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Multiple Fungicide Resistance in *Botrytis*: A Growing Problem in German Soft-Fruit Production

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1. Introduction

In the mild and humid climate of northwestern Europe, fungal pre-harvest rots are a major factor limiting the production of soft-fruits such as strawberries and raspberries. By far the most important fungal disease is grey mould caused by *Botrytis cinerea* Pers.:Fr., now known to be an aggregate of at least two distinct species (Fournier *et al.*, 2005; Giraud *et al.*, 1999). Primary infections are initiated at flowering, resulting in a quiescent colonisation of floral organs (Bristow *et al.*, 1986; Puhl & Treutter, 2008). Upon ripening of the infected fruit, a brown rot becomes apparent (Fig. 1A) which rapidly engulfs the entire fruit, culminating in the production of conidiophores (Fig. 1B). If mild and humid conditions prevail at harvest time, conidia released from fruits with primary infections may infect healthy fruits, causing a catastrophic grey mould epidemic (Fig. 1C). Repeated fungicide applications during flowering are therefore essential to control *B. cinerea* in soft-fruit production.

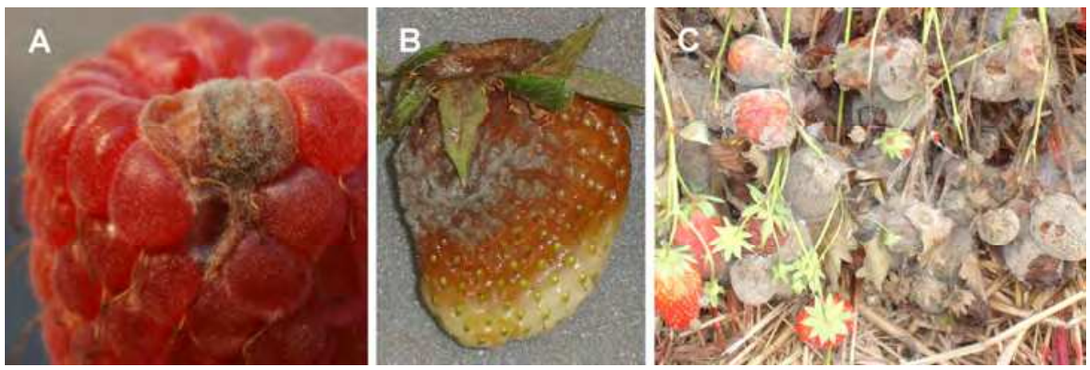

Fig. 1. Stages of *Botrytis cinerea* infections in soft-fruits. (A) Escape of a limited infection from quiescence in a ripening raspberry fruit. (B) Development of a spreading brown rot with the first crop of conidia on an infected strawberry fruit. (C) Occurrence of severe secondary infections during mild and humid weather in a strawberry field in early July 2007.

Northern Germany is a major soft-fruit producing region comprising some 4,000 ha strawberries, 1,500 ha blueberries, 100 ha raspberries and smaller areas dedicated to gooseberry, redcurrant and blackberry production. During the past five years, severe losses

because previous workers have obtained heterogeneous results (Gullino *et al.*, 1989; Hunter *et al.*, 1987; Northover & Matteoni, 1986). If a suitable broad-spectrum fungicide can be found, this should be registered for grey mould control with some urgency.

Similar trials should also be performed with alternative control agents such as inducers of systemic acquired resistance or biological control organisms. As with broad-spectrum fungicides, efficacy should be evaluated as an effect on the spread of fungicide resistance, rather than (or in addition to) grey mould control *per se*.

4.3 Issues of cultivation

Crop cultivation should aim to maximise yields as well as create conditions which optimise fungicide efficacy. Nitrogen fertilisation of strawberries should be reduced to about 60 kg ha^{-1} *per annum* which is sufficient to ensure a good yield whilst avoiding soft plant tissues susceptible to *B. cinerea* infections. Periods of leaf wetness should be reduced to a minimum by using drip irrigation if possible, or alternatively by using rather than extending natural periods of leaf wetness for overhead irrigation. Strawberry or raspberry crops grown in poly-tunnels or under fleece for early cropping should be aerated regularly in order to reduce periods of leaf wetness. Likewise, the planting distance should be sufficient to ensure a good ventilation of leaves and flowers.

Hygiene measures aimed at reducing inoculum should be given a high priority. Thus, rotting or mouldy fruits should be collected separately and removed from the field especially during the first pickings of the season. Likewise, infected raspberry canes should be pruned and removed from the field before bud burst.

4.4 Outlook

In contrast to pome fruit farming, there is no commercially relevant organic soft-fruit production in Germany, the chief reason being dramatic pre- and post-harvest losses to grey mould. Clearly, non-chemical crop protection measures alone are insufficient to provide acceptable control of *B. cinerea* in Northern Germany. However, as we have discussed in the present chapter, a similar situation may soon hold for the current crop protection strategy based on specific fungicides. Fungicide resistance development in *B. cinerea* should catalyse a change of paradigm towards a truly integrated crop protection concept embracing both chemical and supplementary non-chemical measures. There should be ample rewards for fruit farmers willing to embark on such a concept because of a stable demand for fresh and regionally produced soft-fruits on the market.

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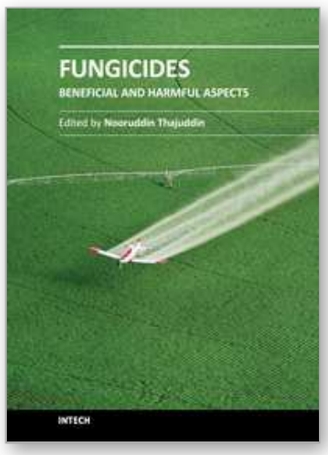

Fungicides - Beneficial and Harmful Aspects
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Fungicides are a class of pesticides used for killing or inhibiting the growth of fungus. They are extensively used in pharmaceutical industry, agriculture, in protection of seed during storage and in preventing the growth of fungi that produce toxins. Hence, fungicides production is constantly increasing as a result of their great importance to agriculture. Some fungicides affect humans and beneficial microorganisms including insects, birds and fish thus public concern about their effects is increasing day by day. In order to enrich the knowledge on beneficial and adverse effects of fungicides this book encompasses various aspects of the fungicides including fungicide resistance, mode of action, management fungal pathogens and defense mechanisms, ill effects of fungicides interfering the endocrine system, combined application of various fungicides and the need of GRAS (generally recognized as safe) fungicides. This volume will be useful source of information on fungicides for post graduate students, researchers, agriculturists, environmentalists and decision makers.

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