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研究论文

温室茄子（*Solanum melongena* L.）光合数学模型与光合生化模型模拟分析

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摘要　针对植物光合与内外环境因子间的关系以及光合“午睡”现象中的气孔限制与非气孔限制问题，以温室茄子‘茄杂一号’为试材，对叶室温光组合方式下测定的净光合速率*Pn*对胞间CO_2浓度*Ci*响应曲线，和人工增施CO_2处理下测定的*Pn*日变化进程，进行了光合数学模型和Farquhar、von Caemmerer和Berry的光合生化动力学模型（简称为FvCB模型）模拟分析。采用美国思爱迪生态仪器有限公司的CI-301PS光合作用测定仪进行净光合速率（*Pn*）、光合有效辐射（*PAR*）、气温（*Ta*）、叶温（*Tl*）、环境二氧化碳浓度（*Ca*）、胞间二氧化碳浓度（*Ci*）和空气相对湿度（*Hr*）参数测定。其结果表明，无论是*Pn*对*Ci*的响应曲线还是光合日进程中，数学模型对Pn的拟合度明显优于为FvCB模型。因此，通过数学模型可以解析出光合日进程受单一环境因子（*PAR*、*Ta*、*Ca*、*Hr*）及其复合环境因子的综合影响。然而，FvCB模型模拟结果显示出，温光组合下受Rubisco（即RuBP羧化/加氧酶）数量与活性及动力学特性限制的羧化速率A_c、受RuBP（1,5-二磷酸核酮糖）再生限制的羧化速率A_j以及受TPU（磷酸丙糖）可利用量限制的羧化速率A_p对Ci响应的主控作用呈现交替变化趋势。其交替变化转折点胞间二氧化碳浓度$C_{i\,cj}$在强光高温组合中较高，而在弱光低温组合中较低；同时还发现，$C_{i\,cj}$和$C_{i\,jp}$受叶温的影响强于光照。光合日进程中的FvCB模型模拟分析揭示出，早晨和傍晚弱光下为A_j限制时段；晴天上午和中午前后的充足日照下为A_c限制时段。多云和阴天下A_j的限制时段延长。增施CO_2会延长A_j的限制时段，同时相应缩短A_c的限制时段；冬季2次增施CO_2的出现了A_p限制时段。

关键词　日光温室,茄子,CO2施肥,光合日变化,光合生化模型
分类号　Q141，Q945.11，Q948，S641.1

Analysis of photosynthetic simulation by a biochemical model or mathematical model in greenhouse eggplant

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Abstract In the relationship between photosynthesis and environmental factors or biochemical factors or between stomatal limitation and non-stomatal limitation in depression of photosynthesis at noon, photosynthetic simulations by a mathematical model (a regression equation between net photosynthetic rate (Pn) and intercellular CO_2 concentration (*Ci*) or other environmental factors including photosynthetic available radiation (*PAR*), air temperature (*Ta*), ambient CO_2 concentration (*Ca*) and relative humidity (Hr)) or FvCB model (Farquhar-von Caemmerer-Berry biochemical model of leaf photosynthesis) were analysed. The model examined the response curve of net photosynthesis (*Pn*) and intercellular CO_2 concentration (*Ci*) measured under treatments of combined photosynthetic available radiation (*PAR*) and leaf temperature (*Tl*), over a photosynthetic diurnal course measured under 1100±100 μl/L CO_2 enrichment in greenhouse microclimates on eggpl ant （*Solanum melongena* L.） F_1 hybrid ‘QIEZA-1’. The parameters of *Pn*, *PAR*, *Ta*, *Tl* (leaf temperature), *Ca*, *Ci* and *Hr* were measured with a CI-301PS photosynthesis analyzer. In terms of either response of *Pn* on *Ci* or photosynthetic diurnal course, the mathematical model imitated measured Pn much better than the FvCB model. The simulation by the mathematical model indicated that photosynthetic diurnal course could be influenced by both a single environment factor and complex ones. The simulation of the FvCB model showed that a dominant role of the rate of carboxylations changed from one to another among A_c, A_j, and A_p as C_i increased combined with increase of *PAR* and *Tl*. A_c was limited by the amount, activation state and kinetic properties of ribulose-1,5-bisphosphate carboxylase/oxygenase (rubisco). A_j was limited solely by the rate of ribulose-1,5-bisphosphate (RuBP). A_p was limited by the rate of triose-phosphate utilisation (TPU). C_i c_j, intercellular CO_2 concentration of the change point of dominance from A_c to A_j, was a higher under high *PAR* and *Tl* than low *PAR* and *Tl*. $C_{i\ cj}$ and $C_{i\ jp}$, intercellular CO_2 concentration of the change point of dominace from A_j to A_p, was influenced more strongly by *Tl* than *PAR*. The FvCB model also indicated that the limiting carboxylation rate was A_j in the early morning and toward evening, and it was A_c in the late morning and at noon. Period of A_j limitation might be extended by cloudy weather and CO_2 injection once per day. A_p limitation occurred with application of CO_2 injection twice a day.

Key words greenhouse _ eggplant _ CO2 enrichment, photosynthetic diurnal course _ biochemical model of leaf photosynthesis

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