Feature

By Sharella Schop
PhD student

Investigating Mature Plant Resistance to aphids as a way to prevent Virus Yellows infections in the field

Aphids are the vector species of yellowing viruses in sugar beet. In Europe, Beet yellows virus, Beet mild yellowing virus, and Beet chlorosis virus are most prevalent and can result in yield losses up to 47%[1]. In the past, neonicotinoids were used against aphid infestation in the field. However, because of the current restrictions on the outdoor use of neonicotinoids and the limitations on suitable chemical substitutes, there is a need for alternative ways to prevent aphid infestation in the field and subsequent virus infections. In sugar beet, a resistance mechanism against aphids called "Mature Plant Resistance" (MPR) is already known. Aphids which feed on plants that have reached the 14th leaf stage, will die. Prior to their death, a black stomach deposit is formed, which seems to be related to the death of the aphids (Fig 1)[2]. Understanding the molecular pathway underlying MPR and elucidating the cause of death of the aphids, is necessary to exploit this trait and avoid aphid infestations and virus infections in the field.

The PhD project "The control of beet yellowing viruses through mature plant resistance" started in September 2019 and is a collaboration between BBRO, SESVanderHave, Cosun Beet Company, IRS (Dutch Institute for sugar Beet Research, and Wageningen University.

Fig. 1. Aphid with a black stomach deposit

The major aim of this project is to understand the underlying pathway of the resistance mechanism and to elucidate the interaction between yellowing viruses and MPR, as it is known that yellowing viruses are able to interfere with the resistance pathway. In the past two years, the focus of the project has been on investigating the toxicity effects of MPR on the aphids, investigating the variation in MPR between beet genotypes, and identifying how MPR is affected by environmental stimuli. Also experiments have focussed on the identification of the black stomach deposit. However, further experiments are still needed to resolve the identity of the black deposit.

In May 2020, a field trial was sowed to investigate possible variation in MPR between six genotypes of which seeds were provided by SESVanderHave. At four timepoints during the growing season, the effect of MPR on aphid survival was determined for all six genotypes. Eighty-seven days after sowing MPR was highest for all genotypes; within eight days after placing aphids on the plants between 73% and 85% of the aphids had died (depending on plant genotype). In figure 2, the average percentage of aphids that formed a black deposit during the field experiment is given for each timepoint, clearly showing an increase over time. In addition,

References

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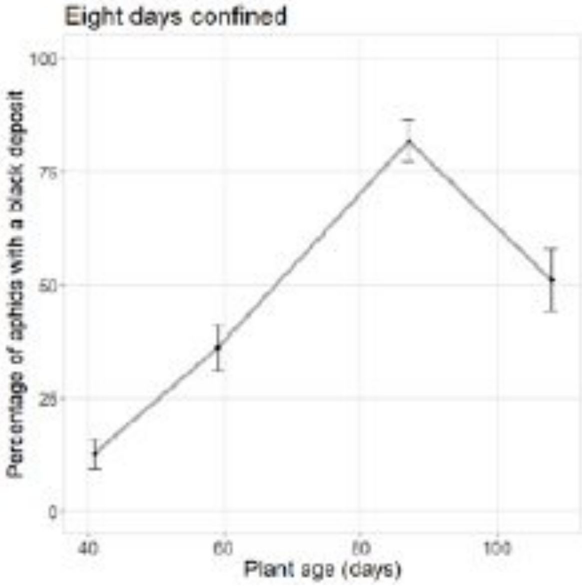

Fig. 2. Field experiment to determine variation in mature plant resistance between genotypes. Left) picture of leaves infested with aphids. Right) Percentage of aphids that formed a black deposit on sugar beets at different infection moments during the growing season.

significant differences between genotypes could be observed (results not shown). There were also many interaction effects between the genotypes and plant age. This means, that at a specific time point genotypes showed relatively high levels of MPR, while at another time point, the same genotypes showed relatively low MPR. At certain moments during the trial temperatures were extremely high (timepoint 3), which could have influenced the physiology of the plants and thereby affecting MPR. We are currently investigating what kind of physiological changes (affected by environmental stimuli) are resulting in increased MPR.

Climate-controlled experiments were also performed to investigate variation between sugar beet genotypes (Fig. 3). Under these controlled conditions, differences in MPR between genotypes were much smaller. In addition, genotypes that resulted in high MPR in the field trial showed relatively low MPR in the climate-controlled experiment. Based on the results of the field trial and the climate chamber experiment, we expect environmental effects to play a major role in MPR, while genetic variation may play a less important role. To investigate this further, the effect nutrients and heat stress, will be investigated in climate-controlled experiments in the near future.

Apart from investigating the variation in MPR between sugar beet genotypes, we also studied the toxicity effects of MPR on the aphids in more detail. Aphids were confined on young and old sugar beet leaves of 6-week-old plants. On 6-week-old sugar beet plants aphids can form colonies, thus MPR was

Fig. 3. Climate-controlled experiments performed in the climate chambers of The Dutch Sugar Beet Research Institute IRS

expected to be low or absent on those leaves. However, preliminary research already showed that on the older leaves of 6-week-old sugar beet plants, MPR was present and aphids would form a black deposit and die within two weeks after placement. Therefore, we were curious to find out how aphid behaviour and health was affected by different levels of MPR on young and old leaves. For this, aphids were confined on young and old leaves and aphid mortality, fecundity and formation of black deposits was monitored.

The percentage of aphids that formed a black deposit and died was much higher on old sugar beet leaves, compared to young sugar beet leaves. In addition, fecundity was much lower on old leaves compared to young leaves (Fig. 4).

The results obtained in the last two years provide new information on the biotic and abiotic factors involved in MPR. Further research is currently underway to identify the underlying pathway involved in MPR by attempts to identify the chemical composition of the black stomach deposit in the aphids

With this PhD project, we aim to gain more insight in the mechanism(s) underlying MPR in sugar beet. This information may help breeding companies to breed for earlier activation of MPR or a higher intensity of MPR and help develop farming practices better exploiting MPR to control aphids and yellowing viruses.

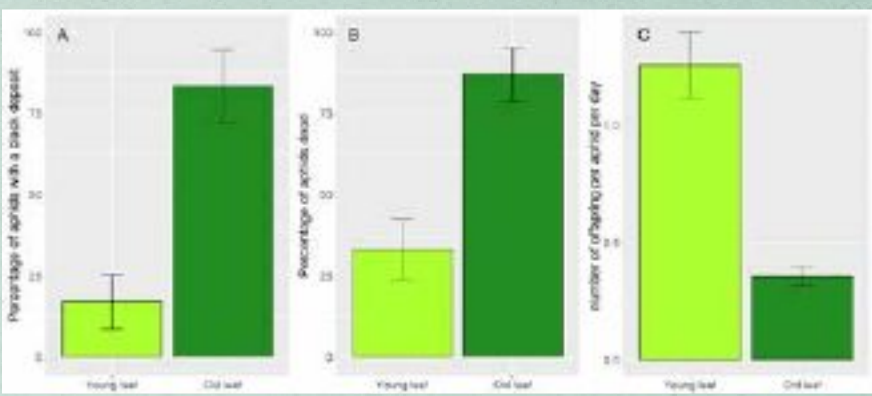

Fig. 4. The effect of MPR in young and old leaves of 6-week-old sugar beet plants on A) the percentage of aphids with a black deposit, B) percentage of aphids that died, and C) fecundity.