Supporting information

Article Title

Improving High Light Tolerance of Tobacco Plants: Adequate Magnesium Supply Enhances Photosynthetic Performance

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Supplemental Figure S1.

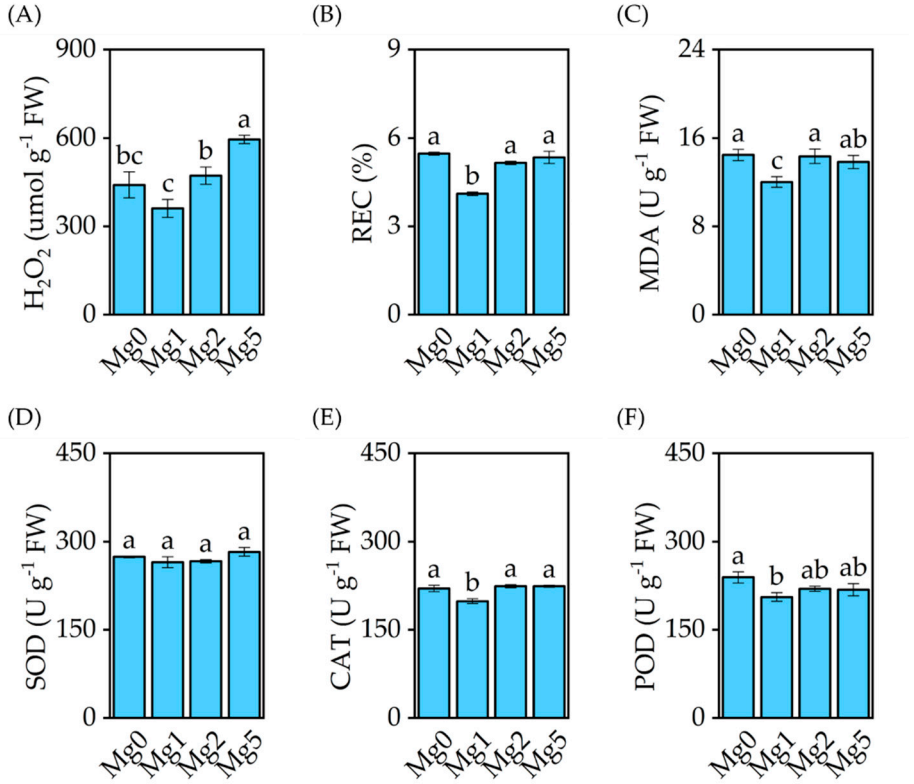


Figure S1. The impact of magnesium on tobacco physiological metabolism under normal light. The results of leaf oxidation indicators and antioxidant enzyme activities showed that the physiological indicators at different magnesium supply levels were relatively better with Mg1. Therefore, Mg1 was used as the control in this study. (A) The concentration of hydrogen peroxide (H_2O_2) in tobacco leaves 100 days after sowing. (B) Relative electrolytic leakage (REC) of leaves. (C) Malondialdehyde (MDA) concentration of leaves. (D) Activities of superoxide dismutase (SOD), (E) catalase (CAT) and (F) peroxidase activity (POD) in leaves. Hydrogen peroxide (H_2O_2). Mg0, Mg1, Mg2, and Mg5 (0, 1, 2, and 5 mol Mg), grown under 750 μmol m^{-2} s^{-1} light intensity. The data presented in the bar graphs are expressed as means ± standard errors ($n = 3$). Means followed by the same small letter are not significantly different ($P < 0.05$).

Supplemental Figure S2.

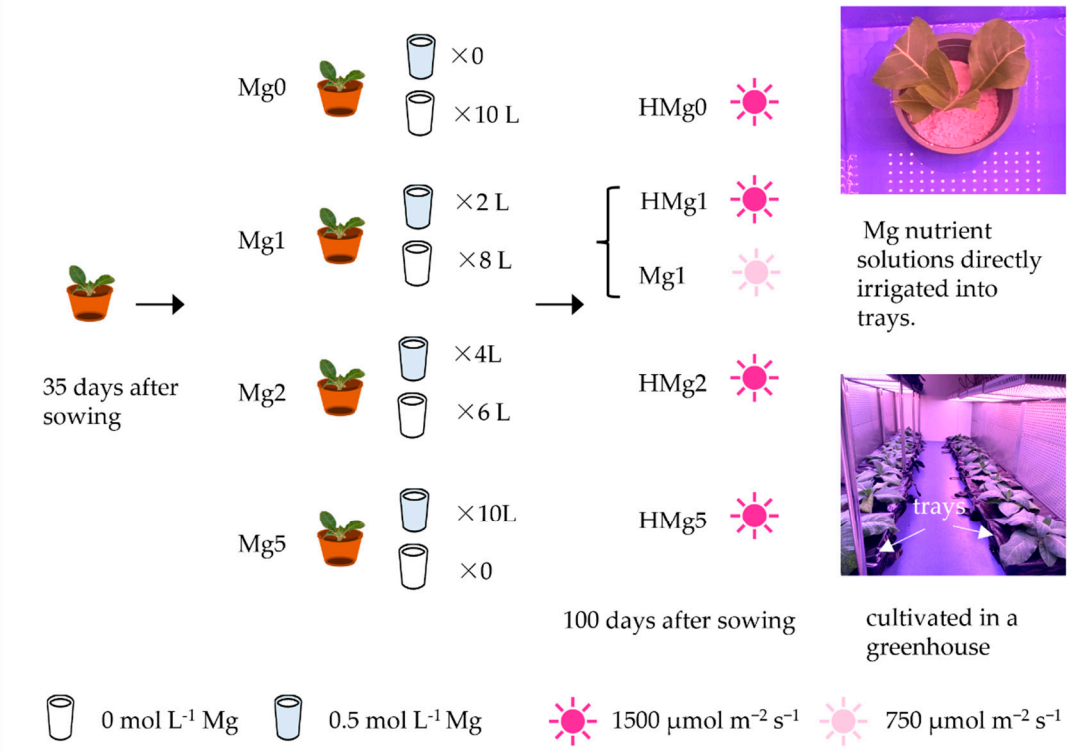


Figure S2. The plant treatment model. Different magnesium (Mg) nutrient solutions were applied starting 35 days after sowing. The Mg-deficient (0 mol L^{-1} Mg) and Mg–sufficient (0.5 mol L^{-1} Mg) nutrient solutions were identical except for their Mg content. Different nutrient solutions were used for ten irrigations, after which all plants were irrigated with the Mg-deficient nutrient solution. Different light intensity treatments were applied 100 days after sowing, with Mg1 normal light treatment as the control. Specifically, 10 plants treated with Mg1 were transferred to another greenhouse (Temperature test chamber WIPGC–01, Fujian Jiupo Biotechnology Co., Ltd. China) and subjected to normal light conditions (12-h light, 25℃, 750 μmol m^{-2} s^{-1} / 12 h–dark, 20℃, 0 μmol m^{-2} s^{-1}). The remaining plants (including HMg0, HMg1, HMg2, HMg5) were treated under high light intensity conditions (12–h light, 25℃, 1500 μmol m^{-2} s^{-1} / 12 h–dark, 20℃, 0 μmol m^{-2} s^{-1}). The light treatment lasted for 10 days. The plants were cultivated in a greenhouse environment, with nutrient solutions directly irrigated into the trays. Mg1: 1 mol Mg, tobacco seedings grown under 750 μmol m^{-2} s^{-1} light intensity. HMg0, HMg1, HMg2, and HMg5 (0, 1, 2, and 5 mol Mg), grown under 1500 μmol m^{-2} s^{-1} light intensity for 10 days.

Supplemental Figure S3.

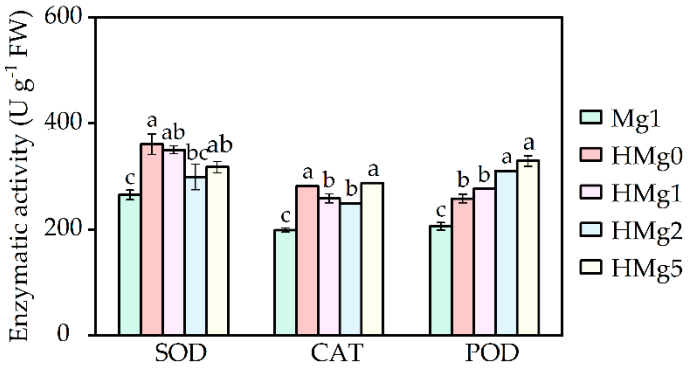


Figure S3. Activities of superoxide dismutase (SOD), catalase (CAT) and peroxidase activity (POD) in leaves. Mg1: 1 mol Mg, tobacco seedings grown under 750 μmol m^{-2} s^{-1} light intensity. HMg0, HMg1, HMg2, and HMg5 (0, 1, 2, and 5 mol Mg), grown under 1500 μmol m^{-2} s^{-1} light in-tensity for 10 days. The data presented in the bar graphs are expressed as means ± standard errors ($n = 3$). Means followed by the same small letter are not significantly different ($P < 0.05$).

Supplemental Figure S4.

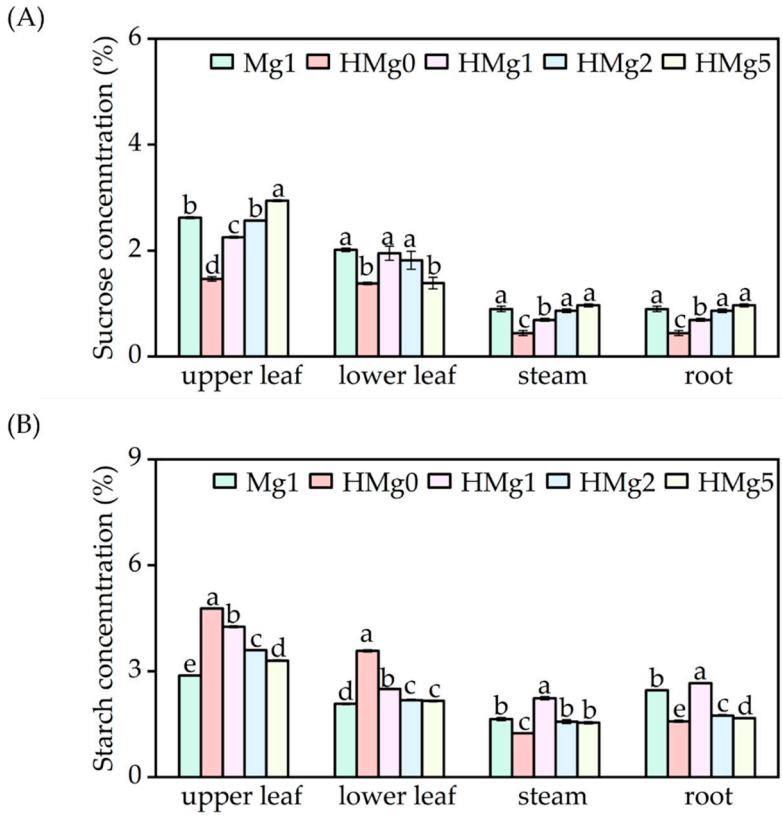


Figure S4. Effects of different Mg-supplies tobacco seedings on starch and sucrose concentration under normal/high light. Mg1: 1 mol Mg, tobacco seedings grown under 750 μmol m^{-2} s^{-1} light intensity. HMg0: 0 mol Mg, grown under 1500 μmol m^{-2} s^{-1} light intensity for 10 days. HMg0, HMg1, HMg2, and HMg5 (0, 1, 2, and 5 mol Mg), grown under 1500 μmol m^{-2} s^{-1} light in-tensity for 10 days. The data presented in the bar graphs are expressed as means ± standard errors (n = 3). Means followed by the same small letter are not significantly different ($P < 0.05$).

Supplemental Figure S5.

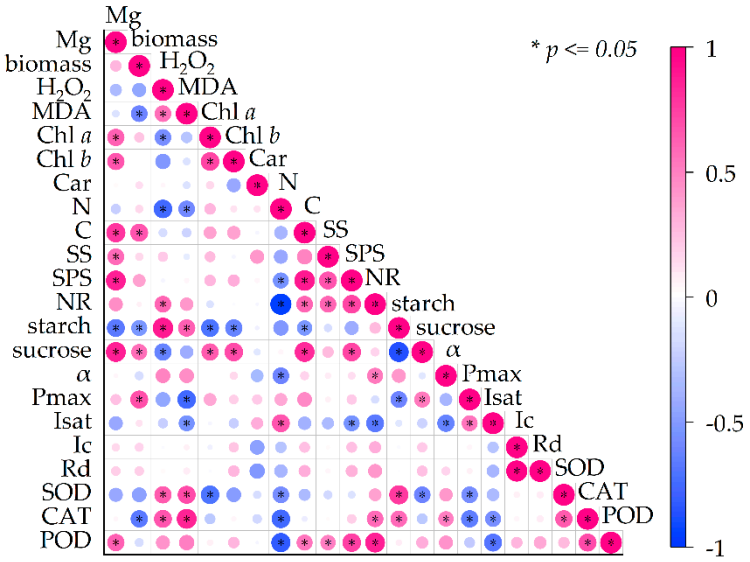


Figure S5. CoA matrix for traits evaluated in tobacco. The measurements of biomass, magnesium (Mg), carbon (C), nitrogen (N), sucrose, and starch concentrations were taken from the upper leaves of plants. sucrose synthetase (SS), sucrose phosphate synthase (SPS), the initial quantum efficiency (α), maximum net photosynthetic rate (Pmax), light compensation point (Ic), dark respiration rate (Rd), nitrate reductase (NR), superoxide dismutase (SOD), catalase (CAT), peroxidase activity (POD).

Supplemental Table S1.

Table S1. The physical and chemical properties of cultivated sand and water.

Nutrient	Potassium	Magnesium	Calcium
sand (mg kg^{-1})	112.84 ± 2.65	153.27 ± 3.88	457.79 ± 9.35
water (mg L^{-1})	-	0.92 ± 0.0069	8.19 ± 0.11

The data presented in the table are expressed as means ± standard errors ($n = 3$).

Supplemental Table S2.

Table S2. Improved Hoagland nutrient solution formulate.

Species	Content (L^{-1})
KH_2PO_4	1.41 mM
KNO_3	4.98 mM
$Ca(NO_3)_2 \cdot 4H_2O$	4.66 mM
Fe-EDTA	0.10 mM
$CuCl_2$	0.41 μM
$ZnCl_2$	0.77 μM
$MnCl_2$	9.10 μM
H_3BO_3	46.26 μM
$H_4MoNa_2O_6$	0.13 mM
Fe-EDTA	0.10 mM

Supplemental Table S3.

Table S3. Parameters measured and calculated from the Chl *a* fluorescence (OJIP) transient [43,44,65,68-70].

Fluorescence parameter	**Description**
$V_J = (F_{2ms}-F_0)/(F_m-F_0)$	Fluorescence intensity at the J−step (2 ms)
$V_I = (F_{30ms}-F_0)/(F_m-F_0)$	Relative variable fluorescence at I−step (30 ms)
S_m = Area/(F_m-F_0), where Area is the area above the OJIP curve between F_0 and F_m and the F_m asymptote	Standardized area above the fluorescence curve between F_0 and F_M is proportional to the pool size of the electron acceptors on the reducing side of Photosystem II.
RC/CS_m	Reaction center density per cross section
$N = (S_m/S_S)$, where $S_S = V_J/M_0$	Number indicating how many times Q_A is reduced while fluorescence reaches its maximal value (number of Q_A redox turnovers until F_M is reached); S_S, normalized curve above O−J curve.
$ABS/CS_m = M_0 (1/V_J) (1-(F_0/F_m))$	Apparent antenna size of per cross section
$TR_0/CS_m = M_0/V_J$	Trapping flux leading to Q_A reduction per cross section
$ET_0/CS_m = (M_0/V_J) (1-V_J)$	Electron transport flux per cross section at t=0
$TR_0/ABS = 1-F_0/F_m = F_v/F_m$	Maximum quantum yield of primary photochemistry at t=0

$ET_0/ABS = (F_v/F_m)\ (1\text{-}V_J)$	Quantum yield for electron transport at t=0
$ET_0/TR_0 = 1\text{-}V_J$	Probability (t=0) that a trapped exciton moves an electron into the electron transport chain beyond Q_A^-
RE_0/CS_m	Electron flux of reduction end electron acceptors at the PSI acceptor side, per cross section
$PI_{abs} = (RC/ABS)\ (TR_0/ABS)/(1\text{-}TR_0/ABS))\ (ET_0/TR_0/(1\text{-}ET_0/TR_0))$	Performance index (PI) on absorption basis, Performance index (potential) for energy conservation from photons absorbed by PSII to the reduction of intersystem electron acceptors
PI_{total}= PI abs $(1\text{-}V_J)/(1\text{-}V_I)/(1\text{-}(1\text{-}V_J)/(1\text{-}V_I))$	Performance index of electron flux to the final PSI electron acceptors, Performance index (potential) for energy conservation from photons absorbed by PSII to the reduction of PSI end acceptors
$DI_0/RC = ABS/RC\text{-}TR_0/RC$	Dissipated energy flux per RC at t=0

Supplemental Table S4.

Table S4. Results of Two-way ANOVAs on tobacco morphological traits.

Treatment	Magnesium	Light intensity
Upper leaves biomass	***	ns
Lower leaves biomass	***	**
Steam biomass	***	ns
Root biomass	***	ns
Upper leaves Mg concentration	***	**
Lower leaves Mg concentration	***	ns
Steam Mg concentration	***	**
Root Mg concentration	***	***
H_2O_2 concentration	**	***
MDA concentration	ns	*
Chl *a*	*	*
Chl *b*	**	ns
Car	ns	ns
Upper leaves N concentration	***	***
Lower leaves N concentration	***	***
Steam N concentration	***	***
Root N concentration	***	***
Upper leaves C concentration	***	**
Lower leaves C concentration	***	*
Steam C concentration	***	*
Root C concentration	**	ns
Sucrose synthetase	***	ns
Sucrose phosphate synthase	***	**
Nitrate reductase	***	***
Upper leaves sucrose concentration	***	***
Lower leaves sucrose concentration	**	ns
Steam sucrose concentration	***	**
Root sucrose concentration	***	***
Upper leaves starch concentration	***	***
Lower leaves starch concentration	***	***

Steam starch concentration	***	***
Root starch concentration	***	***
α	ns	*
Pmax	ns	ns
Isat	ns	*
Ic	ns	ns
Rd	ns	ns
Superoxide dismutase activity	ns	***
Catalase activity	***	***
Peroxidase activity	***	***

The steric symbol (*) represents the significance at $P < 0.05$, (**) represents the significance at $P < 0.01$, (***) represents the significance at $P < 0.001$, and ns denotes the non-significant difference.