BOTANY

Reactive Nitrogen Species (RNS)

M.Sc. (Botany) Sem IV

Plant Physiology

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Reactive Nitrogen Species (RNS)

Reactive Nitrogen Species (RNS) act together with ROS to damage cells, causing **nitrosative stress.** Therefore these two species are often collectively reffered to as ROS/RNS or sometime **RONS** means Reactive Oxygen and Nitrogen Species. RONS also cause oxidative stress.

RNS are continuously produced in plants as by-product of aerobic metabolism or in response to stress. The term RNS includes radicals like nitric oxide (NO) and nitric dioxide (NO_2) as well as nonradicals such as nitrous acid (HNO_2) and dinitrogen tetra oxide (N_2O_4) among others.

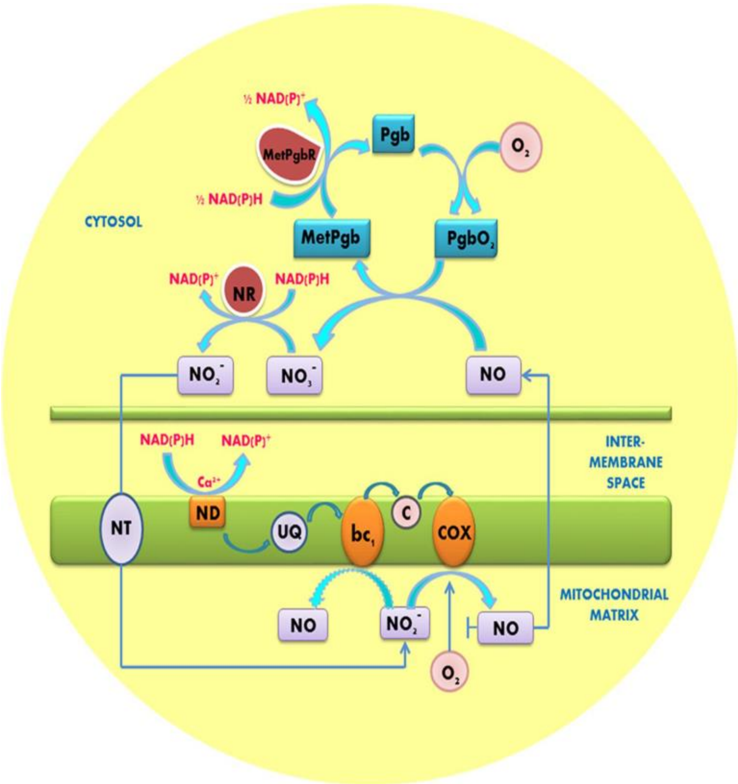
Nitric oxide (NO) has an important function as a key signalling molecule in plant growth, development and senescence as well as RNS like ROS also play an important role as signalling molecule in the response to Environmental (abiotic) Stress. Similarly, NO is a key mediator in co-operation with ROS, in the defence response to pathogen attacks in plants.

Main RNS are as following:

Free Radicals	**Non Radicals**
Nitric oxide $NO^{\cdot}$	Nitrous acid HNO_2 , Nitrosonium cation NO^+
Nitric dioxide $NO_2{}^{\cdot}$	Nitroxyl anion
Nitrate radical $NO_3{}^{\cdot}$	N_2O_4 and N_2O_3

In plants there are several potential sources of NO including enzymatic and nonenzymatic systems.

Hypoxic and anoxic conditions result in the energy crisis that leads to cell damage. Since mitochondria are the primary organelles for energy production, the support of these organelles in a functional state is an important task during oxygen deprivation. Plant mitochondria adapted the strategy to survive under hypoxia by keeping electron transport operative even without oxygen via the use of nitrite as a terminal electrons acceptor. The process of nitrite reduction to nitric oxide (NO) in the mitochondrial electron transport chain recycles NADH and leads to a limited rate of ATP production. The produced ATP alongside with the ATP generated by fermentation supports the processes of transcription and translation required for hypoxic survival and recovery of plants. Non-symbiotic hemoglobins (called phytoglobins in plants) scavenge NO and thus contribute to regeneration of NAD^+ and nitrate required for the operation of anaerobic energy metabolism. This overall operation represents an important strategy of biochemical adaptation that results in the improvement of energy status and thereby in protection of plants in the conditions of hypoxic stress.



Nitrite reduction and NO formation occur in mitochondrion and cytosol of a plant cell

plant mitochondria in the conditions of oxygen deficiency can reduce nitrite to NO, which can help in increasing their energy efficiency for supporting active transcription and translation processes in the hypoxic cells. In the reactions with ROS, NO forms peroxynitrite and other RNS such as N_2O_3 which play a role as signals during the nitrosative stress.

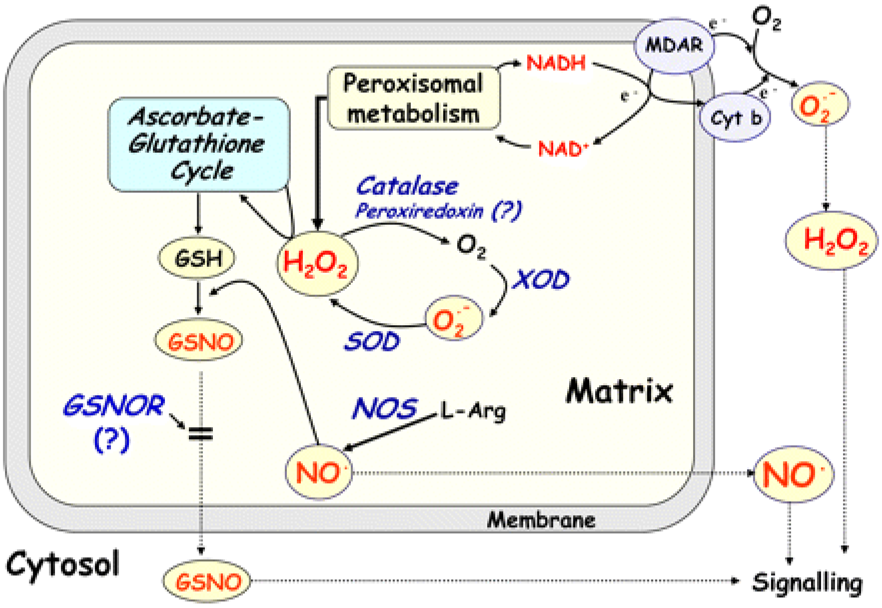
nitrite reduction to NO takes place in root mitochondria from various species, such as pea, barley, *Arabidopsis* and tobacco, and determined the *K*m value for nitrite reduction to NO (175 µM). This allowed estimating nitrite concentration needed for NO production. Since under hypoxia nitrite reduction to ammonium is inhibited (Botrel et al., 1996), the accumulated nitrite can act as a substrate for NO formation. This reaction is highly sensitive to oxygen, which has a *K*i value of approximately 0.05% or 0.6 µM (Gupta and Igamberdiev, 2011). Gupta and Kaiser (2010) demonstrated that this process occurs in the membrane but not in the matrix of mitochondria. The complexes III and IV of the mitochondrial electron transport chain were shown to be the sites for NO production.

$NO_2^- + 2H^+ + e^- \rightarrow NO + H_2O$

In peroxisomes of leaves and roots from salt-tolerant tomato plants, there was an up-regulation of the antioxidative systems in response to salt-induced oxidative stress.

The existence of a reactive oxygen and nitrogen metabolism in plant peroxisomes and the presence in these organelles of a complex battery of antioxidative enzymes, emphasizes the importance of these organelles in cellular oxidative metabolism.

Plant peroxisomes have a ROS- and RNS-mediated metabolic function in leaf senescence and certain types of abiotic stress. Until recent years, mitochondria and chloroplasts were considered to be almost exclusively responsible for the intracellular oxidative damage induced by different stresses. However, peroxisomes can have two antagonistic roles in cells, as oxidative stress generators and as a source of ROS and RNS signal molecules. These organelles could act as subcellular indicators or sensors of plant stress and senescence by releasing signaling molecules to the cytosol and triggering specific changes in defense gene expression.



Model of the role of peroxisomes in the generation of the signal molecules H2O2, O2-, NO and GSNO (S-nitrosoglutathione).