SLUTRAPPORT

GUDP-projekt [01/08/2018-30/04/2022]

Sprayless

Reduced fruit waste by non-chemical approaches to control strawberry grey mould

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gudp

Grønt Udviklings- og Demonstrationsprogram

Projektet, som er beskrevet i denne rapport, er støttet af Grønt Udviklings- og Demonstrationsprogram, GUDP, som er en erhvervsstøtteordning under Ministeriet for Fødevarer, Landbrug og Fiskeri.

GUDP giver tilskud til projekter, der understøtter grøn og bæredygtig omstilling af fødevareerhvervet, og programmet dækker hele værdikæden fra primærproduktion til forarbejdningsindustri og afsætningsled.

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FAKTA OM PROJEKTET

- Projektperiode: 01-08-2017 to 31-07-2021
- Projektdeltagere: AU, Gartnerirådgivningen, Lindflora, SW Horto, I/S Lykkesholm, Peter Stybe Petersen, Per Nielsen
- Bevilling fra GUDP: 5.058.310 kr.
- Projektleder: Antonios Petridis (since March 2020; former project leader: Marianne Bertelsen)

FORMÅL

The overall aim of the project is to ensure that the Danish strawberry growers are not (and will not be) challenged by grey mould strains that are multi-resistant to pesticides, thereby enabling Danish consumers to have access to high-quality strawberries that are produced with less pesticide input and last longer on the self.

PROJEKTETS RELEVANS

Grey mould, caused by *Botrytis cinerea* and related *Botrytis* spp., is by far the most important fruit disease of strawberries. *Botrytis* spp. are high-risk pathogens with respect to the development of resistance against fungicides with specific modes of action. All fungicides currently registered for grey mould control in Denmark, Germany, Norway and many other European countries belong to this type. Farmers' observations of increasing grey mould problems in the face of intensive spray schedules have led to investigations revealing high and rising levels of fungicide resistance in Germany and Denmark. Of particular concern are multi-resistant (MR) strains expressing simultaneous resistance to all five currently used fungicide classes and unaffected by any of the available fungicides.

How fungicide-resistant *Botrytis* strains colonize soft-fruit fields is not well understood. There is evidence that the share of resistant strains in a population is related to the intensity of preceding spray seasons, i.e. that a farmer can enrich his field with resistant strains by conducting intensive fungicide sprays. There is also evidence from raspberries that MR strains can be introduced into production fields with contaminated nursery material and the same could also be the case for strawberries. Whilst it is reasonable to assume that contaminated nursery plants are a critical source of subsequent crop failures due to resistance problems, no routine tests to quantify these contamination levels have been developed so far.

Based on small-scale field experiments it can be postulated that a moderate schedule of three sprays at flowering can give a higher overall efficacy than more frequent sprays, and that the picking and removal of infected fruit especially at the beginning of harvest can delay the outbreak of a grey mould epidemic.

In addtion, cooling of the strawberries is fundamental to retain fruit quality by lowering grey mould infestations. At present, fruits are not cooled until they reach the pack houses leaving a 3-hour gap from picking to cooling. Research in Florida has shown that rapid cooling in the field may reduce the infection by up to 30%, but whether this is also true for colder climates needs further investigation. The content of this project has been developed to examine these ideas with a view to providing a sound basis for a more sustainable Danish strawberry production system.

HOVEDRESULTATER

To achieve project's goal, we used a holistic approach that focused on supplementing and partly replacing the fungicide sprays with a quality control of nursery plants, reducing fungicide applications to a maximum of 3-4 sprays at flowering, and applying hygiene measures that retard the spread of fungicide-resistant strains of Botrytis in strawberry fields.

First, we determined the extent of *Botrytis* infection and resistance status by screening plants from two different providers (German vs. Dutch) differing in contamination with Botrytis. These plants were also subjected to different fungicide treatments during flowering (0, 3, and 6 sprays). We found that the *Botrytis* isolates on fruits harvested from the plants of German origin had lower shares of resistance to all fungicides compared with those from the Dutch isolates, and this applied to the frequency of multi-resistant strains too. However, the impact of fungicide treatments was less pronounced, although a higher share of fungicide resistance was always evident in the high-intensity spray schedule in both the German and the Dutch plants. This work highlights the importance of having a clean planting material, as nursery plant contamination with fungicide-resistant *Botrytis* strains contributes to the further development of fungicide resistance in the field, and keeping sprays to a minimum possible (i.e. 3 sprays).

We then conducted a trial to examine the on-farm spread of multi-resistance strains. In particular, Botrytis-infected fruits were harvested from a commercial field and from our plants according to their distance from the edge of the commercial field, whereby the number of plants increased with increasing distance. Our results confirmed that there were no differences in resistance spectrum between Botrytis isolates harvested from any part of the field. Interestingly, a massive increase in the levels of resistance to individual fungicides as well as in the share of MR isolates was observed at harvest as compared to the nursery plants. These data confirmed our previous estimation that a contamination of max. 10% of nursery plants with MR strains is a threshold beyond which commercial strawberry production is compromised under conditions of intensive fungicide use.

We also compared two different growing conditions (open field vs. tunnels) and strawberry types (June-bearing vs. everbearing) to see the selection pressure according to production system and strawberry type. In contrast to our hypothesis (higher share of MR strains in open field), we did not find any difference between the two production systems, probably due to lack of proper hygiene practices and ventilation within tunnels. Moreover, we did not find any difference between June-bearing and everbearing varieties.

Finally, we found that different transportation practices of harvested strawberries do not have a significant influence on shelf-life and fruit quality; however, rapid cooling does impact on shelf-life and could result in 15-20% less waste.

PROJEKTFORLØB OG ERFARINGER

The project lasted for 4 + 1 years, and although we managed to perform the activities described in the application, we had to adjust some of them or design new experiments because of several unpredictable challenges that we experienced throughout the project period. These challenges were associated with the change in project leadership halfway the project, the Covid-19 outbreak that occurred in a critical period of the project, the dry seasons that resulted in very low infection rates, and a massive loss of plants due to as yet unknown reasons. However, despite those challenges we persevered and brought the project to completion. ,

KONKLUSION OG PERSPEKTIVERING

Grey mould is the most important fruit disease of strawberries that can develop resistance against fungicides with specific modes of action. In this project, we developed a Botrytis resistance test to nursery plants, examined the on-farm spread of multi-resistance strains, and explored ways to reduce the spread of multi-resistance strains in the field and prolong the shelf-life of strawberries.

A resistance test of nursery plants can make predictions about the likely development of grey mould in a strawberry field during its production period, but this is strongly influenced by the subsequent use of fungicides too. Furthermore, six sprays gave much higher proportions of multi-resistant isolates than three sprays, while failing to provide any enhanced grey mould control efficacy. Finally, rapid cooling prolonged the shelf-life of strawberries resulting in less waste.

Based on our findings, we recommend to strawberry providers and growers the following:

1. Take care to obtain nursery plants free from multi-resistant grey mould. If there is a reason to doubt the quality of the nursery material, a fungicide resistance test can be arranged by HortiAdvice.
2. Excessive growth promotes grey mould. Therefore, restrict nitrogen fertilisers to the necessary minimum.
3. It is not the number, but the type of Botrytis isolates that matters. If fewer than 5% of plants harbour multi-resistant strains, no grey mould problems will be encountered during normal seasons and under normal spraying regimes of three or a maximum of four sprays at flowering.
4. If 5-10% of plants harbour multi-resistant Botrytis, fungicide sprays must be reduced to three per season in order to avoid a catastrophic enrichment of these strains in the first year.
5. If over 10% of plants harbour multi-resistant isolates, serious Botrytis problems are to be expected in conditions where repeated fungicide sprays are necessary. Under these conditions, it is preferable not to use such heavily contaminated nursery plants. Instead, these should be rejected or planted in less challenging situations.

FORMIDLING

- Projekt skal bekæmpe resistent gråskimmelsvamp i jordbær og sænke pesticidforbrug, MST 2017
- Resistent gråskimmel er et voksende problem for danske jordbæravlere, DCA 2018
- Joerdærtematag, (2018, 2019)
- Food Festival, 2019
- ‘A matter of time: The decline of grey mould fungicide resistance in Danish strawberries’ (2022) (to be published in Gartner Tidende)

- ‘A matter of quality: The role of clean nursery material in grey mould fungicide resistance in strawberries’ (2022) (to be published in Gartner Tidende)
- ‘The impact of rapid cooling on strawberry post-harvest shelf life and quality (2022) (to be published in Gartner Tidende)

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