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Bioderived green carbon quantum dots boost plant growth and photosynthesis in Maize

Abstract:

The process of photosynthesis accounts for 90 % of the dry matter produced in crops. To improve photosynthesis, it is more sustainable to employ ecologically safe nanomaterials in order to reduce the risks associated with using metallic or inorganic nanoparticles in plants. This work demonstrates a sustainable method of employing green synthesized fluorescent nitrogen-functionalized carbon quantum dots (NCQDs) produced from a bioderived carbon precursor (whole-grain wheat flour) using a unique two-step green synthesis approach. The organic NCQDs application to maize seedlings significantly improved photosynthetic efficiency and upregulated genes (ZmPEPC, ZmRUB, ZmPPDK, ZmNADP-ME, ZmNADP-MDH and ZmCA) involved in CO2 fixation and carbon assimilation, which greatly increased maize biomass and carbohydrate synthesis. Interestingly, application of NCQDs improved chlorophyll, root-shoot fresh weights, dry masses, and plant height in both hydroponics and seed priming. The UV – vis spectrum of NCQD exhibited excitation dependent emission and strongest emission observed in the range of blue light (445 nm) at the excitation between 360 – 390 nm. After receiving NCQD treatment, the amount of total soluble carbohydrates was 32.8 % greater than in the control group due to increased photosynthetic efficiency, stomatal conductance, electron transport rate (ETR), effective quantum yield of PSII (ΦPSII) and CO2 fixation. The ETR, maximum quantum efficiency (Fv/Fm), maximum fluorescence (Fm), ΦPSII, chlorophyl a (Ca), chlorophyl b (Cb) and carotenoid (Cx+c) contents were also higher in NCQD treated plants exposed to UV (A, B and C) as compared to the control group. However, UV light harvesting ability was greater under UV-A and UV-B exposure as compared to UV-C owing to the harvesting ability of NCQD falls under UV-A and UV-B wavelength ranges. The MTT assay demonstrated that the NCQD cytotoxicity towards HeLa cells was also negligible. This novel study proved that bioderived non-toxic fluorescent NCQDs, by supplementing light harvesting capacity of chlorophyll (in vivo), enhanced the efficiency of the photosystem, improved the electron transport chain, upregulated the expression of genes related to CO2 fixation and carbon assimilation, and improved the machinery responsible for photosynthesis in maize.

Biography

Yinbo Gan has completed his PhD at the age of 30 years from Groningen University and postdoctoral studies from National University of Singapore, Lancaster University and University of York, Department of Biology. He is the director of Plant Molecular Biology Lab from College of Agriculture and biotechnology, Zhejiang University. He has published more than 100 papers in reputed journals and has been serving as an editorial board member for four SCI journals.