ENTOMOVECTORING IN BERRY AND FRUIT CULTIVATION IN FINLAND: THE CHANGE IN CAP AND ITS IMPLICATIONS FOR THE FUTURE

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Abstract. *The new support scheme for Finnish fruit and berry growers is explained by Reskola, V-P. (2015), Ympäristökorvaus käynnistymässä. Puutarha & Kauppa Nr. 3/2015, p. 14. In Finland, new CAP measures dealing with environmental subsidies to agriculture, propose to change the statutes and to include specifically entomovectoring. Conventional growers, who replace chemical fungicide sprays by entomovectoring of microbial products on their berry and fruit crops for a minimum of 5 years, will receive 500 €/ha/year in environmental support. It is expected that the new subsidy scheme will encourage berry and fruit growers to take up the alternative method. The model which Finnish legislation is providing might help other countries also to adopt a similar scheme. What is at stake in Finland are the consequences of unguided introduction of the new technology. There is no infrastructure to support the introduction and uptake of the entomovectoring technology. In case growers run into problems, no infrastructure is available to provide knowledge and know-how for the introduction of the new technology. If the technology fails on the fields, it is because of the mode of introduction.*

Key words: *antagonist, Apis mellifera, apple, biological control, Bombus, Botrytis cinerea, CAP, Clonostachys rosea, dispenser, entomovectoring, environmental subsidies, fungal diseases, Fusarium avenaceum, Gliocladium catenulatum, integrated control, new CAP measures, organic production, Prestop® Mix, raspberry, strawberry.*

INTRODUCTION

In Finland, new CAP measures dealing with environmental subsidies to agriculture, have changed the statutes to include specifically entomovectoring. Conventional growers, who replace chemical fungicide sprays by entomovectoring of microbial products on their berry and fruit crops for a minimum of 5 years, will receive 500 €/ha/year in environmental support. The new support scheme for Finnish fruit and berry growers is explained by Reskola (2015). It is expected that the new subsidy scheme will encourage berry and fruit growers to take up the alternative method. The model which Finnish legislation is providing might help other countries also to adopt a similar scheme. The following sections are based on an article (Hokkanen et al., 2015) reporting on the results gathered in an Europe-wide EU ERA-NET CORE ORGANIC 2 project BICOPOLL (Biocontrol and Pollination).

WHAT IS THE PROBLEM WE ARE DEALING WITH?

Gray mold *Botrytis cinerea* is one of the most important airborne diseases of fruits and berries, like strawberry, blueberry, and raspberry, and can seriously reduce yield and postharvest quality (Strømeng, 2008). The disease results mainly from latent infection of flower parts, which under favorable conditions develops into rot once fruit begins to ripen. The open flower, white bud, and senescent flower stages are most susceptible to infection, whereas flowers at the green bud stage are relatively resistant. Infections at the white bud stage, however, are much less likely to lead to gray mold than infections at the open flower stage. The incidence of gray mold correlates strongly with environmental variables during the flowering period, particularly long periods of high relative humidity. Gray mold is managed principally by protecting flowers from infection.

Using biocontrol agents to manage *Botrytis* has received much attention in the last decade. The use of pollinating insects for the biological control of plant diseases and pests has its origins in the early 1990s (Peng et al., 1992), when honeybees were first used to disseminate biological control agents to strawberry flowers as a replacement for insecticides. Subsequently the concept was termed ‘entomovector technology’ by Hokkanen and Menzler-Hokkanen (2007), and a more systematic development of the pollinator-and-vector technology was established. This environmentally friendly control strategy, where control agents against plant pathogens and insect pests, are delivered directly onto crop flowers, while simultaneously fulfilling the pollination requirement, represented an innovative way of crop protection for organic as well as conventional cropping systems. Because the appropriate BCA is colonizing the flowers, natural disease suppression is achieved as a consequence of the frequent pollination visits at each inflorescence (Smagghe et al., 2012). The unique concept of entomovectoring incorporates several ecological components, including pollinators, biocontrol agents, and plant pathogens and/or insect pests (Kevan et al., 2008). However, its success is based on mutual and compatible interactions between the appropriate components of the vector, control agent, formulation, and dispenser, and the safety of the environment and human health, in particular the operator/manager at the farm. One of the reasons which has led to the development of the entomovectoring technology as a biocontrol strategy was the need to reduce the application of environmentally harmful synthetic pesticides. Concerns regarding the impact of conventional chemical pesticides on human health and the environment, and the development of resistance by pests, have led to the search for alternative methods. Also, biological control methods, where BCAs have been used as conventional applications (e.g., biofungicides), often have resulted either in poor control, or in too high application costs, resulting in slow progress towards an ideal system. The entomovectoring technology represents a promising alternative, wherein pollinators achieve a dual role: control agents are directly delivered on the target location (i.e., the flowers), while the pollination needs are fulfilled (Mommaerts & Smagghe, 2011; Jedrzejewska-Szmek & Zych, 2013; Ceuppens et al., 2015). In this way the BCA forms an effective disease and pest management tool during flowering of the crop, and during the development of fruits, since the flowers are the main location of infection by plant pathogens (e.g., *B. cinerea*) and insect pests (e.g., the western flower thrips *Frankliniella occidentalis*). Control of these infections by the entomovector technology can thus increase marketable fruit and berry yields (Mommaerts et al., 2011), and even play a role in controlling post-harvest diseases, such as *Alternaria alternata* (Nallathambi et al., 2009).

WHAT IS OUR CONTROL AGENT?

For a good description of the control agent used for our field trials, consult the following link, patent application: http://www.google.com/patents/US5968504

It is known that fungi of the genus *Gliocladium* have fungicidal activity. *Gliocladium virens* strains, especially the *G. virens* strain G1-3, have been described in patent literature. A problem in the use of this species has been the difficulty to produce a formulation of this fungus, in which the viability of the fungus would keep on a satisfactory level during the storage of the formulation.

The Product “Prestop® Mix” is based on *Gliocladium catenulatum* fungal strains, which were found to be very active against a number of deleterious fungi.

The product Prestop® Mix is based on the active ingredient of fungal strains belonging to the species *Gliocladium catenulatum* and optional carriers. Examples of such formulations are compositions suitable for seed dressing, or to treat the soil.

The soil samples, from where the fungal strains of the invention have been isolated, were collected in the years 1989 to 1991 from different parts of Finland, mainly from the research stations of MTT (Agricultural Research Center), from different soil types, and different crop rotations using barley and wheat as bait plants. The samples were taken from the root layer (from the depth of 0 to 15 cm). Several subsamples were taken from each field, which were pooled to samples of 1 to 2 liters.

The fungal strains isolated from the soil samples were tested with the screening method described in the FI patent application 94 0463. Then five strains were found, which gave very good results. The strains, which were named *Gliocladium catenulatum* J1446, *Gliocladium catenulatum* M67-6, *Gliocladium catenulatum* J2734, *Gliocladium catenulatum* M2423 and *Gliocladium catenulatum* M3081, where characterized at DSM (Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH) in Germany. These strains have been deposited on May 19, 1994 according to the Budapest Treaty to the DSM depository by the accession numbers DSM 9212, DSM 9213, DSM 9214, DSM 9215 and DSM 9216, respectively.

PATHOGENICITY OF THE FUNGAL STRAINS

Efficacy of the J1446 fungal strain in the control of plant diseases was tested in a number of tests on eight plant species in total. None of the tests showed any detrimental effect of J1446 to the development

of the plants, even when in some of the tests especially the seeds of the plants were treated, sometimes with quite high doses. On the basis of this it is evident that J1446 does not impede the development of the plants.The mycelia of the fungal strain J1446 have not been noticed to penetrate into the mycelia of other fungi.
The *G. catenulatum* fungal strains have proven to be promising to be used in the biological control of plant diseases. The strain J1446 effects well against three very common soil-borne causes of damping-off: *Rhizoctonia solani, Pythium* and *Fusarium* fungi. Additionally, good results have been obtained with the strain J1446 in the control of seed-borne diseases cause by the fungi *Alternaria* and *Fusarium*. With the fungal strains and their formulations good results have been obtained by using amounts, which are realistic in the cultivation in practice. It is also very promising that when mixed with the growth medium they have in tests kept their ability to control soil-borne diseases for long times.

STRAWBERRY AND RASPBERRY GREY MOLD CONTROL

Peng et al. (1992) and Yu and Sutton (1997) reported good control of grey mold in raspberries and strawberries using *Gliocladium roseum*, reducing *B. cinerea* incidence from 90 to 68%, and from 64 to 48%, respectively. To our knowledge, results reported in Hokkanen et al. (2015) represent the first successful use of entomovectoring by growers over large cropping areas. A review of entomovectoring (Mommaerts & Smagghe, 2011) provided a listing of numerous other studies with a wide variety of target diseases, pests, crops, and antagonistic BCA, but could not identify practical applications in crop protection – other than our case in Finland. In the ERA-NET CORE ORGANIC 2 project BICOPOLL the group provided evidence that the control of *B. cinerea* on strawberry by using entomovectoring is possible across Europe, and that control results are similar to chemical fungicides. Furthermore, our Finnish on-farm research results with raspberry (Hokkanen et al., 2015) confirmed that grey mold can be controlled with entomovectoring in commercial production of that crop as well.

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