Journal Home: www.bioticainternational.com

Popular Article

Article: RT0382

Biotica Research Today

Vol 2:10 1063/1064

2020

Modulation of Plant Immunity by Circadian Rhythm

Sneha R. Patil[1*] and C. Senthilraja[2]

[1]Dept. of Plant Pathology, College of Agricultural Technology, Theni, Tamil Nadu (625 562), India

[2]Dept. of Plant Protection, Horticulture College and Research Institute, TNAU, Periyakulam, Tamil Nadu (625 604), India

Open Access

Corresponding Author

Sneha R. Patil

e-mail: snhpatil70@gmail.com

Keywords

Biological clock, Circadian rhythm, Defence, Plants

How to cite this article?

Sneha and Senthilraja, 2020. Modulation of Plant Immunity by Circadian Rhythm. Biotica Research Today 2(10): 1063-1064.

Abstract

Almost all living organism on Earth have evolved the ability to assimilate environmental and internal signals to determine time and accordingly adjust their behaviour, metabolism and physiology. This evolved ability of the organisms to judge time is based on the concept of biological rhythm or circadian rhythm or circadian clock which is an endogenous time keeper and plays crucial role for multiple biological processes in many organisms. Plants also activate time dependent defence with various strategies to forestall daily attacks of pathogens and pests and to modulate responses to specific invaders in a time of day dependent manner. Likewise, pathogen also functions in a clock dependent manner to create infection and suppress the host defence. A better understanding of the role of circadian clock in plants immunity will help in regulating the management strategies.

Introduction

Circadian clock/ circadian rhythm is an internal biological clock that helps the organism to anticipate the predictable day and seasonal changes that occur in the environment as a consequence of earth's rotation. It was first identified in housefly by Jeffrey. C. Hall, Michael. W. Young and Michael Rosbash, for which they were awarded with Nobel Prize. Circadian clock in humans help in adjusting the body temperature, blood pressure, sleeping and waking pattern according to the changes in environment within a period of 24 hours. Circadian clock generally accounts for a period of 24 hours depending upon the earth's rotation around its axis. Similar to the circadian rhythm in insects and humans, plants also utilize this endogenous timekeeper for carrying out various essential day to day activities. Opening and closing of flowers, stomata, production of ROS, activation of plant innate immunity, photosynthesis, hormone signalling, metabolism and nutrient uptake, enzyme activity, gene expression, cold response, flowering and growth, etc. are all regulated by the circadian clock in response to the changes in climate during the period of 24 hours.

Circadian Clock in Plant Defence

The biological clock is responsible for regulating around seven different immunity mechanisms in plants *viz.*, i) Circadian clock genes and disease resistance, ii) Circadian clock regulated stomatal dependent and independent defence, iii) Circadian clock regulated PTI and ETI, iv) Circadian clock regulated hormone signalling, v) Circadian clock regulated SA and SAR, vi) Circadian regulated JA mediated resistance, and vii) Circadian clock regulated reactive oxygen species.

Article History

Received in 21th October 2020

Received in revised form 27th October 2020

Accepted in final form 28th October 2020

E-mail: *bioticapublications@gmail.com*

Circadian Clock Genes and Disease Resistance

There are several circadian genes that regulate various defence mechanisms in plant system. *CCA1* and *LHY* gene participate in stomatal operations, ROS homeostasis and defence gene expression. They are active for short period during morning hours. *TOC1* gene is active for short period during evening hours and regulates Stomatal opening and closure, ROS response and defence gene expression. *TIC* gene functions during evening hours for short period and acts as a negative regulator of JA response and affects ROS response. The *ELF3, ELF 4, LUX* and *ZTL* genes exhibit arrhythmic activity during evening hours and affect the ROS response in plants. Thus, it is clear that the entire defence system of plants is governed by these clock genes.

Circadian Clock Regulated Stomatal Dependent and Independent Defence

Stomata not only plays an important role in photosynthesis and transpiration, but also paves entry for several pests and pathogens into the plant system. Stomata generally opens during day time and closes during night time. This time dependent activity of stomata is monitored by the clock genes in response to the changes in light and humidity in a diurnal cycle. Plants usually express enhanced resistance to pathogens at night than in morning. Only in case of mis-expressed clock genes particularly *CCA1, LHY, TOC1, LUX* and *TIC*, disrupted diurnal stomatal opening and closing can be observed.

Circadian Clock Regulated PTI and ETI

Circadian clock plays an important role in the regulation of PTI and ETI. The basal defence mechanism in plants i.e. PTI is governed by the circadian clock and is more active during the day time, while the circadian clock mediated ETI is more prominent during night hours.

Circadian Regulated Hormone Signalling

The role of SA and JA is well known as defence hormones, but six major plant hormones (auxin, cytokinin, ethylene, gibberellic acid, abscisic acid and brassinosteroid) also play an important role in defence regulation by balancing growth and defence throughout the plant life cycle. These enzymes are all controlled directly by the core clock proteins and are more active during day time. Except for SA all other enzymes are active during day time.

Circadian Regulated SA and SAR

SA and associated SAR are governed by the clock genes. Basal SA levels oscillate daily, with a peak at night. Expression of major genes affecting SA levels including *ICS1, EDS1, EDS5* and *ACD6* also shows circadian oscillations. *NPR1* monomer accumulates rhythmically with a peak at night.

Circadian Regulated JA Mediated Resistance

The JA pathway is also circadian mediated. The JA level oscillates during a day with a peak at midday. Expression of some key JA biosynthetic genes is circadian regulated. Expression of some core JA signalling genes *e.g.*, *COI1, MYC2* and *JAZ* show circadian cycling that is dependent on the clock protein *TIC.*

Circadian Clock Regulated Reactive Oxygen Species

The circadian clock has been implicated in regulating ROS production, scavenging and signalling. The cycling expression of these ROS genes is largely dependent on *CCA1, ELF3*, *LUX* and *TOC1* genes.

Conclusion

The circadian clock regulates multiple immune responses in the plant system, thus modification in these clock genes successfully helps in management of various pest and pathogens. Addition or deletion of these clock genes in the plants would make the plants sturdier and more resistant to various pests and pathogens. This would reduce the use of chemicals and also reduce the environment toxicity created due to these chemicals. This concept needs to be further exploited so that it could be practically implicated in majority of the crops other than *Arabidopsis.*

References

Bendix. C., Marshall, M.C., Harmon, G.F., 2015. Circadian clock genes universally control key agricultural traits. Molecular Plant, 1-18.

Lu, H., McClung, R.C., Zhang, C., 2017. Tick Tock: circadian regulation of Plant Innate Immunity. Annual Review of Phytopathology, 55, 12.1-12.25.