Seaweed Extract: A Potential Biostimulator, Biodegradable and Eco-Friendly Resource for Plant Defense

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A rapidly growing world population has highlighted the need to significantly increase food production in the context of a world with accelerating soil and water shortages as well as climatic stressors. This situation has generated new interest in the application of seaweed extracts because of their potent plant growth enhancing properties through metabolic benefits, triggering disease response pathways and increasing stress tolerance. The basis for these benefits is complex and poorly understood. Seaweed extracts are complex and have been demonstrated to possess novel mechanisms for increasing crop productivity.

Plants incessantly encounter abiotic and biotic stresses that limit the growth and productivity. However, conversely, plant growth can also be induced by treatments with various abiotic and biotic elicitors. This situation has generated new interest in the application of seaweed extracts because of their potent plant growth enhancing properties through metabolic benefits, triggering disease response pathways and increasing stress tolerance. The major constraints in rice production are biotic and abiotic stresses (Ansari et al., 2015). Each year, these stresses cause large-scale crop losses, which are expected to escalate as climate change is projected. Fungicides are crucial strategies for managing fungal diseases in rice since they are the most destructive worldwide. The excessive use of fungicides causes fungicidal stress.

Besides, fungicide application also has more significant impact on the residual levels in the crop. Reducing pesticides in agriculture is essential to minimize the environmental impact and improve the sustainability of agricultural systems (Van Oosten et al., 2017). As a result, agricultural practices have evolved towards organic, sustainable, or environmentally friendly practices. Organic molecules such as seaweeds may be used as one of the strategies to minimize pesticide use. Unlike pesticides, these organic compounds are non-toxic and non-polluting (Pal et al., 2015).

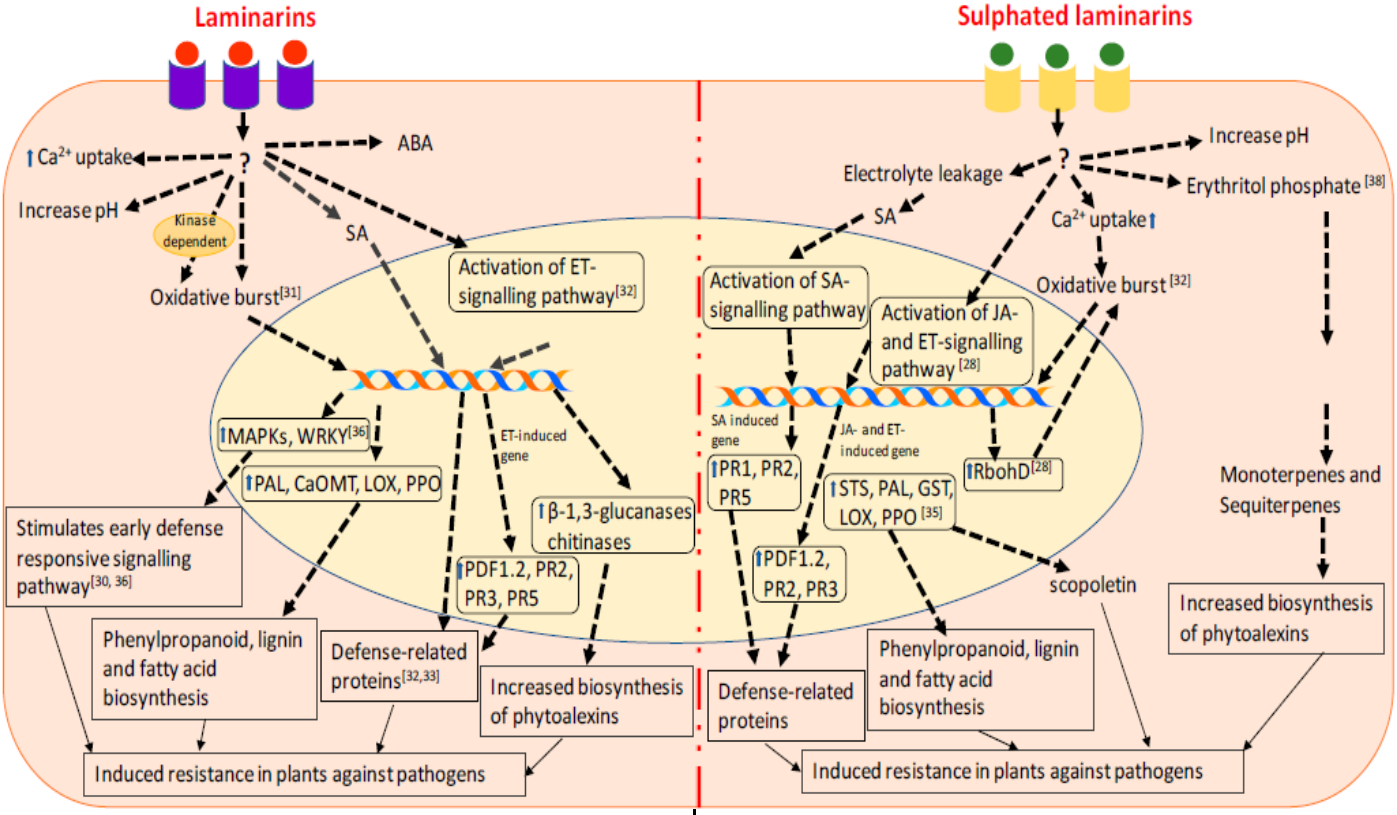

Fig. 1: Schematic representation of the cellular functions and signalling pathways involved in defense mechanism elicited in laminarin and sulphated laminarin (Shukla et al., 2021).

Seaweed extracts have been shown to promote plant growth, minimize abiotic stresses by regulating molecular, physiological, and biochemical processes (Jithesh et al., 2019). In general, abiotic stress responses involve the production of Reactive Oxygen Species (ROS), ionic imbalance, altered Ca^{2+}, K^{+} signalling, stomatal behaviour and leaf temperature as well as the induction of heat stress factor genes (HSFs) and other transcription factors (TFs) which limit the growth and productivity of plants (Jithesh et al., 2019; Lin et al., 2022). Seaweed extracts are emerging as commercial formulations to boost tolerance by targeting multiple stress pathways. Seaweeds are red, green and brown macroalgae representing 10% of marine productivity (Van Oosten et al., 2017).

The red and brown algae make up the vast majority of seaweed formulations. Tropical red seaweeds are macroalgae that can accelerate plant metabolism and boost plant efficiency. The presence of phytohormones and several organic molecules acting as compatible solutes has been attributed to the beneficial effects of seaweed extracts. High concentrations of phenolic compounds with antioxidant properties that protect against stress-induced ROS can be used to improve stress tolerance.

Seaweeds are an important part of the aquatic and coastal ecosystems and have commercial importance in improving agricultural productivity (Ali et al. 2021). Some bioactive elicitors in different seaweed extracts induce pathogen-associated molecular patterns (PAMPs) because of their structural similarities to pathogen-derived molecules. This is accomplished by priming or eliciting the induced systemic resistance (ISR) and systemic acquired resistance (SAR) pathways' defence responses (Shukla et al. 2021).

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