Strigolactone and its quintet: Signalling network of Shoot branching

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Introduction

As with increases in global population, demand for food has increased but the arable land decreased looking for ways to raise the grain yield has become a priority. To meet this challenge new plant varieties with Ideal Plant Architecture that produce much higher yield needed to be produced.The nature and relative arrangement of each component within a plant determine its architecture which is the manifestation of a balance between the environment's extrinsic limitations and the plant's internal development processes at any given moment. Plant architectural analysis is essentially a global, multilevel and dynamic approach to plant development.
A key component of plant architecture that establishes the contact between the plant and its surroundings is shoot branching. It contributes to essential processes such as the establishment and leaf area distribution that determine light interception and photosynthesis, which in turn influence growth and yield. It is an intricate process that includes bud outgrowth and shoot extension, and these in turn respond to endogenous signals (Hormones such as Strigolactone, Auxin, Cytokinin, and Abscisic acid) and exogenous signals (Light and Nitrate).

Hormones: Endogenous signals

In hormonal regulation, When the concentration of Auxin is higher it promotes Strigolactone (SLs), a Carotenoid-derived hormonal signal via auxin transporter PIN1 which upregulates the expression of BRC1(BRANCHED 1)transcription factor, a key repressor for shoot branching which integrates both endogenous and exogenous inputs and mediates control of branching by regulating axillary bud potential to grow (Wang et al., 2019). SL degrades the protein D53 (DWARF 53) and SMXL 6/7/8 (SUPPRESSOR OF MORE AXILLARY GROWTH2-LIKE) in rice and Arabidopsis respectively are down-regulated which in turn release the negative regulator of branching such as IPA1 (Ideal Plant Architecture1) and SPL 9/13/14/15 (SQUAMOSA PROMOTER BINDING PROTEIN-LIKE), leads to the transcriptional activation of BRC1 and inhabits the lateral growth.

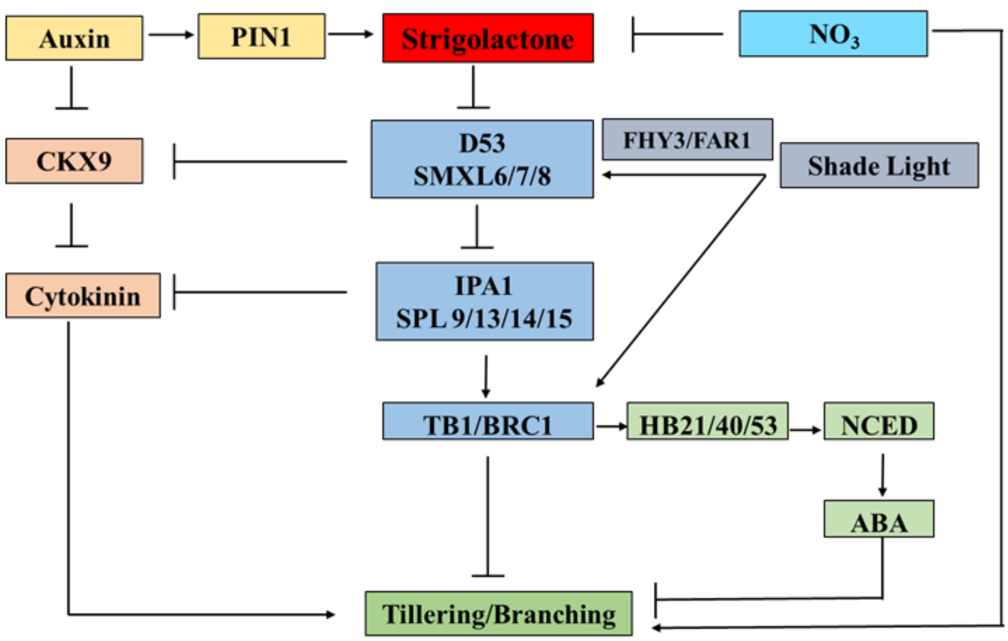

Fig 1: A complex regulatory/signalling network of Shoot branching.

Simultaneously, Auxin directly inhabits the cytokinin action that plays key roles in axillary bud initiationand outgrowth, in addition to the various process of plant growth. In the case of SLs, Cytokinin and SLs have shown antagonistic/synergistic effects on various plant's developmental processes.

In rice CKX9 (CYTOKININOXIDASE/DEHYDROGENASE 9), an SL-responsive gene that encodes a cytokinin oxidase to catalyze the degradation of cytokinin and regulates the plant height and tillering (Duanet al., 2019).

Shade light and Nitrate: exogenous signals

In Arabidopsis, FHY3(Far-red elongated hypocotyls) and FAR1 (Far-red impaired response) are thetwo transcriptional factorwhich is essential for light signaling.Under simulated shade treatment, the accumulation of FHY3 and FAR1 decline and the transcript levels of SMXL6 and SMXL7 are down-regulated leading to increased expression of BRC1 and reduced branching (Xieet al., 2020). Further, the expression of BRC 1 induces transcription of HB 21/40/53 [HOMEOBOX PROTEIN] homeodomain leucine zipper protein transcription factors. Together with BRC1, HB 21/40/53 enhance the gene expression NCED3(9-CIS EPOXICAROTENOID DIOXIGENASE 3), which in turn leads to local accumulation of ABA and it inhibits bud/tiller outgrowth (González-Grandíoet al., 2017).

Nitrate (No3-) directly influences the action of SL and Cytokinin synthesis in shoot and root respectively. N limitation may affect branching by increasing SL synthesis and decreasing CK synthesis in roots (De Jong et al., 2014).

Conclusion

SL and its quintet's pathway is an important integrator of metabolic and nutritional signals in shoot branching. Tillering/Branching, a key determinant of Plant architecture enables fine-tuning of plant phenotype thus increasing yields, particularly under high-density planting conditions.

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