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STRIGOLACTONES: THE HIDDEN SIGNALS SHAPING PLANT GROWTH

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Abstract

Strigolactones were known fairly recently and identified in their function as plant hormones long after their assignment in the process of parasitic weed germination, but before being recognized as endogenous growth regulators. It is this dual role that this paper attempts to discuss- as rhizosphere external messengers and internal endogenous coordinators of development; however, our goal is to unveil how SLs act on branching, root architecture, leaf senescence, and stress adaptation while contributing to agricultural challenges due to their connection with Striga infestation. Results from recent studies reiterate the fact that SLs interact in a complicated way with other hormones as they guide plants to conserve water under conditions of drought and nutrient stresses. Recent breeding and biotechnology progress are opening up further opportunities for using these pathways toward improved resilience and productivity. Decoding SL signaling will transcend matters of mere interest within plant biology into a pathway toward sustainable crop management.

Keywords: Plant hormone signaling, Parasitic weeds (*Striga*), Strigolactones, Stress adaptation

Introduction

Strigolactones (SLs) are a new class of plant hormones that were formally recognized in the early 2000s. They were first identified as substances released by roots that trigger the germination of parasitic seeds and help form partnerships with mycorrhizal fungi. Since then, they have become key players in regulating plant growth. Unlike traditional hormones, which were found by observing visible developmental changes, SLs were discovered through their chemical signaling in the soil. This aspect makes their development unique and scientifically interesting (Dun *et al*., 2009).

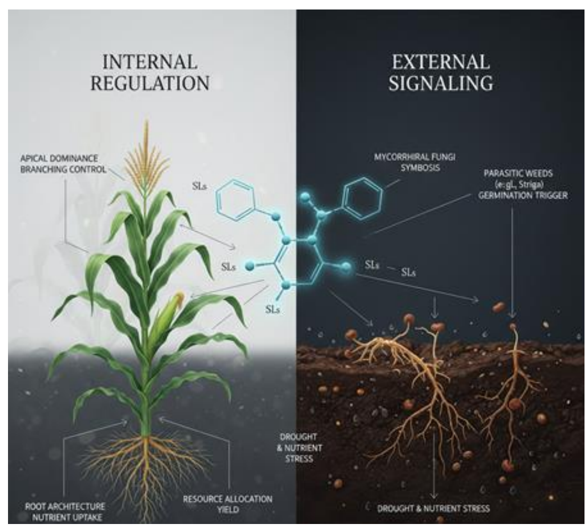

Figure: Strigolactones as hidden plant signals. Inside the plant, they guide growth by shaping roots, limiting extra branches, and reallocating nutrients during stress. In the soil, they signal to responsive fungi but can also awaken harmful weeds like Striga.

SLs are important for both internal and external functions. Internally, they control shoot branching, root structure, and how plants use resources, all of which are connected to crop yield. Externally, they act as signals in the soil, attracting beneficial fungi while also, unfortunately, encouraging parasitic weeds like Striga. This dual role has sparked both hope and discussion. With increasing evidence of their involvement in stress responses, especially during drought and nutrient shortages, strigolactones are paving the way for new approaches to plant adaptation and crop improvement.

Background & Discovery

The history of strigolactones (SLs) has its origin in African soils that were infected with Striga, as the farmers had reported that only when close to host crops like sorghum or maize germination could occur. This was explained in the 1960s by the release of a chemical signal, since named Strigol, by root exudates which formed the wider group known as strigolactones, characterized by a lactone-based structure (Wu *et al.*, 2025).

Originally, SLs were perceived as environmental burdens, since they also induced germination of Orobanche, which is also a devastating parasite. Nevertheless, they proved to favor colonization by arbuscular mycorrhizal fungi redefining them as an evolutionary signal promoting favorable symbioses [Insert reference]. One significant conceptual change was when SL-deficient mutants were found to exhibit excessive branching making SLs internal regulators of plant architecture. SLs are known today as carotenoid-derived butenolide molecules, which combines developmental regulation with rhizospheric communication and is a conjunction of parasitic weed biology, symbiosis, and plant adaptation to nutrient stress (Dun *et al.*, 2009).

Roles in Plant Growth and Development

Strigolactones are the traffic lights in a city of developing tissues, which instruct some of our organs to advance and other ones to hold up. Their most notorious role is the regulation of shoot branching. The signal is virtually red with the high levels of strigolactone which inhibits the growth of the axillary buds. This is to make sure that the plant does not dissipate energy by generating excessive number of branches or tillers in case of scarcity of resources. On the contrary, a decrease in strigolactone activity eliminates this brake and more branches develop. This is usually manifested through thicker canopies by farmers of strigolactone-deficient types.

Root architecture is formed below ground by strigolactones. They cause lengthening of primary roots and they stimulate deeper root penetration instead of extensive lateral diffusion. Practically, they direct the root system as a compass towards the ground and enable plants to search a deeper layer of soil to get water and nutrients. This role plays a significant role especially in drought or case of nutritional stress where deeper root system may be the difference between success and failure.

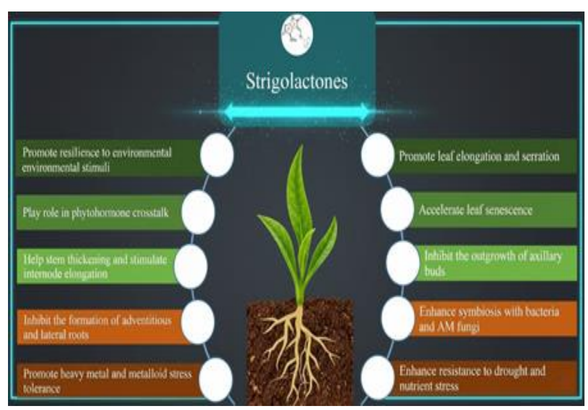

Figure: Multifaceted roles of strigolactones in plants. (Source: Wani *et al.*, 2020)

The other effect of their influence is in leaf senescence. Strigolactones speed up the process of aging in older leaves, channeling the nutrients to tissues or seeds in development. Although this could seem like a drawback, it is a strategic move taken into consideration, where the plant would recycle the resources of those organs that are not as productive to those that would guarantee reproduction (Brewer *et al.*, 2013).

Strigolactones and Stress Adaptation

Stressed plants have trade-offs in conserving energy, water-seeking, or nutrient reallocation and strigolactones have a role in directing the choice. During drought, SL signaling enhances deeper root development, and alters stomatal behavior to reduce water loss, to make the plant survive instead of grow excessively.

SLs interact with other hormones--auxin controls root development and abscisic acid controls stomata such that SLs play a role to refine these pathways and orchestrate entire-plant responses (Wu *et al.*, 2025). This synergistic position has seen SL pathways as potential breeding or targeted therapy to enhance drought and nutrient-stress resistance, but pragmatic application must prevent undesirable effects, especially promoting the germination of parasitic weeds.

Agricultural Importance & Human Angle

Strigolactones are small plant signals which aid in making roots grow deeper, to make partnerships with useful fungi and in controlling the number of branches made by a plant. But they also cause the germination of parasitic weeds such as Striga and Orobanche to adhere themselves to roots. Striga is able to reduce sorghum and millet harvests by approximately half in certain regions in Africa and Asia, hence, it is a very significant issue to small farmers.

It is quite straightforward: when strigolactone release is reduced, parasites may also be reduced, but root development and beneficial fungal associations may also be undermined. So solutions need to be cautious and domestic.

Breeders and biotechnologists have the ability to modify the way plants respond to or produce these signals, but the mods must be evaluated in a variety of climates and agronomical systems and applied in conjunction with excellent agronomy to safeguard harvests. (Zwanenburg *et al.*, 2013).

Future Outlook

Now researchers have to transform lab discoveries regarding strigolactones into something useful to farmers. In one method, synthetic strigolactone-like compounds are used to induce the process of parasitic weed suicide germination prior to the planting of crops. The development of other targeted compounds might be in the development of stronger roots or to allow the plants to endure drought. These concepts are indicative of a new type of agrochemical which tries to enhance resilience and not just yield. Combined with breeding programs, strigolactone-based technology could be useful in creating climate-sensitive crops and making agriculture in resource-scarce locations more sustainable.

Conclusion

Strigolactones demonstrate that small indicators can alter our agricultural practices. Initially identified due to the action of waking parasitic weeds, we now realise that they also regulate the branching, root development and the way in which plants adapt to the stress. Their experience is a lesson to remember that unexpected observations may turn into useful instruments.

The knowledge of these cues can not only enhance the study of plant biology, but also indicate the new avenues to ensure food security. With changing climate, training to operate with cues such as strigolactones, as well as breeding and technology may prove as useful as any of the traditional methods in creating resilient crops.

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