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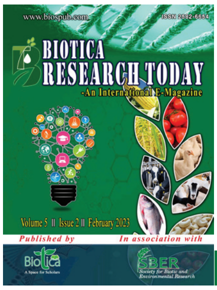

Strigolactone: A Novel Class of Plant Hormone with Immense Possibilities

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Abstract

Strigolactones are a group of chemical compounds produced in plant roots. Due to their mechanism of action, these molecules have been classified as plant hormones. Strigolactones (SLs) are carotenoid-derived signaling molecules that primarily instigate the germination of root-parasitic plants and symbiotic fungi. Hence, the SLs act as the chemical identifier for the parasites and arbuscular fungi to detect their host plants. Further studies have identified many diverse functions of SLs in the physiology and development of plants. Due to their multiple roles, these hormones are suitable targets for sustainable agricultural applications. Besides, in the last few years, studies have provided clues about some unique natures of SLs in therapeutics, *e.g.*, anti-cancer agents, glucose metabolism, *etc*. These functions of SL can also potentially be utilized in diagnostics and medication in near future.

Keywords: Hormone, Plant stress, Strigolactone, Sustainable agriculture

Introduction

Hormones are considered to be the most important Plant Growth Regulators (PGR). Unlike animals, plants only have these chemical messengers which are able to modulate or control almost all physiological activity. Hormones like abscisic acid (ABA), ethylene (ET), and salicylic acid (SA) have also a significant role in the amelioration of resistance against biotic and abiotic stress factors. In some cases, hormones also act as signaling molecules and contribute to building up communications between plants and other organisms such as plant-plant interaction, plant-insect interaction, plant-microbes interaction, *etc*. (Mishra *et al.*, 2017). The strigolactones (SLs) are emergent plant hormones (a class of carotenoid-derived terpenoid lactones), initially reported as germination promoters of root parasitic plants, *Striga* sp. as the name implies (Mashiguchi *et al.*, 2021). SLs are released from the roots of eighty percent (80%) of total land plant species and were reported also to induce the symbiosis between plant and arbuscular mycorrhiza (AM) by stimulating the branching of the hyphae of mycorrhizal fungi (Mishra *et al.*, 2017). Later on, with the progression of the study, many other important functions of SLs involving plant architecture, physiology as well as stress response have continuously been reported (Alvi *et al.*, 2022).

The *in plant* Biosynthesis of SLs

SLs exhibita tricyclic lactone structure (ABC ring), to which a methylebutenolide (D ring) remains connected to the core with an enol-ether bridge. Till now more than 30 SLs have been identified. Based on the presence and absence of a complete ABC ring they are classified as canonical SLs and non-canonical SLs. Besides, the stereochemistry of the B-C ring junction of natural canonical SLs is divided into two major groups - strigol and orobanchol (Alvi *et al.*, 2022). Carlactone (CL), the common endogenous precursor of these SLs, is synthesized from all-*trans*-β-carotene within the plastid. The carotenoid isomerase DWARF27 (D27), CAROTENOID CLEAVAGE DIOXYGENASE 7 (CCD7), and CCD8 are plastidial enzymes capable to convert all-*trans*-β-carotene into 9-cis-β-carotene, 9-cis-β-apo-10’-carotene and finally CL, simultaneously (Mashiguchi *et al.*, 2021). This CL is then moved to the cytosol and is further oxidized by several enzymes present there to form different types of SLs. In *Arabidopsis* the chromophore P450 enzyme MAX 1, CYP711A1, converts the CL into carlactonic acid (CLA), whereas in rice (*Oryza sativa*) Os900 (CYP711A2) converts the CL into CLA, 18-Hydroxy-carlactonic acid (18-OH-CLA) and finally 4-Deoxyorobanchol (4DO). The 4DO is further converted into orobanchol by Os1400 (CYP711A3). On the

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other hand, in cotton (*Gossipium arboretum*) one of the MAX 1 homologs, CYP722C converts the CLA into 5-deoxystrigol, which is a strigol type SL (Yoda *et al.*, 2021) (Figure 1).

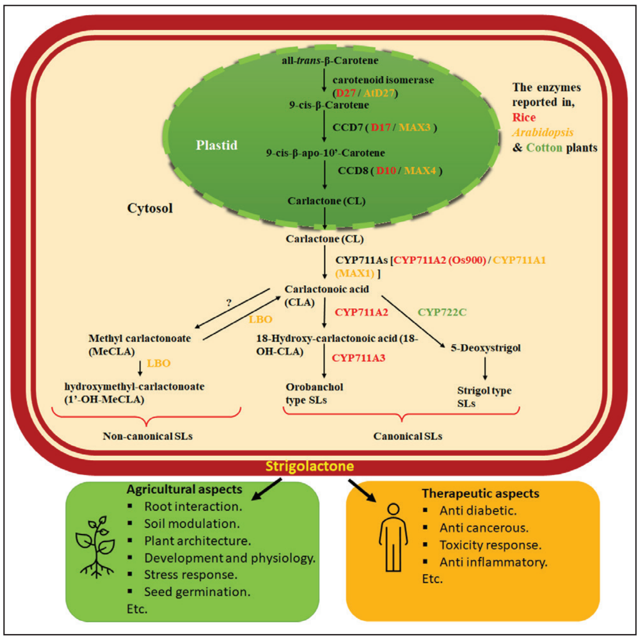

Figure 1: Strigolactone biosynthetic pathway in plants [Plastid localized carotenoid isomerase, CCD7, CCD8 enzyme produce carlactone (CL) from all-trans-β-carotene. CL is then oxidized by CYP711As to produce Carlactonoic acid (CLA) in the cytosol. From this CLA different types of enzymes, reported in different plants, produce various types of SLs, like canonical (strigol, orobenchol) and non-canonical SLs. The enzymes coloured in red are found in rice, orange in Arabidopsis and green in cotton plants.]

Functions of SLs in Plant System

Initially, SLs were only known for the promotion of germination of root parasitic plants, but recently several physiological and developmental functions of SLs were reported (Alvi *et al.*, 2022).

1. Structural, Growth and Physiological Regulation

- Helps in seed germination.
- Promotes leaf senescence.
- Promotes root elongation.
- Promotes root hair formation and elongation.
- Suppress adventitious rooting.
- Promotes apical dominance by promoting auxin transport and PIN accumulation.
- Inhibits shoot branching.
- Determines shoot architecture.
- Delay leaf senescence by restoring the leaf colour, chlorophyll content, and nutrient leaching.
- Promote ABA-mediated stomatal closing.
- Promotes colonization of AM in roots by inducing hyphal growth and branching.
- Increase nodulation under nitrogen deficiency in legumes.

2. Abiotic Stress Tolerance

- Helps plants in overcoming nutrient starvation by promoting rooting and arbuscular mycorrhizal symbiosis.
- Drought tolerance.
- Salinity stress tolerance.
- Resistance to heavy metal toxicity.
- Heat stress tolerance.

D27, the Master Regulator of SLs Biosynthesis?

As discussed, the SLs are synthesized in plastids and essentially involve the carotenoid biosynthesis pathway. They are derived from the precursor, carlactone (CL) which is a β-carotene derivative. The first step of any biosynthesis is the most important step. The first essential enzyme in this biosynthesis pathway is D27, which converts trans-β-carotene to 9-cis-β-carotene in the plastid. The detailed structural information on D27 is still elusive. More extensive structural information is urgently needed to confer the structure-function relation of this primary enzyme. The function of D27 also determines the soil quality of the rhizosphere region which may regulate root-microbiome interaction. It also links the SL pathway with other hormone biosynthesis pathways. Once the structural information and detailed genomic and functional genomic data encompassing D27 have been unveiled, it could be utilized in different aspects of agricultural developments (Mashiguchi *et al.*, 2021).

The Potentiality of SLs in Future Agricultural Applications

Strigolactones have a broad-spectrum function in crop improvements and agro-economy. Although, a long way to go but this potentially emergent plant hormone demands more scientific attention for its dramatic future applications possibilities (Dell'Oste *et al.*, 2021). The possible future potential of SLs is summarised as follows.

1. Control of Parasitic Plants

Plants that produce less amount of SLs are less susceptible to several parasitic plants like *Striga* (witch weeds) and *Orobanche* (broomrapes) as SLs promote the germination of these plants. SL analogs can be potentially used to control these parasitic plants *via* suicidal germination.

2. Nutrient Assimilation

Both natural and synthetic SLs are able to promote root elongation, root hair formation, and symbiotic relations with AM. SLs can also reduce the rate of nutrient leaching. These strategies can be used to increase yield and the quality of the food grain by improving nutrient assimilation.

3. Stress Resistance

SLs induce abiotic stress tolerance in plants are discussed before and this can be used as a solution to the massive yield loss problem caused by several abiotic stresses like drought, salinity, temperature, *etc*. The involvement of this hormone in the biotic stress tolerance pathway has also been studied. The crosstalk of SLs with other hormonal pathways needs to be dissected for their application in stress tolerance.

The Effect of SLs on Human Health

• The effect of SLs on glucose metabolism is reported in recent years. And can enhance insulin signaling thus it could be a potential treatment for diabetes.

• It shows anti-inflammatory activity.

• SLs and SL analogs can act as anti-cancer agents by inhibiting tumor formation in both *in vitro* and *in vivo* conditions. They can target rapidly dividing cells, block the cell cycle and promote apoptosis (Dell'Oste *et al.*, 2021).

Conclusion

Strigolactones are one of the most recent plant hormones discovered so far. Many aspects of this hormone are still unknown; this group of hormones has a wide potential in both the agricultural and medical fields. A detailed study regarding the enzymes involving the biosynthesis pathway and the interaction of this hormone with other metabolic pathways is further needed. More focused work with SLs will be believed to open more opportunities in sustainable agriculture, plant stress biology, cancer research as well as diagnostics shortly.

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