Light Regulation of Nodulation Through Plant Hormone Signaling Network

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In addition to the usage in photosynthesis, light also regulates the development of both the shoot and the root of plants. Although nodulation is a beneficial symbiosis between the plant and its rhizobial symbiont, it is highly energy costive. We found that red light stimulates and far-red light inhibits nodulation of *Medicago truncatula*, suggesting the involvement of the phytochrome system. The *giraffe* mutant of *Medicago truncatula*, isolated in our lab, has defects in response to red and far-red light and exhibits a classic photomorphogenic phenotype. We found that *giraffe* mutants are insensitive to both red light stimulation and far-red light inhibition of nodulation. Nodulation on grafted plants showed that the *GIR* gene is required in the shoot to mediate red light stimulation of nodulation which indicates the involvement of a secondary shoot to root signal in light regulation of nodulation process. Blue light also inhibits nodulation of *Medicago truncatula* and *Lotus japonicus*, but does not require the *GIR* gene. In addition, red light stimulates and enhances the induction of early nodulation genes such as *ENOD11* and *NIN*. In contrast, blue light does not inhibit the induction of *ENOD11* suggesting that blue light and red light regulate nodulation via different mechanisms. Plant hormones such as abscisic acid (ABA), auxin, cytokinin, jasmonic acid and ethylene, play a significant role in light signaling and regulation of nodulation [1-5]. We found that nodulation of the ethylene-insensitive mutant, *sickle*, is resistant to the inhibitory effect of far-red light on nodulation, but responds normally to the stimulatory effect of red light. We also found that ABA signaling is down-regulated by red light and up-regulated by blue light. Both ethylene and ABA have been shown to negatively regulate nodulation [6, 7], suggesting the involvement of a complex plant hormone regulatory network in the light regulation of nodulation.

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