Photoprotective capacity under dynamic light conditions varies across the maize canopy

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Crops in the open field grow in extremely dynamic light environments: cloud cover, sun angle, wind, and self-shading within dense canopies can alter light intensity by orders of magnitude within seconds. When light intensity is too high for all the energy to be used for photosynthesis, photoprotective mechanisms are induced to prevent damage to the photosynthetic machinery and subsequently relaxed when light becomes limiting. Nonphotochemical quenching (NPQ), wherein excess light energy is dissipated as heat, is one of the most universal and important photoprotective mechanisms in plants. NPQ responses are fast but not instantaneous, often lagging behind light fluctuations and temporarily limiting photosynthetic efficiency and resulting in substantial losses to carbon assimilation. Within the complex structures of plant canopies, there is significant spatial variation not just in light availability, but also in the frequency, duration, and amplitude of light fluctuations. Leaves at different levels have distinct anatomical, structural, and metabolic characteristics, and whilst our understanding of NPQ responses to dynamic light has increased substantially, how those responses vary within the leaf canopy is not yet fully understood. We studied variation in photoprotective and photosynthetic capacity across the maize canopy by comparing NPQ induction and relaxation dynamics and carbon assimilation under steady and fluctuating light conditions. Top leaves not only had higher photosynthetic capacity in steady state but also exhibited greater adaptability to changing light conditions – NPQ induction and relaxation were faster in top than in bottom leaves, suggesting more effective photoprotection at that canopy position. Concomitantly, top leaves had higher assimilation relative to steady state after light-step changes, further indicating faster responses to fluctuating light. These findings underscore the importance of considering canopy position for models of photoprotective responses and whole-canopy photosynthesis.