REVIEW OF RESEARCH

PHYTOCHELATINS : A FRIEND IN NEED FOR PLANTS

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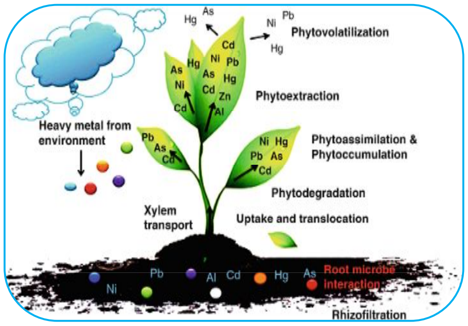


ABSTRACT:

The accumulation of heavy metals in the environment poses serious risk to the well-being of living organisms.The heavy metals causes stress alike in plants and animals due to the formation of reactive oxygen species (ROS).Plants unlike animals are immobile and has developed different efficient defense system like phytochelatins (PCs) within their cells to overcome such dangers . Phytochelatins are oligomers of glutathione which acts as chelaters and by metal sequestering process helps to determine and counteract the detrimental effects of heavy metal stress in plants.

KEYWORDS: *Heavy metal,Stress, ROS, Phytochelatin .*

1.INTRODUCTION:

Heavy metals is ubiquitous in nature and non degradable. Their accumulation in the environment is considered to be hazardous to both plants and animals at specific concentrations. Sequestration and Chelation of metals by particular ligands are two mechanisms used by plants to avoid or counteract the harmful effects of metal stress. Chelation is a Greek word derived from “chelos” meaning for claw. It is a phenomenon especially involved in heavy metal detoxification. During the process, a cation or mineral ion forms a complex ring structure by an organic molecule, the chelating agent.

Metal stress leads to reactive oxygen species or ROS formation in plant tissue.

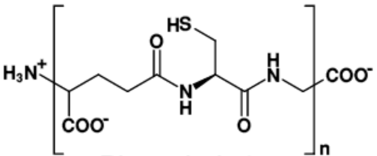
Furthermore metal toxicity may also result in decreased water potential, inhibition of growth, reduction in photosynthesis, inhibition in enzyme activities, oxidation of proteins and apoptosis or cell death.

In plants, the two best-characterized metal-binding ligands in plant cells are the phytochelatin**s** and metallothioneins.

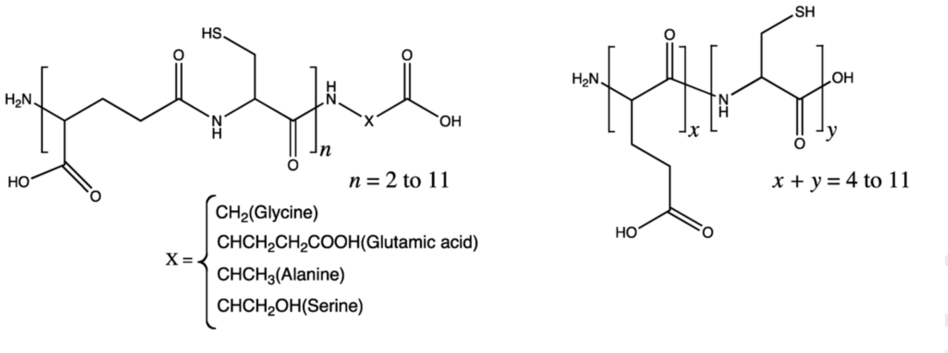
Phytochelatin**s** are oligomers of glutathione which plays an important part in detoxification of metals especially heavy metals. Phytochelatin was first discovered in 1981 in fission yeast (*Schizosaccharomyces pombe)* and was named cadystin. They were later identified in higher plants where they are transported into the vacuole.

Chemical structure of Phytochelatin

Phytochelatins are structurally related to glutathione (GSH). They are non-protein cysteine-rich oligopeptides (c-Glu-Cys)n-Gly, with increasing repetitions of the dipeptide Glu-Cys attached through a c-carboxylamide bond , where n varies from 2 to 11(Fig.1).In iso-phytochelatins, it has been observed that the polymer is capped C-terminally by amino acid residues of serine, glutamine, glutamic acid whereas in homo-phytochelatin, it is generally capped with beta-alanine.



Phytochelatin



Phytochelatin analogs (PCs) Protease-catalyzed co-oligopeptides of Glu/Cys

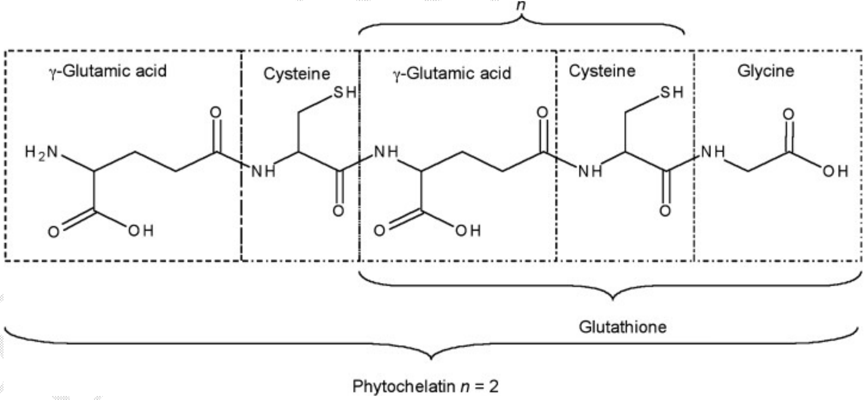
Fig.1. Structure of Phytochelatin

Classification of Phytochelatins

Metallothionins are intracellular, low molecular weight, cysteine rich metal binding proteins broadly classified into four categories from MT-I to MT- IV according to their position of cysteines (Anjum*et al.*, 2015). Phytochelatins are analogous to class III metallothionins. The terminal amino acid at the carboxyl end varies and further divides the class III MTs into five families (one of the family is PCs).

In plants, phytochelatins are cysteine-rich small peptides consisting of 4-23 amino acids and are generally induced in response to heavy metal stress. The number and position of the cysteine residues found in both Metallothionins and Phytochelatins are sequential and highly conserved unique forms of Cys-x-Cys, Cys-x-y-Cys, and Cys-Cys sequences (x and y represents noncysteine amino acids) [Rauser,1999; Cobett,2000]. PCs have been categorized into PC2, PC3, PC4, PC5, and PC6 etc. based on the number of -Glu-Cys units present.

Given below is an example of phytochelatin structure where n=2 (PC2)



Variations of PC peptides in plants

Phytochelatins and structurally related peptides (Table.1) with different degrees of polymerisation have been obtained from more than 300 species of plants and other organisms. The frequent occurrence of phytochelatin peptides with highly conserved sequences throughout the plant kingdom suggests that the PCs may act as primary metabolites in plants (Clemens,2006;Pal *et al.*,2010).

Table 1 : Different PC like peptides observed in yeast and plants

Sl.No.	**PC-related** γ(EC) **peptides**	**Structure**	**Source**
1	Phytochelatin (Cadystin)	(γ Glu-Cys)n- Gly	Yeast; Plant
2	Homophytochelatin	(γ Glu-Cys)n- Ala	Leguminosae
3	Hydroxymethyl-PC	(γ Glu-Cys)n- Ser	Graminae
4	Desglycine PC	(γ Glu-Cys)n	Yeast;Maize
5	Iso-PC (Glu)	(γ Glu-Cys)n- Glu	Maize
6	Iso-PC (Gln)	(γ Glu-Cys)n- Gln	Horse radish

Biosynthesis of phytochelatin

Phytochelatin synthaseisa specificc-glutamylcysteinyl(c-EC)dipeptidyl transpeptidase (Vatamaniuk et al., 2004). They are largely papain-type proteases (Rea et al., 2004; Vivares et al., 2005) .Phytochelatin synthase (PCS) activity is promoted by heavy metal ions catalyzing the formation of PC from GSH by transferring glutamylcysteinyl residues (gamma-EC) onto GSH (Oven et al.,2002;Beck et al., 2003; Blum et al.,2007).It has been proposed that the strongly conserved N-terminal half of Phytochelatin synthase is responsible for catalysis . Furthermore the activation of the enzyme depends on the binding of metal ions predominantly to cysteine residues within this domain (Vatamaniuk et al., 2000).

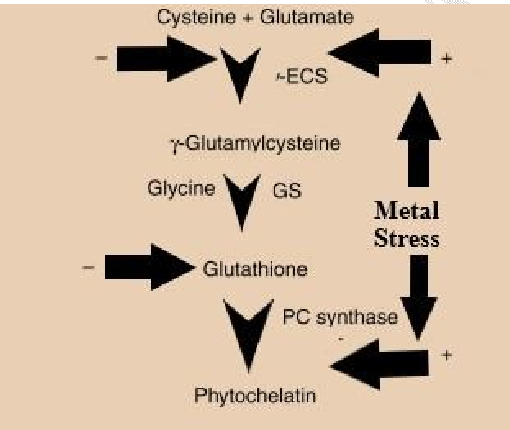


Figure 1. Biosynthesis of PCs in Plants.

GS-conjugates in plants comprise adducts of GSH and secondary metabolites (Alfenito et al., 1998; Marrs et al.,1995)

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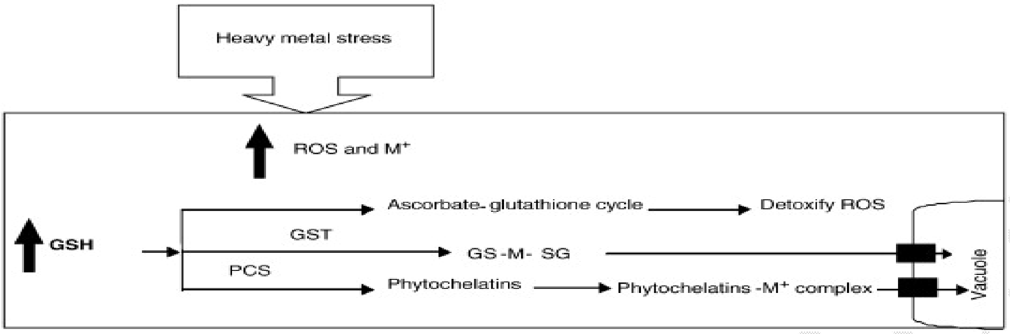
Function of phytochelatin synthase in catabolism of glutathione-conjugates (PDF Download Available). Available from:
https://www.researchgate.net/publication/6550132_Function_of_phytochelatin_synthase_in_catabolism_of_glutathione-conjugates [accessed Jul 21, 2017].
1995)

How does phytochelatins work?

Phytochelatins are induced in response to metal stress rather than produced naturally in plants. The heavy metal ions form complexes as thiolates with GSH-derived phytochelatins (PCs). Formation of these complexes depend on the availability of ligand , kinetics of complex formation including steric factor. In plants, the phytochelatin and metal ion complexes are formed in the cytosol and transported to vacuole (Anjumet al., 2015).The plant vacuole is the transient storage compartment for these mercaptides.



CONCLUSION

Response of plants to biotic and abiotic stress especially induced by HM (Heavy Metal) include chelation and sequestration of metal ions by ligands. PCs which are cysteine rich ligands are ubiquitously present in plants but not in animals.Further work on PCs may enrich our knowledge on their status in animals and provide us more insight in the elusive ways to combat heavy metal stress in both plants and animals.

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