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Fructose and sucrose as priming molecules against pathogens and pests?

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Highlights

- In vineyards, fructose allowed to reduce the doses of copper against *Plasmopara viticola.*
- Fructose showed the same efficacy as the natural pyrethrum against *Scaphoideus titanus.*
- In corn production, sucrose and fructose reduced the number of *Ostrinia nubilalis* larvae.
- The sucrose reduced the frequency of attack of *Helicoverpa armigera.*

Introduction

Sugars could act as "priming" molecules inducing preparation of plants to defend in case of microorganisms' attacks. Theses knowledges led to the new concept of "sweet immunity" where sugars are widely accepted as players in plant innate immunity (Bolouri Moghaddam and Van Den Ende, 2012; Trouvelot *et al*., 2014). The exogenous foliar application of sucrose and D-fructose can induce resistance by antixenosis to the insect egg-laying codling moth (*Cydia pomonella*). In apple orchards, the application of sucrose at 0.01 g/l reduced the means of infested fruits by 41.0 ± 10.0% (Arnault *et al*., 2016). USAGE and SWEET frameworks contributed to explore the efficacy of sugars against pathogens and pests. Here, we reported new interesting results of field trials of the use of fructose and sucrose against downy mildew (*Plasmopara viticola*) and the leafhopper (*Scaphoideus titanus*) in vineyards and, against corn borer (*Ostrinia nubilalis*) and corn earworm (*Helicoverpa armigera*) in corn productions.

Material and methods

For the "downy mildew field trials", several treatments were applied in organic vineyards in 4 experiments between 2012 and 2014 (cultivars Gamay and Côt). The aim was to test the efficacy of fructose at 10 mg/l in combination with reduced copper dose (100 g/ha or 150 g/ha) compared to the reference copper dose (400 g/ha to 600 g/ha). Each bioassay was

randomised in block. The downy mildew assessment was done with the disease severity on fruits and leaves (percentage of organs covered by sporulating lesions).

For the “leafhopper field trials”, the objective was to compare the applications of sucrose and fructose at 10 mg/l on larvae (3 applications before the larvae stage) or associated with natural pyrethrum. One experiment was conducted in Vaucluse in 2016 on Sauvignon cultivar. Larvae were counted on 50 leaves per block.

Concerning the corn borer and the “corn earworm field trials”, the objectives were to test the effect of sucrose and fructose at 100 mg/l and 1 g/l. The two field trials located in Landes and in Bouches-du-Rhône were randomised in block. The first application of sugar was carried out in the seed line at the time of sowing and then the two following applications were carried out in the treatment of the aerial parts on maize (stages 2-3 leaves and 4-5 leaves).

Results and discussion

In the Gamay vineyards, the reduced copper modality combined with fructose at 0.01 g/l was intermediate between the modality of reduced copper and the maximal dose of copper. In the Côt vineyard, the modality of reduced copper with fructose at 0.01 g/l was as effective as the treatment with maximal dose of copper.

On grapevine, the sucrose at 0.01 g/l seemed to increase the action of pyrethrum on the populations of leafhoppers *S. titanus*. Fructose, used alone, has a comparative or even better efficacy than the one of pyrethrum only. The application of sucrose at 1 g/l and 10 g/l or sucrose at 1 g/l associated with fructose at 1 g/l reduced the number of corn borer larva per plant with an efficacy up to 50%. The association of sucrose + fructose at 1 g/l provided the best efficacy. The applications of sucrose at 1 g/l and 100 g/l made it possible to reduce the frequency of the attacked ears by corn earworm larvae with efficacy of 15 and 23%, respectively.

In conclusion, the applications of sugars were first tested with success to control the codling moth (*C. pomonella*) in apple trees and opened a door to the development of new strategies. This work brings new interesting results in organic vineyard for the biocontrol of the leafhopper and the downy mildew and in maize productions against the corn borer and the corn earworm.

Foliar applications of sugars are presented as methods of stimulating plant immunity to control pathogens and insects but the mechanisms were not yet elucidated. Several hypotheses can be advanced. A single sugar applied on leaves without any injury can induce a plant response. The output and input of the sugars through the cuticle follow the photosynthesis rhythm. One might think that a basic natural immunity (innate immunity) should be partially maintained by this mechanism. The application of sugar could be at the origin of a stress or a self-damage signal. The sugar should be present at the wrong time somewhere in the apoplast, in the plasma membrane or within the cell in the cytosol. At this occasion the immunity could be magnified. The host-specific non-pathogen associated epiphytic microorganisms can induce leaking of metabolites from plants and/or produce them. Their possible contributions to chemical signals given by the leaf surface are an issue that should not be ignored. The role of epiphytic microorganisms and genes involved in the plant-defence system (apple and vine) are explored in the framework SWEET (CAS DAR 2016-2019). Furthermore, sucrose and fructose have been approved for the control of European corn borer and codling moth as basic substances (EC implementing Regulations No 916/2014 and 2015/1392, respectively).

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