Popular Article
TRENDS IN AGRICULTURE SCIENCE
Vol.3 Issue 08 August 2024, Page: 2155-2158

"Plant Epigenetics and Viral Pathogenesis"

Vanthana M
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
DOI:10.5281/TrendsinAgri.13624124

The epigenetic modifications of plants are essential for their growth, development, survival and reproduction even during adverse conditions. The modifications at the DNA level, histone proteins, and non-coding RNA have made plants evolve against various abiotic and biotic stress factors. The change in the phenotype without any change in the genotype was first proposed by Conrad Hal Waddington in 1942, a leading evolutionary British biologist. Epigenetic trait has been defined as a "stably heritable phenotype resulting from changes in a chromosome without alterations in the DNA sequence" (Berger *et al*. 2009). They are the important source of phenotypic variation in natural populations. Unlike mammals in which epigenetic modification occurs during embryonic development, plants undergo epigenetic modification throughout their life cycle due to the presence of self-replicative stem cells called meristems. Plant viruses use the host machinery for their survival, whose multifunctional protein indeed acts as pathogenecity determinants though not all the factors involve in pathogenesis necessarily involves in essential process of life cycle. The replication, movement, encapsidation and transmission plays a crucial role in viral pathogenesis. The plants have evolved many mechanisms to defend itself from many pathogens, among which epigenetic modification enables them to combat many pathogens including plant viral infections. The availability of many new advanced technologies has led to a deeper understanding of the regulation of gene expression through epigenetic modifications. DNA methylation is well-studied and well understood phenomenon of epigenetic modifications which can be traced using techniques like sodium bisulfite sequencing (Frommer *et al*, 1994), chromatin immunoprecipitation and next generation sequencing. Thus, the understanding of epigenetic modification grows rapidly in search of novel crop improvement and crop protection strategies.

MECHANISMS OF EPIGENETICS:

DNA METHYLATION

Published: 30 August 2024
ISSN: 2583-7850

DNA methylation is one of the most important epigenetic mechanisms in all eukaryotes. The methylation occurs to the cytosine base in symmetric (CG and CHG, where H is A, T, or C) and asymmetric manner (CHH). It is very specific and occurs at the 5' position of the cytosine.

HISTONE MODIFICATIONS

Histone modification is another pivotal epigenetic molecular mark present in all organisms. DNA is complexed with histones to form nucleosomes. Each nucleosome consists of histone octamer viz., H2A, H2B, H3, and H4. The histone modification targets the basic amino acids such as lysine and arginine at the N-terminal regions of the histone. These are covalently modified by different processes including methylation, acetylation, phosphorylation, and ubiquitination. These changes alter the expression of genes enveloped around the histone.

VIRAL PATHOGENESIS:

The various proteins essential for the life cycle of the viruses like replicase protein, movement protein, coat protein, suppressor, and other viral factors are involved in viral pathogenesis. Not all the determinants are involved in pathogenecity but they remain crucial for development of viral infection in plants.

RNA VIRUS

Majority of the plant viruses are RNA viruses with positive single strand genome. Among the RNA viruses potyviruses are the most known plant virus infecting many plants. Cheng and Wang, 2013, reported that potyviruses upon entry into a plant cell, various steps such as virion disassembly, and translation of potyviral genomic RNAs generates 2 polyproteins that are proteolytically processed by 3 protease domains into 11 viral proteins (VRs). This includes coat protein (CP), nuclear inclusion b (NIb) which is the only viral RNA-dependent RNA polymerase (RdRp), 2 viral suppressors of RNA silencing (VSRs), e.g., HC-Pro and VPg. Viral replication complexes (VRCs) are formed to catalyze viral replication. Viral dsRNAs,(as replicative intermediates, or generated by de novo synthesis or as a result of internal pairing of viral RNA) trigger RNA silencing mechanism to suppress viral infection. While VSRs suppress RNA silencing to overcome plant defense mechanism and promote viral infection. VSRs also suppress small interference RNAs (siRNAs) that regulate post-transcriptionally resistant (R) genes which mainly encode nucleotide-binding site leucine-rich repeats (NB-LRR) receptors. On upregulation of NB-LRR, effector-triggered immunity (ETI) is activated. Potyviral dsRNAs function as a pathogen-associated molecular pattern (PAMP) to induce PAMP-triggered immunity (PTI). Potyviral CP act as VIIS and suppresses PTI. Other elements such as NIb are recognized by some R proteins and activate ETI. Plants perceive viral infection by BAK1 and SERK1 which results in activation of PTI. Followed by hypersensitive response (HR), necrosis

Published: 30 August 2024
ISSN: 2583-7850

and systemic acquired resistance (SAR). These are associated with changes in salicylic acid (SA), jasmonic acid (JA), ethylene (ET), nitric oxide (NO) and hydrogen peroxide (H2O2) levels. As a result, various defense genes including those regulated by non-expressor of pathogenesis related genes-1 (NPR1) are upregulated. Potyviral NIb targets the nucleus where it is sumoylated by SUMO3(SMALL-UBIQUITIN LIKER MODIFIER 3 – activator of NPR1), which inhibits sumoylation of NPR1. These Sumoylated NIb retargets the cytoplasm for viral replication and thus acts as VIIS.

DNA VIRUS

The DNA virus redirects host gene expression to accumulate host DNA polymerases to assist the viral genome amplification. The proteins of geminivirus interact with plant transcription machinery, DNA replication process and proteins related to cell division, plant metabolism, defense and stress-related proteins. The viral genomes encode Rep and C3 which are essential for virus replication process. The rolling circle replication of Geminivirus takes place in the nucleus of an infected plant cell. The dsDNA Replcative Form intermediates act as templates for replication and transcription. These in association with cellular histone proteins form viral minichromosomes (Pilartz & Jeske, 1992, 2003), to repress or activate chromatin. Rodríguez-Negrete *et al*, 2013 reported that the Geminivirus Rep protein suppresses the expression of plant DNA methyltransferases, METHYLTRANSFERASE 1(MET1) and CHROMOMETHYLASE 3 (CMT3), in both locally and systemically infected tissues. In addition to the Rep protein, another viral protein C4 displayed a distinct TGS suppressor activity.

The counter strategy of plant viruses

Viral suppressors mediate the gene silencing pathway which is the major plant defense mechanism against virus infection eg: HC-PRO, TAV, 2b, P19 proteins, etc (Garcia and Pallas,2015)

CONCLUSION:

The epigenetic modification in plants which is a natural phenomenon helps in evolution of plants against various stresses. Though RNA mediated gene silencing is one of the mechanism to silence genes, its involvement in plant epigenetics is still unclear.The deeper understanding of these mechanisms can enhance the strategies used for the development of resistant plant against virus diseases and many other diseases too. The co evolution of plant and the pathogen is a continuous process which provided the extreme resistance in plants. Unravelling this epigenetic modification can result in novel management strategies for many plants viral diseases.

References

Published: 30 August 2024
ISSN: 2583-7850

Berger SL, Kouzarides T, Shiekhattar R, Shilatifard A (2009) An operational definition of epigenetics. *Genes Dev* 23:781–783

Cheng, X. and Wang, A., 2017. Multifaceted defense and counter-defense in co evolutionary arms race between plants and viruses. *Communicative & integrative biology*, 10(4): 508-25.

Frommer M, McDonald LE, Millar DS, Collis CM, Watt F, Grigg GW *et al* (1994) A genomic sequencing protocol that yields a positive display of 5-methylcytosine residues in individual DNA strands. *Proc Natl Acad Sci* USA, 89(5):1827–1831

García, J.A. and Pallás, V. 2015. Viral factors involved in plant pathogenesis. *Current opinion in virology*, *11*: 21-30.

Pilartz M, Jeske H. 1992. Abutilon mosaic geminivirus double-stranded DNA is packed into minichromosomes. *Virology,* 189: 800–802.

Pilartz M, Jeske H. 2003. Mapping of abutilon mosaic geminivirus minichromosomes. *Journal of Virology*, 77: 10808–10818.

Rodríguez-Negrete, E., Lozano-Durán, R., Piedra-Aguilera, A., Cruzado, L., Bejarano, E.R. and Castillo, A.G., 2013. Geminivirus Rep protein interferes with the plant DNA methylation machinery and suppresses transcriptional gene silencing. *New Phytologist*, *199*(2): 464-475.

Published: 30 August 2024
ISSN: 2583-7850