Tea Tree Oil Induced Resistance

Subjects: Plant Sciences
Contributor: Héros José Maximo

The essential tea tree oil (TTO) derived from *Melaleuca alternifolia* plant is widely used as a biopesticide to protect crops from several plant-pathogens. TTO was approved by the European Union (EU) and included in the positive list of the EU, in Annex I of Directive 91/414/EEC for registration of Plant Protection Products. TTO is classified as a low risk substance in Europe. This oil is in large use in cosmetics and in medicine.

Keywords: Melaleuca alternifolia ; Tea Tree Oil ; Plant Protection ; Plant Microbe Interactions ; Fusarium oxysporum ; Xanthomonas campestris ; Systemic Acquired Resistance (SAR) ; Induced Systemic Resistance (ISR) ; Priming ; Agriculture ; Agriculture

1. Introduction

Plants are exposed to various pathogens in their environment and have developed immune systems with multiple defense layers to prevent infections [1][2]. However, often pathogens overcome these resistance barriers, infect plants and cause disease. Pathogens that cause diseases on economically important crop plants incur huge losses to the agriculture industry and important ecosystems [3][4].

Chemical pesticides have often been used to control diseases in plants, but this conduct is associated to negative environmental impacts, potential human exposure to pesticides, and deposition of residues on the plant organs. However, the effectiveness of synthetic pesticides has been reduced by the frequent development of resistance by the pathogens. Hence there is a great demand for safer, alternative and effective agents [5].

Bananas, the world's most important fruit in terms of production, volume and trade [6] and among the world's top 10 staple foods, is seriously threatened by Fusarium wilt (FW) caused by the fungus Fusarium oxysporum f. sp. cubense (Foc). The fungus penetrates the plant through the root system and may causes plant death. After the death of the mother plant, the fungus continues infecting the daughter plant and remains active on the clump for years [7][8][9].

The tomato production is yearly affected by disease caused by Xanthomonas spp. [10]. The disease is characterized by necrotic lesions on the leaves, stems, petals, flowers, and fruit [11]. During the initial stages of symptom development, circular water-soaked lesions appear, which later dry and turn dark brown to black with a wet to greasy appearance [12].

Both microorganisms are important because of the losses they can cause in crop production. No chemicals are known to control Fusarium wilt [8] and they are very limited for bacterial diseases.

An alternative procedure to protect plants against disease is to activate their inherent defense mechanisms by specific biotic or abiotic elicitors. Plants can be induced to switch on defense reactions to a broad range of pathogens as a result of prior exposure to pathogens or to various chemicals or physical stresses. Induced resistance is expressed locally, at the site of the infection or systemically, at sites located far from the initial infection. Upon recognition of the initial stimulus by the plant, a signal transduction pathway is set in motion, that includes intra and intercellular signals, and results in the activation of defense mechanisms, mostly by the expression of new genes [13][14].

During the interactions with microorganisms and molecular patterns from the environment, plants produce several hormones that act as signals that trigger the production of antimicrobial compounds and activate defense in general [15][16]. Upon recognition, plants produce salicylic acid, jasmonate and/or ethylene as major defense signals [17]. Salicylic acid (SA), for example, plays an important role in defense in biotrophic interactions. SA biosynthesis is induced in the infection site where it contributes to reactive oxygen species (ROS) production and cell death in a positive feedback [18][19][20][21]. Jasmonate (JA) and ethylene (ET), on the other hand, are generally associated to the regulation of defenses against herbivores and necrotrophic pathogens, although exceptions can be seen [22][23]. The activation of both jasmonic acid and ethylene pathways is frequently associated with induced systemic resistance (ISR) [20]. Thus, the genes for the three defense related pathways can be considered as molecular markers to study induced resistance in plants.

Frequently, SAR or ISR are accompanied by the priming effect. Priming is a phenomenon in which a plant activates their defense system by recognizing a molecular pattern from the environment in the absence of a pathogen and no development of disease, the defense system is deactivated and the plant turns back to homeostasis [14]. However, if the plant is subsequently challenged by a pathogen or abiotic stress, through epigenetics, it can activate their defense system more rapidly and robustly [24][25][26]. Inducing priming is preferable rather than the classic resistance induction where the plants may allocate too much energy on defense and that may affect growth and production. [24][25].

The global search for plant-protection solutions, that are both environmentally safe and efficacious, is an important aspect of sustainable agriculture. This is driven by the need to supply food to the ever-growing world population, and the call for chemical load reduction.

2. The Essential Tea Tree Oil (TTO)

The essential tea tree oil (TTO) extracted from Melaleuca alternifolia plant, contains many components, mostly terpenes and their alcohols, was found to be an effective antiseptic, bactericide [27][28][29] and more recently as an effective fungicide [30][31][32]. Based on TTO, as an active ingredient, a natural fungicide Timorex Gold® (22.3 EC W/V), was prepared in order to enable the use of TTO on plant tissue [33]. In numerous crops, including bananas and fruit trees, this product was found effective against a broad range of plant-pathogenic fungi [32][33][34][35]. The high effectiveness of TTO raised questions regarding its ability to perform as a resistance inducer. TTO is highly applied in banana and tomato plants worldwide, however very little is known about its mode of action in these hosts physiology.

Thus, this study was undertaken to examine the induction of systemic resistance in field-grown banana plants to Fusarium wilt and greenhouse-grown tomato plants to bacterial disease. Symptoms, peroxidase and β-1,3-glucanase activities, and the expression of different marker genes related to SAR and ISR were evaluated in response to early treatment with the TTO.

3. Conclusions

TTO is able to prime tomato plants to have a strong defense reaction to subsequent challenges, such as mechanical wounding. These results also demonstrate that TTO provides protection to the plant independently of the fungicide effect.

Data in this entry paper also show that TTO can be consider as an efficient resistance inducer, since it has enhanced the expression of marker genes in non-symptomatic banana plants for both SAR and ISR at the three main defense related pathways—salicylic acid, jasmonic acid and ethylene. To the best of our knowledge, this is the first report on the effect of TTO as a resistance inducer, which opens new possibilities for this product to be used in strategies to control pathogens by decreasing the number of traditional defensive applications and inhibiting the spread of both *Fusarium oxysporum* in banana and *Xanthomonas campestris* in tomato as well as other type of pathogens in different crops.

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