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European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

PM 10/19(1)

Phytosanitary treatments
Traitments phytosanitaires

Hot water treatment of strawberry plants to control *Aphelenchoides besseyi* and *Aphelenchoides fragariae*

Specific scope

This Standard describes the hot water treatment of strawberry plants against *Aphelenchoides besseyi*. It may also be used against *Aphelenchoides fragariae*.

Specific approval and amendment

First approved as PM 3/52 in 1993-09.
Revised and transferred to series PM 10 in 2012-09.

Introduction

Aphelenchoides besseyi (Nematoda: Aphelenchoididae – EPPO A2 list) infests strawberries, and other plants, on which it is a causal agent of summer dwarf or crimp disease. Consignments of rice (*Oryza sativa*) seeds or of plants of strawberry (*Fragaria ananassa* and *Fragaria chiloensis*) are considered to present the main risk of introduction of this pest. It is recommended that seeds of rice from countries where *A. besseyi* occurs are tested according to EPPO Phytosanitary procedure PM 3/38. Plants for planting of strawberry should either come from an area where *A. besseyi* does not occur, or should have been treated by a method to kill nematodes on the plants. Details about biology, distribution and economic importance of *A. besseyi* can be found in EPPO/CABI (1997) and PQR (EPPO, 2012). For its identification, see EPPO Diagnostic Protocol PM 7/39 (EPPO, 2004).

Commodities/regulated articles

Fragaria ananassa (FRAAN).
Fragaria chiloensis (FRACH).
Treatment should be applied to fresh plants and to plugs.

Pests

Aphelenchoides besseyi (APLOBE).
Aphelenchoides fragariae (APLOFR).

Treatment schedule

Pre-treatment		Hot water treatment		Post-treatment	
Time (min)	Water *T* (°C)	Time (min)	Water *T* (°C)	Time (min)	Ambient *T* (°C)
30	30	10	46	10	Room temperature

Treatment conditions

It is preferable that plants are treated individually to ensure each plant is in contact with hot water so the core of the plants will reach the appropriate temperature. Alternatively, treatment can be applied to a group of not more than 20 plants. Tray plants are not well suited to this treatment.

Prior to treatment, strawberry plants should have been inspected during the growing season and should have no symptoms, or only minor symptoms, of infestation with *A. besseyi* or *A. fragariae*. Plants with moderate or high levels of damage will not survive treatment. The plants to be treated should be actively growing and not in a dormant state.

Pre-treatment

The plants should be washed, and all developed and mechanically damaged leaves removed by breaking them at the base of the petiole. Pre-treatment (immersion of plants in water at 30°C for 30 min) is necessary to avoid plant mortality resulting from treatment.

An additional storage period of 7 days prior to treatment at a temperature between −2 and 0°C is useful because these conditions decrease the thermotolerance of the pest.

Treatment

The plants should be immersed in water at 46°C for 10 min; longer immersion at this temperature reduces the survival rate of strawberry plants.

The main condition of the successful treatment is even warming of the plant mass in water.

Post-treatment

Treated plants should be cooled immediately in water at room temperature (but not below 15°C) for 10 min, and should be aerated and placed in cold storage for 24 h. The storage of treated plants at a cool temperature does not increase the efficacy of treatment, but removes thermal shock and improves their survival rate.

Since hot water treatment damages reproductive organs of plants, the treated plants should then be grown in the nursery to produce non-infested plants for production (Metlitskiy, 2002). As mentioned above, the treatment usually kills almost all developed leaves. However, in 7–10 days new leaves start to grow.

Equipment

Equipment should be specially designed to maintain exactly the required temperature throughout the plant material by an efficient mixing system. Adequate equipment is described in Boudon-Padieu & Grenan (2002), Groupe de Travail National (2006), and ICA (2007).

Hot water tanks in which treatment is to occur should:

- be purpose-built;
- be constructed from inert (with a low chemical reactivity at high temperature) material
- have a means of circulating and heating water in order to maintain a consistent uniform temperature and appropriate thermal insulation with a lid to limit heat loss;
- have appropriate measurement and recording equipment (see below).

An open-mesh cage, or similar device, for immersion of strawberry material in the tank, should:

- be constructed from an inert (with a low chemical reactivity at high temperature) material;
- allow adequate circulation of hot water around the strawberry material;
- have a clearance from the tank on all sides (e.g. 150 mm);
- have a mesh lid or other device to ensure all material remains fully immersed during treatment.

Temperature sensing and recording systems should have a combined overall accuracy of not more than ±0.5°C. A minimum of three sensors should be used for each tank. One sensor should be located at a depth of 100 mm from the base of the tank, another at 100 mm from the surface, and the third inserted into the centre of the load mass (Metlitskiy, 2002).

Efficacy of treatment

Efficacy of this treatment is reported by Christie & Crossman (1935). Metlitskiy (2002) also reported on more than 50 years' practice of using hot water treatment for more than 100 varieties of strawberry.

An experiment is described by MacLachlan & Duggan (1979) in which strawberry runner initials were treated at 45 and 50°C for 10 and 15 min. Plants did not tolerate the treatment at 50°C, and there was a significant reduction in plant survival when the treatment at 45°C was continued for 15 min. The results showed that runner initials will tolerate 45°C for 10 min provided they are pre-heated in warm water and then immersed in cold water after treatment.

Difference in temperature sensitivity

The level of damage to strawberry plants depends on cultivar, on climate conditions after planting, and on adaptability of the plants to local conditions. Strawberry plants with slightly pubescent leaves and thin petioles, such as the Chilean species (*Fragaria chiloensis*) – Lucida Perfecta, Miche Shidler – have been observed to be less heat-resistant.

However, varieties used worldwide, such as Senga Sengana or Cambridge Favorite, are the least sensitive. Qui *et al.* (1993) also noted that 10–15 min at 46.1°C killed *A. fragariae* without damaging the five cultivars tested (Chandler, Douglas, Fern, Pajaro and Selva).

Enquiries

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