



Plant Protection Service
Ministry of Agriculture, Nature and Food Quality

Pest Risk Assessment *Fusarium foetens*

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Version: 2.0
Date: April 2010

Pest Risk Assessment

Fusarium foetens

1. Reason for performing the PRA

In April 2002, a PRA for *Fusarium foetens* was finalized after the finding of an outbreak of the fungus in November 2000 in the Netherlands on a breeding/propagation company (Baayen et al. 2002). At that time the fungus and disease had not been described before (EPPO Reporting Service 2003/14; Neubauer et al. 2002). Morphological and phylogenetic studies described the fungus as a new species, distinct from *Fusarium begoniae* and other species within the *F. oxysporum* complex (Schroers et al., 2004). The fungus causes basal rot, vein yellowing and wilting symptoms causing rapid death of its primary host plant, *Begonia elatior* hybrids. It was suggested to list the fungus on Annex II A2 of the EU directive 2000/29/EC and to regulate the fungus for propagation material of *Begonia elatior*. Since an outbreak in January 2002 on a breeding/propagation company, the fungus is under official control for propagation material by the Plant Protection Service (NPPO of the Netherlands). In 2005 *Fusarium foetens* was added to the EPPO Alert list (EPPO Reporting Service 2005/111). In 2007 the fungus obtained an EPPO A2 status and at present it is on the EPPO Action List.

Since the first version of the PRA in April 2002, new information has become available about *Fusarium foetens* especially about its impact under practical conditions and possibilities to control the disease (DLV Facet, 2004; Wohanka et al., 2005; Elmer, 2008). Since the detection of the disease, breeding, propagation and retail marketing companies of *Begonia elatior* have taken measures to control the pest. In 2004, The Dutch Plant Protection Service detected a second outbreak in propagation material and measures were imposed for eradication. To date no other additional findings in propagation material are known in the Netherlands but the fungus is still present on companies growing pot plants for retail market. In this update of the first PRA, we especially describe the experiences with the disease and evaluate control measures taken by companies since 2002.

2. Scientific names and taxonomy

Class: Deuteromycetes
Order: Moniliales
Family: Tuberculariaceae
Genus: *Fusarium*
Species: *foetens*

Classification is based on the anamorph name, as the teleomorph connection is still unknown.

3. PRA-area

The Netherlands

4. Host plant range (Worldwide)

Primarily *Begonia x hiemalis* (known as *B. elatior* hybrid).

The fungus is highly pathogenic to several *Begonia X hiemalis* cultivars (f.e. 'Batik', 'Bazan', 'Bellona', 'Berseba', 'Boll', 'Dark Britt', 'Fotch', 'Julie', 'Nadine', 'Netja Dark', 'Picote' etc.). However, other *B. elatior* cultivars are less susceptible (i.e. 'Angel Wing' and 'Rex') (Elmer et al., 2004). Other *Begonia* hybrids, such as *Begonia X rex-cultorum*, *Begonia X cheimantha* and *Begonia X tuberhybrida* are also susceptible to the disease (Elmer, 2008). Other *Begonia* species (i.e. *B. partita*, *B. boliviensis*, *B. cinnabarina*, *B. coccinea*, *B. schmidtiana* and *B. semperflorens-cultorum*) are not recorded to develop typical symptoms (Brand et al. 2005). In *Begonia rex* a stunting is observed in two cultivars. Determining the specific pathogenicity within the genus *Begonia* remains a daunting task.

Pathogenicity testing by the NPPO of the Netherlands further revealed that the fungus is not a pathogen on *Saintpaulia ionantha*, *Impatiens walleriana*, *Pelargonium zonale* and *Euphorbia pulcherrima*, which are commonly grown in nurseries together along with *B. x hiemalis*. Furthermore, the significance of vascular discoloration in inoculated *Cyclamen persicum* is not yet determined.

5. Host plant range (PRA area, including acreage)

Begonia x hiemalis. See also question 4.

Acreage: 28 ha in 2003 and 22 ha in 2004 (Anonymous, 2006)

6. What is the current area of distribution of the pest?

Netherlands: first found in 2000 and still present at *Begonia* pot plant companies (see question 13).

Germany: first found in 2001, and occasionally since then in Sachsen-Anhalt, Schleswig-Holstein, Nordrhein-Westfalen, Niedersachsen. It was stated that most infected plants originated from the Netherlands, but in some cases from non-European countries (EPPO Reporting Service 2005/110).

United Kingdom: first found in 2002 (Jones, 2002). It was stated that infected consignments originated from Denmark and the Netherlands.

Norway: found in 2007 or earlier. Present status not known. (EPPO document 07-13690, available at http://www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRA_documents.htm)

USA: *F. foetens* was found in Connecticut in 2003 and 2004 (Elmer et al., 2004).

Japan: *F. foetens* was found in Miyagi Prefecture in 2005 (Sekine et al., 2008).

Uncertainty:

Propagation companies in the Netherlands regularly obtain nursery stock of *Begonia elatior* from countries in South America and Africa. Since the origin of *Begonia elatior* is most likely located in tropical rainforest areas of South America or Africa (Doorenbos et al., 1998), the origin of the new *Fusarium* species could have been countries in South America and/or Africa.

7. What is the international phytosanitary status?

Not known as a quarantine pest.

F. foetens is on the A2 list of EPPO (European and Mediterranean Plant Protection Organisation) and thus recommended for regulation. In the Netherlands, emergency measures are in place for propagation material since January 2002.

8. Does it occur in the Netherlands?

Yes. Pest status: "present, not in plants for planting, under official control".

9. Probability of entry: pathway analysis

Pathway 1 – Propagation material

The fungus is already present in the PRA area, and likely entered from the southern hemisphere with latently infected *Begonia* plants for breeding or nursery stock. Since *Begonia* is not native to Europe, the new fungus could have entered the PRA area directly from an area where it exists on wild *Begonia* species (tropical forests). Indirectly, after having first reached *Begonia* nurseries in the southern hemisphere, the fungus could have followed trade contacts within the European Union. The main pathway for further spread within the PRA area consists of (rooted) cuttings

marketed by propagation companies to companies producing *Begonia* pot plants for retail marketing. Products of retail marketing companies in the Netherlands are not a pathway for further spread since these *Begonia* plants are final products and are not used for propagation nor sold to other *Begonia* producing companies.

Present situation in the Netherlands

In the Netherlands, two large companies produce propagation material. These propagation companies also have breeding activities. The breeding/propagation companies produce (rooted) cuttings for Dutch pot plant producing companies but also for companies in other EU-countries and non-EU countries. Non-rooted cuttings are produced at locations in third countries and may be directly sold to customers or first rooted at Dutch propagation/breeding companies in the Netherlands.

Pathway 2 – Soil adhering to plants for planting

Many *Fusarium* species are soilborne (Smith *et al.*, 1988). Therefore soil adhering to roots of imported plants of *Begonia elatior* could serve as a pathway for introduction. However, for both propagation and retail marketing of *Begonia* plants in the Netherlands, exclusively new potting soil or soil mixture is used. Therefore, this pathway is unlikely for introduction into and further spread in the Netherlands.

Pathway 3 – Spread by natural means

The fungus reproduces easily, producing microconidia and macroconidia (spread by air and water), and chlamydoconidia (survival structures in soil). Spread by natural means will usually only cover short distances. In view of the limited number of *Begonia* producing companies in the Netherlands and since cultivation is mostly in protected conditions throughout the year, spread by natural means is not considered an important pathway for the fungus. Companies in the Netherlands often make use of recirculated water systems which may cause infection of new batches of cultivated propagation material of *Begonia* at the same company. However such companies commonly use strict sanitation measurements.

Although the sexual (teleomorphic) stage of the fungus is not (yet) known to occur, air-borne ascospores could contribute to spread indoor and especially outdoor. However, outdoor cultivation of *Begonia elatior* is not common practice in the Netherlands during winter months. Moreover, companies cultivating *Begonia elatior* in the Netherlands rely on protected cultivation for most part of the year, including summer months. This pathway is, therefore, considered of minor importance.

Conclusion pathways:

Infected propagation material is probably the only relevant pathway. Without any control measures the fungus can easily be introduced and spread by import and trade of propagation material.

10. Probability of establishment

Outdoors

Outdoor establishment of the fungus in soil is unlikely since *Begonia elatior* is foremost cultivated indoors in the PRA area. Furthermore in case of outdoor cultivation, this predominantly takes place in pots and not in free soil.

Probability of establishment outdoors: unlikely (uncertainty: low)

Indoors: protected cultivation

The fungus is present on companies producing *Begonia elatior* plants in the Netherlands already for many years despite hygienic measures (DLV facet, 2004; information obtained from Dutch pot plant companies, see also question 13).

Probability of establishment indoors: very likely (uncertainty: low)

11. How likely is the pest to spread in the PRA-area? (naturally and by human assistance)

See question 9. The fungus can easily spread by trade of infected propagation material if no control/phytosanitary measures are taken. Natural spread is unlikely to occur.

Probability of spread: very likely (this is the potential probability of spread by trade of infected propagation material)

Note. At present, propagation companies are free of *F. foetens* due to strict hygienic measures and, therefore, the actual probability of spread is low (see question 14).

12. What is the potential damage when the pest would become introduced? (without the use of control measures)

Fusarium foetens kills the plant or makes the plant unsuitable for trade. In an ebb-and-flow system, the fungus can easily spread (Wubben *et al.*, 2003) and once the nutrient solution has become infested all plants irrigated by this nutrient solution can become infected. Under experimental conditions, percentages diseased plants in an ebb-and-flow system were near 100% (Van der Gaag *et al.*, 2007).

In 2002, an investigation was carried out under growers of *Begonia* pot plants using an inquiry (DLV Facet, 2004). Seventy-nine per cent of the growers that produced *Begonia* year round and twenty-two per cent of growers that did not produce *Begonia* year round had problems with *F. foetens*. Most of them had plant losses in some cultivars but four companies, all with an ebb-and-flow system had serious problems (figures on plants losses were not mentioned). On an average, the yearly loss was €23,000 per ha on all companies that had been investigated. The number of growers interviewed was not indicated in the report.

In 2008, the total turnover of *Begonia* pot plants at auctions in the Netherlands totalled 17.3 million plants for retail marketing worth 19.8 million euro (Anonymous, 2009). Without control measures, cultivation of *Begonia* on retail marketing companies, propagation companies and breeding companies is at risk.

Potential economic impact without any control measures: very high (uncertainty: low)

13. Which control measures are available?

Fungicides

Benzimidazole fungicides may suppress the pathogen but not eliminate the fungus (information from *Begonia* growers to H. Cevat, Plant Protection Service, 2001). At present, carbendazim is not registered any longer in the Netherlands (www.ctb-wageningen.nl; accessed: April 2010), but the related fungicide thiophanate-methyl may have a similar effect. However, since these fungicides cannot eliminate the pathogen, they are no good option for control of *F. foetens*. In practice, fungicides are also not used against *F. foetens*.

Suppressive potting mixtures

Addition of green waste compost to potting mixtures may partially control the disease but certainly not eradicate the fungus (Van der Gaag *et al.*, 2007).

Resistant varieties

In practice, some cultivars appear to be less susceptible and in experiments cultivar 'Dark Britt' was less susceptible than cultivar 'Berseba' (Wubben *et al.*, 2003; DLV facet, 2004). Cultivars are, however, grown for certain colours rather than for their level of resistance against diseases.

Growing systems

In practice, more problems have been observed with companies growing plants in ebb-and-flow systems than in companies growing plants on irrigation mats (Wubben *et al.*, 2003b; DLV facet, 2004). In experiments, about 10 times more plants were diseased in the ebb-and-flow system than

in an system with irrigation mats after infestation of the nutrient solution (Wubben et al., 2003b). An explanation may be the lower volume of drainwater. In an ebb-and-flow system only 10% instead of 90% of the water is drained off after irrigation. This may result in lower numbers of spores released into the nutrient solution.

Hygienic measures

Destruction of infected plant material in combination with hygienic measures (disinfestation of the whole system) is presently the only option to eradicate the disease. These measures have been used to eradicate the pest successfully from propagation companies in the Netherlands in 2002 and 2004.

DLV Facet (2004) has recommended various hygienic measures among others disinfestations of the irrigation water and growing surfaces. It was reported that pot plant producing companies had taken specific hygienic measures against *F. foetens* since 2002 and that problems with the pathogen had clearly decreased by 2004 (DLV Facet, 2004).

In 2010, totally four to five large companies produce Begonia pot plants during the whole year and 2-3 companies produce Begonia pot plants at a smaller scale in specific periods of the year (information obtained from growers). In February 2010, three of the large companies were asked about the situation of the disease. *F. foetens* was still present at these *Begonia* companies but plant losses were minimal or low due to hygienic measures. In the past *F. foetens* had caused major problems and as a consequence the companies had installed machines to disinfest the drain water after each irrigation turn (UV or heat treatment). They also regularly inspect the plants for symptoms and remove symptomatic plants. At present, plant losses due to *F. foetens* were minimal at two out of the three companies (diseased plants are incidentally found and removed) and low at one company (plant losses 1% at maximum, but usually lower). It was mentioned that the hygienic measures were essential to control the pathogen and only since about 2 years plant losses were at such a low or minimal level on 2 out of the 3 companies. According to these companies, the general situation is that *F. foetens* is still present at Begonia pot plant companies but plant losses are low or minimal due to hygienic measures.

Application of disinfectants

Low concentrations of disinfectants might control spread by *F. foetens* without being phytotoxic (Elmer, 2008), but such applications are not registered in the Netherlands (www.ctb-wageningen.nl; accessed: April 2010).

Conclusions control measures

Hygienic measures taken by Begonia pot plant nurseries, especially disinfestations of the drain water after irrigation, are effective in controlling *F. foetens* resulting in low or minimal plant losses.

14. What is the expected damage when the pest would become introduced? (with the use of control measures)

In 2000, when the first problems with *F. foetens* occurred (and before that time) *Begonia* growers did not take specific measures against soil-borne pathogens or pathogens that are being spread by the nutrient solution. In January 2002 and December 2004, official measures were implemented after finding of the pathogen on breeding/propagation companies in the Netherlands. *Begonia* plants were destroyed and hygienic measures were imposed. The measures successfully eradicated the pest at the breeding/propagation companies as confirmed by inspections. However, at that time the fungus was already present on many pot plant producing companies in the Netherlands (DLV Facet, 2004).

Since 2002, *Begonia* pot plant companies have taken measures against *F. foetens* and plant losses due to the pathogen have decreased and are presently low or even minimal. Nonetheless, growers still consider *F. foetens* as an important pathogen because hygienic measures are still needed to control the pathogen (see above: question 13).

Propagation companies have taken measures to avoid (new) infestations, for example by testing each candidate plant for *F. foetens* (Information from Naktuinbouw). Rapid reliable *in planta* molecular testing is presently available (Weerd et al., 2006).

An important question is to which extent the official measures for propagation material implemented since January 2002 have contributed to the effective control of the disease. In 2002, an estimated 79% of companies growing Begonia pot plants year round had problems with *F. foetens* (DLV Facet, 2004). Thus, the official measure had not prevented the infestation of a relatively large number of pot plant producing companies before 2002. Following the first findings of the pathogen in 2000, plant losses already had decreased by 2004 probably mainly due to hygienic measures implemented by pot plant producing companies (DLV Facet, 2004). This was before the finding of the pathogen at a propagation/breeding company followed by implementation of official eradication measures in December 2004. One may speculate that the official measures may have stimulated or forced propagation companies to produce pathogen free propagation material. However, it is also in their interest to produce pest free material and, therefore, these companies also take stringent measures against non-regulated pests. Since the detection of the infestation in December 2004, *F. foetens* has not been detected at breeding/propagation companies any more despite regular visits by inspectors of the official inspection body, Naktuinbouw. Thus, it is concluded that hygienic measures taken by both propagation and pot plant producing companies on a voluntary basis are probably the (main) reason for the decrease in problems with *F. foetens* since 2002.

Potential economic impact with control measures: low (uncertainty: low)

Note. With strict hygienic measures the impact at pot plant producing companies is low. However, investments to control the pest have been relatively high, e.g. investment in machines for disinfestation of the drain water.

15. Effect on export markets

F. foetens is not known as a quarantine pest in other countries. However, it is recommended by EPPO for regulation and countries may take emergency measures after detection of the fungus. In 2004, the UK has notified two interceptions of *F. foetens* in imported Begonia propagation material (Europhyt). Export of propagation companies may be affected after (repeated) interceptions/findings of infected propagation material. The two large breeding/propagation companies in the Netherlands export propagation material to other EU- and non-EU countries. Their export will probably be affected when propagation would (repeatedly) be infected.

Potential effect on export markets: high (uncertainty: medium)

Note: Since December 2004, no new infestations of *F. foetens* have been recorded at breeding/propagation companies in the Netherlands and these companies have taken hygienic measures to avoid infestation and potential problems with export.

16. Summary and conclusions

Detected in 2000 for the first time, *F. foetens* was a new pathogen. At the time of first finding, the fungus and disease were new and had not been described before. In April 2002 a PRA was finalized by the NPPO of the Netherlands and it was suggested to list the fungus on Annex II A2 of the EU directive 2000/29/EC and to regulate the fungus for propagation material of *Begonia elatior* because of its potential high impact for Begonia pot plant industry. However, the fungus has not been regulated by the EU so far. Since an outbreak in January 2002 on a breeding company, the fungus is under official control for propagation material by the Plant Protection Service (NPPO of the Netherlands). The present PRA is an update of the previous PRA and has included new information that has become available since April 2002. The conclusions of this updated PRA are:

- Infected propagation material is probably the only relevant pathway for *F. foetens*. Without any control measures the fungus can easily be introduced and spread by import and trade of propagation material.
- *F. foetens* can potentially cause high yield losses, up to 100% in *Begonia* pot plants.
- *F. foetens* is still present on *Begonia* pot plant producing companies in the Netherlands despite official measures for propagation material implemented since January 2002.
- Hygienic measures taken by *Begonia* pot plant nurseries, especially disinfections of the drain water after irrigation, are effective in controlling *F. foetens* and plant losses at pot plant producing companies due to *F. foetens* are presently low or minimal.
- It is not possible to assess to which extent the official measures implemented since 2002 in the Netherlands have contributed to the control of the pathogen. Observations suggest that voluntary hygienic measures taken by both pot plant producing companies and propagation companies have led to effective control of the pathogen.
- Control (hygienic) measures at pot plant producing companies will also be needed in the future even if the emergency measures for propagation material in the Netherlands are being continued because pot plant producing companies have not been able to completely eradicate the pathogen.

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