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The Ability of Cucumber to Oxidize in Photosystem-I Demonstrates its Tolerance to Cold Stress

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Description

Low temperatures hinder plant growth and prevent photosynthesis. Cucumber (*Cucumis sativus* L.) is a plant that is sensitive to cold, so growing it in a greenhouse during the winter takes a lot of energy. Therefore, it is desirable to have a useful stress marker for selecting cucumber cultivars that are chilling-tolerant. By measuring photosynthetic parameters, we evaluated chilling-stress damage in various cucumber cultivars in this study. After chilling, the majority of cultivars showed decreases in the quantity of active PS-I (Pm) and the quantum yield of photosystem (PS) II (Fv/Fm and Y(II)). In contrast, Y(ND), the ratio of PSI reaction center chlorophyll P700 in its oxidized state (P700+), varied between cultivars and was perfectly inversely correlated with Y(NA), the ratio of P700 that was not photooxidizable. P700+ has long been known to build up in stressful conditions and protect plants by reducing the production of reactive oxygen species. In point of fact, cultivars that were unable to induce Y(ND) after chilling stress displayed growth retardation with decreases in leaf area and chlorophyll content. As a result, cucumber chilling-stress tolerance can be evaluated with the help of the Y(ND) marker. How the electron transport reaction is carried out in the photosynthetic electron transport chain around photosystem I (PSI) remains a contentious issue. As the absorbance shifts between 820 and 830 nm, the oxidized P700, PSI's reaction center chlorophyll, is the measurable component. By employing saturated-pulse illumination (SP;), the photo-oxidizable P700's existence probability was previously estimated to be the quantum yield at PSI [Y(I)]. 10,000–20,000 mol photons per square second. The Y(I) value, which was higher than the reaction rate at PSII and was regarded as the quantum yield of PSII, was used to estimate the Electron Transport Rate (ETR) at PSI, particularly under stress conditions such as CO2-limited and high light intensity conditions. As a result, it has been hypothesized that the stress condition enhanced the extra electron flow at PSI and played a significant role in dealing with the excessive light energy. However, there were some indications that the excessive electron flow at PSI could be overlooked from other perspectives. We demonstrated in this study that the restriction on electron donation to PSI made it simple to misestimate the SP-estimated Y(I) value.

Electron and Proton Transitions

In addition, we estimated the light-to-dark transition's quantitative turnover rate for P700+. However, P700's turnover rate was significantly lower than PSII's ETR. The current methods still make it difficult to estimate the ETR quantitatively at PSI. A series of electron and proton transfers are involved in the photosynthetic apparatus's in vivo, light-dependent production of ATP and reductants. Absorption spectroscopy and chlorophyll fluorescence analyses are used to estimate electron fluxes through photosystem I (PSI) and through photosystem II (PSII) in vivo. Absorption spectroscopy allows for the in vivo analysis of proton fluxes across the thylakoid membranes by measuring light-induced electro-chromic shifts. Guideline of these electron and proton transitions is expected for the thylakoids to fulfill the fluctuating metabolic needs of the cell. In order to balance light use for the production of ATP and reductants with the current metabolic requirements, chloroplasts have a diverse and adaptable array of mechanisms that regulate electron and proton fluxes. It is possible to gain insight into the operation of such regulatory processes in vivo by non-invasively probing electron and proton fluxes across the thylakoid membranes as well as through PSI and PSII. We guessed that cyclic electron stream around photosystem I (CEF-PSI) partakes in the enlistment of non-photochemical extinguishing (NPQ) of Chlorophyll (Chl) fluorescence when the pace of photosynthetic straight electron stream is electron-acceptor restricted. In intact tobacco plant leaves at various light intensities and partial pressures of ambient CO_2 (Ca), the relationships between photosynthesis rate, electron fluxes through both PSI and PSII (Je (PSI) and Je (PSII)) and Chl fluorescence parameters were examined simultaneously to test this hypothesis.

Photosynthetic Complexes

The rate of photosynthesis decreased when Ca was decreased, but Je(PSI) and Je(PSII) remained constant at low light intensities. The fact that Je(PSI) was greater than Je(PSII) suggests the existence of CEF-PSI. Both Je (PSI) and Je (PSII) benefited from increased photosynthesis when the light intensity was increased. The strong positive correlation between NPQ of Chl fluorescence and Je(PSI)/Je(PSII) also existed at high light and low Ca alone. By driving NPQ of Chl fluorescence, these findings suggested that CEF-PSI contributed to the dissipation of photon energy beyond that consumed by photosynthesis. The primary physiological function of CEF-PSI in higher plant photosynthesis is discussed. In addition to oxygenic photosynthesis's major photosynthetic complexes, new electron carriers have been discovered in the thylakoid membranes of higher plant chloroplasts. A plastidial NAD(P)H dehydrogenase (NDH) complex and a plastid terminal Plastoquinone Oxidase (PTOX) are two of the minor components in the stroma lamellae. By reducing Plastoquinones (PQs), the NDH complex participates in one of two electron transfer pathways around photosystem I (PSI). The other likely involves the newly discovered PGR5 and an unidentified Ferredoxin-Plastoquinone Reductase (FQR). The mutant phenotype and the presence of higher amount of the NDH complex and PTOX in response to environmental stress conditions suggest that these components likely play a role in the adaptation of photosynthesis to changing environmental conditions. The existence of a complex network of mechanisms regulating the expression and activity of the NDH complex. We propose that the NDH-dependent cyclic pathway around PSI, in conjunction with PTOX, regulates cyclic electron transfer activity by tuning the redox state of intersystem electron carriers in conditions of high ATP demand (such as high temperature or water limitation). Because of serious pressure conditions, PTOX related to the NDH as well as the PGR5 pathway may likewise restrict electron tension on PSI acceptor and forestall PSI photoinhibition.