Electronic supplementary information

Supplementary protocols

^{13}C-RGO was prepared by reducing ^{13}C-GO in chemical reaction. Vitamin C was adopted as the reducing reagent, because of its benign nature and the mild reduction condition. After gentle mixing, the vitamin C/^{13}C-GO mixture was incubated at 60 °C for 4 h at the mass ratio of 1:1 without stirring. A black RGO dispersion was formed and filtered with a filter paper (pore size: 0.45 mm). The filter cake was washed with deionized water before lyophilisation.

Both RGO and GO had changes in elemental composition and chemical bond structure during the 20-days cultivation period (the culture concentration is the same as ^{13}C-labeled graphene bioaccumulation measurement: RGO at 0.66 mg/mL and GO at 0.60 mg/mL), compared with the control group (without pea culture). The XPS analyses indicated that the elemental contents of RGO with pea culture for 20 days were 72.06 at% for C and 24.70 at% for O, where the C atoms could further be divided into C-C (49.13%), C-O (41.85%), C=O (3.59%) and O=C-O (5.43%) (Figure. S1a). Without pea culture, the values were 75.13 at% for C and 21.38 at% for O, and the C 1s XPS spectrum was fitted into C-C (57.20%), C-O (23.15%), C=O (11.56%) and O=C-O (8.09%) (Figure. S1b). In the pea culture system, the increases of O content and C-O bond were obvious for RGO, while C=O and O=C-O bonds decreased. The XPS analyses indicated that the elemental contents of GO with pea culture for 20 days were 67.81 at% for C and 30.74 at% for O, and the C1s XPS spectrum was fitted into C-C (56.71%), C-O (48.64%), C=O (4.98%) and O=C-O (9.67%) (Figure. S1c). In absence of pea culture, the values of GO were 71.20 at% for C, 27.85 at% for O, while C atoms were assigned to C-C (49.31%), C-O (33.55%), C=O (8.95%) and O=C-O (8.19%) (Figure. S1d). Obviously, GO was reduced more in pea culture system.

Supplementary figures

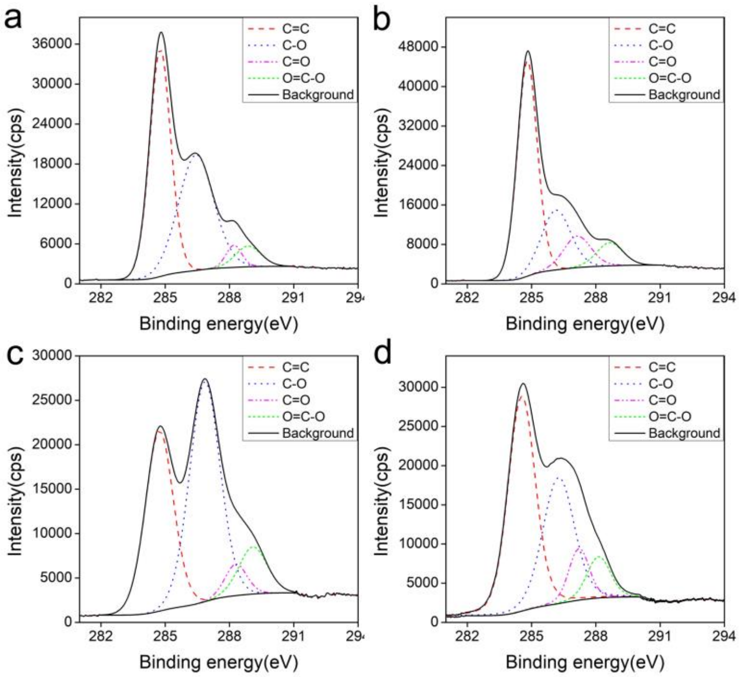

Fig. S1 C1s XPS spectra of RGO (a-with pea culture; b-without pea culture) and GO (c-with pea culture; d-without pea culture) in Hoagland nutrient solution after 20 days.

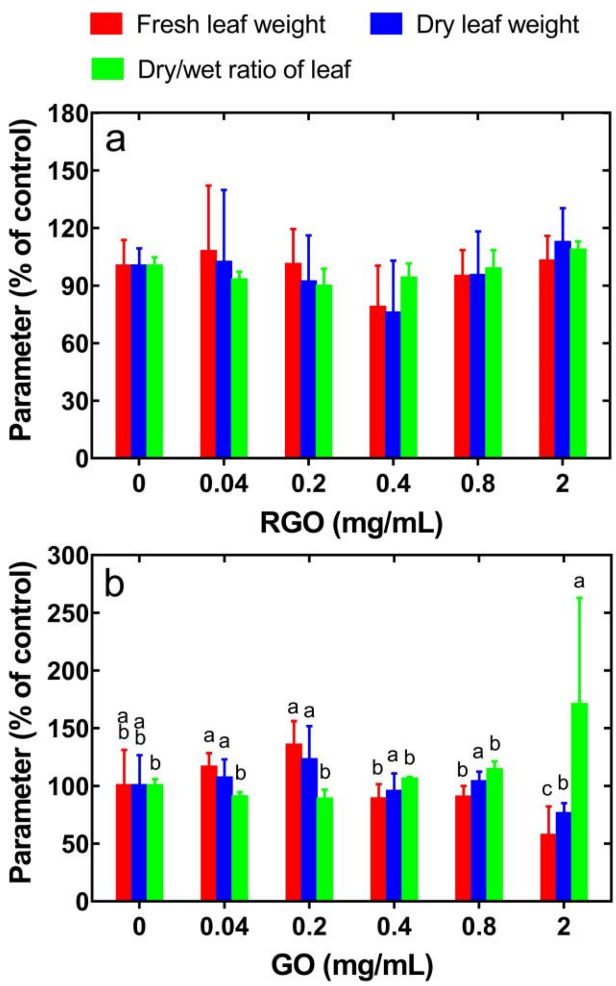

Fig. S2 Influence of RGO (a) and GO (b) on the biomass of leaves. Different letters in each column for each parameter indicate significant differences between the two groups (Student's *t*-test, p <0.05) (n=30).

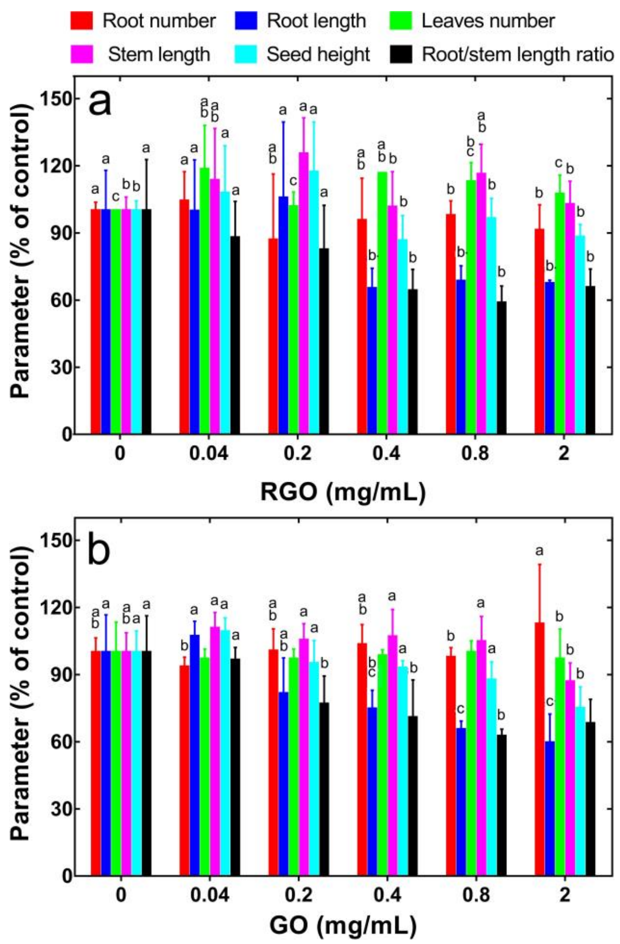

Fig. S3 Influence of RGO (a) and GO (b) on the root and leaf development of pea. Different letters in each column for each parameter indicate significant differences between the two groups (Student's *t*-test, $p < 0.05$) (n=30).

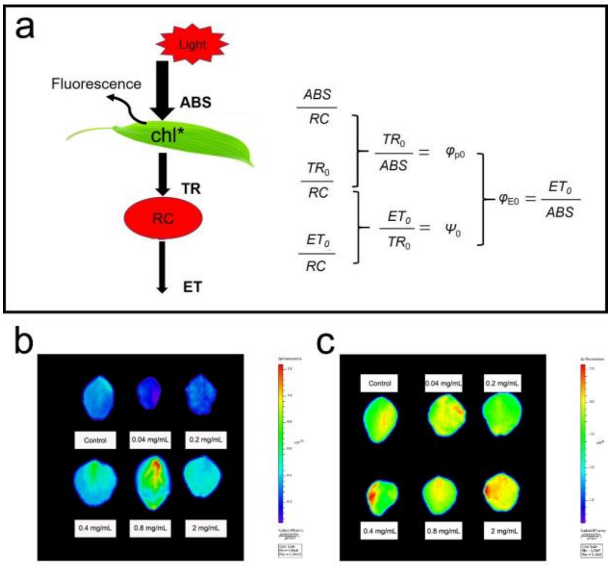

Fig. S4 (a) A simplified scheme for the energy cascade from light absorption to electron transport; (b, c) the preliminary chlorophyll-fluorescence images of leaves were obtained by living optical imager after treatment in the dark for 30 min (b-under RGO culture; c-under GO culture).

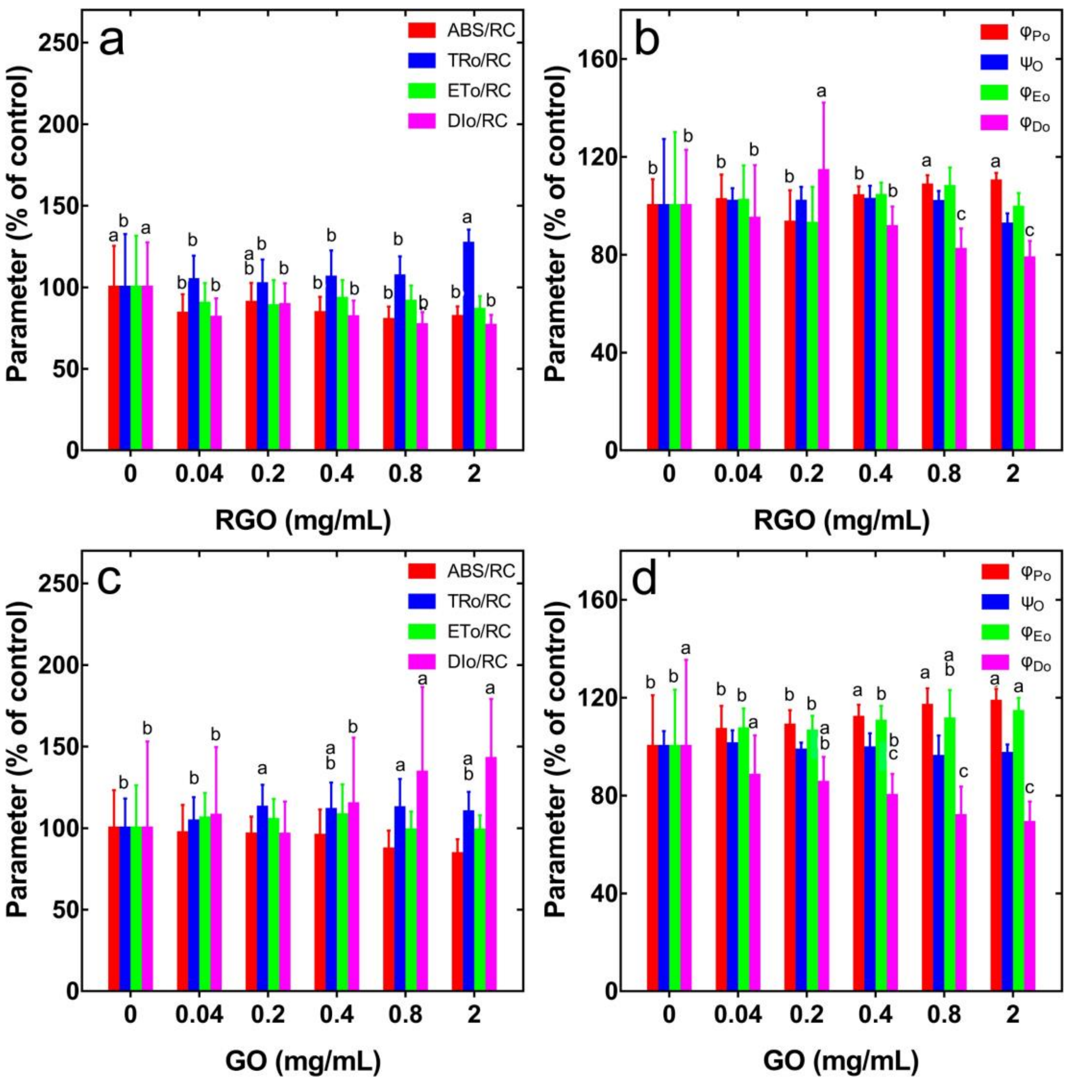

Fig. S5 Influence of RGO (a-the specific energy fluxes in PS II reaction center, b-the ratios of energy flux in PS II reaction center) and GO (c-the specific energy fluxes in PS II reaction center, d-the ratios of energy flux in PS II reaction center) on the chlorophyll fluorescence parameters (*ABS*/*RC*: absorption flux per PS II reaction center, TR_O/RC: trapped energy flux per PS II reaction center, ET_O/RC: electron transport flux per PS II reaction center, DI_O/RC: dissipated energy flux per PS II reaction center, $\varphi_{Po}=TR_O/ABS$: maximum quantum yield of primary photochemistry, $\psi_O=ET_O/TR_O$: the probability that a trapped exciton moves an electron into the electron transport chain beyond Q_A^-, $\varphi_{Eo}=ET_O/ABS$: quantum yield of electron transport, $\varphi_{Do}=DI_O/ABS$: quantum yield of energy dissipation). Different letters in each column for each parameter indicate significant differences between the two groups (Student's *t*-test, $p<0.05$) (n=15).

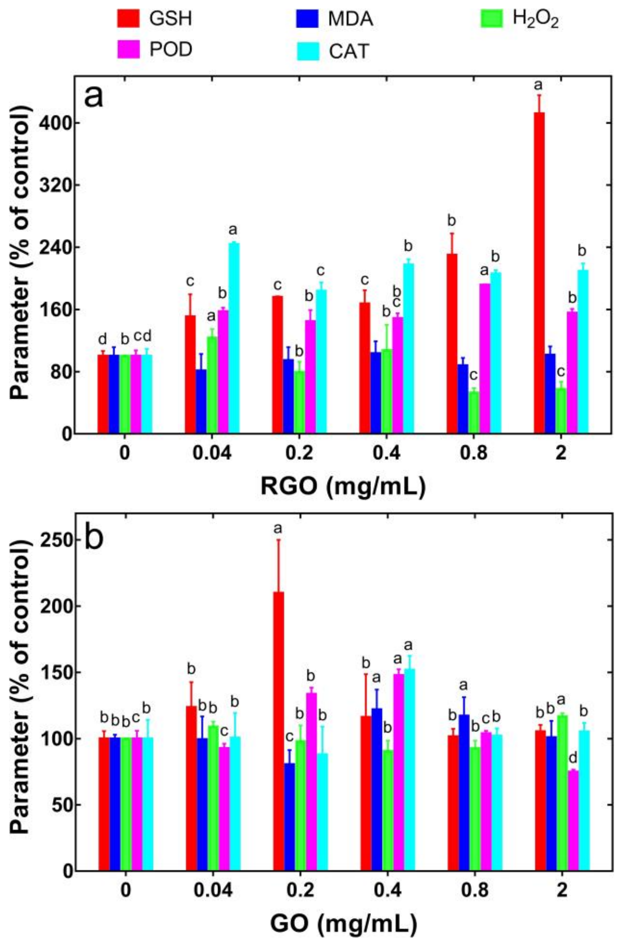

Fig. S6 Influence of RGO (a) and GO (b) on the oxidative stress of roots (GSH: glutathione, MDA: malondialdehyde, H_2O_2: hydrogen peroxide, POD: peroxidase, CAT: catalase). Different letters in each column for each parameter indicate significant differences between the two groups (Student's *t*-test, $p < 0.05$) (n=6).

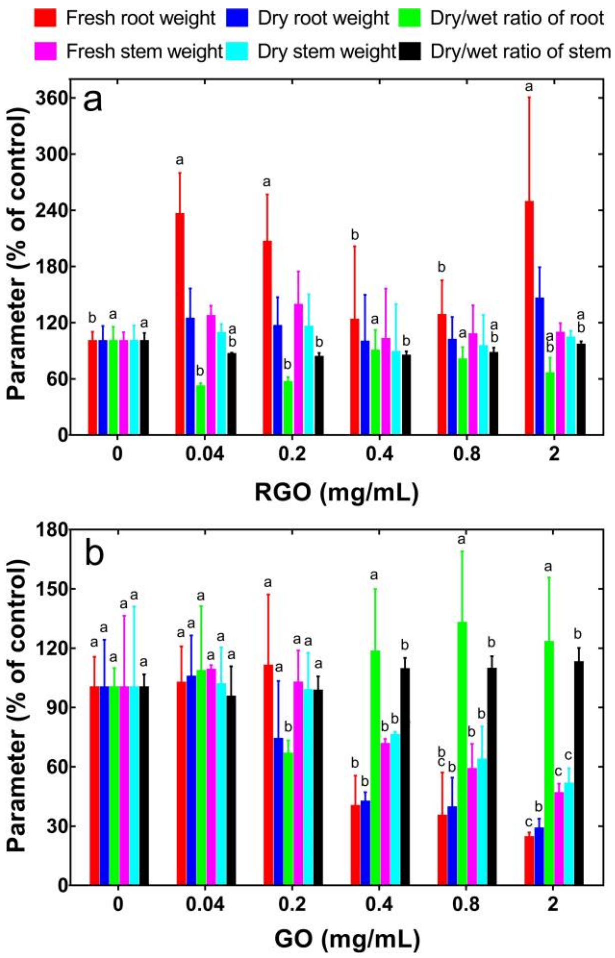

Fig. S7 Influence of RGO (a) and GO (b) on the biomass of roots and stems. Different letters in each column for each parameter indicate significant differences between the two groups (Student's *t*-test, $p < 0.05$) (n=30).

Supplementary table

Table S1. XPS data of graphene samples separated at Day 10, 15 and 20.

	C element	O element	C=C	C-O	C=O	O=C-O
RGO	80.27%	18.75%	73.49%	20.77%	2.96%	2.79%
RGO without pea at 20 d	75.13%	21.38%	57.20%	23.15%	11.56%	8.09%
RGO with pea at 10 d	71.15%	25.88%	48.14%	44.14%	3.13%	4.63%
RGO with pea at 15 d	72.26%	24.89%	49.05%	41.96%	2.39%	6.59%
RGO with pea at 20 d	72.06%	24.70%	49.13%	41.85%	3.59%	5.43%
GO	64.96%	33.72%	40.16%	50.64%	4.66%	4.54%
GO without pea at 20 d	71.20%	27.85%	49.31%	33.55%	11.56%	8.19%
GO with pea at 10 d	68.20%	30.74%	38.79%	46.32%	10.07%	4.81%
GO with pea at 15 d	67.78%	28.85%	31.64%	52.28%	13.33%	2.75%
GO with pea at 20 d	67.81%	30.74%	56.71%	48.64%	4.98%	9.67%