



Mechanism of Elicitors' Activity in Plant Cell and Tissue Culture for Production of Secondary Metabolites

Seyed Mohammad Hashemi

Biotechnology and Plant Breeding Department, University of Tehran, IRAN



Global Summit on
Herbals & Natural Remedies
October 26-27, 2015 Chicago - USA

Introduction

In recent years, plant cell and tissue culture has received a great deal of attention, because of some advantages including, products on a large scale and high rate of secondary metabolites, good reproducibility and renewable source of valuable medicinal compounds (Kim et al 2012; Jeandet et al 2014). However, many type of plant cell and tissue cultures often do not produce adequate amounts of the required medicinal compounds. In many cases, the secondary metabolites synthesis can be improved with the use of “elicitors”. Also, elicitors plays an important role in expression of secondary metabolite and signaling molecule genes that cause enhanced of commercially compounds synthesis (Yin et al 2012; Hao et al 2014; Qin et al 2014)

Elicitation

One of the most significant methods for increasing of secondary metabolites production is elicitation. In this system “elicitors” plays a very important role to stimulating of components synthesis and expression of secondary metabolites genes. In general, upon perception of such an attack by the plant, a cascade of signal transduction pathways is initiated that leading to increased expression of genes involved in plant secondary metabolites pathways. On the other hand, many factors involved in plant cell and tissue culture elicitation, some of significant factors including, specificity of elicitor, duration of treatment, cell or tissue growth phase, elicitor concentration, composition of medium and light or other rays are more effective (Shinde et al 2009; Verma et al 2014).

Classification of Elicitors

Sometime, elicitors for plant cell, classified into two groups, “general elicitors” and “race specific elicitors” or “effectors” that depend to specificity of the defense response induced in plant species (Di et al 2008). The other classification system, elicitors are classified as physical or chemical, biotic or abiotic and complex or defined depending on their origin and molecular structure (Angelova et al 2006) (Table 1). Nowadays, biotic and abiotic elicitor are important in the plant redox system, for instance, to scavenge of reactive oxygen species (ROS) in oxidative stress. Metal ions (Co^{2+} , Ni^{2+} , Fe^{2+} and Ag^+) and glutathione are abiotic elicitors that stimulate the accumulation of plant secondary metabolites in different plant species (Spollansky et al 2000; Flores-Sanchez et al 2009; Zhao et al 2010). Biotic elicitors such as Yeast cellwall, Fungal extract or spore, Mycelia cell wall, bacteria, viruses, as well as abiotic elicitors. It is well known that treatment of plants with elicitors causes an array of defense reactions, including the accumulation of a range of plant defensive secondary metabolites in whole plants or in cell cultures.

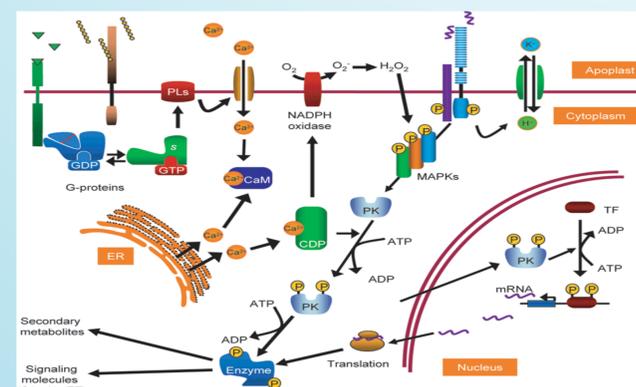


Fig 1. Effect of elicitors on expression of secondary metabolite and signaling molecule genes

Activity of Elicitors

Elicitor signal transduction is a multiple component network with various reactions to establish an efficient defense. These multiple components contain of some parallel or cross-linking signaling pathways leading to different target responses. An elicitor-signaling pathway may be differ with perception of different elicitor signals or with target defense responses. Plant signal molecules, such as, reactive oxygen species (ROS), jasmonic acid (JA), salicylic acid (SA), ethylene (E), nitric oxide (NO) etc., play the significant role in transmission the elicitor stimulation to intracellular defenses responses. The sequentially occurring events in elicitor- induced defense responses can be organized as follows (Fig. 1): recognized of elicitor molecules by specific receptors on the plasma membrane. GTP binding proteins (G-proteins) may be coupled to receptors and mediate elicitor-induced ion channel activation that cause biosynthesis of various secondary metabolites in plants (Sudha and Ravishankar 2002). Ion fluxes, especially Ca^{2+} influx, cause cytosolic free Ca^{2+} , extracellular and cytoplasmic acidification or alkalization, mitogen-activated protein kinase (MAPK), peroxidases activation spiking (Hamada et al 2012; Belchí-Navarro et al 2013), NADPH oxidase activation and phospholipases (Zhang et al 2009; Hong et al 2010), which further generate other signaling messengers, such as reactive oxygen species (ROS) that are very important signals for early defense gene expression, such as in *Salvia miltiorrhiza* hairy root cultures, Ca^{2+} influx is required for elicitor-induced ROS production (Liang et al 2012). On the other hand, JA and ET cause late defense response gene expression and secondary metabolites synthesis (Zhao et al 2005). diacylglycerol (DAG), Inositol-1,4,5-trisphosphate (IP3), cAMP, lysoPC, jasmonic acid (JA), ethylene, nitric oxide (NO), cADP ribose, and salicylic acid (SA). All these messengers compose paralleling or cross- linking pathways to integrate signals for regulation of transcription factors (TFs). Many transcription factors integrate these signaling to activate gene expression by transcription machinery. Also transcription factors play an important role in analysis of the DNA sequence of secondary metabolite gene may help to predict the possible regulation of the gene (Liu et al 1999; Chen and Rajewsky 2007). Most genes for secondary metabolite synthesis are later response genes (Chiron et al 2000).

Conclusion

In sum up, it should be noted that to date rapid success has been obtained in the production of commercial components using plant cell and tissue cultures. The supply of these secondary metabolites is however, often having many limitations including low yields of the desired compounds, incomplete understanding of the biosynthetic pathways and the technological processes involved in extraction and purification of these compounds. On the other hand, nowadays, many type of elicitors and elicitation methods using for investigation of growth rate of cell, understanding of biosynthetic pathways, and extraction or purification of these metabolites. All of these are for finding an especial way to increasing the production of secondary metabolites, which among them elicitors has an especial role. Here we reviewed the classification of elicitors, mechanisms of elicitors' activity, and applications for the production of secondary metabolites in plant cell and tissue culture.

Reference

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Elicitors							Abiotic	physical
Chemical								
Biotic							Abiotic	Wound
Defined composition								
Carbohydrates			Proteins	Lipids	Glycoprotein	volatiles	Complex composition	Metal ions (lanthanum, europium, calcium, silver, cadmium), oxalate
Polysaccharid	Oligosaccharides	Peptides	Cellulase, Elicitins, Oligandrin	Lipopolsaccharides	Not characterized	C6-C10	Yeast cell wall, Fungal extract or spore, Mycelia cell wall	
Alginate, Pectin, Chitosan, Guar Gum	Galacturonides	Glutathione						

Table 1. Classification of elicitors for plant cell