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Plant Cell Elicitation for Secondary Metabolite Production

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ABSTRACT: Plants, an irresistible resource that is necessary for the survival of all living things. Plants act as a biological chemical factory and repository for the production of variable secondary metabolites which are produced through secondary metabolic pathways using their enzyme complexes. These secondary products have pharmacological activity and used to make medicines and other commercially valuable products like beverages confectionaries, dyes, and taste enhancers, etc. one such medicinal plant that has these values and uses is *Hemidesmus indicus*. The roots of the *Hemidesmus* plant are demulcent, alterative, diaphoretic, diuretic, and act as a blood purifier. *Hemidesmus indicus* has also been used in the medicinal field in ancient times in India. The roots of *Hemidesmus indicus* are very useful in diagnosing the diseases such as Diabetes and urinary diseases. Apart from Diabetes and urinary disorders, the roots of *Hemidesmus indicus* are also useful in the treatment of neural as well as cardiac disorders. Nowadays, secondary metabolite are isolated from cultivated plants, because their chemical production is either very difficult process or expensive. The precise mechanism by which elicitation increases secondary metabolism in plants or plant cells in vitro is not fully understood, despite the fact that elicitation does increase secondary metabolism in plants. This opens the door for extensive research to be conducted in the field of biosciences regarding the utilization of plant cells for the production of secondary metabolites.

Keywords: Elicitation, Secondary Metabolites, Biotic Elicitors, Abiotic Elicitors.

INTRODUCTION

Plant ingredients and nutritional value have been studied extensively for decades because plants are such an important part of our daily diet. In addition to the fundamentals, Metabolites are substances that are produced by the body (*e.g.*, carbohydrates, lipids, and amino acids). Higher plants can also generate a large range of low-energy compounds. Secondary metabolites are molecular weight molecules. Secondary metabolites are chemicals found in plants that do not play a recognized role in the upkeep of basic life processes in the plants that produce them, they do, however, play a vital part in the relationship of the species, plant, and its surroundings. The manufacturing of these Compounds are frequently low in concentration (less than 1% dry weight) and are dependent on the physiological and developmental stage of the animal has a big impact on cultivation (Oksman-Caldentey *et al.,* 2004). Bioactive components or phytopharmaceuticals, which are used in the pharmaceutical business, are abundant in higher plants. Some natural products generated from plants include medications such as anti-cancer drugs include morphine, codeine, cocaine, and quinine, among others. Colchicines, catharanthus alkaloids, belladonna alkaloids steroids such as physostigmine, pilocarpine, and reserpine, as well as physostigmine, pilocarpine, and reserpine diosgenin, digoxin, and digitoxin are all types of diosgenin. Several of these pharmaceuticals are still in use today and they are frequently ineffective. Synthetic alternatives with the same properties have been discovered with pharmacological specificity and efficacy (Rahman & Mujib 2007). Currently, one-fourth of all prescribed medications in industrialized countries are made in China. According to the WHO, 11% of medications are produced solely from flowering plants. Plant-derived drugs are also a major market in Western countries value. In the United States alone, prescription medications containing phytochemicals were worth more than $30 billion in 2002 (Rahman & Mujib 2007). Due to secondary metabolites' physical and chemical properties, importance of nanomaterials, and increasing usage in different disciplinary sciences, the scientific communities have focused on their enhancement by different elicitors. However, the exact mechanism of elicitation is yet to be elucidated. Researchers have revealed that metal nanoparticles can cross through the roots or leaf by capillary action (Sanjukta *et al*., 2016).

Treatment of undifferentiated cells with elicitors such as methyljasmonate, salicylic acid, chitosan, and heavy metals can increase the synthesis of secondary metabolites in many circumstances (Poulev *et al*., 2003). Secondary metabolites are generated only in organ cultures such as hairy root or shooty teratoma (tumor-like) cultures in some situations. Hairy roots generate alkaloid (Sevón & Oksman-Caldentey 2002) but shooty teratomas produce Monoterpenes.

However, there are a few exceptions. Production of rosmarinic acid on a smaller scale, cell cultures of *Coleus blumeii* have also proven successful big scale, as well as sanguinarine, which has a potential market in cell cultures of bacteria have been used to create mouth hygiene products. *Papaver somniferum* is a somniferous plant (Rahman & Mujib 2007). A good example of a high-value item is a paclitaxel is a medication made partly from plant cell cultures, an anti-cancer medicine derived from the bark of 50–100 trees, pacific yew trees that are 60 years old (*Taxus brevifolia*). Despite these few successful examples, producing secondary metabolites in cell or organ cultures is far from simple, and various technical barriers, such as poor productivity and process technology challenges (such as bioreactors and growing conditions), must be overcome. Elicitation is discussed in this review as a method for increasing the generation of secondary metabolites from medicinal plants. The definition of elicitors, categorization of elicitors, method of elicitation, elicitor features, and application of elicitors to medicinal plants have all been discussed.

An elicitor is a chemical that, when administered to a live cell system at minute quantities, begins or enhances the manufacture of certain molecules. Elicitation is the process of inducing or enhancing metabolite production by adding tiny quantities of elicitors (Radman *et al.*, 2003). Elicitation is one of the most successful ways for enhancing secondary metabolite biotechnology production now in use. Elicitors are chemicals that promote secondary metabolism to protect the cell and the entire plant (Poulev *et al.,* 2003). Elicitors are classified into two categories based on their origin: biotic and abiotic. Abiotic elicitors are chemicals that are not biological in origin and are mostly inorganic compounds like salts or physical forces (Rahman & Mujib 2007). Inorganic substances, such as salts or metal ions, have been utilized to boost bioactive molecule synthesis by altering plant secondary metabolism. PSM can be elicited by salts such as $AgNO_3$, $AlCl_3$, $CaCl_2$, $CdCl_2$, $CoCl_2$, $CuCl_2$, $HgCl_2$, KCl, $MgSO_4$, $NiSO_4$, $VOSO_4$ and Zn ions.

EFFECTS OF BIOTIC ELICITORS ON SECONDARY METABOLITES PRODUCTION

Biotic elicitors are biological substances such as polysaccharides derived from plant cell walls, including chitin, cellulose, pectin, etc., and microorganisms. The mechanism is based on the contact of the elicitor and the receptor, which results in a series of biochemical reactions. The elicitor binds to a receptor on the plasma membrane, which initiates the process. The contact between the elicitor and the receptor causes changes in the ions present across the cell membrane, such as the influx of calcium ions (Ca^{2+}) and the efflux of cations (K^+) and anions (Cl^-) (Shabala & Pottosin 2014). In medicinal plants, biotic elicitors have been used to boost secondary metabolite production (Naik & Al-Khayri 2016). Major Secondary pharmaceutical products includes alkaloids, glycosides, flavonoids, volatile oils, tannins, and resins. They can be used as adaptations to environmental stress or as a source of information. Chemicals that are defensive, protective, or harmful against microorganisms, insects, and herbivorous predators are higher.

Polysaccharide Elicitors. Polysaccharides are mainly cell wall components often derived from endophyte cell wall digestion by plant hydrolases as an elicitor. Heteropolysaccharides make up most of their structures (Chen *et al.,* 2016). They are divided into two groups: exogenous, which includes chitin, chitosan, and endogenous, which involves pectin cellulose (Szepesi & Szollosi 2018). Polysaccharides play a crucial role in cellular communication, stress resistance, and other functions. Antimicrobial metabolites are frequently elicited using polysaccharides (Li *et al.,* 2019; Paulert *et al.,* 2009).

In cell suspension cultures of *H. perforatum*, chitin promoted the synthesis of phenylpropanoid and naphthodianthrone. It inhibits the production of flavonoids due to suppressed chalcone-flavanone isomerase activity (Gadzovska Simic *et al.,* 2014, 2015). The polysaccharide agaropectin promoted the synthesis of the naphthoquinone shikonin in cultured *Lithospermum erythrorhizon* cells. Chitosan treatment of *Plumbago rosea* cultures enhanced plumbagin content (Naik & Al-Khayri 2016b). The cell wall–derived elicitor oligogalacturonic acid significantly boosted the ginseng saponin concentration in a Panax ginseng cell solution (Naik & Al-Khayri 2016). In shoot cultures of *Ruta graveolens,* chitin or chitosan stimulated the synthesis of coumarins and fluoroquinolone alkaloids (Orlita *et al.,* 2008). In the cell system of *V. vinifera*, chitosan increased the formation of trans–resveratrol as well as viniferins (Taurino *et al.,* 2015). Dextran, a polysaccharide found in bacterial cells and produced by the enzyme dextran sucrase from sucrose, may be utilized as a powerful elicitor. When wounds caused by *B. cinerea* infection on *Solanum lycopersicum* L. were treated with dextran as well as laminarin, they produced a lot of phenylpropanoid and flavonoids (Bhaskar *et al.,* 2021).

Yeast elicitors. Yeast extract is one of the most common elicitors used to research plant defence responses and secondary metabolite production. It boosted the production of numerous key metabolites in various plants (Bhaskar *et al*., 2021). It is a key elicitor with a high vitamin B-complex content (Maqsood & Abdul 2017). When a yeast cell wall extract was applied to hairy root cultures of *P. ginseng C.A. Meyer*, the saponin concentration rose dramatically (Bhaskar *et al.*, 2021). Yeast extracts increased ethylene production and bacterial resistance in tomatoes (Naik & Al-Khayri 2016) and beans (*Phaseolus vulgaris*) (Kuhn *et al*., 2015). In the root culture of *Perovskia abrotanoides*, yeast extract triggered the synthesis of tanshinone (Zaker *et al*., 2015). It is also utilized to elicit anthocyanin and phenolic compounds in *Vitis vinifera* L cell suspension cultures (Bhaskar *et al*., 2021). In *Catharanthus roseus*, eliciting yeast extract boosts vinblastine and vincristine production in protoplast-derived tissues and plantlets (Maqsood & Abdul 2017).

Fungal Elicitors. The breakdown products, metabolites, secreted compounds, or fermented liquid of fungi, which can also be classed as oligosaccharides, proteins, or fermented liquid, are used as fungal elicitors (Algar *et al*., 2012). One of the most efficient tactics for inducing phenylpropanoid/flavonoid biosynthesis pathways in plant cells is to use pathogenic and nonpathogenic fungal preparations as elicitors (Lattanzio *et al.*, 2006).

In research, it is found that the addition of fungal elicitors *Aspergillus niger* and *Fusarium oxysporum* at a concentration of 0.1 g/L and 0.75 g/L in *Hypericum triquetrifolium* resulted in the highest yields of rutin were 23.5 times and 7.7 times, respectively. When treated with biotic elicitor *A. niger*, as the concentration of elicitor increases, the catechin compound in leave cultures of *H. triquetrifolium* also increases (Basit *et al.*, 2021).

The fungal species *Trichoderma atroviride* releases trehalose. Trehalose can help keep lipids and protein membranes stable (Govind *et al.*, 2016). Plants produce trehalose in response to abiotic stressors such as drought, salt, and oxidative stress. It encourages rapid plant growth, reproduction, high crop productivity, soil nutrient uptake, higher yield, and abiotic and biotic stress resistance (Sood *et al*., 2020). The much more suitable, eco-friendly, non-toxic, and organic product that provides natural growth stimulation and a bio-control agent to the developing agriculture industry alongside the current traditional chemical fertilizers on the market is a trehalose elicitor with proof of disease resistance (de Britto *et al.*, 2021).

Bacterial Elicitors. The suppression of H6H (Hyoscyamine 6–hydroxylase) expression by bacterial elicitors promoted the production of scopolamine in adventitious hairy root cultures of *Scopolia parviflora* (Jung *et al*., 2003). *Taverniera cuneifolia* roots contain a significant quantity of glycyrrhizic acid (GA), which is why it is thought to have therapeutic effects. When comparing untreated control roots of *Taverniera cuneifolia* to *Rhizobium leguminosarum* challenged culture, the most extraordinary glycyrrhizic acid rise was seen in *Rhizobium leguminosarum* challenged culture. Furthermore, glycyrrhizic acid content increased significantly in *Agrobacterium rhizogenes*, *Bacillus aminovorans*, as well as *Bacillus cereus* challenged cultures. *Agrobacterium tumefaciens*-challenged root cultures, on the other hand, showed no significant increase in glycyrrhizic acid concentration (Awad *et al*., 2014b).

Hypericum perforatum looks to be a viable alternative for treating mild to moderate depression. After being challenged with Rhizobacterium, seedlings of *H. perforatum* showed a progressive rise in hypericin as well as pseudohypericin. It has been found that these bacterial elicitors are beneficial when released into the culture medium and conveyed through the roots. The impact can be replicated in shoot cultures. As a result, these elicitors have much potential to improve phytopharmaceutical production (Javier Gutiérrez Mañero *et al.*, 2012). Coronatine, a phytotoxin generated by *Pseudomonas syringae*, strongly increased taxane synthesis in taxane medium cell cultures (Onrubia *et al*., 2013) and viniferins production in *Vitis vinifera* cell cultures (Naik & Al-Khayri 2016).

EFFECT OF ABIOTIC ELICITORS ON SECONDARY METABOLITE PRODUCTION

Elicitation is the method which is widely used for the production of useful secondary metabolites. Abiotic elicitation is the process in which the plant cells or plant tissue cultures are treated with the diverse abiotic elicitors which trigger the synthesis of Phytochemicals (Thakur *et al.*, 2019). These Elicitors act as signal molecules initiating a cascade of reactions which leads to the expression of regulatory genes causing higher accumulation and synthesis of secondary metabolites (Halder *et al.*, 2019).

Abiotic Elicitors are substances of Non – Biological origin that are broadly classified into three categories-Physical, Chemical and Hormonal. Physical Abiotic elicitors include UV radiations, Osmotic stress, Salinity, Draught, Thermal stress, PH, Ozone, Temperature, Gas Toxins, Light etc. (Thakur *et al.*, 2019; Naik & Al-Khayri 2016). Chemical Abiotic Elicitors consist of Heavy metals like copper-cu, calcium-ca, cadmium-cd, silver -Ag, selenium-Se, $AgNO_3$, $CdCl_2$, $CuCl_2$, $CuSO_4$, $NiSO_4$ and other mineral salts (Thakur *et al.*, 2019; Naik & Al-Khayri 2016). A lot of Elicitation studies have extensively used various plant Hormones because of their role in plant defense mechanisms. For Example – Jasmonic Acid, Salicylic Acid, Gibberellic Acid, Methyl Jasmonate etc (Naik & Al-Khayri 2016). The effectiveness of these elicitors depends upon a variety of parameters like concentration, Duration of exposure, Culture types, culture stage, Medium Composition etc (Halder *et al.*, 2019).

Table 1: List of widely used Abiotic Elicitors used for the secondary Metabolite Production.

Physical Abiotic Elicitors	Chemical Abiotic Elicitors (Include Heavy metals)	Hormonal Abiotic Elicitors
UV Radiations – UV-A, UV-B, UV-C	Silver (Ag)	Jasmonic Acid
Temperature	Cadmium (Cd)	Methyl Jasmonate
Osmotic Stress	Cobalt (Co)	Salicylic acid
Draught	Copper (Cu)	Gibberellic Acid
Thermal stress	Zinc (zn)	Acetylsalicylic acid
PH	Iron (Fe)	
Ozone	Lead (pb)	

(Artés-Hernández *et al.*, 2022; Halder *et al.*, 2019; Thakur *et al.*, 2019; Naik & Al-Khayri 2016; Jan *et al.*, 2021)

EFFECT OF PHYSICAL ABIOTIC ELICITORS ON SECONDARY METABOLITE PRODUCTION

UV exposure. UV radiations have been extensively used as Abiotic Elicitors in plant Hairy Root cultures for secondary metabolites production (Artés-Hernández *et al.*, 2022). Based on wavelength, UV radiations are further classified into 3 types – UV- A, UV-B, UV-C. Application of optimal dose of UV-B increased 1.3 folds accumulation of total AG (3.43mg g-1 DW) content compared to the non-treated control (2.64 mg g-1 DW) in A. membranaceus hairy root cultures (AMHRCs) (Halder *et al.*, 2019). 34 days old AMHRCs were most effective in enhancing isoflavonoid yield (2.29-fold, 533.54 µg g^{-1} DW) compared to control (232.93 µg g-1 DW) when treated with UV -B of intensity 86.4 kJ m^{-2} (Halder *et al.*, 2019). A higher amount of Flavonoid is also observed in the Hairy root culture of *Fagopyrum tataricum* when treated with UV -B (Halder, Sarkar & Jha, 2019). Higher yield of essential oils and phenolic content and low amount of toxic beta–asarone was observed with Increasing UV–B exposure in field-grown plants (Thakur *et al.*, 2019). When *Catharanthus roseus* plants, exposed to UV–B light, it showed higher production of vinblastine and vincristine which is helpful in the treatment of leukaemia and lymphoma (Naik & Al-Khayri 2016).

Temperature. Temperature is another factor that influences the metabolic activities of plants. Elevated temperature and low temperature both increase the production of secondary metabolites. In *Panax quinquefolius*, Higher Heat stress enhanced leaf senescence and concentration of the secondary metabolite in roots (Thakur *et al.*, 2019). Normally 17–25°C Temperature is used for the callus induction and growth of cultures. Incubation of *Melastoma malabathricum* at lower temperature range (20 ± 2°C) showed higher anthocyanin production than those grown at 26 ± 2°C and 29 ± 2°C (Naik & Al-Khayri 2016) shoots of *Hypericum perforatum* culture Showed higher hypericin and hyperforin content when cultured at 35°C (Naik & Al-Khayri 2016).

Salinity. Salinity Exposure also stimulates the production of different secondary metabolites like phenols, terpenes, alkaloids, flavonoids and steroids which play role in plant defensive response (Jan *et al.*, 2021). Higher salinity causes cellular dehydration and osmotic stress which causes reduction of the cytosolic and vacuolar volume resulting in the low accumulation of secondary metabolites (Thakur *et al.*, 2019). certain species of plants show higher anthocyanin under salt stress (Thakur *et al.*, 2019). Salt treatment in *Datura innoxia* showed an increased concentration of total alkaloid content in young leaves (Naik & Al-Khayri 2016). A significant increase in anthocyanin concentration was also observed in *C. roseus* under saline conditions. Furthermore, *Triticum aestivum and Trifolium repens* also showed an increased concentration of Glycine betaine in salinity (Naik & Al-Khayri 2016).

Drought. Drought stress can also greatly reduce plant growth and affect secondary metabolite content. *Bupleurum chinense* showed a significant increase of the anti-inflammatory saikosaponins when treated in mild water stress (Jan *et al.*, 2021). Similarly, Moderate Drought, stress had a great effect on the production of rosmarinic, ursolic, and oleanolic acid in *Prunella vulgaris* (Jan *et al.*, 2021).

Effect of Chemical Abiotic Elicitors on Secondary Metabolite Production. Heavy metals are the most widely used as Abiotic Elicitors in the agrotechnology sector and industries because of their high bioaccumulation and toxicity (Jan *et al.*, 2021). They affect the Metabolic activities of plants by inhibiting enzymes involved in the production, which directly influence the making of photosynthetic pigments, sugars, proteins and nonprotein thiols (Jan *et al.*, 2021) . Metals like Ag, Cd, Co, Fe, Ni, Cu are extensively used to provoke the synthesis of Secondary Metabolites in various plants (Thakur, Bhattacharya, Khosla & Puri, 2019). Increased oil content up to 35% was observed in *Brassica juncea* when treated with metals like Fe, Cr, Zn etc (Jan *et al.*, 2021). Cadmium chloride ($CdCl_2$) or silver nitrate ($AgNO_3$) provoked the overproduction of hyoscyamine and scopolamine in hairy root cultures of *B. candida* (Jan *et al.*, 2021). Application of 15 µM Ag+ stimulated the gene expression of the tanshinone biosynthesis pathway which produced 1.8-fold tanshinone IIA (a diterpenoid) content as compared to Untreated control in hairy root cultures of *S. Castanea*

Diels f. tomentosa (Halder *et al.*, 2019). Similarly, the application of Ag+ at 15 µM concentration in S. miltiorrhiza hairy root cultures showed lithospermic acid B (LAB), from approx. 5.4% to 18.8% (Halder *et al*., 2019). 1 mM of cadmium salts in root cultures of *Datura stramonium* induced the rapid accumulation of high levels of sesquiterpenoid–defensive compounds, notably lubimin and 3–hydroxylubimin (Naik & Al-Khayri 2016).

Table 2: Effects of Different Biotic Elicitors on Plant for Secondary metabolites production.

Plant species	Elicitors	Secondary Metabolites	References
Perovskia abrotanoides	Yeast extract	Cryptotanshinone Tanshinone IIA	(Zaker *et al.*, 2015)
Plumbago rosea	Yeast extract	Plumbagin	(Silja *et al.*, 2014)
Salvia miltiorrhiza	Trichoderma atroviride	Tanshinone	(Ming *et al*., 2013)
Vitis vinifera	Chitin	Trans-Resveratrol viniferins	(Taurino *et al.*, 2015)
Hypericum perforatum	Pectin	Hypericin pseudohypericin	(Gadzovska Simic *et al.,* 2014)
Hypericum perforatum	Dextran	Hypericin pseudohypericin	(Gadzovska Simic *et al.*, 2014)
Taverniera cuneifolia	Mucor hiemalis	Glycyrrhizic acid	(Awad *et al.*, 2014)
Hypericum perforatum	Phoma exigua	Phenylpropanoid naphtodianthrone	(Naik & Al-Khayri, 2016)
Gymnema sylvestre	Saccharomyces cerevisiae	Gymnemic acid	Chodiseti *et al.*, 2013)
Gymnema sylvestre	Bacillus subtilis	Gymnemic acid	(Chodisetti *et.al*.,2013)
Datura metel	Bacillus cereus	Atropine	(Shakeran *et al.*, 2015)
Tanverniera cuneifolia	Rhizobium leguminosarum	Glycyrrhizic acid	(Awad *et al.*, 2014)
Hypericum perforatum	Phoma exigua	Phenylpropanoid naphtodianthrone	(Naik & Al-Khayri, 2016)

Table 3: Effects of Different Abiotic Elicitors on Plant for Secondary metabolites production.

Plant species	Elicitors	Secondary Metabolites	References
Fagopryrum tataricum	UV-B	Flavonoid	(Halder *et al.*, 2019)
Catharanthus roseus	UV-B	Vinblastine Vincristine	(Naik & Al-Khayri 2016)
Melastoma malabathricum	Temperature	Anthocyanin	(Naik & Al-Khayri 2016)
Hypericum perforatum	Temperature	Hypericin Hyperforin	(Naik & Al-Khayri 2016)
Datura innoxia	Salinity	Alkaloid	(Naik & Al-Khayri 2016)
C. roseus	Salinity	Anthocyanin	(Naik & Al-Khayri 2016)
Triticum aestivum and Trifolium	Salinity	Glycine betaine	(Naik & Al-Khayri 2016)
Bupleurum chinense	Drought Stress	Saikosaponins	(Jan *et al.*, 2021)
Prunella vulgaris	Drought stress	Rosmarinic Acid Ursolic Acid Oleanolic Acid	(Jan *et al.*, 2021)
Brassica juncea	Metals- Fe, Zn, Cr	Oil content	(Jan *et al.*, 2021)
B. candida	cadmium chloride -($CdCl_2$) silver nitrate- ($AgNO_3$)	Hyoscyamine Scopolamine	(Jan *et al.*, 2021)
S. castanea Diels f. tomentosa	Silver - Ag+	Tanshinone IIA	(Halder *et al.*, 2019)
miltiorrhiza	Silver - Ag+	Lithospermic acid B	(Halder *et al.*, 2019)
Datura stramonium	Cadmium-Cd	Lubimin and 3–hydroxylubimin	(Naik & Al-Khayri 2016)
Brassica rapa spp. pekinensis	Copper oxide nanoparticles (CuO NPs)	Glucosinolates Gluconasturtiin Glucobrassicin 4methoxyglucobrassicin Neoglucobrassicin, 4-Hydroxyglucobrassicin Glucoallysin Glucobrassicanapin Sinigrin Progoitrin Gluconapin	(Halder *et al.*, 2019)

Furthermore, Elicitation with Copper oxide nanoparticles (CuO NPs) in *Brassica rapa* spp. *pekinensis* shows higher expression of MYB34, MYB122, MYB28 and MYB29 genes which control enzymes in the glucosinolate biosynthesis pathway due to which the level of ten glucosinolates (Gluconasturtiin, glucobrassicin, 4-methoxyglucobrassicin, neoglucobrassicin, 4-hydroxyglucobrassicin, glucoallysin, glucobrassicanapin, sinigrin, progoitrin and gluconapin) significantly increased (Halder *et al.,* 2019).

ROLE OF BIOTECHNOLOGY ON ELICITATION

Elicitation, an Effective approach for the Biotechnological products and its variety of Bioactive High-Added Value Compounds in Plant Cell Factories (Ramirez-Estrada *et al.,* 2016). Plant in vitro cultures represent a cost effective and very attractive approach to plant secondary metabolite production (plant cell factory). Among other advantages they constitute the only sustainable and eco-friendly system which can be only obtained by the chemical structures that are biosynthesized by endangered plant species. For ecological and political or geographical point of view the plant which are raw in materials can use the sources of some of the valuable compounds and which are becoming increasingly short in supply. For these reasons, the efforts are being made to invest in biotechnological production of metabolites by means of plant cell and organ cultures. Plant cell factories they contribute for a production of plant secondary metabolites of commercial interest, and they offer a continuous supply by means of large-scale culture. The main advantage for the cultivation of medicinal and aromatic plants in the field- The desired product can be obtained and can be harvested anywhere in the world with strict control of production and quality.

Contamination free plant materials is obtained since the plant cells are free of microorganisms, herbicides, pesticides, and fungicides. Time of growth cycle is reduced from years to weeks. The species which are likely to be endangered can be preserved and can be used in further future. Independence from the geographical or any other environmental fluctuations. Although after trying all these advantages an effort is made in developing plant cell cultures as PSM production systems and commercially successful plant cell factories are still rare which is due to lack of knowledge of plant secondary metabolism and it’s in vitro culture. There are few industry- level process that are established till now to produce some of the compounds such as shikonin, taxol and berberine. But the main challenge is to maintain a biotechnological system at costs below that is of large- scale cultivation of plants.

Elicitation is one of the most effective strategies for enhancing the growth of the secondary metabolites using the biotechnological approach. Though a cell culture can be elicited by physical factors, the addition of biotic or abiotic elicitors to the culture medium is the main methodology used in biotechnological cell cultures. Since it is impossible to consider the great variety of elicitors assayed in plant cell cultures in their entirety, in this we have focused mainly on the action of the most commonly used and effective biotic elicitors for the biosynthesis and accumulation of secondary compounds of great interest for chemical-pharmaceutical industries. In the growth phase the exponential one of plant cell cultures, many metabolites are produced only at low levels, or not all, as primary metabolite are the precursors for the required result. There is evidence that the induction of secondary metabolite production from primary compounds is more effective in the stationary growth phase.

For this reason, a good strategy for a plant cell factory is to establish a two-stage culture, in which the cells are first maintained in an optimal medium for biomass formation and are then transferred to an optimal production medium that stimulates the synthesis of secondary compounds. Plant elicitors are highly effective from biotechnological point of view as it has led to the growth and the production in the new and desired variety of the product of plant. Elicitors had acted as a boon in the field of biotechnology. Elicitation is the most effective techniques for improving the biotechnological production of secondary metabolites. They stimulate any type of plant defense and promoting secondary metabolism to protect the whole cell part. Salts like $AgNO_3$, $AlCl_3$, $CaCl_2$, $CdCl_2$ they can elicit the PSM production and a variety of plant culture such as cell suspensions, hairy roots, and adventitious roots.

CONCLUSION

Metabolites are substances that are produced by the body (e.g., carbohydrates, lipids, and amino acids), Higher plants can also generate a large range of low-energy compounds. Secondary metabolites are molecular weight molecules. Secondary metabolites are chemicals found in plants that do not play a recognized role in the upkeep of basic life processes in the plants that produce them, they do, however, play a vital part in the relationship of the species, plant, and its surroundings The manufacturing of these Compounds are frequently low in concentration (less than 1% dry weight) and are dependent on the physiological and developmental stage of the animal has a big impact of cultivate. Colchicines, catharanthus alkaloids, belladonna alkaloids steroids such as phytostigminine, pilocarpine, and reserpine, as well as phytostigminine, pilocarpine, and reserpine diosgenin, digoxin, and digitoxin are all types of diosgenin.

An elicitor is a chemical that, when administered to a live cell system at minute quantities, begins or enhances the manufacture of certain molecules. Elicitation is the process of inducing or enhancing metabolite production by adding tiny quantities of elicitors, in medicinal plants, biotic elicitors have been used to boost secondary metabolite production, Secondary pharmaceutical products such as alkaloids, glycosides, flavonoids, volatile oils, tannins, and resins are produced. Secondary metabolites could be chemical compounds such as polysaccharides elicitor, yeast elicitors, fungal elicitors, and bacterial elicitors. Some physical abiotic elicitors also effects on secondary metabolites such as, UV rays, temperature, salinity exposure and drought stress.

Elicitation has high role in applications of biotechnology as well, Plant elicitors are highly effective from biotechnological point of view as it has led to the growth and the production in the new and desired variety of the product of plant. Elicitors had acted as a boon in the field of biotechnology. Elicitation is the most effective techniques for improving the biotechnological production of secondary metabolites. They stimulate any type of plant defense and promoting secondary metabolism to protect the whole cell part. Salts like $AgNO_3$, $AlCl_3$, $CaCl_2$, $CdCl_2$ they can elicit the PSM production and a variety of plant culture such as cell suspensions, hairy roots, and adventitious roots.

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Conflict of Interest. None.

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