The signal transduction in phytomelatonin-induced watermelon resistance to abiotic and biotic stresses

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Abstract

Melatonin (N-acetyl-5-methoxytryptamine), a highly conserved molecule, is ubiquitous throughout animals, plants, and all the other kingdoms. Since the first studies showed that melatonin indeed exists in plants, numerous subsequent studies have proven melatonin plays important roles in the regulation of plant defense against various abiotic and biotic stresses; however, the underlying mechanisms remain largely unknown. In recent years, we identified the first melatonin biosynthetic gene *ClCOMT1* cloned from a species in the Cucurbitaceae and confirmed that *ClCOMT1* is a positive regulator of plant tolerance to abiotic stresses. Furthermore, we revealed the role and mechanism of phytohormones (e.g. MeJA and ABA) and second messengers (e.g. H_2O_2 and Ca^{2+}) in melatonin-mediated plant resistance to stresses. For instance, we reported that H_2O_2 is essential for melatonin-induced glutathione and subsequent oxidative stress tolerance in cucumber. Under cold stress, melatonin and ABA interaction is involved in grafting-induced cold tolerance by inducing the accumulation of methyl jasmonate (MeJA) and H_2O_2. MeJA subsequently increases melatonin accumulation, forming a self-amplifying feedback loop that leads to increased H_2O_2 accumulation and cold tolerance. Furthermore, positive interaction between H_2O_2 and Ca^{2+} mediates melatonin-induced CBF pathway and cold tolerance. Under salt stress, melatonin confers plant tolerance by improving photosynthesis and redox homeostasis. Under drought stress, alkanes (C29 and C31) - mediated intracuticular wax accumulation contributes to melatonin- and ABA-induced drought tolerance. Under *fusarium* wilt and aphid stress, melatonin-induced plant resistance essentially involves MeJA and H_2S. Taken together, our series of studies provide novel insight into the mechanism of melatonin-induced plant resistance to abiotic and biotic stresses. Based on these findings, we also have developed a series of plant inducible resistance techniques to benefit the agricultural production.

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Oral report-related papers I published as the first or corresponding author:

1. Chang JJ, Guo YL, Yan JY, Zhang ZX, Yuan L, Wei CH, Zhang Y, Ma JX, Yang JQ, Zhang X*, **Li H*.** 2021. The role of watermelon caffeic acid *O*-methyltransferase (ClCOMT1) in melatonin biosynthesis and abiotic stress tolerance. Horticulture Research, 8(1): 210.
2. **Li H,** Guo YL, Lan ZX, Xu K, Chang JJ, Ahammed GJ, Ma JX, Wei CH, Zhang X*. 2021. Methyl jasmonate mediates melatonin-induced cold tolerance of grafted watermelon plants. Horticulture Research, 8: 57.
3. **Li H,** He J, Yang X, Li X, Luo D, Wei CH, Ma JX, Zhang Y, Yang JQ, Zhang X. 2016. Glutathione-dependent induction of local and systemic defense against oxidative stress by exogenous melatonin in cucumber (*Cucumis sativus* L.). Journal of Pineal Research, 60: 206-216.
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5. **Li H,** Wang Y, Wang Z, Guo X, Wang F, Xia XJ, Zhou J, Shi K, Yu JQ, Zhou YH. 2016. Microarray and genetic analysis reveals that csa-miR159b plays a critical role in abscisic acid-mediated heat tolerance in grafted cucumber plants. Plant, Cell & Environment, 39: 1790-1804.
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13. **Li H,** Guo YL, Cui Q, Zhang ZX, Yan X, Ahammed GJ, Yang XJ, Yang JQ, Wei CH, Zhang X*. 2020. Alkanes (C29 and C31)-mediated intracuticular wax accumulation contributes to melatonin- and ABA-induced drought tolerance in watermelon. Journal of Plant Growth Regulation, 39: 1441-1450.
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Unpublished papers:

1. **Li H**, et al. Methyl jasmonate and sulfuretted hydrogen are involved in melatonin-induced *fusarium* wilt resistance in *Citrullus lanatus* L.
2. **Li H**, et al. Positive interaction between melatonin and methyl jasmonate enhances watermelon defense against aphids via sulfuretted hydrogen signaling.