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Symbiotic nodules formed on legume roots with rhizobia fix atmospheric N_2. Bacteria reduce N_2 to NH_4^+ that is assimilated into amino acids by the plant. In return, the plant provides photosynthates to fuel the symbiotic nitrogen fixation. Symbiosis is tightly adjusted to the whole plant nutritional demand and to the plant photosynthetic capacities, but regulatory circuits behind this control remain poorly understood. The use of split-root systems combined with biochemical, physiological, metabolomic, transcriptomic, and genetic approaches revealed that multiple pathways are acting in parallel [1–6]. Systemic signaling mechanisms of the plant N demand are required for the control of nodule organogenesis, mature nodule functioning, and nodule senescence. N-satiety/N-deficit systemic signaling correlates with rapid variations of the nodules sugar levels, tuning symbiosis by C resources allocation[4]. These mechanisms are responsible for the adjustment of plant symbiotic capacities to the mineral N resources. On the one hand, if mineral N can satisfy the plant N demand, nodule formation is inhibited, and nodule senescence is activated[4,5]. On the other hand, local conditions (abiotic stresses) may impair symbiotic activity resulting in plant N limitation. In these conditions, systemic signaling may compensate the N deficit by stimulating symbiotic root N foraging [2–4]. In the past decade, several molecular components of the systemic signaling pathways controlling nodule formation have been identified, but a major challenge remains, that is, to understand how they contribute to the whole plant phenotypes [6]. Less is known about the control of mature nodule development and functioning by N and C nutritional status of the plant, but a hypothetical model involving the sucrose allocation to the nodule as a systemic signaling process is proposed [4,6]. Altogether these data highlight the importance of organism integration in the biology of rhizobium-legume symbiosis.

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