# A dual specificity protein phosphatase and redox homeostasis in plants

Man has been struggling to understand and define life since the day he became aware of it. Innumerable philosophies and findings over the history of mankind together draw the perspective with which we look at life today. One such perspective defines life as a collection of dynamic chemical transformations (phenomenon known as metabolism) which coordinate to exhibit biological functions. These biological functions in turn, fulfil the three basic principles of life i.e. growth, sustenance and perpetuation.

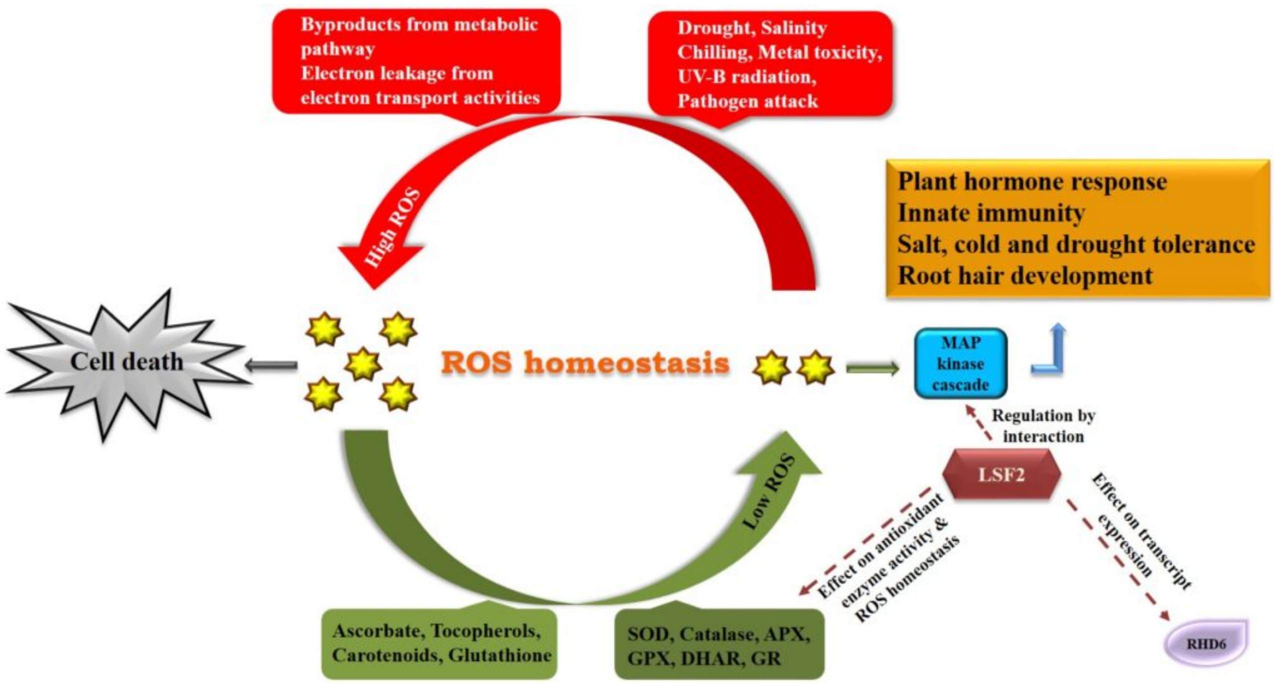


Fig. 1. Schematic diagram showing putative mechanism of action of LSF2 and its effect on ROS homeostasis in plants. The fate of ROS as destructive agents or as second messenger, inside the cell, is determined by the cumulative effect of its generators and scavengers. LSF2 regulates root development by effecting the expression of RHD6 and activity of ROS scavenging enzymes thereby modulating the ROS homeostasis. Dashed arrows indicate possible mechanism of action of LSF2 by interactions with different components of ROS homeostasis.

Every living organism strives to sustain itself against the challenges of nature by maintaining a continuously stable internal environment. This state of stable internal environment termed as ’homeostasis’, depends on a precise balance between components, which are critical to maintain life. Therefore homeostasis is an indispensable and continuous phenomenon within every living form on earth. As the complexity of organism increases the complexity of this intricate system also increases. There are various examples, which advance our understanding of how this state of stable internal environment is maintained in an organism.

Reactive oxygen species (ROS) generation is a consequence of aerobic cellular metabolism. Free radicals such as hydroxyl radical (**?**OH) and non-radical molecules like hydrogen peroxide ($H_2O_2$) are common ROS agents, formed in different cellular compartments as by-products of metabolic pathways. In plants, various environmental stresses (drought, salinity, heat and chilling to name a few) are reported to induce excessive production of ROS, thereby causing oxidative damage to biomolecules ultimately resulting in cell death through a genetically controlled process called programmed cell death (PCD). Contemporarily, low levels of ROS act as signaling molecules in the plant cell and have been reported to be involved in the regulation of elongation and differentiation of root cells. This dual behaviour/property of ROS is dependent on a sensitive equilibrium existing between productions and scavenging of these reactive molecules and is known as ‘ROS homeostasis’.

As most plants are sessile organisms and cannot move away from their place, they are at a much higher risk of undergoing environmental stresses as compared to motile organisms. Therefore plants have developed a robust system, encompassing enzymatic and non-enzymatic anti-oxidative agents (anti-oxidants), to maintain ROS homeostasis to ultimately maintain normal metabolic fluxes and diverse cellular functions under various environmental threats. More than 150 genes and various chemical moieties together regulate the ROS production and turnover.

Protein phosphatases catalyse dephosphorylation reactions to counteract the phosphorylation caused by kinases. They are pivotal part of this reversible phosphorylation-dephosphoryaltion control mechanism in biological processes. LIKE SEX FOUR2 (LSF2) is a dual-specificity phospho-glucan phosphatase involved in the diurnal starch metabolism in plants. This enzyme, found to be localized in choloroplast and cytoplasm, dephosphorylates C3-glycosyl residues, thereby playing a critical role in degradation of phosphorylated glucan moieties of starch. LSF2 is a member of dual-specificity phosphatase (DSP) family encompassing two more members SEX4 (Starch excess 4) and LSF1 (Like Sex four 1), which are also involved in starch degradation. Recently, LSF2 is also implicated in ROS homeostasis in the model plant, *Arabidopsis thaliana.* Comparative analysis of wild type, homozygous T-DNA inserted mutants (*lsf2-1*), and complementary transgenic lines (*lsf2-1:AtLSF2*) unravelled the role of LSF2. Experimental investigations including ROS status, activities of anti-oxidant enzymes, and root morphology of wild and transgenic plants under various oxidative stress conditions revealed that LSF2 influences ROS homeostasis and root development by regulating the activity of anti-oxidant enzymes, which in turn scavenge ROS moieties and bring down their concentration to permissible levels inside the cell. Moreover, LSF2 was demonstrated to interact with a member of MAP kinase family (MPK8), which forms a highly conserved signaling pathway to transduce a whole gamut of stress responses including ROS accumulation. These results conclude that LSF2 affects the root length and root hair density in plants, and at the same time act as a positive regulator of ROS homeostasis under various oxidative stress conditions.

These finding substantiate the novel role of LSF2 in maintaining ROS homeostasis thereby influencing root development under oxidative stress conditions in plants. Identification and characterization of other components of ROS homeostasis is a prime subject of investigation for plant biologists presenting another step towards their quest to understand nature.

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## Publication

The LIKE SEX FOUR2 regulates root development by modulating reactive oxygen species homeostasis in Arabidopsis.
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