Phytochrome B Output Module Sets Thermosensing Photobody Number and Tunes Arabidopsis Adaptation

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Phytochrome B (phyB) is a plant photoreceptor that forms nuclear photobodies involved in temperature sensing. While photobody size has been studied, the mechanism controlling photobody number remains unclear. This project tested whether photobody number is determined by the phyB Output Module (OPM) and regulated by the Photosensory Module (PSM), and whether natural variation in OPM tunes this property for climate adaptation. Using Arabidopsis seedlings expressing fluorescently tagged phyB constructs—including isolated OPM, OPM point mutants, and natural phyB variants—and 3D fluorescence microscopy, PBs were manually quantified from z-stack images of more than 90 nuclei per genotype. Full-length phyB exhibited temperature-dependent photobody number, decreasing from ~5 photobodies per nucleus at 16 °C to ~3 at 27 °C. In contrast, OPM-only constructs formed ~10 condensates per nucleus independent of temperature, indicating that OPM provides intrinsic nucleation activity while PSM restrains this activity to confer temperature sensitivity. Targeted OPM mutations reduced photobody number, demonstrating that nucleation strength is encoded by OPM sequence. Analysis of the 1001 Arabidopsis Genomes dataset identified climate-associated OPM variants; notably, a hot-climate OPM allele produced markedly fewer photobodies (~1 per nucleus). Together, these results establish photobody condensate number as a tunable molecular trait linking protein sequence variation to plant thermosensing and climate adaptation. Furthermore, they identify OPM as a potential target for engineering temperature-resilient crops.

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