucumbers where the blossoms can be reduced or so extensively damaged that no fruit is produced. The cucumber fruit often show severe distortion. Estimated yield losses of 20% have been reported in cucumber, and a decline in the cucumber production in British Columbia (Canada) is attributed to the spread of *F. occidentalis* (EPPO/CABI, 1997).

TSWV, of which *F. occidentalis* is regarded the most suitable vector, has become an increasingly important factor contributing to economic losses in many food and ornamental crops throughout the world. Destructive outbreaks of TSWV have occurred in France and Spain in protected and field crops of tomatoes. Crop losses may be as high as 100%. As much as 50-90% crop loss in lettuce was reported from Hawaii. In some areas of Argentina, Brazil, Canada, Denmark, Italy, Netherlands, UK and USA, TSWV has become one of the most important diseases (EPPO/CABI, 1997).

In Norway there is no good statistics available or other easily accessible information that could be used to assess and calculate very accurately the losses individual growers have suffered due to the introduction of *F. occidentalis*. This information could, however, become available if a systematic search in old files at the Norwegian Food Safety Authority (Mattilsynet) was done and all incidences of interceptions/introductions of *F. occidentalis* before 1997 was located. Further investigations in old files at the Norwegian Horticultural Growers Association and at Statens Forvaltningstjeneste, followed by interviews of individual growers about each case, could probably reveal this information. The financial conditions for this assignment did not allow for such a task to be conducted. It should still be evident to the reader that the introduction and establishment of this extremely polyphageous pest has caused producers severe losses in terms of destruction/eradication of goods related to quarantine regulations, and in form of non-saleable plants as a result of direct attack of *F. occidentalis.*

The more pronounced direct costs in connection with *F. occidentalis* nowadays when the pest is no longer a quarantine pest to Norway is the increased costs of monitoring (sticky traps, scouting, and labour) and pesticides because a direct pest has a very low economic threshold before treatment becomes a necessity. Other additional costs like damping of soil or other measures of disinfecting and cleaning empty greenhouses between cropping seasons followed by surveillance with sticky traps are also costs carried by individual growers to combat this pest (see Annex 5 for more details).

The greenhouse area in Norway is about 2.002 hectare, of which greenhouse vegetables is about 0.650 hectare, production of pot plants and decoration plants about 0.880 hectare, and cut flowers about 0.300 hectare (the rest is production of berries and tree-nurseries) (Statistisk Sentralbyrå, 1999). About 1.830 hectare will almost continuously on a year-round basis contain host plants of *F. occidentalis* and/or TSWV. In 2003 the production value of these crops was 377.4 mill NOK for greenhouse vegetables and 1077.0 mill NOK for flowering pot plants, decoration plants and cut flowers (Source: Norwegian Horticultural Growers Association).

From the numbers above it is possible to predict potential crop losses caused by *F. occidentalis* which in the worst case scenario (or 100% crop loss) would be about 1454.4 mill NOK per year. If one assumes that the proportion of infested greenhouses at any given time during the year is somewhere between 30-40% (see section 3.6 above), then potential crop losses caused by *F. occidentalis* would be between 436-582 mill NOK per year. These numbers are only rough estimates and assessments based on the information available, and should only be seen as such, not as accurate measurements.

Of course, growers do in most cases manage to take their precautions and spray against *F. occidentalis* if the population level becomes above the economic threshold. Since it is not allowed to use chemical pesticides against *F. occidentalis* in greenhouse vegetables, we are left with a production area of about 1.180 hectare containing flowering pot plants, decoration plants and cut flowers, which may potentially be sprayed one to several times a year against *F. occidentalis*. Since we do not have accurate information about the spraying rate or the accurate number of m^2 infested and re-infested with *F. occidentalis* per year, or the number of unsuccessful treatments where the treatments has to be repeated, we do not find it appropriate to make an assessment of the spraying costs for this species. But we do conclude that the use of insecticides against this pest is significant.

3.10 Indirect economic impact

Growers may sometimes be reluctant to report possible incidences of quarantine pests to the authorities. A positive identification of a quarantine pest immediately releases instructions of quarantine regulations, destruction of plants and/or comprehensive and systematic spraying programs to eradicate the pest. Unfortunately when *F. occidentalis* initially became a problem there was not in place a public/governmental fund covering a full compensation for the losses individual growers suffered through such eradication programs. This could be one of the main reasons why the presence of *F. occidentalis* appeared to have been highly under-reported by Norwegian growers in the late eighties and early 1990s.

Some compensation was, however, provided to some growers through a fund at the Norwegian Horticultural Growers Association during 1987-1991 (see Annex 7), and later through Statens Forvaltningstjeneste. In the early stages these compensations only covered direct loss of plants and planting material, and not additional and indirect costs such as increased labour to carry out the instructions; cost of pesticides; loss of production time during period of quarantine and eradication; loss of contracts when not able to deliver plants and seedlings in time; loss of reputation; and perhaps as a combination of the others also loss of future contracts. The history shows examples of growers that went bankrupt due to the financial losses they suffered because of a quarantine pest. It may be questioned whether the rapid spread and establishment of *F. occidentalis* in Norway could have been delayed or perhaps even controlled if funds for a more comprehensive compensation were available at an early stage. One can only speculate upon how much could have been saved for both growers and authorities if this species had not become established in Norway.

Other indirect costs that could not be calculated within the budget of this report includes salaries for and equipment used by officials at the regulatory authorities involved in surveillance and inspection at entry points; eradication programs when introduced; follow up controls of such programs; training of personnel for recognition and identification of the pest; and the costs of carrying out the action plan in 1991 (Trips-aksjonen, see section 3.6).

3.11 Environmental impact

Pesticides

The use of pesticides to eradicate and combat *F. occidentalis* has been quite extensive and for some crops it is still the only reliable alternative (see section 3.8 control measures and Annex 5 for details on spraying programs). Today growers do not have many insecticides to choose between (see below), as several of the previous chemicals have been phased out and are no longer legal on the market. It has been reported from several countries that the thrips has developed resistance against all the chemicals listed below.

Conserve is an insecticide containing the active ingredient spinosad. It gives serious health damage by long-term exposure and if swallowed. It is poisonous to aquatic organisms and may have negative long-term effects in aquatic ecosystems. It is also poisonous to bees and other insects. It has been reported to lack effect against *F. occidentalis* at one occasion in Norway.

Mesurol contains the active ingredient merkaptoditur. It is very poisonous to aquatic organism, and may also give negative long-term effects in aquatic ecosystems. It is poisonous to bees and other insects as well as to birds. It has been reported reduced effect of the chemical against *F. occidentalis* in Norway.

Vertimec contains the active ingredient abamectin. It is very poisonous to aquatic organism, and may also give negative long-term effects in aquatic ecosystems. It is poisonous to bees and other insects.

Zolone Flo containing the active ingredient fosalon is listed as one of the pesticides recommended to use if both *F. occidentalis* and TSWV have been detected (Annex 5). It is very poisonous to aquatic organisms, and may also give negative long-term effects in aquatic ecosystems. It is poisonous to bees and other insects, as well as to earthworms.

Perfekthion 500 C, which contains the active ingredient dimetoat, is also listed as one of the pesticides recommended to use if both *F. occidentalis* and TSWV have been detected (Annex 5). It is dangerous to breath in and to swallow, may give serious damage to the eyes and allergic reactions by skin exposure. It is also very poisonous to aquatic organisms, and may give negative long-term effects in aquatic ecosystems. It may also cause contamination of the groundwater. It is poisonous to bees and other insects, and to birds.

Dimetoat was listed as one of the pesticides detected in brooklets and rivers in Norway, and was found in 8 out of 1218 samples taken during 1995-2002 (Ludvigsen & Lode, 2002). Dimetoat is recommended for use in cereals, grass, cabbages and decoration plants in the field in addition to greenhouse crops (not vegetables), so it is difficult to determine where the chemical came from (i.e. whether the chemical found came from control measures taken against *F. occidentalis* one can only speculate about). The investigation did not include a search for the other four insecticides listed above.

Implications for IPM programs and for Biodiversity
F. occidentalis is regarded as a pest that has severely contributed to making biological control difficult to use in several greenhouse crops and even impossible to use in others. As a result, other greenhouse-pests that could more or less easily have been controlled by predators and parasitoids also need to be controlled by chemical insecticides when *F. occidentalis* is present, because the treatments against *F. occidentalis* are more poisonous to the natural enemies (see pesticide section above) than to the pests themselves.

Introduction of non-indigenous species may severely distort already established IPM-programs and in particular those relying on biological control agents. As an implication, effort should be made and phytosanitary measures should be actively used to avoid such introductions in the future. Unfortunately, the opposite may become the reality, as import of decoration plants, flowering pot plants, seedlings and plants for further cultivation, and plants for outdoor use have only increased the last 15 years or so, while the control and inspection of such goods at the entry sites has not. More recently also trees and bushes that have been grown in the fields in other countries and which carry a part of that soil when exported are increasingly imported. There is reason to believe that in the future several non-indigenous organisms will be introduced to the country and probably at a higher frequency than we have seen so far. In fact, it is only when such organisms become a pest problem or specific investigations are carried out that these organisms may be noticed. It is very likely that organisms that do not pose immediate threats to crops or are very visible in other ways have been introduced but never recorded. Such organisms may pose a severe threat to the biodiversity in the long term.

In this respect *F. occidentalis* is an example of a very aggressive and invasive non-indigenous species that quickly managed to establish itself in Norwegian greenhouses. Only the cold climate in winter has hindered the species from also establishing outdoors, since suitable host plants are available everywhere (Annex 1).

3.12 Prospects for the future
F. occidentalis should be regarded as a well established pest that will remain present in Norwegian greenhouses in the overall future. Programs or actions to eradicate it from these environments are likely to fail, because the chance of having it re-introduced through imported goods are very high. The heavy burden such programs put on the growers, scientists and phytosanitary authorities, and the environment is another weighty reason that similar actions as ‘Trips’aksjonen’ from 1991 may not be repeated. The thrips is now treated like any other greenhouse-pest by growers, extension service, scientists and phytosanitary authorities, and specific action is only taken if connected to the presence of TSWV.

Around the world it is now recognised that invasive alien species have caused and are causing environmental damages and are associated with high costs of control (Pimentel, 2002). The invasion of non-native species into new ecosystems is accelerating as the world’s human population multiplies, and as goods are transported ever more rapidly on an increasing global scale and thereby creating opportunities for unintentional introductions (stowaways). Most plant and animal introductions have been intentional to increase and diversify food production, while most invertebrates and microbe introductions have been accidental.

International actions to combat the threat posed by invasive alien species to crops and biodiversity have intensified in recent years (Baker et al, 2005). For instance the International Plant Protection Convention (IPPC) has released its twenty-1st International Standards for Phytosanitary Measures (ISPM), which clearly shows that IPPC has reviewed its role in protecting biodiversity. IPPCs standards are give additional authority due to their recognition by the Sanitary and Phytosanitary Agreement of the World Trade Organisation (WTO-SPS) (WTO, 1994).

4. Potato late blight, *Phytophthora infestans* (Mont.) de Bary

4. 1. Introduction

The late blight disease of potatoes caused by *P. infestans* is the most devastating disease of potatoes in the world. *P. infestans* is probably one of the best known plant pathogens because it was responsible for the Irish potato famine of the late 1840s. The destruction of the entire potato crop resulted in death of over a million people due to famine and related diseases and another million people emigrated from Ireland (Nelson, 1995).

The late blight pathogen probably originated in Mexico. Until the “second migration” in the late 1970s the *P. infestans* population in highland Mexico appeared to be sexual and consisted of both A1 and A2 mating types and was genotypically highly diverse (Fry et al. 1993).

It is believed that only one mating type of *P. infestans*, A1, was introduced from Mexico to Europe in the mid 1800s (“first migration”). This restricted the pathogen to clonal reproduction and vegetative spread, resulting in a highly uniform population. The first report of A2 isolates found in Europe came in 1984 (Hohl and Iselin, 1984). This report initiated screening for mating type in field samples and culture collections and it was shown that the A2 mating types had been present in Europe since at least 1980 (Spielman et al., 1991; Fry el al., 1993). When comparing isolates of *P. infestans* collected in the Netherlands, the United Kingdom and Germany before 1980 to isolates collected in the Netherlands after 1980 a shift towards an increase in both genetic and race diversity was found (Drenth et al, 1994). Both the occurrence of A2 and the shift in population diversity strongly indicates a major change in the European pathogen populations. The reason for this change was attributed to a second migration from Mexico to Western Europe. It is widely believed that the new strains migrated within consignments of ware potatoes imported into Europe in the dry summer of 1976 (Niederhauser, 1991).

There are indications of a changed behaviour of late blight under field conditions (Drenth et al, 1994; Day and Shattock, 1997). A compilation of historical late blight survey data from Finland discloses a clear trend towards an earlier start of the epidemics. Another recent observation is that the problems with late blight in the northern parts of Finland are increasing (Hannukkala, unpublished).

4.2 Identity
P. infestans (Mont.) de Bary is a member if the phylum Oomycota, class Oomycetes, order Peronosporales, and family *Pythiaceae*. The phylum Oomycota does not belong to the fungi but to a kingdom called Chromista (Stamenopiles). This kingdom contains brown algae, diatoms, oomycetes, and some other similar organisms (Agrios 2005).

Organisms belonging to the phylum Ooomycota have biflagellate zoospores, with longer tinsel flagellum directed forwards and shorter whiplash flagellum directed backwards. Diploid thallus with meiosis occurring in the developing gametangia. Gametangial contacts produces thick-walled sexual oospore (Agrios 2005).

There are two mating types (A1 and A2). If an individual of one mating type interacts with an individual of the other mating type, sexual structures (oogonia and antheridia) are stimulated in both individuals. Fertilization occures in the oogonium, which matures into a thick-walled oospore that can survive adverse conditions, such as dry and cold (Stevensen et al. 2001). More detailed characteristics of P. *infestans* are given in the book of Erwin and Robeiro (1996). Pictures of different pathogen structures are shown in Figure 2.

4.3 Host range and distribution
The pathogen has a limited host range (mainly solanaceous host) (Erwin and Robeiro 1996). Potato is the most important host plant for *P. infestans.* Among other food crops tomato (*Lycopersicon esculentum* Mill.) is an important host plant. Eggplant (*Solanum melongena* L.) might also be infected by this pathogen. Petunia (*Petunia* x *hybrida* Hort.), used as ornamentals, are also host for *P. infestans*.

The pathogen is present worldwide. In Norway late blight has only been reported on potato and tomato (Herbarium specimens at Bioforsk Plant Health and Plant Protection Division). The pathogen has been recorded in all counties except Finmark (se more details below regarding history of late blight in Norway). However there are also indications that the pathogen is present there (Hermansen, unpublished). Late blight on tomato has been recorded in all counties except Hedmark, Sogn og fjordane, Nordland, Troms and Finnmark (Mycological herbarium-material at Bioforsk).

Other possible host plants in the Norwegian flora are mentioned in section 4.6 and in Annex 7.

4.4 Symptoms and methods for identification and detection
All parts of the potato plant are susceptible to infection by *P. infestans*. The name *blight* is appropriate for this disease since the individual leaf, stem, and petiole lesions can cause the massive destruction commonly observed in an epidemic (Stevenson et al., 2001).

The symptoms are normally visible on leaves as brown lesions (Figure 3). Very young lesions on foliage appear as irregularly shaped small necroses, and a small area of tissue surrounding the lesions often turns light green. Stem lesions might also be developed. These are dark brown and sometimes water-soaked. Under moist conditions a white “downy mildew” of sporangia and sporangiophores are visible in conjunction with the lesions. This is mainly visible on the underside of the leaves in at the margin of the necroses and most abundant on the tissue surrounding it (Figure 4).

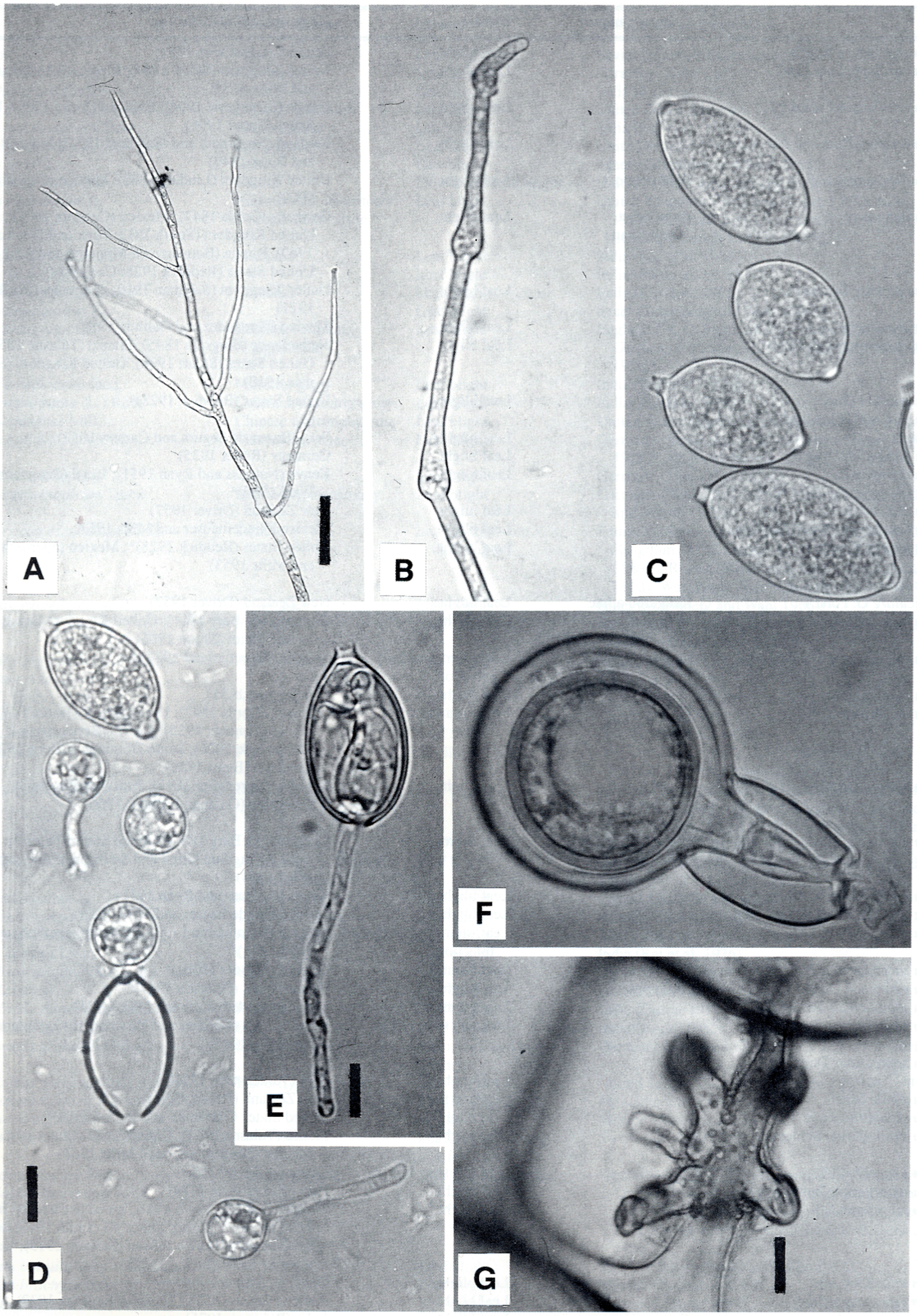

Figure 2. *Phytophthora infestans***.** A, Sporangiophore; B, sporangiophore branch showing swellings at successive sites of sporangium formation; C, sporangia germinating by zoospores (D) and germ tube (E); F, oospore with antheridium; G, haustoria within tuber cells. Bar in A= 50 µm; bars in D, E, and G= 10 µm. (Scanned from Erwin and Robeiro, 1996)

Tuber infections are initially somewhat superficial, but the pathogen might penetrate deeply into the tubers. In the absence of secondary pathogens the tuber blight lesions are reddish brown, dry, and granular (Figure 5 and 6). More detailed descriptions of symptoms are given by Stevenson et al. 2001.

Under moist conditions, when sporulation is visible the pathogen is easy to identify with the naked eye. Otherwise a stereo-microscope could be used for identifying the typical sporangia and sporangiophores (Figure 2). If no sporulation is visible an incubation of the diseases tissue in a humid chamber at about 20 °C over night is recommended. Then a re-examination of sporulation should be carried out. Isolation of the pathogen on artificial medium is also possible using e.g Rye agar or Pea agar. Then further identification of the pathogen can be made by classical mycological methods or by molecular methods. PCR primers for detection of *P. infestans* are available and might also be used for detection of latent infections in tubers (Hussain et al., 2005).

Figure 3. Late blight infected potato leaf (photo Arne Hermansen)

Figure 4. Late blight infected potato leaf seen from the underside with white sector of sporangia and sporangiophores in the border of the necrotic tissue (photo Arne Hermansen)

Figure 5. Late blight infected potato tuber (photo Arne Hermansen)

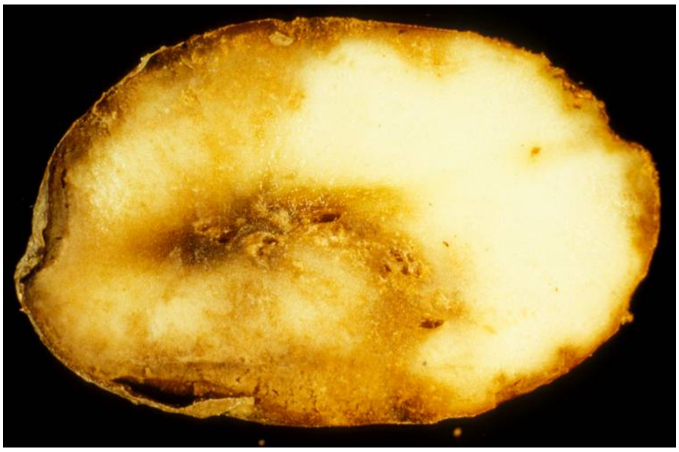

Figure 6. Late blight infected potato tuber (photo Vibeke Hjønnevåg)

4.5 Biology and epidemiology

The pathogen survives as mycelium in infected potato tubers (seed potatoes, volunteers, dumps). From infected tubers the mycelium grows up in the potato stems and in humid periods sporangia are formed at 10-24 °C. These sporangia are spread by wind and rain splash to potato leaves and stems. If these are wet for a critical period the pathogen might infect. The sporangia germinate either directly, by forming a germ tube (at temperatures of 18-24 °C), or inderictly, by producing zoospores (at 8-18 °C). Infection of susceptible tissue can occure within 2 hr of contact between the host and the pathogen, but most infections require longer wet periods. After some days with latent period (at optimal conditions as short as 3 days) symptoms are visible and new sporangia might be formed in the border between healthy and injured tissue (Figure 4). These might be spread and infect new leaves and several asexual generations of spores might be produces. After a few weeks of an epidemic the potato haulm might be totally killed by the pathogen (Stevensen et al. 2001).

Potato tubers are infected during the growing season mainly via movement of sporangia from infected haulm to the soil. Zoospores are formed and are transported via soil water to the tubers. The incidence of tuber infections is highly variable from one year to the next and from one cultivar to another. Tubers might also be infected during the harvest procedure if infected soil and haulm comes in contact to tubers and these tubers are wet for some time afterwards. Tuber infection is also possible during handling and subsequent storage; however this is probably rare (Stevensen et al. 2001).

Tubers are sometimes shipped very long distances. Therefore infected tubers are very important in the long-distance dispersal of the pathogen ("first and second migration" section 3.1).

In locations where mating type A1 and A2 coexist, as in Norway, hybrid oospores are formed. These can function as survival structures in soil. Early attacks of late blight presumably originated from oospores in the Nordic countries have been reported (Andersson et al., 1998; Lehtinen & Hannukkala, 2004). Experiments in Norway indicate that *P. infestans* oospores survive for at least 5 winters (Nordskog et al. unpublished). Oospores germinate and produce a sporangium, which might infect as other sporangia mentioned above. The disease cycle is summarized in Figure 7. below.

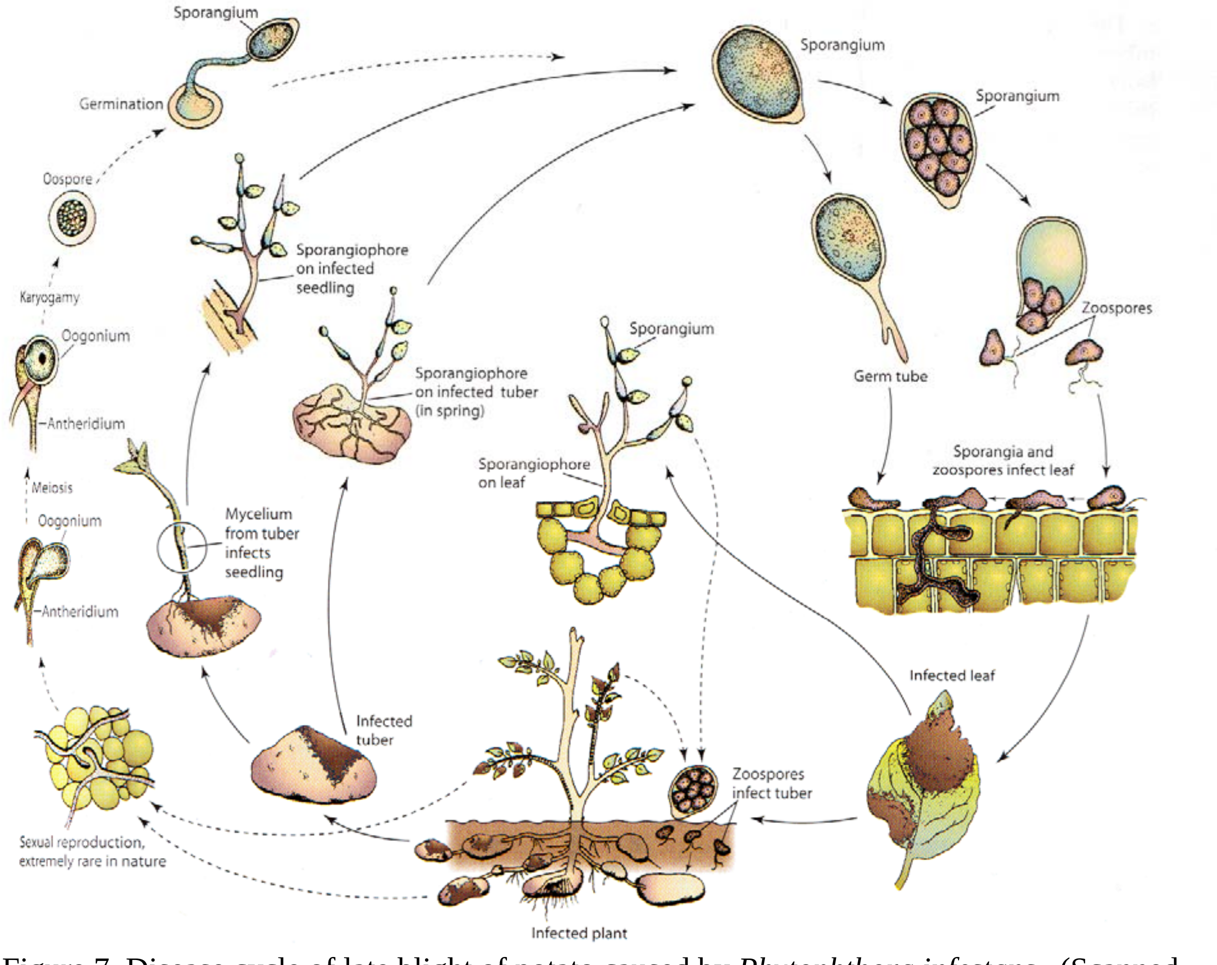

Figure 7. Disease cycle of late blight of potato caused by *Phytophthora infestans*. (Scanned from Agrios, 2005)

4.6. The history of late blight in Norway (related to the first and second migration mentioned in section 4.1)

Potato late blight has been present in Norway at least since 1841. That year the disease caused problems in Sogn og Fjordane County at the west coast (Svensen, 1852). The first herbarium material collected is from 1879 (Information in the Mycological herbarium at Bioforsk). Late blight has been considered as one of the most important plant diseases in Norway (Brunchorst, 1887). However, in Troms County in Northern Norway the disease did not cause significant problems until the 1950s (Andersen, 1975). As in many other European countries *P.infestans* population surveys started approximately 150 years after the pathogen was introduced.

The A2 mating type was first found in Norway in 1993, which was the first year of a population survey (Hermansen & Amundsen, 1995). Out of 642 isolates tested in the survey from 1993-96, 25 % were A2. Differences in the ratio of A1/A2 were evident between regions and A2 was not found in northern areas (Hermansen *et al.*, 2000). Among 335 isolates tested from different parts of Norway in 2003, the frequency of A2 was 40 % (Hermansen *et al.,* 2005). A relatively stable frequency of mating type A1 and A2 was found in a study of samples taken during different parts of the season (Bergjord & Hermansen 2001). Mating type A2 was first found in the middle of Norway in 1999 (Hermansen *et al.*, 2001). In a study from 2004, A2 was still not recorded among 110 isolates from Northern Norway (Hermansen *et al*., 2005). However in a survey from 2005, A2 was found in Troms county (Hermansen et al. unpublished). Oospores of *P. infestans* are also regularly found in leaves from blighted commercial crops of potatoes in Southern Norway (Dahlberg *et al*., 2002).

Metalaxyl resistant isolates was first found in 1988 (Magnus & Hjønnevåg, 1989). In a survey of 491 isolates from 1996, 59 % were resistant to metalaxyl. Tuber isolates were more often resistant than isolates from leaves. The proportion of intermediate sensitive isolates was highest in areas with the highest frequency of A2, and metalaxyl resistance was most frequent among A1 isolates (Hermansen *et al.*, 2000). In a recent study of 75 isolates sampled in 2003, only 12 % of the isolates were resistant to metalaxyl (Hermansen *et al.*, 2005).

Genetic fingerprinting of 102 isolates from 43 fields in 1996 using RG57 fingerprints revealed 21 polymorphic fingerprint loci. A total of 51 different multilocus genotypes were identified, and 35 of these were only found once. The N1 genotype, which was widely spread in Norway, could be a clonal lineage. The results from this study indicated that sexual reproduction is contributing significantly to the genetic variation of *P. infestans* in Norway (Brurberg *et al*., 1999). Results from use of SSR markers for genetic fingerprinting of 50 isolates sampled in 50 different fields in 2003 confirm these indications (Brurberg *et al*., unpublished).

Virulence was tested among 105 Norwegian isolates from 1996, and all known virulence genes were found. Race 1.3.4.7.10.11 was most common (R9 was not included in the differential set) (Hermansen *et al*., 2000). Studies of virulence among 50 isolates from the 2003 population confirm these findings (Hermansen *et al*., unpublished).

4.7. Control measures

Phytosanitary measures - control of primary inoculum sources

Dumps and volunteers

In Norway the temperature often drops below zero during winter time. Thus potato tubers in upper parts of dumps and soil profiles are mostly killed by frost. However, in some years and situations plants might develop from surviving tubers. In northern parts of the region thick snow cover often prevents freezing of the soil and tubers can remain viable in spite of the very cold aerial temperature. Volunteer plants are an increasing problem also in northern production regions.

Seed

As discussed above, the problems with inoculum coming from dumps and volunteer plants are of less importance in cold climates. This will make infected seed tubers, together with oospores, the most important primary infection sources in the Nordic countries (unpublished data). Control of seed tuber inoculum is not easy. The most important strategy is to use seed tubers free of late blight infections. However, seed lots might contain blighted tubers although the mother plants have been treated regularly against blight during the growing season. Even low levels of leaf blight might cause severe tuber blight problems (Nærstad 2002). No seed treatment with fungicides effective against late blight is allowed in the Nordic countries. If the seed lot is infected use of systemic fungicides early in the season might delay the first infections in the field. In Norway farmers are advised to use this strategy if they suspect primary infection from the seed lot (Hermansen and Nærstad 2005).

Oospores

The importance of oospores as soil borne inoculum is determined both by their formation in plant tissue and their survival in soil. Cold winters with frozen soil will conserve oospores between growing seasons and result in a germination peak in spring coinciding with the planting of the potato crop. This will further increase the importance of oospores as source of inoculum. In an inoculated field trial in Sweden it was not possible to recover isolate from the soil after 15 months (Andersson and Sandström, unpublished). Experiments starting in 1998 with buried oospores in soils in the Nordic countries indicate, using tetrazolium bromide (MTT) as a viability stain (Sutherland and Cohen 1983), that the oospores are capable of surviving at least five winters in our harsh weather conditions (Nordskog et al. unpublished). Danish and Finnish studies of the correlation between crop rotation and early late blight infections shows a clear trend that infections started earliest in fields without rotations. The decline in early infections was most evident after three or more year rotation (Bødker et al. 2006). The same correlation between rotation and early infections has been observed in early potatoes in South Sweden (Andersson, unpublished). This indicates that a sound crop rotation is important and is an effective way of reducing the risk of soil borne infections of *P. infestans*. Although three years between potato crops seems to be sufficient under practical situations even longer rotations is probably needed to rule out the potential influence of surviving oospores.

Chemical control

Most widely used contact fungicides in the Norway are fluazinam (Shirlan) and mancozeb products. The translaminar and systemic products in mixtures with contact fungicides altogether have approximately 10 % of the market. Most widely used active ingredients in mixtures with mancozeb are dimethomorph (Acrobat WG) and propamocarb hydrochloride (Tattoo). Recently registered fungicides are mixtures of zoxamide and mancozeb (Electis) and fenamidone and mancozeb (Sereno). All approved late blight fungicides in Norway are listed in Table 1.

Characteristic for the production areas in Norway is short growth period, but extremely rapid crop growth in nearly 24 h daylight in the middle of the season. Therefore the generally recommended spray intervals (7-10 days) for contact fungicides are definitely too long during high inoculum pressure in these conditions where new unprotected growth can be 10-15 cm within one week.

The blight risk and number of fungicide applications needed for adequate blight control varies considerable between seasons, climatologically diverse regions within Norway and type of production. Roughly 3 to 8 applications are carried out in Norway with an average number of approximately 5 to 6 sprays per season (Schepers 2004).

Two major strategies in fungicide programs are applied in Norway. In large farms fixed 5 to 7 day spray intervals with mancozeb or fluazinam have proved feasible. The dose rate can be adjusted according to prevailing blight risk. In smaller farms it is possible to adjust spray intervals between 5-14 days and choose translaminar or systemic and contact fungicides according to weather forecast, crop growth stage and blight risk (see Forecasting/ DSS section below). Fluazinam are recommended at the end of spray program due to good tuber blight control.

Resistance to metalaxyl appeared in blight populations in potato production areas very soon after introduction of the fungicide in 1980s. Increased tolerance to the fungicide has been reported from Norway (Hermansen et al. 2000). The development of tolerance of potato late blight against propamocarb hydrochloride has recently been monitored in the Nordic countries. There are no indications of failures in the efficacy of the product although individual isolates capable to grow in high concentrations have been found (Hannukkala et al. 2005). Resistance development against other fungicides has not been monitored in Norway.

Prevention of tuber blight
A normal procedure to reduce the risk of tuber blight is killing of the haulm prior to harvest. In large parts of the Nordic area the growing season is short, thus it is important to keep the haulm green as long as possible to obtain high yields. Thus a five year project was started in Norway in 2003 to see if it is possible to harvest “on green haulm” without increasing the risk of tuber blight in certain situations e.g. when the level of leaf blight is low and fungicides are used close to harvest. Haulm killing 14 days prior to harvest reduced the number of spores in the haulm and soil at harvest and the level of tuber infection related to harvest on green haulm with or without treatment with fluazinam 7 days before harvest. However the treatment with fluazinam before harvest reduced the number of infective spores in the soil at harvest related to untreated green haulm (Hermansen *et al.* 2004). The frequencies of tuber infections in these fields were relatively low, although the amount of viable inoculum in the soil at harvest sometimes was high. Results from these field trials indicated that dry climatic conditions at harvest limited the frequency of tuber infections during harvest (Nærstad and Hermansen, unpublished data).

Table 1. Approved fungicides in Norway in 2006 (Norwegian Food Safety Authority)

Trade name	**Active ingridient**
Dithane Newtec	mankozeb
Shirlan	fluazinam
Acrobat WG	dimetomorf + makozeb
Tattoo	propamokarb-HCL + mankozeb
Sereno WG	fenamidon + mankozeb
Electis	zoksamid + mankozeb

Integrated pest management (IPM)

Use of resistant cultivars

The cultivars foliar resistance may be used to reduce the fungicide input in late blight control (Bus *et al.*, 1995; Clayton & Shattock, 1995; Fry, 1978; Fry *et al.*, 1983; Gans *et al.*, 1995; Grünwald *et al*., 2000; Nærstad, 2002; Shtienberg *et al.*, 1994). However, it is very risky to exploit the foliar resistance if the field resistance to tuber blight is low (Nærstad, 2002). In Norway resistance to tuber blight is tested by application of inoculum to freshly harvested tubers (Bjor, 1987). In field trials with cultivars with different tuber resistance score and reduced fungicide input it was found that the amount of tuber infection in the field mainly was determined by the cultivar and the differences between treatments were marginal in most cultivars. However the correlation between the tuber resistance score and the observed tuber infection frequency in the field was low, probably because of the effect of cultivar specific avoidance of inuculum (Nærstad, 2002). In Denmark the resistance to tuber blight is tested by application of inoculum in the field after partly defoliation, and methods are close related to the Eucablight protocol: “Field test for tuber blight resistance” (www.eucablight.org). This type of field resistance to tuber blight, also includes the cultivar specific effect of avoidance of inoculum in addition to intrinsic tuber resistance.

Forecasting/Decision Support Systems (DSS)

To protect the crop against late blight infections, potato growers need information related to the environment, the host and the pathogen. In Norway information and decision support aiming at late blight control is disseminated via the Internet (www.vips-landbruk.no). Bioforsk is responsible for dissemination of agrometeorological and related information to the agricultural sector. This is done in close collaboration with the Norwegian meteorological institute and the extension service. Weather data are available from Bioforsks weather station network established in important agricultural areas in the 1990s in Norway (Magnus et al. 1991). All information is disseminated via the Internet and increasingly via SMS to Mobile phones.

In Norway accumulated and daily risk values from NegFry is available in VIPS (www.vips-landbruk.no) together with the Försund rules developed in the late 1950´s (Hermansen and Amundsen 2003). Monitoring of first attack of late blight in important potato growing areas are carried out by the advisory service and are displayed in VIPS. This system is a part of a collaborative Internet application established in 1998 by the development of the Internet based Web-blight system, http://www.web-blight.net (Hansen et al. 2001).

Due to the dramatic change in the biology of the late blight pathogen, it was decided to initiate basic biological studies enabling update of models and decision rules. A common Nordic framework for development of a core Internet based late blight decision support system was established in 2003. This framework facilitates that future development of late blight DSS applications and components can be exchanged between partner countries.

Due to structural changes in agriculture in Norway the number of farmers decreases, but at the same time the areas increases, including number of fields with potato grown by each farmer. This is a barrier for using complex models and decision rules that operates on field level and as input requires detailed observations in each field. Facing this situation a simple, 7-day spray-schedule-DSS (Blight Management) was developed integrating reduced dosages of fluazinam (Shirlan), host resistance, infection pressure and epidemic phase. This new DSS concept is currently tested in the Nordic countries alongside with other late blight control strategies.

4.8 Economic impact

The total annual costs in Norway caused by potato late blight sums up to about 55 to 65 million NOK depending on the year. The different aspects of the estimated costs are described below.

Fungicides and application costs

On average for the period 2000 – 2004 potato fields were treated with fungicides 5.57 times per season to control potato late blight. The calculation of the average treatment frequency is based on the statistic of fungicide trade 2000-2004 (Mattilsynet, 2005) and the total potato production area in the same period. The fungicide trade was relatively low in 2000 and 2001 and relatively high in 2004, due to increased tax on fungicides in 1999, 2000 and 2005 and hence stockpiling in 1998, 1999 and 2004. The total potato production area in average for the period 2000 –2004 was 147.931 daa (Statistisk Sentralbyrå, 2006). When calculating the average treatment frequency no corrections are made for the fluctuation in trade caused by increased tax on fungicides. The average fungicide cost pr treatment was 26.55 NOK/daa based on the 2004 prises from Felleskjøpet and the average fungicide trade in 2000-2004. The average contractor price for pesticide application is 620 NOK/hour (Agjeld, 2005) and the average time used is estimated to 3 minutes per daa. The average application cost is estimated to 31 NOK/daa per treatment. The total fungicide cost to control potato late blight in Norway was 21,88 million NOK per year and the application cost is estimated to 25,55 million NOK per year.

Actual losses (yield and quality)

Even though late blight fungicides are applied according to warnings or at regular intervals, it is relatively common to get small amounts of infections of *P.infestans* in the foliage. The gross yield reduction caused by light infections is normally small compared to the loss caused by infections in the tubers. Most potato packing companies and some of the potato processing industry has a “zero tolerance” to tuber blight. This is caused by the risk of blight development during storage and spread of the disease during handling. All companies take test samples of the potato lots before buying them. In 2005 the late blight risk was low in most of Norway. Based on findings of tuber blight in the test samples, 0-5% of the potatoes were rejected or downgraded to other productions with a higher tolerance of tuber blight. In average for five potato-packing companies 1,46 % of the potatoes were rejected in 2005. However, 4% were rejected in average in the worst years. The total net sales production in 2005 was 295.826 tonn, with a value of 520,1 million NOK (NILF, 2005). The economically loss for the farmer is estimated to 4,97 million NOK in 2005 and 13,73 million NOK in the worst years. During packing for consumption the potato packing companies discharged about 0,05 –0,5 % of the tubers due to late blight in different years. In the quality control of the packed potatoes in the 2004/ 2005 season tuber blight was found in 4% of the tested samples (Verdal J. personal communication)

Cost for inspection, research, advisory service, VIPS
Norwegian Food Safety Authority inspects the potato quality at the wholesalers and in the groceries shops. In the season 2004/2005 they inspected 800 samples. The cost per sample is 2000 NOK. One of the quality defects they are looking for is dry rots and tuber blight is one of the dry rots. They found tuber blight in 4% of the samples. Tuber blight is one of 19 quality defects and hence the cost of inspection is estimated to 84.210 NOK (Verdal J., personal communication).

During the last years about 1,6 million NOK are used on potato late blight research annually at Bioforsk.

The research and experimental groups gives advice to the potato producers on late blight control. The potato companies also often have their own advisors, which also give advice on late blight control. In addition the suppliers of pesticides give advice on how to control late blight. In total it is estimated that it is used about 2,5 “man-labour year” on late blight advice to the potato farmers. The total cost of this advisory service is estimated to about 1 million NOK annually.
It is produced a daily warning of the late blight risk in VIPS and the cost of producing these warnings is estimated to 375.000 NOK. In addition there is cost of inspection in the fields for early attacks and registration on web-blight in VIPS of approximately 300.000 NOK annually.

4.9. Environmental impact

Effect of the pathogen on the natural ecosystem
P. infestans is not a pathogen normally causing disease problems in natural ecosystems in Norway. Thus there are no direct reported effects of the pathogen in this respect. However there are several plant species that might be infected (Erwin and Robeiro, 1996) by the pathogen. In Annex 7 a list of 21 plant species reported as hosts by Erwin and Robeiro, 1996 and which are present in the Norwegian flora (Lid & Lid 2005). These plants mainly belong to the *Solanaceae* family, but there are also plants belonging to *Asteaceae*, *Convolvulaceae* and *Polygonaceae*. Some of the host plants have in the literature only been reported as artificially inoculated hosts.

If the plants listed in Annex 7 were infected by *P. infestans* in Norway it would probably only cause minor damage and the effects would probably be temporary on the natural ecosystem.

Effects of late blight fungicides on the natural ecosystem

Properties of the fungicides
Mankozeb and fluazinam are the two main fungicides used for late blight control in Norway. Norwegian Food Safety Authority is responsible for pesticide regulations. In 2002 a evaluation of mankozeb (Kraggerud et al. 2002) and fluazinam (Dæhli et al. 2002) was made. In these evaluation documents the following judgements were made regarding the risk in the environment. I addition some more detailed information is given (Ole M. Eklo, personal communication):

Mankozeb
The results of the adsorption experiment show that mankozeb is not mobile in soil. However one of the metabolites ETU, has low adsorption in soil. Because of the high mobility of ETU, the metabolites can represent a risk of contamination of groundwater. However, the fast degradation reduces the risk of ETU reaching the groundwater. But reaching the groundwater, low microbial activity and low temperature will slow down the degradation and the compound will be more persistent. ETU is found in small rivers and ground water in Norway and in the Netherlands. The dosage in the Netherlands is at the same level as in Norway, but the number of applications is much higher.

Primary decomposition of mankozeb in water/sediment is very high. According to octanol/ watercoefecient the potential for bioconservation of mankozeb is low.

Risk of effects on organisms
Terrestrial environment
Mainly temporary effects are observed for microorganisms involved in the metabolism of nitrogen and respiration. In one experiment significant effects on populations of microorganisms were observed for as long as for 3 months. There is no information on exactly how large this effect was. Mankozeb has moderate to low acute toxicity for earthworms. Mankozeb is moderately toxic for some other beneficial organisms. Low toxicity for bees and birds make mankozeb a low risk pesticide for these organisms. There is no risk for chronic effects on earthworms. There might be some risks for birds. However the probability that birds will be exposed to mankozeb for a long period is low since it is so quickly decomposed. We do not know if the metabolites have an effect on bird reproduction.

Aquatic environment
Mankozeb is extremely toxic for algae and for *Daphnia magna* in acute experiments. In addition it is extremely toxic for fish in acute experiments and toxic for fish and *D. magna* after cronic exposure. A security border of 20 m is necessary to avoid negative effects on aquatic organisms.

Long term experiments with ETU shows a much lower toxicity. This implicate that mankozeb is causing the effects and not the metabolites. Mankozeb is easily degraded in water and the fungicide is not used more than 2-3 times per season. Therefore it is of low risk for chronic effects on *D. magna*. Long term experiments with fish also give effects at low concentrations. However there are no long term experiments done for the metabolites. Therefore it is harder to draw conlusions regarding possible chronic effects on fish.

Fluazinam
Fluazinam is low water soluble, has high to very high adsorption in soil and low to medium mobility in column leaching studies. Fluazinam has medium to low aerobic and anaerobic primary decomposition in soil and has low risk of leaching to ground water.

Decomposition of fluazinam in water/sediment systems is high to very high and the potential for bio concentration is high.

Risk of effects on organisms
Terrestrial environment
Fluazinam has low risk for terrestrial organisms.

Aquatic environment
Fluazinam is toxic to very toxic for algae and very toxic for *D. magna* in acute experiments. In addition fluazinam is very toxic to rainbow trout and carp fish after long term exposure. A security border of 5 m is necessary to avoid negative effects on *D. magna* which is the most sensitive species. There is no risk of effects to aquatic organisms after surface runoff (Dæhli et al. 2002). Data from JOVA (se below) in 2005 indicate that this statement might be too categorical.

Results from the monitoring program in Norway
JOVA (Soil and water monitoring) of different watersheds in agricultural areas in Norway has been carried out for several years by Bioforsk (Earlier Jordforsk and Planteforsk). In the report from the 2002 program (Ludvigsen & Lode 2003) data from detection of pesticides in brooks and rivers in 1995-2002 is summarized. An environmental risk index for aquatic organisms ("ERI") has been made for different pesticides and the limits are different for each pesticide. For ETU, fluazinam and metalaxyl this limit is 0.26, 0.55 and 280 µg/l respectively. (Metelaxyl is a fungicide not longer approved in potato and the last year for use was 2005.) For ETU (mankozeb) 44 samples have been tested during 1995-2002 and ETU was found in 30 % of the samples, but only 1 sample had more than the ERI limit. Fluazinam has been analysed in 600 samples and was detected in 1 % of the samples. No samples had more than the ERI limit. However, data from 2005 has shown that the ERI limit has been exceeded in some cases (Ole M. Eklo, personal communication). Metalaksyl has been analysed in 1218 samples and was detected in 11 % of the samples, but no samples had more than the ERI limit. There have also been some tests of ground water in agricultural areas during 1997-2002 (Ludvigsen & Lode 2003). A total of 22 wells were tested and 125 analyses were carried out. Pesticides were found in 11 (50 %) of the wells. 7 of these wells had higher concentration of pesticides than limits recommended for drinking water in waterworks. Of the three late blight fungicides tested only metalaxyl has been found in these wells. The Norwegian Institute of Public Health has concluded that there is no health risk to drinking the water from the tested wells with the detected concentrations of pesticides.

Effect on human health
National Institute of Occupational Health has studied diseases among Norwegian farmers related to exposure of pesticides. Recently they published an article about possible links between mankozeb exposure and thyroid cancer and neural tube defects in farmer's families (Nordby et al., 2005). Data from this study is still under discussion in the Scientific board in the Norwegian Food Safety Authority. Economical impact of a possible link between late blight fungicides and cost related to human health is not covered in this report.

4.8. Prospects for the future

P.infestans is a well established pathogen in Norway since the first migration from Mexico to Europe around 1840. Later changes in the pathogen population have occurred during a second migration to Europe. Thus both mating types are present and also oospores are formed in plant tissues. In addition to a new primary inoculum source, supplementing infected tubers in survival of the pathogen outside tubers, the pathogen population is more diverse than earlier. How this will develop in the future is not easy to predict. However, a more diverse *P. infestans* population could more easily adapt to resistance in the hosts and also cause increased resistance problems towards fungicides. New genotypes could also easier adapt to more diverse climatic conditions causing problems in more diverse environment.

Global warming might also cause a more conducive climate for *P. infestans* in currently sub-optimal regions for the pathogen in Norway. Today late blight problems are normally much less in mountainous areas and in Northern Norway than in coastal areas in Southern Norway. A rise in the temperature by 1-3 °C could probably have great influence on late blight epidemic at many locations.

P. infestans is a pathogen that we probably will have to deal with as long as we are producing potatoes in Norway. Both in conventional and integrated potato production control strategies will probably continue to use effective fungicides. However in ecological potato production use of resistant cultivars will be the most important control strategy.

5. Conclusions

5.1 Western flower thrips, *Frankliniella occidentalis* (Pergande)

The introduction and establishment of *F. occidentalis* in Norwegian greenhouses has been a burden to both growers and the society. Growers have suffered financial losses in terms of costs of carrying out comprehensive quarantine instructions (1986-1996) and also through direct crop loss and costs of control measures (1986-2006). Growers have also suffered in terms of health risks as they have used pesticides more frequently and thereby been exposed to pesticides more often. Introduction of the species has also implied an increased effort from extension service, phytosanitary authorities, and scientists, the costs involved are, however, difficult to assess. Introduction of the species has distorted IPM-programs, in particular those IPM-programs fundamented on biological control agents, since natural enemies are more sensitive to pesticides than the pests. The establishment and continuous re-introductions of the species through import has also increased the risk of introducing TSWV and other *Tospovirus* species of which *F. occidentalis* is a vector. The establishment of *F. occidentalis* has resulted in an increased use of pesticides, in terms of comprehensive eradication programs during 1986-1996, and in terms of a more frequent spraying regime (see Annex 5) from 1997 and onwards. The insecticides used to combat *F. occidentalis* are also used against other insect pests in both greenhouse and field crops, and therefore the statistics available could not reveal how much of these pesticides have actually been used to combat *F. occidentalis* only. Such detailed investigations would require a lot more research than there was scope for in this report. There is however, no doubt that the introduction of the species has caused a more frequent use of pesticides in greenhouse crops in Norway.

If attacks of *F. occidentalis* are left untreated and in particular if in combination with TSWV, one can estimate a potential crop loss in Norwegian greenhouse production to be close to

100%, or about 1 454.4 mill NOK per year. A more realistic assumption taking host plants and possible infected area into account would be a potential loss between 436-582 mill NOK per year. The number of chemical treatments in infected greenhouses depends on the success of the treatments, re-infestation rate, and at any time available host plants. Since we do not have information about the accurate spraying rate or the accurate number of m^2 infested with *F. occidentalis* as per today, we do not find it appropriate to make an assessment of the spraying costs or the amounts of pesticides used to control it. We do, however, conclude that the use of pesticides against this pest is significant compared to if the pest was not introduced and established in Norway. We also conclude that the production area of about 2.002 hectare greenhouse vegetables, flowering pot plants, decoration plants and cut flowers, are under constant threat of being infected with *F. occidentalis* both via import and/or domestic production and distribution of goods.

5.2 Potato late blight, *Phytophthora infestans* (Mont.) de Bary

P. infestans, causing potato late blight, is a pathogen that has been present in Norway for about 150 years. A new migration of the pathogen from Mexico to Europe happened about 1980 and the new pathogen population is now present in Norway. We probably will have to deal with potato late blight as long as we are growing potatoes in Norway.

The total annual costs in Norway caused by potato late blight sums up to about 55 to 65 million NOK depending on the year.

Available data about the properties of the two main late blight fungicides and monitoring data from the JOVA program indicates that use of late blight fungicides in Norway only have minor and temporary effects on the natural ecosystem.

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Annex 1

Host plants reported for *Frankliniella occidentalis*

The table consists of plants where *F. occidentalis* has been reported (found). Often, the qualifications of the species as a host plant have not been examined. The table is based upon data from Ahlberg (1924), Sakimura (1935), Bailey (1938), Bovien and Thomsen (1950), Cumber (1959), Franssen and Mantel (1962, 1965), Becker (1974), Dimitrov (1977), Bournier, Olsen and Solem (1982, 1983), Yudin et al. (1986), Broadbent et al. (1987), Oliver and Baker (1987), Palmer et al. (1989), Zur Strassen (1989), Jenser (1990), Alford (1991), Allen and Matteoni (1991), Olsson (1991), Talekar (1991), Vierbergen and Mantel (1991), Smith et al. (1992), Lemmety and Lindquist (1993), Lacasa (1994), Stenseth (1994), Lacasa et al. (1995a, 1995b), Vierbergen (1995a, 1995b). (Modified after Blystad & Johansen (1996).)

Host plants of *Frankliniella occidentalis*	**Occurrence in Norway**	+ + : Attractive host plant + : Host plant. sp. : Plant species in the genus are host plants, species not specified.
Achimenes	greenhouse	+ +
Ageratum houstonianum	annual	sp.
Alstromeria aurea (A. aurantiaca)	greenhouse	sp.
Amaranthus blitum		sp.
Amaranthus caudatus	annual	sp.
Amaranthus graecizanzs		sp.
Amaranthus hybridus	wild	+
Amaranthus powellii		sp.
Amaranthus retroflexus	wild	+
Amaranthus spinosus	wild	+
Amaranthus viridens		+
Anemone coronaria	greenhouse	sp.
Anemone sp.		+
Anthirrinum sp.	annual	+
Anthurium andreanum	greenhouse	+
Anthurium scherzerianum	greenhouse	+
Arachis hypogaea		+
Arcticum lappa	wild	+ +
Aster amellus	perennial	sp.
Aster cordifolius		sp.
Aster ericoïdes		sp.
Aster lateriflorus		sp.
Aster novae-angliae	perennial	sp.
Aster novi-belgii	perennial	+
Begonia sp.	greenhouse	+
Beta vulgaris	vegetable	+

Host plants of *Frankliniella occidentalis*	**Occurrence in Norway**	+ + : Attractive host plant + : Host plant. sp. : Plant species in the genus are host plants, species not specified.
Bidens pilosa		+
Bidens pilosa var. minor		+
Brachycome iberidifolia	annual	sp.
Brachycome multifida	annual	sp.
Brassica oleracea var. *botrytis*	field vegetable	+
Brassica rapa ssp. chinensis	field vegetable	+
Bromelia sp.		sp.
Calendula officinalis	annual	+
Callistephus chinensis	annual	+
Campanula americana		sp.
Campanula isophylla	greenhouse	sp.
Campanula pyramidalis		sp.
Campanula rapunculoides	weed	sp.
Capsella bursa-pastoris	weed	+
Capsicum annuum	vegetable	+ +
Capsicum sp.	greenhouse	+
Celosia cristata	annual	+
Chamomilla suaveolens *(Matricaria matricaroides)*	annual	sp.
Chenopodium album	weed	+
Chenopodium ambrosioides	weed	+
Chenopodium. murale	weed	+
Chrysanthemum coronarium	annual	sp.
Cichorium intybus	wild	+
Cirsium arvense	weed	+
Citrullus lanatus	(greenhouse)	+
Convolvulus arvensis	weed	+
Conyza bonariensis		+
Cordyline fruticosa *(C. terminalis)*	greenhouse	+
Coronopus didymus	wild	+
Crepis pulchra		+
Crotalaria incana		+
Crotalaria mucronata		+
Cucumis sativus	greenhouse	+ +
Cyclamen persicum	greenhouse	sp.
Cyclamen sp.	greenhouse	sp.
Cynara scolymus		+
Dahlia pinnata *(D. variabilis)*	greenhouse/ annual	+ +
Dahlia sp.	greenhouse/ annual	+ +
Datura stramonium	wild	+

Host plants of *Frankliniella occidentalis*	**Occurrence in Norway**	+ + : Attractive host plant + : Host plant. sp. : Plant species in the genus are host plants, species not specified.
Delphinium sp.	perennial	+
Dendranthema-Grandiflorum-hybrids (D. morifolium)	greenhouse	+ +
Desmodium unicinatum		+
Dimorphoteca sp.	annual	sp.
Emilia javanica (E. sonchifolia)		+
Fatsia japonica	greenhouse	+
Felicia sp.		sp.
Ficus sp.	greenhouse	sp.
Galinsoga ciliata (G. quadriradiata)		+
Galinsoga parviflora	weed	+
Gardenia jasminoides	greenhouse	+
Geranium sp.	wild	sp.
Gerbera sp.	greenhouse	+ +
Gladiolus sp.	annual	+
Gloxinia sp.	greenhouse	sp.
Gomphrena globosa	annual/ greenhouse	+
Gypsophila paniculata	greenhouse/ perennial	+ +
Hoya carnosa	greenhouse	+
Impatiens-New-Guinea-hybrids (I. hybridus)	greenhouse	+ +
Kalanchoë blossfeldiana	greenhouse	+
Lactuca sativa var. capitata	field vegetable/ greenhouse	+
Lactuca sativa var. crispa		+
Lactuca sativa var. longifolia		+
Lantana sp.		+
Lathyrus odoratus	annual	+
Leucanthemum vulgare (Chrysanthemum leucanthemum)	wild/ weed	+
Leucanthemum-Maximum-hybrids (Chrysanthemum x superbum)	perennial	sp.
Limonium sp	annual/ greenhouse	+
Lycopersicon esculentum	vegetable	+
Malva parviflora	wild	+
Marrubium vulgare	wild	+
Matricaria sp.		sp.

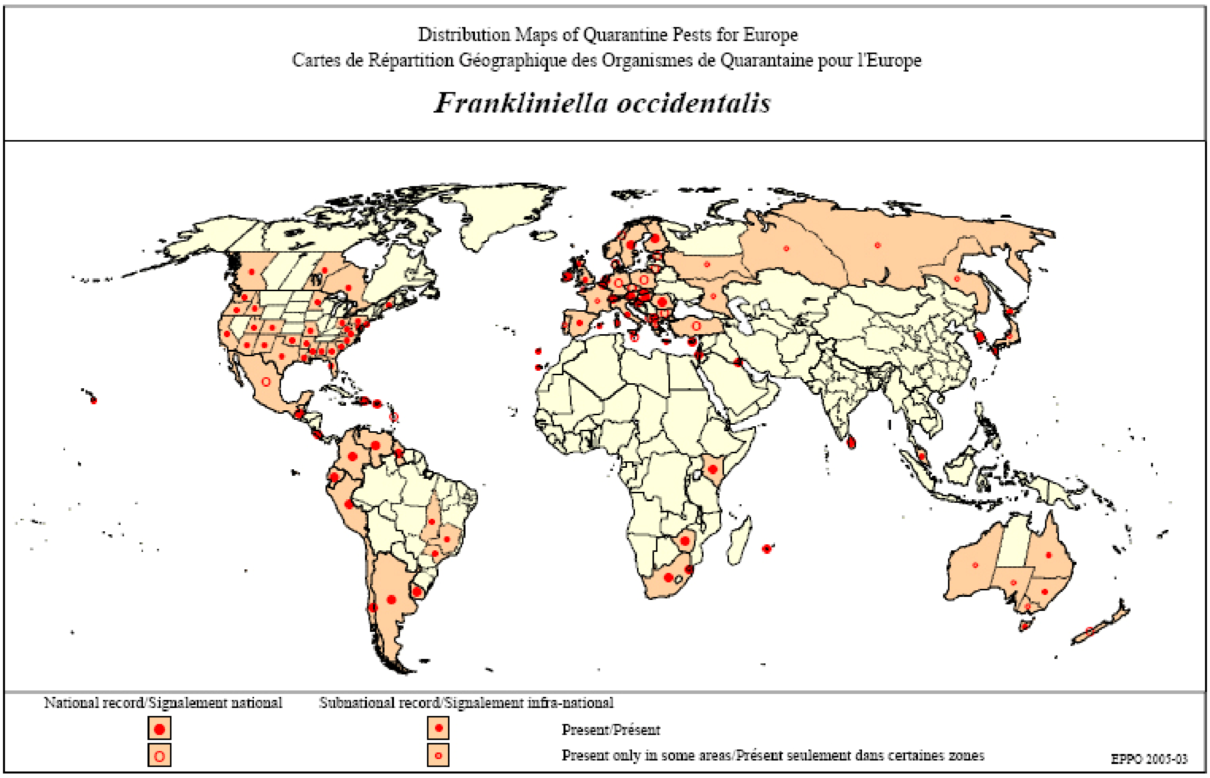
Host plants of *Frankliniella occidentalis*	**Occurrence in Norway**	+ + : Attractive host plant + : Host plant. sp. : Plant species in the genus are host plants, species not specified.
Matthiola sp.	annual/cut flowers	sp.
Medicago polymorpha	wild	+
Melilotus officinalis	annual/wild	+
Nicandra physalodes	annual	+
Nicotiana glauca		+
Nicotiana glutinosa		+
Nicotiana tabacum		+
Ocimum sp.	herb	sp.
Oenothera biennis		+
Pelargonium-Peltatum-hybrids	greenhouse	+ +
Pelargonium-Zonale-hybrids	greenhouse	+ +
Petunia-hybrids	greenhouse/ annual	+ +
Phalenopsis sp.	greenhouse	+
Phaseolus vulgaris	field vegetable	+
Phlox sp.	annual	sp.
Physostegia virginiana	perennial	+
Pisum sativum	field vegetable	+
Polygonum aviculare	weed	+
Polygonum persicaria	weed	+
Portulaca oleracea	herb	+
Primula sp.		sp.
Ranunculus sp.		sp.
Ranunculus arvensis	wild	+
Rhododenron sp.	greenhouse/ field	+
Rumex crispus	weed	+
Saintpaulia sp.	greenhouse	+ +
Salvia sp.	greenhouse	sp.
Schefflera	greenhouse	+
Schizanthus sp.	annuals	+
Schlumbergera truncata	greenhouse	+
Sedum sp.	wild/perennials	+
Senecio jacobaea	weed	+
Senecio vulgaris	weed	+ +
Sinningia speciosa	greenhouse	+
Solanum melongena		+
Solanum nigrum	wild/weed	+
Solanum nodiflorum		+
Solanum tuberosum	field crop	+
Solidago sp.	wild	+
Sonchus sp.	weed	sp.
Sonchus oleraceus	weed	+

Host plants of ***Frankliniella occidentalis***	**Occurrence in Norway**	+ + : Attractive host plant + : Host plant. sp. : Plant species in the genus are host plants, species not specified.
Spathiphyllum sp.	greenhouse	+
Spinacia oleracea	field vegetable	+
Stellaria media	weed	+
Stephanotis floribunda	greenhouse	+
Streptocarpus sp.	greenhouse	+ +
Tagetes sp.	annual	sp.
Taraxacum officinale	weed	+
Trachelium sp.		sp.
Trifolium repens	wild	+
Tropaeolum majus	annual	+
Verbascum thapsus	wild	sp.
Verbena sp.		sp.
Verbena litoralis		+
Verbesina enceloides		+
Vicia faba	field vegetable	+
Vigna unguiculata (V. sinensis)		+
Zantedeschia aethiopica (Richardia africana)	greenhouse	+
Zinnia elegans	annual	+

Annex 2

EPPO Distribution map of *Frankliniella occidentalis*

Source: EPPO distribution map of quarantine pests. http://www.eppo.org/QUARANTINE/insects/Frankliniella_occidentalis/FRANOC_map.htmEPPO, version 2005-03. Accessed 09/03/2006.



Annex 3

Import to Norway of saleable plants and plants for further cultivation from different countries in 2003. The overall majority of the consignments contains host plants of *Frankliniella occidentalis* and/or of Tomato spotted wilt virus (TSWV). The last column shows the status of *F. occidentalis* in the respective countries.

Data from The Norwegian Horticultural Growers Association; EPPO/OEPP: A2 no.177, dated 2005-03.

Country	Flowering Pot Plants/ Decoration Plants		Seedlings & Plants for Further Cultivation		*Frankliniella occidentalis*
	Tons	1000 NOK	Tons	1000 NOK	X, A, B, C, D, E, F, H, J, K *)
Belgium	156.7	5 863.8	0.5	11.3	X
Brasil			91.2	4 786.7	X
Costa Rica			23.7	554.4	X
Denmark	1 533.1	48 302.8	89.6	4 959.6	B
Finland					A
France			0.1	61.0	B
Germany	838.9	22 672.5	17.4	2 058.2	B
Guatemala			0.5	11.5	X
Holland	1 682.2	62 475.5	14.5	886.8	A
Israel	0.04	8.0	2.7	1 164.7	A
Italy	56.1	1 280.7	1.7	911.9	A
Kenya			13.7	1 542.0	X
New Zealand			0.1	14.7	B
Nigeria			0.007	2.2	No information
Poland	4.2	45.6			B
Portugal	6.6	130.4	0.3	154.1	B
Saudi Arabia			0.018	4.8	No information
Singapore	0.05	1.5	0.048	4.8	K
South Africa			0.9	246.7	A
Spain	2.8	150.2	1.7	777.0	A
Sri Lanka			2.0	29.0	X
Sweden	116.2	873.0	1.9	518.3	A
Thailand			1.5	8.9	K
Togo			13.4	102.8	No information
United Kingdom	0.01	3.1			A
USA			0.02	33.8	A
Vietnam	0.4	46.8			No information
Total	4 397.2	141 853.9	277.5	18 844.4	

*) : X=Present, no distribution detail; A=Present, widespread; B=Present, restricted distribution; C=Present, few occurrences; D= Absent, pest no longer present; E=Absent, pest eradicated; F=Absent, intercepted only; H=Absent, confirmed by surveys; J=Absent, invalid record, K=Absent, unreliable record.

Annex 4

Interceptions of Tomoto spotted wilt virus (TSWV) to Norway 1996-2005. *Frankliniella occidentalis* was removed from the A-list of quarantine pests in 1997. The A-list contains pests with zero tolerance on import to Norway.

Data provided by D.R. Blystad, Bioforsk/Plantehelse.

Year	***County***	***Plant species infected***
1996	Sør-Trøndelag	*Aglaonema, Antirrhinum majus, Begonia cheimantha, B. hiemalis, B. pendula, Calathea, Clorophytum, Cdiaeum, Cyclamen, Doronicum, Exacum, Ficus benjamina, F. pumial, Gerbera, Gladiolus, Hedera, Hypocyrta, Impatiens, Kalanchoe blossfeldiana, Maranta, Osteospermum, Papaver nudicaule, P. orientale, Pelargonium, Peperomia sp, Polyscias, Primula, P. aurikula-hybrider, Saintpaulia-ionantha-hybrider, Saxifraga, Schefflera, Streptocarpus*
1997	Rogaland	*Begonia hiemalis, Kalanchoe blossfeldiana*
1997	Buskerud	*Brachycome iberidifolia, B. multifida, Carilion, Lobelia sp. Richardii, Lupinus polyphyllus, Lycopersicon*
1997	Hordaland	*Lobelia*
1997	Hedmark	*Begonia cheimantha, Lobelia sp.*
1997	Nordland	*Begonia hiemalis, Dahlia sp., Osteospermum, Pelargonium-peltatum-hybrider*
1997	Vest-Agder	*Diffenbachia sp.*
1997	Oppland	*Begonia hiemalis*
1998	Aust Agder	*Begonia hiemalis Bankos*
1998	Aust Agder	*Aeschynanthus sp., Begonia cheimantha, Cyclamen sp., Hydrangea sp.*
1998	Buskerud	*Brachycome iberidifolia, B. multifida, Lobelia, Lupinus polyphyllus-hybrid, Lycopersicon*
1998	Hedmark	*Begonia hiemalis, Dahlia sp., Hedera sp.*
1998	Nordland	*Begonia hiemalis, Dahlia sp., Dendranthema x grandiflorum, Hedera sp., Hypocyrta, Osteospermum sp., Pelargonium peltatum*
1999	Akershus	
2000	Sør Trøndelag	
2001	Hordaland	
2002	Sør-Trøndelag	*Begonia hiemalis*
2002	Vest-Agder	*Begonia, Kalanchoe, Hydrangea*
2002	Østfold	*Cyclamen*
2002	Rogaland	*Coreopsis*
2002	Sør-Trøndelag	*Begonia, mm*
2004	Akershus	*Kalanchoe blossfeldiana*
2005	Øst-Agder	*Kalanchoe*

Annex 5

Bekjempelses- og Rengjøringsprogram for Amerikansk blomstertrips (ABT). (Programs to combat/eradicate *Frankliniella occidentalis*)

Intensivprogram for kjemisk bekjempelse av amerikansk blomstertrips (*Frankliniella occidentalis*) etter påvisning av tospovirus i veksthuskulturer

Tospovirus er en karanteneskadegjører som overføres av amerikansk blomstertrips og som gjør stor skade i veksthuskulturer. I veksthusanlegg hvor det er påvist tospovirus må amerikansk blomstertrips bekjempes 100 % fordi den kan være smittebærer. Følgende program anbefales ved bekjempelse av amerikansk blomstertrips ved påvisning av tospovirus:

FØR BEHANDLING:

1. Fjern alt ugras og alle planter som ikke kan nås med sprøytevæska for å hindre resmitting med trips etter behandling.
2. Alt plantemateriale som er sterkt smittet av trips og/eller ikke er salgsvare skal fjernes.
3. Plantene bør beskjæres for å komme bedre til med sprøytevæska.
4. En stor del av tripsen lever i blomster og blomsterknopper hvor de er beskyttet mot sprøytevæska. Fjern derfor alle blomster og blomsterknopper.
5. Fjern alt planteavfall, dekkingsmateriale o.lign. fra gulvet. Dette fjerner en god del prepupper og pupper som de kjemiske midlene har dårlig virkning mot.
6. Veksthuskonstruksjoner (vegger, tak, ganger, overflater under bord, tomme bordoverflater, o.l.) rengjøres grundig med vann som er tilsatt desinfeksjonsmiddel. Bruk høytrykksspyler hvis mulig.

BEHANDLING:

Alt plantemateriale i alle de smittede avdelingene av veksthusanlegget behandles **samtidig** over en periode på 5-6 uker i et rotasjonsprogram med minst 2 av følgende midler:

	Metode	*Ant. sprøytinger*	*Virkemåte*	*Blomsterskade*
Mesurol 500 SC (merkaptodimetur)	Trykksprøyte (100 ml/100 l vann) eller kaldtåkeaggregat (200 ml/daa)	1 gang pr. uke	Kontaktmiddel mot larver og voksne trips.	Cyclamen og Saintpaulia
Conserve (spinosad)	Trykksprøyte (75 ml/ 100 l)	1 gang pr. uke (**ikke mer enn 3 behandlinger etter hverandre**)	Kontaktmiddel mot egg, larver og voksne trips.	Saintpaulia, o.a. kulturer.
Vertimec (abamectin)	Trykksprøyte (50 ml/100 l vann)	1 gang pr. uke (**ikke mer enn 2 behandlinger etter hverandre**)	Midlet har begrenset systemisk og translamminær aktivitet. **Virker bare mot larver**.	Ikke oppgitt på etikett
Zolone Flo (fosalon)	Trykksprøyte (125 ml/100 l vann)	1 gang pr. uke	Kontaktmiddel mot larver og voksne trips.	Ikke oppgitt på etikett
Perfection 500 C (dimetoat)	Trykksprøyte (60 ml/100 l vann)	1 gang pr. uke	Systemisk middel mot larver og voksne trips.	Flere kulturer kan skades, se etikett

ETTER BEHANDLING:

Når behandlingen er avsluttet henges limfeller opp i alle avdelinger for å undersøke om tripsen er borte. Gartneriet kan erklæres fritt for amerikansk blomstertrips hvis det ikke er funnet trips på fellene i en periode på 2-3 uker etter siste behandling (ved 20-25^{o}C).

MERK: Det må veksles mellom de ulike midlene for å hindre resistensutvikling hos tripsen. Det er påvist resistens hos amerikansk blomstertrips mot både Mesurol, Conserve, Vertimec og fosformidler og andre midler i utlandet. I Norge er det rapportert om sviktende virkning av Mesurol, og i et norsk veksthus mistet Conserve virkninger etter ensidig bruk over noen uker. Dersom det er mistanke om resistensutvikling må sprøytingen avsluttes og de smittede delene av veksthusanlegget må tømmes og reingjøres. Se " Program for rengjøring av tomme veksthus etter påvisning av tosposvirus og amerikansk blomstertrips (*Frankliniella occidentalis)*".

Program for rengjøring av tomme veksthus etter påvisning av tospovirus og amerikansk blomstertrips (*Frankliniella occidentalis*)

Tospovirus er en karanteneskadegjører som overføres av amerikansk blomstertrips, og som gjør stor skade i veksthuskulturer. I veksthusanlegg hvor det er påvist tospovirus må amerikansk blomstertrips bekjempes 100 % fordi den kan være smittebærer. Dette gjøres best ved tømming av smittede deler av veksthusanlegget og rengjøring etter følgende program:

1. Alt plantemateriale, inkludert ugras, skal fjernes, puttes i sekker og graves ned eller brennes. Sekkene skal lukkes igjen før de tas ut av de infiserte avdelingene slik at smitte ikke spres.

2. Fjern, og desinfiser eller destruer potter, dyrkingsmatter/-sekker, plastdekke, undervanningsmatter, o.l.

3. Foreta en grundig rengjøring av veksthuskonstruksjoner (tak, vegger, ganger, gulv, under bordene, bordoverflater, o.l.) med vann tilsatt rengjøringsmiddel. Bruk høytrykksspyler hvis mulig.

4. **Jordgulv kan dampes** ned til 5-10 cm dybde eller det øverste jordlaget kan fjernes. Dette vil drepe jordlevende trips-stadier.

5. Alternativt kan **veksthuset brakkes**: Trips drepes ved å varme opp tomme veksthus til 40°C i 2-3 dager. Tripsen kan også drives fram fra jorda og sultes ut ved oppvarming til 30°C i ca. 1 uke eller 25°C i ca. 14 dager. Det er svært viktig at luftfuktigheten holdes så lav som mulig (metningsdeficit < 4,67 kPa), og at den aktuelle temperaturen oppnås alle steder hvor tripsen kan gjemme seg.

6. **Kjemisk behandling**: Per i dag finnes ingen kjemiske skadedyrmidler som er tillatt til damping/gassing av veksthus etter at plantemateriale, dyrkingsmateriale m.m. er fjernet.

7. Ugras o.a. vertplanter utenfor husene i en sone på minst 9 meter fra veggene fjernes for eksempel ved jordfresing, brenning/flamming eller ved bruk av ugrasmidler. Blomsterkasser og lignende utenfor husene fjernes. Dette er viktig for å unngå tilbakesmitting av tospovirus og trips utenfra.

8. Etter rengjøring henges limfeller opp i alle avdelinger for å undersøke om tripsen er borte. Gartneriet kan erklæres fritt for amerikansk blomstertrips hvis det ikke er funnet trips på fellene i en periode på 2-3 uker etter siste behandling ved 20-25^{o}C. Hold temperaturen oppe over 20^{o}C i perioden med overvåking slik at tripsen er aktiv. Ved lave temperaturer blir flygeaktiviteten redusert, og tripsen vil ikke fanges så lett på fellene. Under 15^{o}C går utviklingen svært langsomt, men tripsen kan likevel overleve i ukevis på planter, i jord og planteavfall o.lign., og kan gi nytt angrep og smitte av tospovirus når temperaturen i veksthuset økes igjen.

Utviklingstid i dager hos ulike stadier av amerikansk blomstertrips:

Temperatur	Stadier på blad			Jordlevende stadier		Totalt fra egg til voksen
	Egg	1. larvest.	2. larvest.	Prepuppe	Puppe	
15 °C Bønner	11	5	9	3	6	34
20 °C Bønner	6	2	5	2	3	18
25 °C Bønner	3	2	5	1	2	13
30 °C Bønner	4	1	4	1	1	11
37 °C Krysantemum	3	1	2	1	1	8

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Norsk institutt for planteforsking
Plantevernet

INTENSIVPROGRAM FOR BEKJEMPELSE AV AMERIKANSK BLOMSTERTRIPS (*Frankliniella occidentalis*) PÅ PRYDPLANTER I VEKSTHUS.

1. Fjern alt ugras og alle planter som ikke kan nås med sprøytevæske. Også alt plantemateriale som er sterkt smittet og/eller ikke er salgsvare fjernes.

2. Vegger, tak, ganger, overflater under bord, tomme bordoverflater, o.l. reingjøres grundig med vann tilsatt reingjøringsmiddel så godt det lar seg gjøre. Bruk høytrykkspyler hvis mulig.

3. Tilbakeskjæring og fjerning av blomster og blomsterknopper bedrer effekten av plantevernmidlene.

4. **Alt** plantemateriale i gartnerianlegget behandles samtidig over en periode på 5-6 uker med:

> **Mesurol** i trykksprøyte eller kaldtåkeaggregat én gang pr. uke. Virker mot voksne og larver. Kontakmiddel
> **Dedevap**, damping eller i kaldtåkeaggregat 2 ganger pr. uke. Virker mot voksne og larver. Virker ved kontakt og innånding.
> **Conserve** i trykksprøyte en gang pr. uke i maksimum 3 etterfølgende behandlinger. Virker mot egg, larver og voksne. Kontaktmiddel.
>
> Ved bruk av Mesurol og Conserve er det viktig at plantene dekkes godt med sprøytevæske, spesielt gjelder dette bladundersidene.
> Ingen midler virker mot jordboende stadier.
> **Det må veksles mellom midlene for å hindre resistensutvikling hos tripsen.**

5. Etter behandling er avsluttet henges limfeller opp i alle avdelinger for å undersøke om tripsen er borte. Gartneriet kan erklæres fritt for amerikansk blomstertrips hvis det ikke er funnet trips på fellene i en periode på 2 uker etter siste behandling.

Anbefalte middel og preparatmengder:

PREPARAT	*MIDDEL*	*AVGIFTS-KLASSE*	*PREPARATMENGDE*	
			Trykksprøyte (ml/100 l)	Kaldtåke (ml/daa)
Conserve	Spinosad	3	75	-
Mesurol 500 FS	Merkaptodimetur	4	100	200
Dedevap	Diklorvos	3	Damping med 24 ml/150 m^3	360

Virkning på planter:

Dedevap: Kan skade Achimenes, Alstromeria, enkelte krysantemumsorter, Tradescantia, Peperonia og roser (ved lysfattige forhold).
Mesurol: Skader blomst av Cyclamen og Saintpaulia.
Conserve: Kan skade blomster av Saintpaulia. Kan også skade blomster hos andre kulturer.

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AMERIKANSK BLOMSTERTRIPS (*Frankliniella occidentalis*).
PROGRAM FOR RENGJØRING AV TOMME VEKSTHUS.

Rengjøring foretas når et eller flere veksthus tømmes etter endt kultur. Best effekt oppnås hvis rengjøringen foretas ved et samtidig produksjonsbrudd i hele veksthusanlegget. Varmen skal stå på i husene.

1. **Alt** plantemateriale, inkludert ugras, skal fjernes, puttes i sekker og graves ned eller brennes. Plantematerialet skal puttes i sekker, og disse skal lukkes, før de tas ut av de infiserte avdelingene slik at smitte ikke spres.

2. Fjern og reingjør eller destruer evt. potter, dyrkingsmatter og -sekker, plastdekke, undervanningsmatter, o.l.

3. Foreta en grundig reingjøring av konstruksjoner, tak, vegger og alle andre overflater (ganger, gulver, under bordene, bordoverflater, o.l.) med vann tilsatt rengjøringsmiddel. Bruk høytrykkspyler hvis mulig.

4. Om mulig **dampes jordgulv** ned til 5-10 cm dybde. Alternativt kan det øverste jordlaget fjernes.

5. **Kjemisk behandling**: Foreta behandling med diklorvos (Dedevap), helst i kaldtåkeaggregat, 2-4 ganger med 3-4 dagers mellomrom. Dosering: 360 ml/daa. Temperaturen i veksthuset må være 20-25°C for å få god virkning av midlet. Foreta 4 behandlinger ved 20°C eller 2 behandlinger ved 25°C. Start behandlingen etter at plantemateriale, dyrkingsmateriale m.m. er fjernet. Luftelukene må holdes stengt under behandlingen, og det må luftes grundig ut før man går inn i huset etter damping.

   Alternativt kan veksthuset **brakkes**: Tomme veksthus kan varmes opp til temperaturer som dreper tripsen (> 39°), eller driver tripsen fram fra jorda og sulter dem ut. Jo lavere temperatur, jo lengre tid må temperaturen holdes oppe. Luftfuktigheten må være så lav som mulig.
   - ⇒ Oppvarming til 40°C i 2-3 dager med en metningsdeficit på 4,67 kPa dreper tripsen.
   - ⇒ Oppvarming til 30°C i ca. 1 uke eller 25°C i ca. 14 dager kombinert med lav luftfuktighet bør være nok til å drive fram trips og sulte dem ut.

   NB. Det er svært viktig at den aktuelle temperaturen oppnås alle steder trips kan gjemme seg.

6. Ugras o.a. vertplanter utenfor husene i en sone på 9 meter fra veggene fjernes for eksempel ved jordfresing, flamming eller ugrasmidler. Blomsterkasser og lignende utenfor husene fjernes. Dette er viktig for å unngå tilbakesmitting av tospovirus og trips utenfra.

Utviklingstid i dager hos ulike stadier av amerikansk blomstertrips:

Temperatur	**Stadier på blad**			**Jordlevende stadier**		**Totalt fra egg til voksen**
	Egg	**1. larvest.**	**2. larvest.**	**Prepuppe**	**Puppe**	
15 °C Bønner	11	5	9	3	6	34
20 °C Bønner	6	2	5	2	3	18
25 °C Bønner	3	2	5	1	2	13
30 °C Bønner	4	1	4	1	1	11
37 °C Krysantemum	3	1	2	1	1	8

Annex 6

Examples of financial compensations to growers after loss of marketable plants caused by attack of *Frankliniella occidentalis* during 1987-1991. A fund managed by the Norwegian Horticultural Growers Association.

Data provided by the Norwegian Horticultural Growers Association.

Year	Amount requested NOK	Amount granted NOK
1987	105.100	52.550
1988	589.680	294.840
1988	172.600	86.300
1988	63.000	31.500
1988	69.890	34.945
1988	17.100	8.550
1989	75.236	37.618
1989	145.574	72.787
1989	42.908	21.454
1989	25.768	12.884
1989	150.000	75.000
1990	154.010	72.005
1991	304.348	152.174
1991	18.188	9.094
Total	**1905.214**	**952.607**

Annex 7

Reported host plants (Erwin and Robeiro 1996) that are present in the Norwegian flora (data about distribution from Lid & Lid, 2005) in addition to potato and tomato.

Latin name	**Family**	**Norwegian name**	**Artifically (A) - /Natural (N) infected**	**Distribution**
Atropa belladonna L.	*Solanaceae*	Belladonnaurt	A	Øf 1999 (Being naturlized
Capsicum annum L.	*Solanaceae*	Paprika	N	Øf, Ak, VF (On dumps)
Datura stramonium L.	*Solanaceae*	Piggeple	N/A	Up north to Ntr
Galinsoga parviflora Cav.	*Asteraceae*	Peruskjelfrø	N	Weed; He, Ak, coast from Øf to Ro. ST
Hyoscyamus niger L.	*Solanaceae*	Bulmeurt	N/A	Up to North-Tr
Ipomoea hederacea Jacp.	*Convolvulaceae*	Lodnepraktvindel	N	Øf, Vf
Ipomoea purpurea Roth	*Convolvulaceae*	Purpurpraktvindel	N	Øf, Op, Vf, Ro, SF
Lycium chinense Mill.	*Solanaceae*	Kinabukketorn	A	AA (Ornanmental)
Lycium halmifolium Mill	*Solanaceae*	Bukketorn	N/A	Øf, Ak, Bu, Vf, AA (Ornamental . but also naturalized on fjell og skrotemark)
Nicandra physalodes (L.) Gaertn	*Solanaceae*	Giftbær	A	Øf, Ak, He, Bu, VF, Te, VA, Ro (Innført som prydplante, men oftere med kraftfor)
Petunia x *hybrida* (Hook) P. Vilm.	*Solanaceae*	Hagepetunia	N/A	Ornamental, Øf, Ak, VF, ST
Physalis alkekengi L.	*Solanaceae*	Jødekirsebær	A	Ornamental, Øf, Ak to VA
Rumex acetosa Linn.	*Polygonaceae*	Engsyre	N	All counties
Solanum dulcamara L.	*Solanaceae*	Slyngsøtvier	N	Most counties up to NT
Solanum marginatum L.	*Solanaceae*	Filtsøtvier	N	Øf (ballast)
Solanum nigrum L.	*Solanaceae*	Svartsøtvier	N	In most counties in Southern part, some places up to Tr
Solanum physalifolium Rusby	*Solanaceae*	Fysalissøtvier	N[1)]	Bu
Solanum rosratum L.	*Solanaceae*	Kansassøtvier	A	Some places in the eastern part, and along the coast up to No
Solanum	*Solanaceae*	Sarachasøtvier	N	Ak, Bu

sarachioides Sendt.				
Solanum sisymbriifolium Lam.	*Solanaceae*	Fjørsørvier	A	From ØF and Ak to Ho, and NT
Sonchus oleraceus Linn.	*Asteraceae*	Hardylle	N	All counties

1) Additional host plant reported by Andersson et al. 2003