PLANT PROTECTION CENTRE

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Pest Risk Assessment (PRA) for the South American Leafminer *Liriomyza huidobrensis*

Commissioned by the Norwegian Agricultural Inspection Service

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Pest Risk Assessment (PRA) for the South American Leafminer, *Liriomyza huidobrensis*

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1. Endangered Area

The endangered area is Norway.

2. Identity and Geographic and Regulatory Criteria

Name: *Liriomyza huidobrensis* (Blanchard)
Synonyms: *Agromyza huidobrensis* (Blanchard)
Liriomyza cucumifolia (Blanchard)
Liriomyza langei (Frick)
Liriomyza dianthi (Frick)
Taxonomic position: Insecta: Diptera: Agromyzidae
Common names: Serpentine leaf miner, Pea leaf miner, South American leaf miner (English)
Die südamerikanische Minierfliege (German)
Nerfmineervlieg (Dutch)
Ærteminérfluen (Danish)
EPPO A2 list: No. 152
EC Annex designation: I/A2
Norway: A list (Quarantine pests. Limit of tolerance: 0 %)
Significance: Three known infestations in greenhouses in the southern part of Norway in 1995. Eradicated.

3. Methods for Detection and Identification

3.1 Methods for Detection

Symptoms
Feeding punctures appear as white speckles between 0,13 and 0,15 mm in diameter (Smith et al., 1992). Oviposition punctures are smaller (0,05 mm) and more uniformly round.
Mines are usually white with dampened black and dried areas. (These are the same symptoms listed by Smith et al. 1992, for three similar quarantene pests: *Amauromyza maculosa, Liriomyza sativae* and *Liriomyza trifolii*. The symptoms are also the same for *L. bryoniae*).

Characteristically *L. huidobrensis* (and *L. bryoniae*) mines are along the midrib and lateral veins, mainly depending on the host plant (minireview by Weintraub & Horowitz, 1995). Spencer (1973) reported that on peas, larva may also feed on the outer surface of young pods.

The pest
Eggs in plant tissue or prepupae and pupae either on the foliage or in the soil just beneath the surface, are almost impossible to detect by visual inspection. Mines and larvae can be detected by specifically examining both sides of the lower leaves of the plant. The bigger the mines and larvae are, the easier can they be detected.

3.2 Methods for Identification

An exact characterisation on the basis of morphological characteristics of the pupae, larvae and mines is impossible, and it takes too long to wait for the adults to emerge from the pupae (de Goffau, 1991).

Adult flies may initially be identified by morphological characteristics after a simpliefied key (Smith et al., 1992). All identifications should be confirmed by a specialist.

Only adult males of *L. huidobrensis* (and also adult males of *L. bryoniae, L. trifolii, L. strigata* and *L. sativae*) can be identified with certainty on the basis of their genitalia (Oudman, 1992). Female adults, pupae and larvae can only be identified on the level of groups of species (*L. bryoniae, L. huidobrensis* and *L. strigata* versus *L. trifolii* and *L. sativae*).

To distinguish *L. huidobrensis* from other economically important members of the genus *Liriomyza* (*L. huidobrensis* is specially difficult to distinguish from *L. bryoniae* morphologically), electrophoretic methods of rapidly distinguishing the three species *L. bryoniae, L. huidobrensis and L. trifolii* has been developed (Oudman 1992). The identification can be done on each developmental stage of the pests (larvae, pupae and adults). This has to be done in a laboratory by a specialist.

Sticky traps
Yellow sticky traps can be used to catch adult flies in quarantene rooms and greenhouses.

Water traps
Yellow water traps can be used for the same purpose as yellow sticky traps.

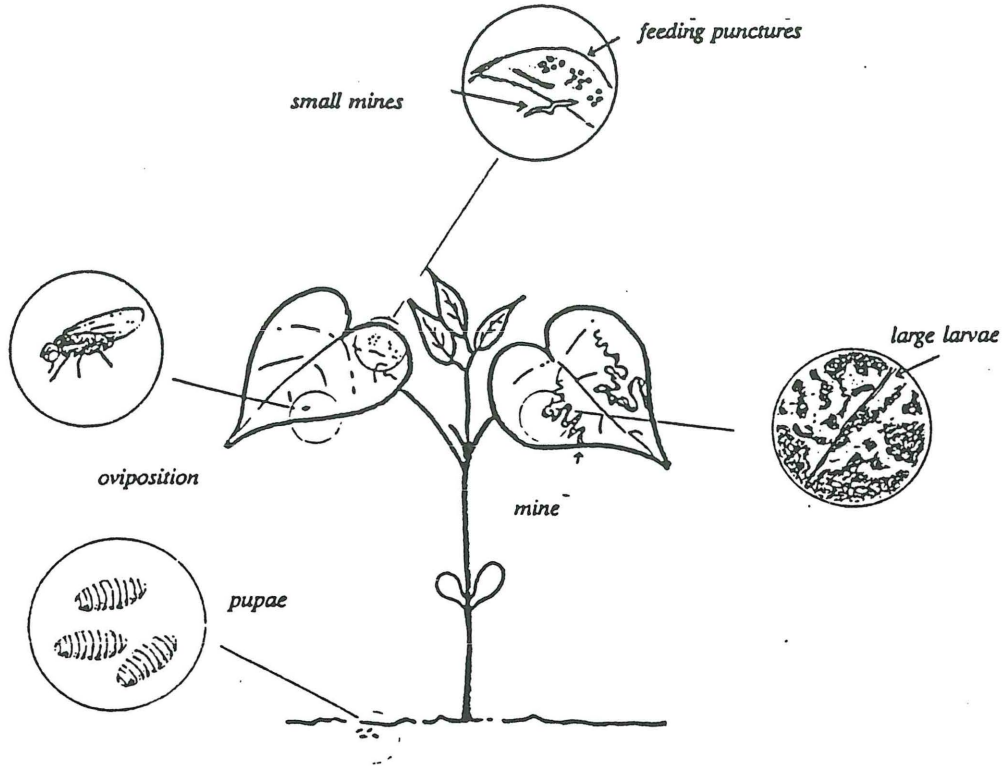
4. Establishment Potential

4.1. Biological Information of the Pest

4.1.1 Life Cycle

A generalized lifecycle of leafminers (*Liriomyza* spp.) is shown in figure 1. Peak emergence of adults occurs before midday (Smith et al., 1992). Because of their positiv phototaxis the adult flies are mostly found on the leaves (Leuprecht,1992). Mating takes place from 24 h after emergence (Smith et al., 1992).

In the southern USA the life-cycle is probably continuous throughout the year. In California *L. huidobrensis* completes its life-cycle in 17-30 days during the summer and in 50-65 days during the winter (Smith et al., 1992).



Figur 1: Generalized lifecycle for leafminers (Liriomyza spp.) (Enkegaard, 1990).

The biology and morphology has been described in the laboratory and in greenhouses on flowers and vegetables under long day or day neutral conditions, and 22-27° C, from different workers, and then generalized by Weintraub & Horowitz (1995) as follows:

Females live up to 18 days and males about 6. Female flies predominantly puncture the upper leaves surfaces with their ovipositor and feed from these holes, males also feed at these puncture sites. The amount of leaf stipling varies from reported averages of 83 (in aster) to 277 (in bean) punctures per day. Eggs are laid in only a small portion, 5-10 %, of the puncture sites. It has been reported that 87 % of eggs laid develop to first instar.

Eggs are laid singly but often close proximity and mostly on the lower leaf surface (table 5, Appendix). The egg hatch in 1,5 to 4 days depending on the temperature and host plant. Development time is shown for some temperatures and host plants in table 3, Appendix.

Larvae feed in the spongy mesophyll of the leaf. Three larval instars develop in the leaf and the mines become progressively larger with each molt. The larval stage may be as short as 3,6 days or as long as 10 days (under greenhouse conditions) (temperatures and host plants in table 3, Appendix).

The larvae makes an exit hole in the leaf surface, through which it emerges to pupate. There is a fourth larval stage (prepupae) between the puparium formation and actual pupation, although it lasts only 4-5 h. Pupation takes place on the ground (in soil or other surface) or may also occur on leaves further down from the original mine (e.g. in cucumber). The pupal stage lasts 7,9-12,6 days (temperatures and host plants in table 3., Appendix) and the pupa varies in colour from light brown to almost black. The very dark coloured puparia have a longer pupal stage (compared with the ligther coloured ones) and may be able to overwinter in Europa.

4.1.2. Development, Diapause and Hibernation

The development of *L. huidobrensis* in relation to temperature is discussed by Leuprecht (1991 & 1992). The number of eggs laid by each female differs between 100-600, depending on temperature and host plant. Developmental rate of the different stages of *L. huidobrensis* depends on the host plant, but most of all on temperature. The optimum temperature for development is 22-27° C.

Olivera et. al. (1994) found that the optimum female reproductivity rate for *L. huidobrensis* occurs at moderate tempreatures around 20° C.

According to Leuprecht (1991 & 1992) the development rate of *L. huidobrensis* on lettuce at 25° C is as follows:

Eggs:	3 days
Larvae:	5 days
Pupae:	9 days
Total:	17 days

Merz (1991) reported that the total development of *L. huidobrensis* could be minimum 16 days. Table 3, Appendix, shows development times of 15,5 (26,7° C) and 15,8 (18,7° C) days on pea and french bean (Enkegaard, 1990).

Studies by Leuprecht (1991 & 1992) do not mention any specific lower threshold temperature for *L. huidobrensis,* however he noted that at temperatures below 20° C the development time increases considerably and the rate of reproduction decreases disconnected. Flies who are repeatadly exposed to low temperatures, stop ovipositing.

Leuprecht (1991 & 1992) used the average temperatures during 24-hours to calculate the degree-days required for the different stages of *L. huidobrensis* to develop:

	Average:	Range:
Egg:	150,50 degree-days	133,93-163,57
Larvae:	136,80 degree-days	104,78-170,60
Pupae:	253,12 degree-days	243,39-267,69
Total:	540,412 degree-days	536,39-547,92

De Goffau (1991) reported that in the Netherlands in about October, the pupae become darker brown and some virtually black. These pupae do not develop as rapidly as in the summer, and are possibly diapause pupae for overwintering, which emerge as flies in the spring. The early attack of *L. huidobrensis* in the Netherlands the spring of 1990 suggested that they overwintered as pupae outdoors. The leafminer was observed flying outdoors above the crop when the sun shone, even on fairly cold days in the spring (beginning April) and autumn (end October) and is clearly less sensitive to cold than *L. trifolii.*

Leuprecht (1991 & 1992) found that after 30 days with temperatures below 0° C (including 8 days below -5° C, and the lowest temperature -9° C), the pupal stage was able to survive outdoors in Germany. He also found that larval stages in the leaves had not survived the same period. There was no emergence of flies from pupae disposed to temperatures below -15° C. Adult flies were not found outdoors when the temperature was 15° C.

Other factors than temperature seem to have great influence on the development of *L. bryoniae* (and probably other *Liriomyza* species as well), these factors are photoperiod and humidity (van der Linden, 1993). Helyer & Ledieu (1990) reported that even in glasshouses (temp. 15-20° C) the pupation period of *L. bryoniae* extended rapidly during August, and after November this phenomenon gradually dissappeared again. Helyer & Ledieu (1990) concluded that this phenomenon indicated photoperiod rather than temperature as the critical factor for development.

Van der Linden (1993) claimes that although photoperiod is probably the critical factor for development, temperature is not completely irrelevant, and that short day length and low temperatures will probably show synergism on the period of extended pupation.

After studying mortality of overwintering pupae of *L. bryoniae* and *L. huidobrensis* in the Netherlands during the winters 1990 and 1991, van der Linden (1993) concluded that both species are able to overwinter outdoors in the Netherlands and may infest crops again the next year. Van der Linden's results supports Spencer (1990) who reported that with *L. huidobrensis* present at 3.000 m in the Andes, it is not impossible that the puparia might survive an European winter outdoors.

4.1.3. Host Plants Reported

L. huidobrensis is a highly polyphagous species, and feeds on a large number of flowers, vegetables and weeds (minireview by Weintraub & Horowitz, 1995). The long list of host plants seems to increase as the pest invades new territories. Some of the more important economic host plants are Cucurbitaceae (gherkin, cucumber, melon), Leguminosae (various bean species), Solanaceae (pepper, tomato, potato, eggplant), Caryophyllaceae (*Dianthus* spp., *Gypsophila* spp.), Chenopodiaceae (spinach, beet) Compositae (thistle, endive, aster, *Chrysanthemum* spp., *Gerbera* spp., lettuce), Cruciferae (Chinese cabbage, radish), Umbelliferae (carrot, celery, parsley) and Violaceae (*Viola* spp.). Host plants reported are listed in table 2, Appendix.

Spencer (1973) mentioned that some local preferences could be noted, eg. *Beta* and *Pisum,* were two of the most favoured hosts both in Argentina and California, tomato served as a host sparingly in Argentina. *Allium* was known as a host both in Venezuela and California. The only

record of Cucurbitaceae was from Argentina. Adaption to a particular host plant after many generations might improve survival on that host (van der Linden, 1993).

In table 4, Appendix, mortality of pupae of *L. huidobrensis* on different host plants is listed.

Wild Host Plants in Norway
The following species are found in Norway (table 2, Appendix):
Amaranthus sp., Anemone, Carduus sp., Carthamus sp., Cirsium arvense, Datura, Galinsoga, Glechoma hederacea, Gypsophila sp., Gypshofila paniculata, Lathyrus, Linum, Matricaria sp., Medicago sativa, Oxalis, Petasites hybridus, Pisum sativum, Primula sp., Ranunculus, Saponaria sp., Senecio vulgaris, Solanum nigrum, Sonchus, Stellaria sp., Tropaelum majus, Vicia faba, Viola sp. (Lid, 1987).

Cultivated Host Plants in Norway
Several of the host plants of *L. huidobrensis* are cultivated in Norway, either in greenhouses, outdoors or both (table 2, Appendix).

In greenhouses important host plants for the pest are cucumber, lettuce and tomatoes among the vegetables, and *Alstromeria, Chrysanthemum, Dahlia* hybrids, *Dianthus, Exacum sp., Gerbera* sp., *Gypshophila paniculata, Gypsophila sp., Petunia* and *Primula sp.* among the ornamental plants.

Outdoors there are several field vegetables who are reported as host plants for *L. huidobrensis*: bean species, carrot, celery, gherkin, chinese cabbage, lettuce, onion, parsley, pea, potato, radish, spinach and sugarbeet. Ornamental plants, reported as host plants for *L. huidobrensis*, are also grown outdoors as annuals, cut flowers or perennials, ex. *Aster sp., Chrysanthemum sp., Dahlia* hybrids, *Dianthus sp., Gypophila sp., Primula polyantha, Verbena* hybrids *and Zinnia.* (See table 2, Appendix, for complete list.)

During the summer several of the host plants listed in table 2, Appendix, are grown in privat gardens, both vegetables and ornamental/bedding plants.

4.1.4. Migration, Dispersal and Transport

Dispersal by natural means
Adult flies are capable of limited flight (Smith et al., 1992). Gratwick (ed., 1992) reported that *L. trifolii* can fly over 100 metres in a few hours but, left undisturbed, they tend to aggregate on individual leaves. It is likely that *L. huidobrensis* is capable of the same. It is therefore likely that dispersal and subsequent infestation may occur, from one greenhouse to the open field or to other greenhouses nearby, or from the open field to greenhouses and between outdoor crops.

In 1989 in Lee Valley in Hertfordshire (UK), there was local spread of *L. huidobrensis* between neighbouring greenhouses (Bartlett, 1992).

Dispersal by human activity
Dispersal over long distances is on planting material or soil of host species in trade (Smith et al., 1992). Cut flowers can also represent a danger as a means of dispersal. For example, the vase life of chrysanthemums is sufficient to allow completion of the life-cycle.

The pest may also be dispersed on equipment and containers which has not been properly cleaned.

4.1.5. Adaptability

The Pest
L. huidobrensis has high adaptability due to the high reproduction rate and fast development on suitable host plants.

Oudman et al. (1993) analyzed the population structure of *L. huidobrensis* in Europe based on allele frequencies at polymorphic enzyme loci, and found a positive relation between geographic and genetic distance. They also included a population from South America in their work, and found that the positive correlation between genetic and geographic distance disappeared.

The high genetic similarities between samples of subsequent years from populations in the Netherlands show that *L. huidobrensis* is established in the Netherlands (Oudman et al., 1993). Further more, the relative low genetic distance between the European populations and the South American population may point to South America as the source of introduction(s) to Europe, and not a spread within Europe as suggested by Trouvé et al. (1991).

With time the population in Europe will reach an equilibrium with respect to gene flow, genetic drift and selection (Oudman et al., 1993). However, even in the short time since the introduction to the Netherlands in 1989, *L. huidobrensis* has shown high adaptability to an environment with nonsimilar climatic conditions compared to the area of origin (South America).

Host plant range
The host plant range of *L. huidobrensis* has increased during the last twenty years as the pest has entered new areas. The pest seems to have high adaptability to new host plants considering the differences in flora between origin and outbreak areas. Spencer (1973) confirmed records on nine families, in 1990 Spencer revised the list of hosts, which comprises 16 families (van der Linden, 1993). The list of host plants presented in this assessment, table 2, Appendix, includes hosts in more than 20 families (de Goffau (1991), EPPO database (1996), De Clercq & Casteels (1992), Spencer (1990), Brødsgaard (1989), Wolf-Dietrich (1992)).

Geographical range
L. huidobrensis was first described from Brasil in 1926 as *Agromyza huidobrensis* Blanchard, and the leaf miner was later described in California as *Liriomyza langlei* Frick. These two as well as two other synonyms, were synonymized by Spencer in 1973 as *Liriomyza huidobrensis*. It occurs in the greater part of South America, and in North America outbreaks have been reported since 1938 (Oudman et al., 1993).

Since 1989 *L. huidobrensis* has established as a pest in the Netherlands and other European countries (United Kingdom, Germany and France (Oudman, 1993)), and appears to be harmful to many crops in greenhouses as well as outdoors (van der Linden, 1993).

In view of the fact that chemical control of this species in Europe is difficult, van der Linden (1993) suggested that the origin of *L. huidobrensis* in Europe, is from South rather than from North America, since there are no problems with chemical control reported in North America.

Tolerance to low temperatures
The observations made by de Goffau (1991), Leuprecht (1991 & 1992) and van der Linden (1993b) on hibernation and that adult flies have been observed flying on fairly cold days in spring and autumn, indicates that *L. huidobrensis* appears to have a great tolerance to low temperatures. In table 10 and 11 information about temperature conditions of five locations in the Southern coastal area of Norway is listed.

4.2. Geographical Distribution

4.2.1. World Distribution

The Pest
Europe: Austria, Belgium, Denmark (eradicated), Finland (eradicated), France, Italy, Malta, Netherlands, Norway (eradicated), Portugal, Spain, Sweden (intercepted only), United Kingdom.
Asia: Cyprus, Israel
Africa: Mauritius, Reunion
North America: Mexico, United States (California, Hawaii and in glasshouses in Florida and Virginia).
Central America and Caribbean: Belize, Costa Rica, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Honduras, Nicaragua, Panama
South America: Argentina, Brazil, Chile, Colombia, Peru, Venezuela

(EPPO/PQR Database, version 3.2, dated 1996-02. EPPO Reporting Service 1994, No. 5. Smith et al., 1992.)

Host Plants
The host plants of this highly polyphageous species are present in almost every country of the world, in glasshouses, outdoors or both.

4.2.2. Occurrence in Norway

The Pest
In the southern coastal part of Norway, there has been three known infestations of *L. huidobrensis* during the summer of 1995.

1. In the first case *L. huidobrensis* was found on *Gypsophila* which was originally imported from a known source in the Netherlands. Later *Gypsophila* imported from the same source as above, were grown for a short period in a quarantine room and based on the mines and larvae that was found, there was reason to supect the plant material infested with *L. huidobrensis*.

2. The second case of *L. huidobrensis* was found on *Verbena* and there were also mines on *Diascia* which indicated *L. huidobrensis*. Later there was an inspection and *L. huidobrensis* was found on cucumber in the same nursery. The origin of *L. huidobrensis* in the second case

is not clear, but it is likely that plant material bought from another grower (see below) carried the pest.

3. The third case of *L. huidobrensis* in Norway was found on *Gypsophila*, and on yellow sticky traps from a greenhouse with *Lilium* and roses, but the pest was probably on weeds in the greenhouse. The imported *Gypsophila* in this nursery was originally from Israel.

Eradication: Immediate action was taken by the Norwegian authorities and the infested crops were destroyed and the infested greenhouses disinfected. No further infestations have been observed and the Norwegian authorities believe that the eradication programme has been successful. During the spring 1996 there will be a close examination outside the three nurseries infested in 1995, to investigate if the pest has survived the winter.

Host Plants
Several host plants are present in Norway, ornamental plants, vegetables and weeds. In glasshouses host plants are available during the whole year, and during the summer suitable hosts are found both in greenhouses and outdoors (including weeds), table 2, Appendix. Greenhouses (with host plants) are present in all parts of the PRA-area, but there are also some regions with higher densitiy of greenhouses than others, like the South-West coastal area and the South-Eastern part of Norway.

4.3. Control Measures of the Pest

4.3.1. Phytosanitary Regulations

L. huidobrensis is a quarantine pest, tolerance limit 0 %, in Norway.

Control at entry: The Norwegian Agricultural Inspection Service carries out inspections at different arrival places for plant commodities to Norway.

As mentioned previously (chap. 3.1), the chance of detecting *L. huidobrensis* during the inspections both at the place of origin (phytosanitary certificate) and arrival might be very small, depending on which life stage(s) of the pest is present.

4.3.2. Chemical Measures

Chemical control of *L. huidobrensis* in Europe (van der Linden, 1993), Israel and South America (Weintraub & Horowitz, 1995) has proven very difficult. In practice there has been increasing evidence that *L. huidobrensis* is more difficult to eradicate, in comparison with *L. trifolii* (Bartlett, 1992).

In California *L. huidobrensis* is listed as a common pest of vegetables and flowers, but even if it is commonly found in flower crops, insecticide application is only occasionally required and it is relatively easy to control (Weintraub & Horowitz, 1995). Recently *L. huidobrensis* has emerged as a pest of vegetable in Salinas and coastal valleys in California.

Insecticides found to be somewhat effective against adult flies in field tests in lettuce and potatoes are deltamethrin, deltamethrin with oxamyl and oxamyl (Weintraub & Horowitz, 1995). Deltamethrin is highly toxic to parasitoids, oxamyl may be less damaging to parasitoids. Larvae and eggs would be the most important stage to target for chemical control. Laboratory and field studies have shown that oxamyl, abamectin, cyromazine and thiocyclam hydrogen oxalate are effective against the larvae. But no effective chemical has been reported against the egg.

Chemical measures against the pupae is disinfection of the soil at the end of the season with metyl bromid or other chemical compounds for sterilization, eg. dazomet (Enkegaard, pers. comm.).

For glasshouse lettuce a single treatment when the pest is detected may be sufficient, but treatment may be repeated at 3-5 days intervals if necessary (Anon., 1994).

Among the insecticides mentioned above, only deltamethrin and dazomet is permitted for use in the PRA area, which means that there are no insecticides available against the larvae. The time of application for deltamethrin (in Norway) is 14 days, and it is not permitted for use in greenhouse-vegetables (Anon., 1995).

Chemical control of *L. huidobrensis* in the PRA area is very difficult because of the reasons mentioned above.

4.3.3. Insecticide Resistance

In the Cañete Valley, Peru, *L. huidobrensis* was collected in the 1940's, but it was not an important pest of any crop at that time (Ewell et al., 1990). Insecticides where first introduced to the valley after the Second World War for use on cotton. Another pest, potato tuber moth (*Scrobipalpula absoluta* (Meyrick)), was causing damage on potato and in the 1970's there were attempts to kill all the insects. The widespread spraying of virtually all green plants with insecticides throughout the year put insect populations under very heavy selection pressure. During this action the local population of *L. huidobrensis* developed resistance to all classes of insecticides.

It has been documented that *L. huidobrensis* in the United Kingdom is resistant to insecticides (Weintraub & Horowitz, 1995). Pesticides normally used against *L. trifolii* are not effective against *L. huidobrensis*.

There has been indications of increasing tolerance against deltamethrin, triazophos, dichlorvos and endosulfan in the UK (Enkegaard, pers. comm.). Experiences from Holland in lettuce and Chrysanthemums has shown no effect against larvae of *L. huidobrensis* of bifenthrin, deltamethrin, diazinon, malathion, methomyl, mevinfos, parathion, propoxur, pyrazofos and triazofos (Enkegaard, pers. comm.).

4.3.4. Biological Measures

In the fields of Peru, *L. huidobrensis* was controlled by a complex of hymenopterous parasitoids until the 1970's when chemical control measures were initiated (Weintraub &

Horowitz, 1995). Since that time the use of chemical control has precluded control of the leaf miner by the parasitoids.

In greenhouses in Europe, *L. huidobrensis* has been controlled successfully with releases of *Dacnusa sibirica* Telenga, *Opius pallipes* Wesmael and *Diglyphus isaea* Walker (all of which are parasitoids of other *Liriomyza* spp.) (Weintraub & Horowitz, 1995). However, these parasitoids are able to control the leaf miners only when conventional chemicals are not applied for the control of other pests.

Initial attempts to use entomopathogenic nematods such as *Steinernema feltiae* (Filipjev) and *Heterorhabditis megidis* Poinar, Jackson and Klein against *L. huidobrensis* have been promising, because the larvae live in a cryptic environment (Weintraub & Horowitz, 1995). Work on *L. trifolii* has shown that nematodes can control the leafminer successfully and be used in conjunction with chemicals such as abamectin, provided that high humidity is maintained.

Dacnusa sibirica, Diglyphus isaea, Steinernema feltiae and *Heterorhabditis megidis* are commercially available in Norway.

4.3.5. Integrated Pest Management Measures

Roditakis & Roditakis (1994) reports that neem seed extract (Neemark) could be considered as a potential candidate for IPM programmes of *L. huidobrensis* in outdoor tomatoes whereas indigenous parasitoids and predators are present.

In the Netherlands an IPM programme is being developed for leafy and tuberous crops, such as lettuce and radish (van der Linden, 1993b). Biological control of leafminers in lettuce is possible, but the use of natural enemies or selective chemicals against other pests and diseases is strictly necessary. In lettuce a low level of infestation by *L. huidobrensis* is acceptable because the mines occur on the oldest leaves, which are trimmed off when the lettuce is harvested. The same might be true for *Chrysanthemum* and a few mines on radish may be sorted out at harvest.

4.3.6. Cultural Measures

Seedlings can be covered with insect nets (0,8 mm) during the hardening period before planting to avoid attack (Anon., 1994). This is used on a limited scale in the Netherlands (de Goffau, 1991).

Midmore & Alcazar (1991) reports that mixed planting of potato cultivars in Peru, could be beneficial but only to farmers who plant both early and late cultivars, under conditions where the early harvest commands a premium price.

Steaming of the soil (disinfection) with a temperature of 93° C in 20 cm depth for 3-4 hours is effective against pupae of *L. huidobrensis* (Johansen, pers. comm.).

4.3.7. Resistant Plants

Raman et. al. (1994) have under field conditions screened potato plants resistant to *L. huidobrensis* (the most important leafminer attacking potatoes in Peru) infestations and maintaining good yields. The mechanism of resistance is ascribed to the high density of glandulat trichomes which physically reduce feeding and restrict oviposition sites.

4.3.8. Monitoring

Continous observations in greenhouses with yellow sticky traps and/or water traps and visual inspections of the plants/seedlings should be used to detect imminent outbreaks of *L. huidobrensis.*

4.4. Conclusion on Establishment Potential

There is a great potential for *L. huidobrensis* to establish in the greenhouse environment in the PRA area. There are also a possibility for establishment outdoors, at least during the summer. Experiences from other parts of Europe (Leuprecht, 1990 & 1991, van der Linden, 1993a) points to the possibility for overwintering of *L. huidobrensis* in the Southern coastal parts of the PRA area (table 10 & 11, Appendix).

5. Spread Potential after Establishment

5.1. Distribution of Host Plants in Norway

Wild Host Plants
The distribution of wild host plants in the PRA area characterised as major or minor hosts of *L. huidobrensis* in table 2, Appendix, is as follows:

Amaranthus sp. 7 species in Norway, usually around waste disposal sites, *Aster* sp. 4 species, (including escapes), *Chrysanthemum* sp. 2 species, 1 is distributed up to Finnmark county and 1 around waste disposal sites, *Dianthus sp.* is distributed in all parts of Norway (5 species, with some differences in distribution among the species), *Gypsophila paniculata* is escaped , *Gypsophila sp.* one species is distributed in all parts of Norway and one around waste disposal sites, *Lathyrus* is distributed in all parts of Norway (18 species, with some differences in distribution among the species), *Medicago sativo* meadows, roads and waste disposal sites , *Pisum sativum* is escaped and *Vicia faba* is escaped (Lid, 1987).

Cultivated Host Plants
Host plants of *L. huidobrensis* are grown in greenhouses in all parts of Norway all year round (Appendix II). During the summer several host plants listed in table 2, Appendix, are grown outdoors as field vegetables/crops or annuals/perennials.

5.2. Spread Potential within Norway

Spread by human activity
In Norwegian greenhouse structures there are often a great variation of different species and cultivars of ornamental plants. Different greenhouse vegetables or combined greenhouse vegetables and ornamental plants are also quite common. This means that almost every greenhouse in Norway grows at least one host plant of *L. huidobrensis* (table 2, Appendix).

The single grower is not capable of producing all the different species and cultivars the market demands, and an extensive trade with other countries and/or between Norwegian growers is very important. The potential for spread of plant material or soil infested with *L. huidobrensis* within Norwegian greenhouses is therefore great.

Spread by natural means
Spread of *L. huidobrensis* between greenhouses is only likely to happen in areas where there is a great concentration of greenhouses, like Rogaland and Buskerud county. However, the long distances between greenhouses in many other areas in Norway lower the possibility of natural spread in these areas.

During the summer several host plants are available outdoors (vegetables, annuals, perennials, weeds (table 2, Appendix), and therefore the spread potential by natural means are greater at this time of the year.

5.3. Natural Enemies of *L. huidobrensis* in Norway

Diglyphus isaea Walker has been found in the Southern parts of Norway (Trandem, pers. comm.). Whether *Dacnusa sibirica* Telenga or *Opius pallipes* Wesmael are present in Norway or not, has not been investigated this far.

The nematode *Steinernema feltiae* (Filipjev) has been found in the Southern part of Norway (Haukeland pers. comm.).

5.4. Conclusion on Spread Potential

After establishment in the PRA area, the spread potential within greenhouse environments of *L. huidobrensis* is great. The spread potential outdoors is probably limited to the surroundings (vegetables, annuals, perennials and weeds) close to infested greenhouses, and could act as a source to reinfest greenhouses with *L. huidobrensis*.

6. Potential Economic Importance

6.1. Type of damage

Photosynthesis is reduced and cosmetic damage is incurred when adult flies stipple plant leaves with feeding punctures and larvae mine the leaves (Weintraub & Horowitz, 1995).

According to de Goffau (1991) the damage caused by an extensive attack of *L. huidobrensis* is greater than that by an earlier American immigrant *L. trifolii*. Damage to the spongy mesophyll caused by *L. huidobrensis* leads to greater reduction in photosynthesis than when the palisade mesophyll is attacked by *L. trifolii*.

In Europe *L. huidobrensis* primarily occurs as a pest in greenhouses, attacking both ornamentals and vegetables (Oudman et. al., 1993). However, in the summer it is also frequently found outdoors, causing heavy infestations. In South America *L. huidobrensis* is a primary pest of potatoes and in California it is listed as a pest of vegetables and flowers (Weintraub & Horowitz, 1995).

6.2. Crop Losses

In young plants and seedlings, mining may cause considerable delay in plant development leading to plant loss (Smith et al., 1992). In 1989 in the Netherlands many lettuce fields had to be ploughed in , because they were no longer saleable (de Goffau, 1991).

In Germany, Leuprecht (1990 &1991) reported of 90-100 % yield losses in the greenhouse crops early grown cucumber and beans. Crop losses of tomatoes were 20-40 %, and in Autumn grown lettuce from very high to toal crop loss. Outdoors the losses differed between culture, time of attack, temperatures and distance to infested greenhouses. Summer lettuce was in some cases not harvested at all, horseradish and radish was impossible to sell with leaves. Celery could only be sold as tubers without leaves.

In Peru, losses in potato due to *L. huidobrensis* have been reported as more than 30 % (Weintraub & Horowitz, 1995).

Production-value of host plants in Norway
The production of plants and vegetables in greenhouses in Norway is economically important. In 1995 the total production-value of vegetables (lettuce, cucumber and tomatoes, all host plants of *L. huidobrensis*), was 265.980.000 NOK (table 1, Appendix). The production-value of ornamental host plants (pot plants, cut flowers, nursery plants) was 170.918.000 NOK (table 1, Appendix). The number of man-labour years involved in the greenhouse-production (vegetables and ornamental plants) of host plants of *L. huidobrensis* in Norway, has been estimated to 687 (table 1, Appendix).

The production-value of vegetables/crops (only host plants of *L. huidobrensis*) grown outdoors during the summer was 816.365.000 NOK in 1995 (table 1, Appendix). The number of man-labour years involved in outdoors production (vegetables/crops) of the same host plants of *L. huidobrensis* has been estimated to 3.503 (table 1, Appendix).

6.3. Loss of Export Markets

Exportation of plant material from Norway to other countries are limited. However, the Norwegian Horticultural Growers Association is working to increase the export of different products, such as seedlings of different species. In 1994 Norwegian growers exported about 877.000 rooted seedlings of four species (Tærum, pers. comm.), and one of these species was *Dianthus caryophyllus,* a host plant of *L. huidobrensis* (table 2, Appendix).

6.4. Increase in Control Costs

An example from the Cañete Valley, Peru: The development in *L. huidobrensis* of resistance to all classes of insecticides, forced farmers to progressively increase the dosage of ever more expensive chemicals (Ewell et al., 1990). The only other potato pest of any significance in the valley is late blight. Nevertheless, in bad years, pest control can account for 40 to 50 % of the cash costs of production. The conclusion drawn by Ewell et al. (1990) to the rising costs of inputs is resulting from a classic «pesticide treadmill».

The situation for a «pesticide treadmill» developing within Norwegian greenhousees is not realistic because the availability of insecticides against *L. huidobrensis* is very limited. The best solution for Norwegian growers will probably be to eradicate the pest, as done in 1995.

The costs of eradication in 1995 has been estimated to a total value of 2.010.500,- NOK for the three growers involved (Norwegian Horticultural Growers Association). The total costs of eradication of 2.010.500,- NOK, can be specified as follows:

1) Loss of plant material:	1.251.389,- NOK
2) Disinfection/Cleaning/Pesticides:	469.779,- NOK
3) Work in connection with destruction of plant material:	272.625,- NOK

6.5. Effects of ongoing Integrated Pest Management (IPM) Programmes

Tomatoes in Norway are grown with minimum use of pesticides, where only 0,048 kg of active ingredients per 1.000 m^2 is used (Sæthre & Hofsvang, 1995). Greenhouse lettuce is also grown with minimum use of pesticides (Sæthre & Hofsvang, 1996). For lettuce grown in water-culture (Grand Rapid) the total amount of active ingredients used per 100.000 lettuces was 0,008 kg, and 0,11 kg active ingredients per 1.000 m^2 for ordinary grown lettuce. The pesticide situation in cucumbers was a total use of 0,607 kg active ingredients per 1.000 m^2. Establishment of *L. huidobrensis* in Norwegian greenhouses would present a serious threat to the present and very positiv pesticide-situation for greenhouse vegetables in Norway.

There are no IPM-programmes for ornamental plants in Norwegian greenhouses at the moment, but for the future IPM-programmes in ornamentals are one of the important aims for both growers and researhers in plant protection. Establishment of *L. huidobrensis* in the PRA area would make a threat to this aim.

6.6. Environmental damage

Establishment of *L. huidobrensis* in the PRA area would probably result in an increase in the use of insecticides in Norwegian greenhouses. Such an increase in the use of pesticides is not desired by all those involved in horticulture in Norway, including the growers, researchers in plant protection and the Norwegian authorities.

Documentation on environmental damage like impact of ecosystem health, caused by *L. huidobrensis* in its existing geographic range has not been found.

6.7. Conclusion on Potential Economic Importance

Production-value of host plants (both vegetables and ornamental plants) of *L. huidobrensis* in Norwegian greenhouses is important (table 1, Appendix). Crop losses could be total considered that no pesticides is available against the larvae (and eggs), only one pesticide is available against the adults (deltamethrin), but it is not permitted for use in greenhouse vegetables. The experiences from the attacks in 1995 is that costs of eradication will be high. The potential for exportation of Norwegian plant material will probably be limited. Establishment of *L. huidobrensis* in Norway would make a threat to ongoing and future IPM-programmes in Norwegian greenhouses.

Outdoors the crop losses will depend on culture, time of attack, temperature and distance to infested greenhouses.

7. Introduction Potential

7.1. Entry

Before entry, the pest has to be associated with the pathway at the origin (countries which Norway import from). How likely the pest is to be associated with the pathway at the origin and carried into the PRA area (Norway) is not easy to predict. However, the many interceptions and/or establishments of *L. huidobrensis* in different countries confirm that the possibility for association is high.

7.2. Import of Host Plants to Norway

Importation of host plants of *L. huidobrensis* to Norway is listed in table 6-8, Appendix. Interceptions of *L. huidobrensis* in other EPPO countries has most commonly occurred on imported *Chrysanthemum* and *Gypsophila* (Smith et al., 1992). Plant commodities liable to carry *L. huidobrensis* are listed in the EPPO/PQR database (1996) (table 9, Appendix), and includes among others, *Chrysanthemum, Dianthus caryophyllus, Gypsophila paniculata*, ornamental and vegetable plants, fruits and vegetables. *Chrysanthemum* sp., *Dianthus caryophyllus* and *Gypsophila paniculata* are imported to the PRA area from countries where *L. huidobrensis* is present (table 6-8, Appendix).

7.3. Number of Consignments and Use

There are no statistics available on the number of consignments of imported plant material to Norway. The amount of importation and use of plant material in the PRA area, such as plants for further cultivation and saleable decoration plants, flowering pot plants and nursery plants, cuttings and small plants of cut flowers, are shown in table 1-2 and 6-8, Appendix.

7.4. Survival of the Pest under the Environmental Conditions of Transport

The many interceptions of *L. huidobrensis* in different countries, proves that the pest is able to survive in transit and also to infest new crops at the place of destination. Transport of plant material (host plants of *L. huidobrensis*) is fast (often send by air) and very common. The life cycle of the pest is of sufficient duration to extend beyond time in transit.

7.5. Detection of the Pest at Entry Inspection

Eggs in plant tissue or prepupae and pupae either on the foliage or in the soil are almost impossible to detect by a visual inspection. Mines and larvae can be detected, but low infestations are easily overlooked.

7.6. Pest Movement into Norway by Natural Means

No documentation has been found that confirms or opens the possibility that movement by natural means could be a way for *L. huidobrensis* to enter Norway. To our knowledge the pest is only occationally found in Sweden (intercepted), Finland (eradicated) and Denmark (eradicated), and only in greenhouses.

7.7. Conclusion on Introduction Potential

There is a great potential for introduction of *L. huidobrensis* on infected plant material into Norway.

8. Overall Conclusion for Pest Risk Assesment

The conclusion of the pest risk assessment for *L. huidobrensis* is that this pest has sufficient economic importance, a great potential for introduction, establishment and spread, for phytosanitary measures to be justified.

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Appendix

Table 1. Economically important host plants of *L. huidobrensis*, production in Norway, production value (NOK) and man-labour years in the production.
Data from the Norwegian Horticultural Growers Association.

Economically important hosts of *Liriomyza huidobrensis*	Production in Norway		Production-value (1.000 NOK)	Man-labour years
Allium cepa	5.060 daa	120,4 tonns	66.323	173
Alstromeria	2,0 mill cut flower		13.120	13
Apium graveolens	750 daa	1,5 tonns	13.117	44
Brassica campestris	3.246 daa	12,1 tonns	48.532	95
Brassica oleracea	16.206 daa	34,0 tonns	111.503	398
Callistephus chinensis	0,2 mill nursery plants		750	1
Chrysanthemum frutescens	0,08 mill. cut flowers 1,5 mill. nursery plants		7.393	8,5
Chrysanthemum morifolium	2,9 mill. pot plants 5,0 mill. cut flowers		66.753	73
Chrysanthemum sp.	0,4 mill nursery plants		1.500	2
Cucumis sativus greenhouse outdoors	 238 daa 638 daa	 9,4 tonns 1,8 tonns	 108.319 8.730	 170 38
Dahlia hybrids				
Dahlia pinnata	0,6 mill nursery plants		3.300	3
Daucus carota	12.039 daa	35,9 tonns	95.414	352
Dianthus caryophyllus	0,3 mill cut flowers		2.250	2
Dianthus chinensis	1,7 mill. nursery plants		8.275	9
Exacum sp.	0,05 mill. pot plants		300	
Gerbera sp.	0,8 mill. pot plants		10.800	11
Gypsophila paniculata	2,4 mill. cut flowers		15.144	15
Lactuca sativa greenhouse outdoors	15,0 mill. heads	2.6 tonns	 44.789 4.977	75
Petroselinum crispum	250 daa	1 mill. bunches	11.620	14
Petunia hybrids	3,9 mill. nursery plants		14.625	22
Phaseolus vulgaris (french bean, pole bean)	926 daa	796 tonns	2.969	17
Phlox drummondii	0,05 mill. nursery plants		188	0,5
Pisum sativum	8.322 daa	3,8 tonns	8.738	152
Primula obconica	1,2 mill. pot plants		8.640	7
Primula polyantha				
Primula sp.				
Raphanus sativus (radish, white radish)	1 mill bunches		3.590	14
Solanum lycopersicum (cherrytomato, tomato)	340 daa	19,4 tonns	112.872	243
Solanum tuberosum	183.500 daa	368.600 tonns	535.266	2.192
Spinacia oleracea	200 daa	250 tonns	1.000	6
Tagetes erecta hybrids	2,0 mill. nursery plants		7.500	11
Tropaelum majus	0,1 mill. nursery plants		375	0,5
Verbena hybrids	0,5 mill. nursery plants		5.125	3
Viola sp.	4,8 mill. nursery plants		18.000	27

Table 2. Host plants reported of *Liriomyza huidobrensis*. The tabel consists of plants where *L. huidobrensis* has been reported (found), and are based upon data from de Goffau (1991), Eppo database (1996), De Clercq & Casteels (1992), Spencer (1990), Brødsgaard (1989), Wolf-Dietrich (1992).

Host plants for *Liriomyza huidobrensis*	Occurrence in Norway	Major hosts= *** Minor hosts= ** Not classified= ¤
Achillea	perennial/wild	¤
Allium ampeloprasum	field vegetable	¤
Allium cepa	field vegetable	**
Allium sativum		**
Alstromeria	greenhouse	¤
Amaranthus sp.	annual/wild	*
Anemone	wild/perennial	¤
Anthirrhinum sp.	annual	¤
Apium graveolens (celery)	field vegetable	***
Aster sp. (aster)	annual/perennial/wild	**
Bellis	annual/perennialwild	¤
Beta vulgaris (sugarbeet)	field vegetable	***
Brassica campestris (chinese cabbage)	field vegetable	¤
Brassica oleracea	field vegetable	¤
Calendula	annual	¤
Callistephus chinensis	annual	¤
Cannabis sativa		**
Capsicum annuum (pepper)	vegetable, privat growing	***
Carduus (thistle)	wild/weed	¤
Carthamus sp.	wild	¤
Chrysanthemum frutescens	greenhouse/annual/(perennial)	***
Chrysanthemum sp.	greenhouse/annual/ perennial/wild	***
Chrysanthemum morifolium	greenhouse	***
Cichorium endivia (endivie)		¤
Cineraria	annual	¤
Cirsium arvense (creeping tistle)	wild/weed	¤
Cucumis melo (melon)	field vegetable/greenhouse (mostly privat growing)	***
Cucumis sativus (gherkin, cucumber)	greenhouse/field vegetable	***
Cucurbita pepo (courgette)	field vegetable (mostly privat growing)	**
Dahlia hybrids	greenhouse/annual	**
Dahlia pinnata	greenhouse/annual	¤
Datura	wild/annual/perennial	¤
Daucus carota (bunching carrot)	field vegetable	¤
Dendranthema	greenhouse	¤
Dianthus barbatus	perennial/(wild)	¤

Host plants for *Liriomyza huidobrensis*	Occurrence in Norway	Major hosts= *** Minor hosts= ** Not classified= ¤
Dianthus caryophyllus	greenhouse/annual	**
Dianthus chinensis	annual	¤
Dianthus cv. Gypsy	annual	¤
Dianthus sp.	greenhouse/annaul/perennial/(wild)	***
Diascia sp.	annual	¤
Eustoma	annual	¤
Exacum sp.	greenhouse	**
Galinsoga	weed	¤
Gazania	annual	¤
Gerbera sp.	greenhouse	**
Glechoma hederacea (ground-ivy)	wild	¤
Gypshophila sp.	greenhouse/perennial/wild	***
Gypsophila paniculata	greenhouse/perennial/ (wild)	***
Lactuca sativa (lettuce, iceberg lettuce)	greenhouse/field vegetable	***
Lathyrus	wild/(annual/vegetable)	**
Liatris	perennial	¤
Linum	wild/(field crop)	¤
Lisianthum sp.		¤
Lobelia	annual/perennial/wild	¤
Matricaria sp.	wild/weed	¤
Matthiola incana (hoary stock)	annual/cut flowers	¤
Medicago sativa	eng/wild	**
Nicotiana alata	annual	¤
Oxalis	wild/perennial	¤
Petasites hybridus (greater coltsfoot)	wild	¤
Petroselinum crispum (parsley)	field vegetable/greenhouse	¤
Petunia hybrids	greenhouse/annual	¤
Phaseolus vulgaris (french bean, pole bean)	field vegetable/privat growing	***
Phlox drummondii	annual	¤
Pisum sativum	field vegetable/privat growing/wild	***
Primula obconica	greenhouse	¤
Primula polyantha	perennial	**
Primula sp.	greenhouse/perennial/wild	¤
Ranunculus	wild/weed/perennial	¤
Raphanus sativus (radish, white radish)	field vegetable/privat growing	**
Saponaria sp.	perennial/wild	¤
Senecio vulgaris (groundsel)	weed/wild	¤
Solanum lycopersicum (cherrytomato, tomato)	greenhouse/privat growing	**
Solanum melongena (egg plant)	privat growing	**

Host plants for *Liriomyza huidobrensis*	Occurrence in Norway	Major hosts= *** Minor hosts= ** Not classified= ¤
Solanum nigrum (black nightshade)	wild/weed	¤
Solanum tuberosum (potato)	field crop/privat growing	***
Solidago	perennial/wild	¤
Solidaster		¤
Sonchus	wild/weed	¤
Spinacia oleracea (spinach)	field vegetable	***
Stellaria sp.	wild/weed	¤
Tagetes erecta hybrids	annual	¤
Trachelium		¤
Tropaelum majus	annual/wild	*
Verbena hybrids	annual	***
Vicia faba	wild/(field vegetable)	**
Viola sp.	annual/perennial/ wild/weed	¤
Zinnia	annual/ perennial	**

Table 3. Development time (days) of *L. huidobrensis* on different host plants (Enkegaard (1990), Leuprecht (1991 & 1992)).

Host	° C	Egg	Larvae	Pupae	Total
Chrysanthemum	26,7	3,0	4,7	9,3	17,0
Asters	26,7	3,0	4,9	9,1	17,0
Pea	26,7	2,9	3,6	8,9	15,5
French bean	18,7	2,1	5,8	7,9	15,8
Horse bean	26,0	2,6	5,0	9,0	16,6
Lettuce	25,0	3,0	5,0	9,0	17,0

Table 4. Mortality of pupae of *L. huidobrensis* on different host plants (van der Linden, 1993).

Host	Mortality %	Relative humidity (%)
Chrysanthemum	64,0	50-60
Asters	71,0	50-60
Peas	26,2	50-60
Beans	15,4	60-80
Tomato (1990)	34,2	-
Tomato (1991)	22,5	-

Table 5. Leaf punctures and mines of *Liriomyza huidobrensis* found in *Gypsophila paniculata* (Malais, Newman, La Salle and Parella, 1992).

	Leafminer activity **	
Plant stratum *	Punctures	Mines
Top	5,32 c	0,15 c
Middle	10,63 b	0,44 b
Bottom	17,87 a	1,48 a

* 20 plants samples per week for 14 weels; 10 leaves sampled from each stratum.
** Means followed by the same letter in the same column do not differ significantly (P=0,05) DMRT. Data transformed log (x+1) prior to analysis.

Table 6. Norwegian import of saleable plants and plants for further cultivation from different countries in 1994. The last column describes the situation of *Liriomyza huidobrensis* in the respective countries.

Data from The Norwegian Horticultural Growers Association, EPPO/PQR Database, version 3.2, dated 1996-02. EPPO Reporting Service 1994, No. 5. Smith et al., 1992.

	Decoration Plants		Flowering Pot Plants			*Liriomyza huidobrensis*
Country	Saleable	For Further Cultivation	Saleable	For Further Cultivation	Sum	A, B, C, X, E, I or N *)
Denmark	3.602.799	6.686.297	3.214.820	5.040.517	18.544.735	E
Holland	581.485	66.640	131.666	120.294	900.085	B
Belgium	50.793	17.075	860.381	0	928.294	B
Germany	0	0	1.007.038	143.650	1.150.688	B
Finland	0	0	0	0	0	E
France	0	0	0	195.796	194.500	B
Israel	0	0	0	337.260	337.800	B
Sweden	0	0	0	0	0	I
Spain	0	0	0	17.800	17.800	X
Guatemala	0	0	0	0	0	X
Costa Rica	0	66.390	0	0	66.300	X
Sri Lanka	0	253.815	0	0	253.816	N
Polen	0	0	0	0	0	N
USA	0	0	0	27.040	27.040	B
Sum	4.235.077	7.090.217	5.213.911	5.882.357	22.421.013	

*) : A=Present, widespread, B=Present, restricted distribution, C=Present, few reports, X=Present, no distribution detail, E=Eradicated, I=Intercepted only, N=Never reported.

Table 7. Import to Norway of cuttings and small plants of cut flowers (only host plants of *L. huidobrensis*) from different countries in 1994. The last column describes the situation of *Liriomyza huidobrensis* in the respective countries.

Data from The Norwegian Horticultural Growers Association, EPPO/PQR Database, version 3.2, dated 1996-02. EPPO Reporting Service 1994, No. 5. Smith et al., 1992.

	Importation of cuttings and small plants of Cut Flowers				*Liriomyza huidobrensis*
Country	*Alstromeria*	*Chrysanthemum* sp.	*Dianthus caryophyllus*	*Gypsophila paniculata*	A, B, C, X, E, I or N *)
Holland	3.163	211.450	106.500	24.995	B
Germany	0	0	20.000	0	B
Israel	0	0	0	24.370	B
Sum	3.163	211.450	126.500	49.365	

*) : A=Present, widespread, B=Present, restricted distribution, C=Present, few reports, X=Present, no distribution detail, E=Eradicated, I=Intercepted only, N=Never reported.

Table 8. Economically important host plants of *Liriomyza huidobrensis*, production in Norway of pot plants, nursery plants and cut flowers, and import of saleable pot plants, cuttings and small plants (1994).

Data from the Norwegian Horticultural Growers Association.

Economically important hosts of *Liriomyza huidobrensis*	Production in Norway of saleable plants (numbers)	Import of saleable plants to Norway (numbers)	Import of cuttings or young plants to Norway (numbers)
Chrysanthemum morifolium	2.903.600	0	675.532
Exacum sp.	55.000	130.134	49.405
Gerbera sp.	456.540	0	21.940
Primula sp.	1.204.400	15.000	20.375
Alstromeria	2.000.000		3.163
Chrysanthemum frutescens	80.000		
Chrysanthemum morifolium	5.000.000		211.450
Dianthus caryophyllus	300.000		126.500
Gyphsophila paniculata	2.400.000		49.365

Table 9. Plant commodities liable to carry *Liriomyza huidobrensis* (EPPO/PQR Database, version 3.2, dated 1996-02).

Plants	Cut Flowers/Branches	Fruits/Vegetables
Apium graveolens	*Chrysanthemum morifolium*	*Apium graveolens*
Capsicum annum	*Dianthus caryophyllus*	*Beta vulgaris*
Chrysanthemum morifolium	*Gypsophila paniculata*	*Lactuca sativa*
Cucumis	Ornamental plants	*Spinacia oleracea*
Dianthus caryophyllus		Vegetable plants
Gypsophila paniculata		
Lactuca sativa		
Lycopersicon esculentum		
Ornamental plants		
Vegetable plants		

Table 10. Normal air temperatures for the year (i.e. the average for each month for the period 1961-1990) measured at five meteorological stations in the coastal area of southern Norway (NORPRE, Plant Protection Centre).

	Locality and Temperature (°C)				
Month	Tomb	Lier	Tjølling	Landvik	Særheim
January	-4,8	-5,5	-3,0	-1,6	0,5
February	-4,6	-5,0	-3,1	-1,9	0,4
March	-0,8	-0,4	0,4	1,0	2,4
April	4,2	4,8	4,6	5,1	5,1
May	10,3	11,0	10,5	10,4	9,5
June	14,7	15,7	15,0	14,7	12,5
July	16,1	17,1	16,7	16,2	13,9
August	15,0	15,7	15,5	15,4	14,1
September	10,6	11,3	11,7	11,8	11,5
October	6,0	6,6	7,6	7,9	8,6
November	0,6	0,6	2,5	3,2	4,4
December	-3,0	-3,5	-1,1	0,2	2,0

Table 11. Number of days with minimum air and soil temperatures below 0°C and minimum daily air and soil temperature in these periods at five locations in the coastal area of southern Norway (NORPRE, Plant Protection Centre).

Locality	Year	Days with mean air temperature below 0°C	Minimum mean daily air temperature (°C)	Days with mean soil temperature below 0°C	Minimum mean daily soil temperature (°C)
				1 cm depht	
Tomb [1)]	1991	77	-10,2	79	-6,7
Tomb	1992	75	-10,3	50	-1,8
Tomb	1993	90	-13,6	89	-1,5
Tomb	1994	87	-19,9	70	-0,7
Lier	1991	28	-6,8	38	-4,8
Lier	1992	92	-11,0	76	-4,5
Lier	1993	102	-14,8	97	-1,4
Lier	1994	107	-20,0	3	-0,02
Tjølling [2)]	1991	45	-10,2	18	-2,4
Tjølling	1992	58	-8.3	0	-
Tjølling	1993	73	-13,2	0	-
Tjølling	1994	73	-14,5	1	-0,4
				10 cm depht	
Landvik	1991	-	-	51	-1,9
Landvik [3)]	1992	34	-6,2	19	-1,1
Landvik [4)]	1993	52	-12,2	12	-1,0
Landvik	1994	57	-8,3	0	-
Særheim	1991	20	-6,1	17	-1,7
Særheim	1992	8	-3,7	0	-
Særheim	1993	27	-5,4	0	-
Særheim	1994	36	-5,2	19	-0,3

[1)] Lacking data for 4 days in March
[2)] Lacking data for 8 days in March and April
[3)] Lacking data for 6 days in January and February
[4)] Lacking data for 5 days in November