Additional files

Figure S1. Effects of low pH on *Citrus sinensis* (**a**) and *Citrus grandis* (**b**) seedlings, *C. grandis* leaves (**c**), and *C. sinensis* (**d**) and *C. grandis* (**e**) roots.

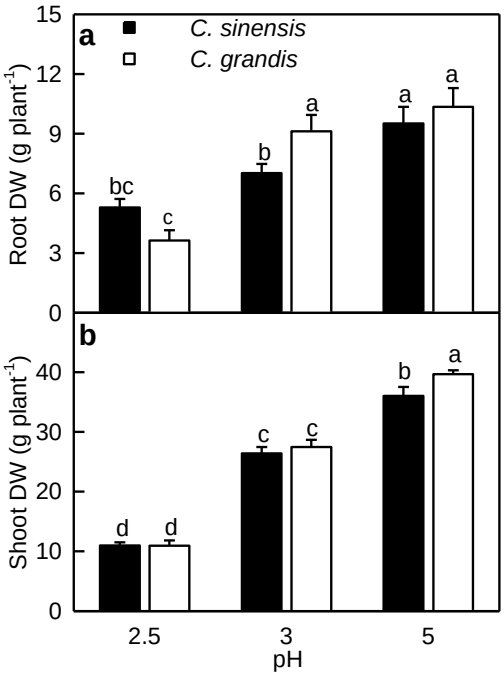

Figure S2. Effects of low pH on root (**a**) and shoot (**b**) dry weight (DW) of *Citrus grandis* and *Citrus sinensis* seedlings. Nine months after the pH treatments began, 10 seedlings per treatment from 10 pots were harvested. The seedlings were divided into roots and shoots (stems + leaves). Their DW was weighted after being dried to a constant weight at 70 ℃. Bar represent mean ± SE (n = 10). Different letters above the bars indicate a significant difference at $P < 0.05$.

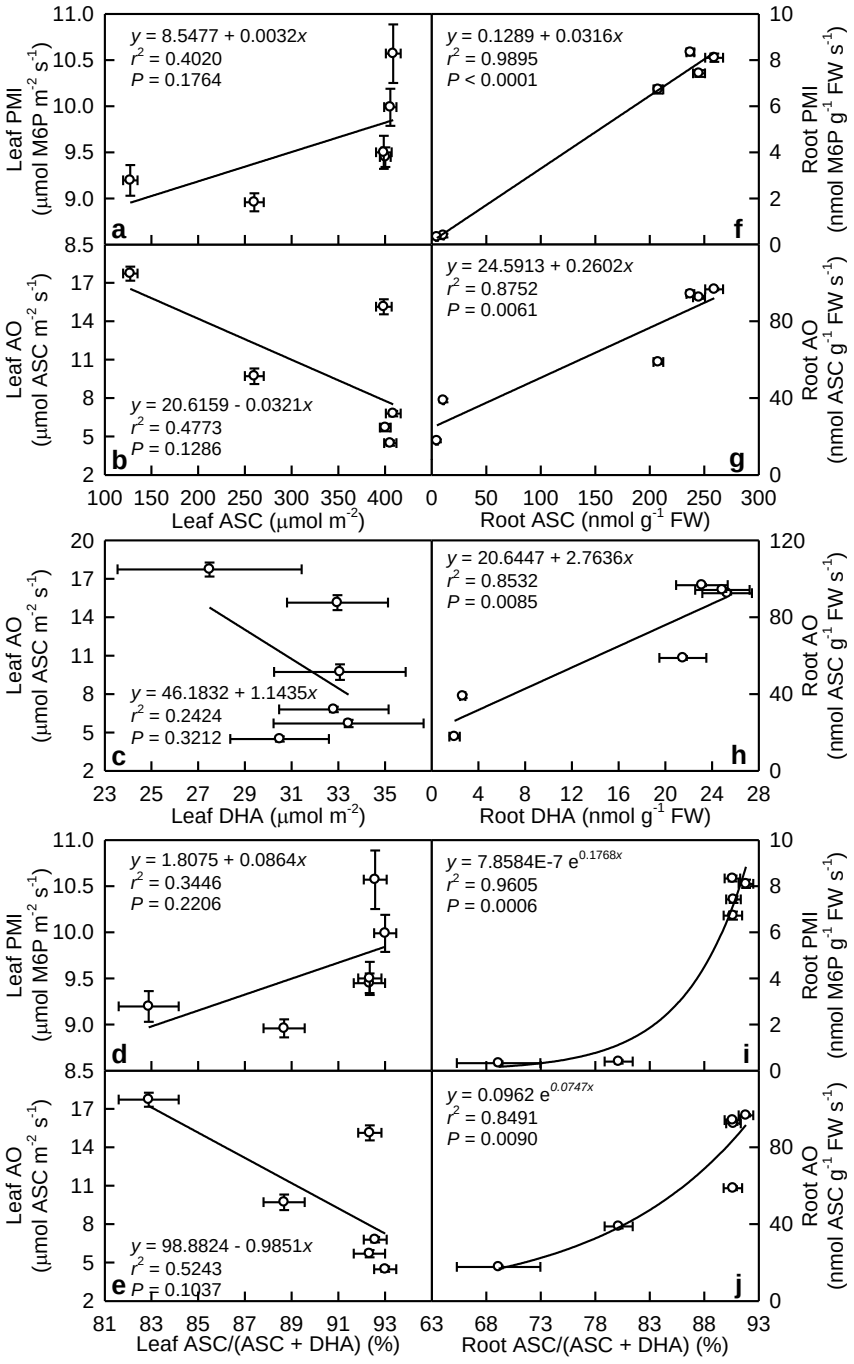

Figure S3. Phosphomannose isomerase (PMI) and ascorbate (ASC) oxidase (AO) activities in relation to ASC and dehydroascorbate (DHA) concentrations and ASC/(ASC + DHA) ratio in leaves (**a-e**) and roots (**f-j**). Points represent mean ± SE for the independent variables (n = 8) and the dependent variables (n = 8).

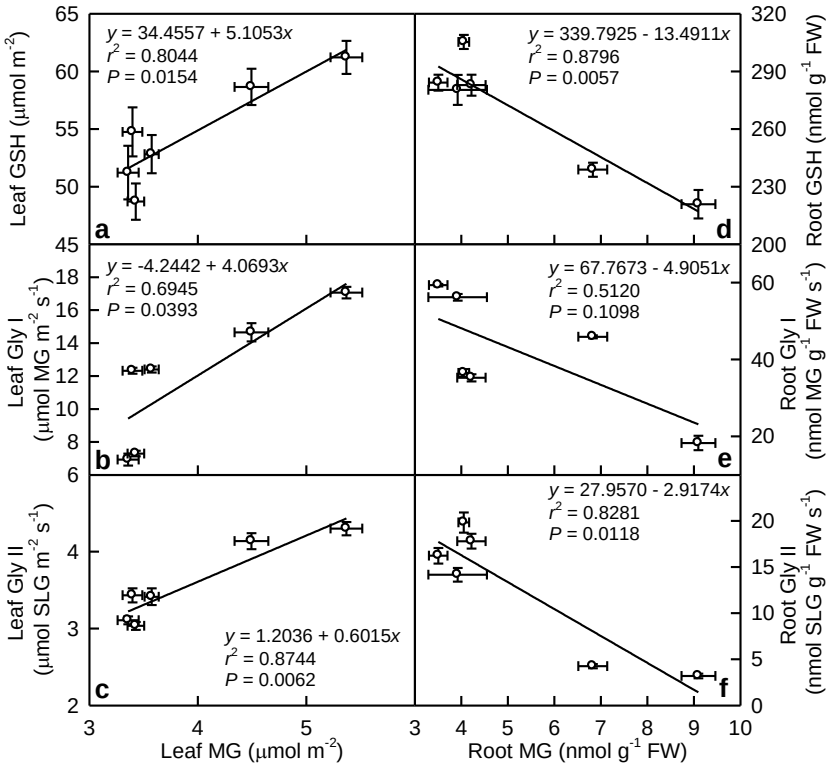

Figure S4. Reduced glutathione (GSH) concentration and glyoxalase (Gly) I and Gly II activities in relation to methylglyoxal (MG) concentration in leaves (**a-c**) and roots (**d-f**). Points represent mean ± SE for the independent variables (n = 4) and the dependent variables (n = 4 except for 8 for GSH).

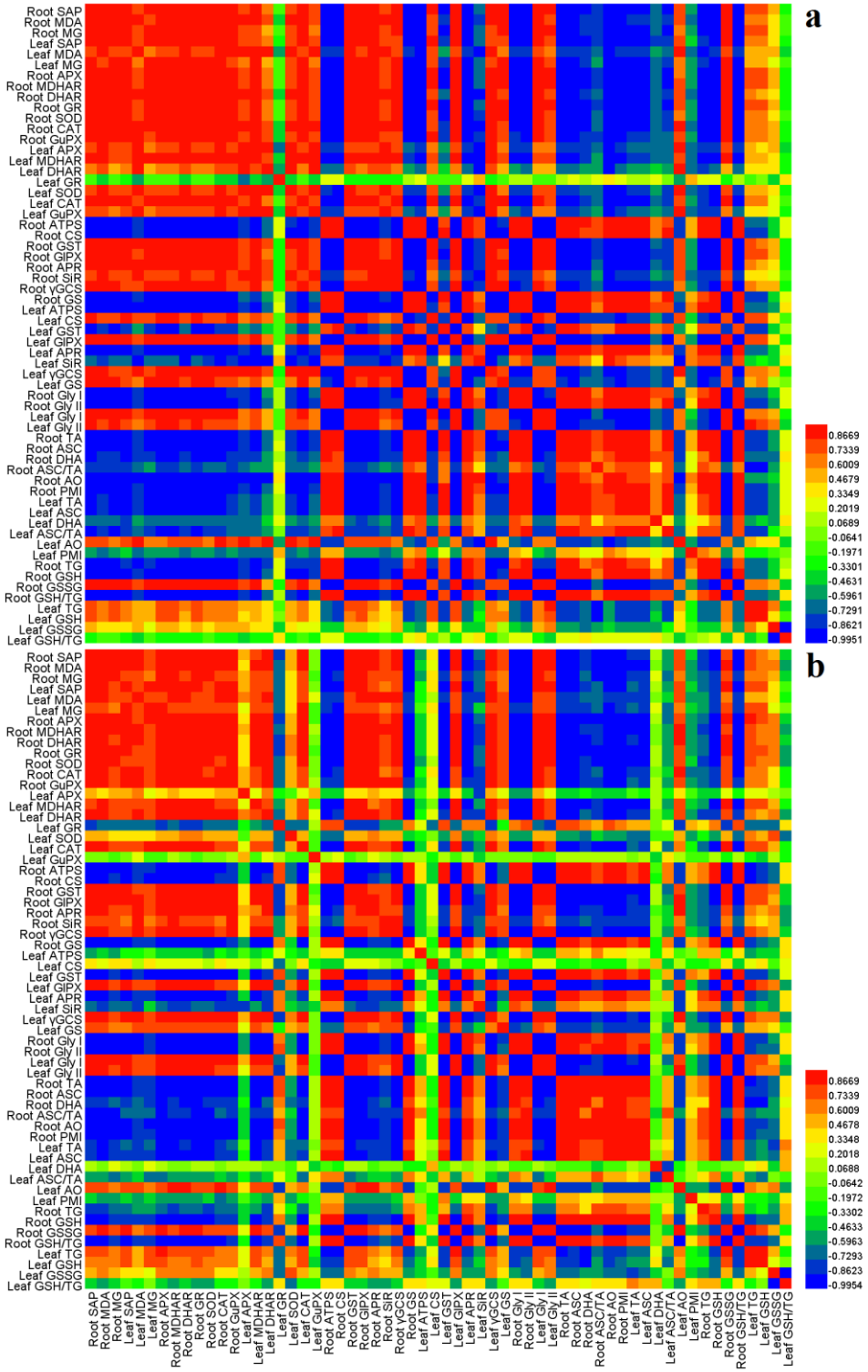

Figure S5. Matrices of Pearson correlation coefficients among the 60 physiological parameters in *Citrus grandis* (**a**) and *Citrus sinensis* (**b**) seedlings. TA: ascorbate (ASC) + dehydroascorbate (DHA); TG: reduced glutathione (GSH) + oxidized glutathione (GSSG).

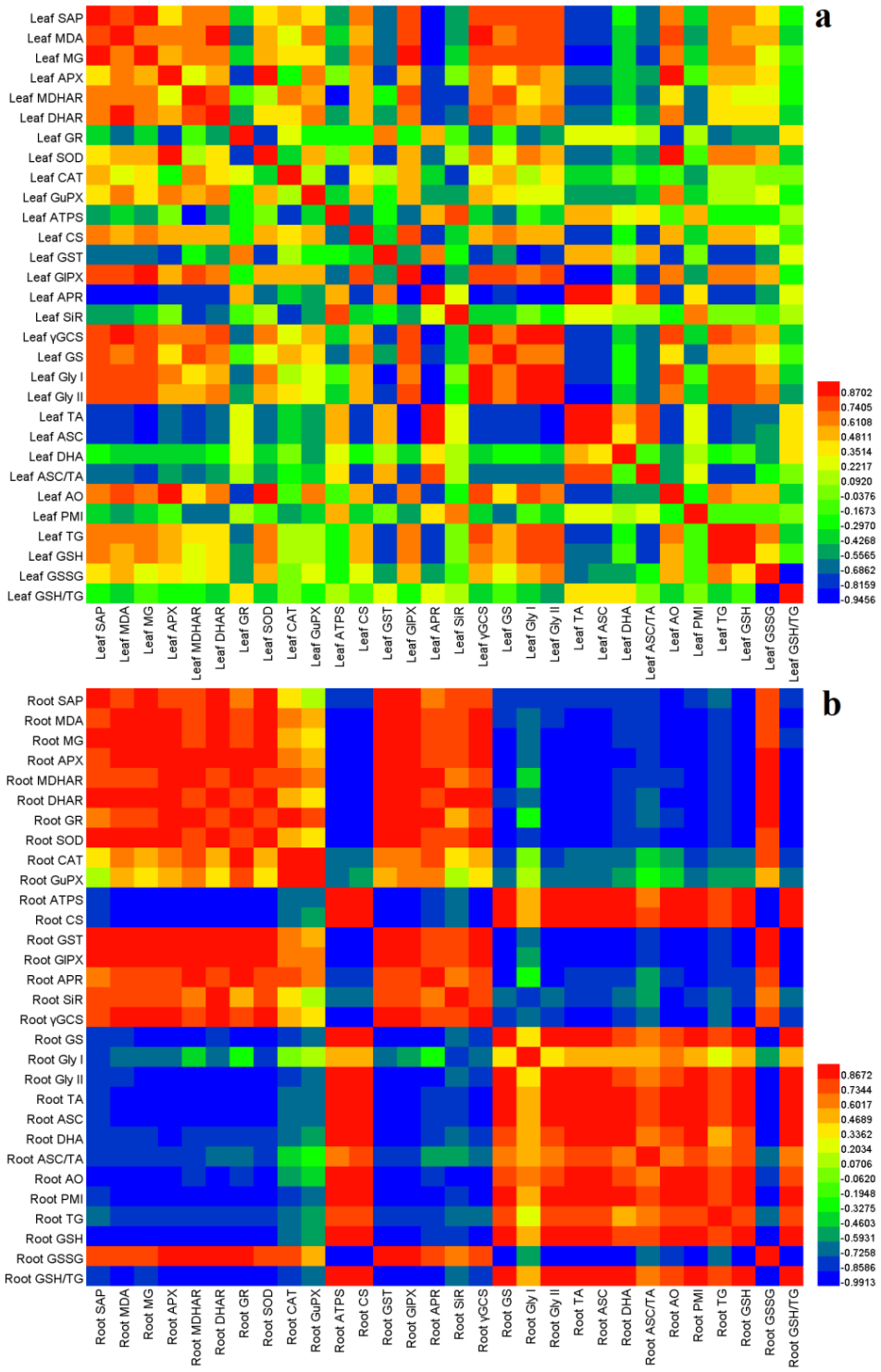

Figure S6. Matrices of Pearson correlation coefficients among the 30 physiological parameters in leaves (**a**) and roots (**b**). TA: ascorbate (ASC) + dehydroascorbate (DHA); TG: reduced glutathione (GSH) + oxidized glutathione (GSSG).

Table S1. Principal component analysis (PCA) for physiological parameters of *Citrus grandis* seedlings

Variables	PC1	PC2	PC3	PC4
Superoxide anion production, MDA and MG				
Root superoxide anion production rate	0.9879	-0.1487	0.0039	0.0184
Root MDA	0.9601	0.1097	0.1327	0.1167
Root MG	0.9567	-0.1939	0.1327	0.0471
Leaf superoxide anion production rate	0.9355	-0.0876	0.0138	-0.0742
Leaf MDA	0.8771	0.3856	-0.0631	0.1476
Leaf MG	0.9214	-0.1192	0.2208	-0.2252
Root antioxidant enzymes				
Root APX	0.9843	-0.1663	0.0142	0.0205
Root MDHAR	0.9872	-0.1299	0.0030	0.0582
Root DHAR	0.9641	0.1730	0.0130	-0.0664
Root GR	0.9888	-0.1376	-0.0108	-0.0287
Root SOD	0.9684	-0.0937	0.1363	-0.0563
Root CAT	0.9795	0.1429	-0.0273	-0.0137
Root GuPX	0.9371	0.0811	-0.0161	0.0984
Leaf antioxidant enzymes				
Leaf APX	0.8492	0.4517	-0.1280	0.0347
Leaf MDHAR	0.9374	0.2745	0.0782	-0.1110
Leaf DHAR	0.7360	0.6194	-0.0113	0.2065
Leaf GR	-0.2675	-0.6974	0.3401	-0.1210
Leaf SOD	0.8868	0.3525	-0.0102	0.1526
Leaf CAT	0.9366	-0.0448	0.1807	-0.0754
Leaf GuPX	0.8232	0.4810	0.0885	0.0140
Root S metabolism-related enzymes				
Root ATPS	-0.9774	0.0818	-0.0554	0.0396
Root CS	-0.9861	0.0894	-0.0298	-0.0833
Root GST	0.9954	0.0108	-0.0070	-0.0206
Root GlPX	0.9890	-0.1233	-0.0538	0.0031
Root APR	0.9719	0.0676	0.0647	-0.0834
Root SiR	0.8637	0.3556	0.2144	-0.0965
Root γGCS	0.9310	0.0399	0.0322	-0.1762
Root GS	-0.9672	0.2136	-0.0233	0.0541
Leaf S metabolism-related enzymes				
Leaf ATPS	-0.9844	-0.0162	0.0237	0.0808
Leaf CS	0.8932	-0.1135	0.0390	0.1642
Leaf GST	-0.8503	0.4261	-0.0652	0.0329
Leaf GlPX	0.9747	-0.1381	0.0753	0.0025
Leaf APR	-0.9831	0.0371	-0.0656	-0.0100
Leaf SiR	-0.8104	-0.5546	-0.0028	0.0619
Leaf γGCS	0.9497	0.1941	0.0036	0.0533
Leaf GS	0.8738	-0.0954	0.3219	-0.0059
Root Gly I and Gly II				
Root Gly I	-0.9479	0.1153	-0.0592	0.2521
Root Gly II	-0.9732	0.1293	-0.0013	0.0011
Root Gly I and Gly II				
Leaf Gly I	0.9603	-0.1965	0.0009	-0.1381
Leaf Gly II	0.9086	-0.2065	-0.2031	0.0749

Root ascorbate and related enzymes				
Root ASC + DHA	-0.9922	0.0929	0.0350	0.0329
Root ASC	-0.9935	0.0879	0.0177	0.0128
Root DHA	-0.8944	0.1304	0.1901	0.2130
Root ASC/(ASC + DHA)	-0.7702	0.2324	0.2205	-0.5133
Root AO	-0.9586	-0.2597	-0.0636	-0.0248
Root PMI	-0.9963	0.0472	-0.0262	0.0087
Leaf ascorbate and related enzymes				
Leaf ASC + DHA	-0.9496	0.2078	0.0173	0.0790
Leaf ASC	-0.9467	0.2125	0.0062	0.0566
Leaf DHA	-0.7109	0.0601	0.2099	0.4525
Leaf ASC/(ASC + DHA)	-0.8526	0.2548	-0.1019	-0.2714
Leaf AO	0.8128	0.4431	-0.1160	0.1081
Leaf PMI	-0.5826	-0.4796	-0.2953	-0.0947
Root glutathione				
Root GSH + GSSG	-0.9151	-0.0977	-0.1216	-0.2100
Root GSH	-0.9836	0.0160	-0.0490	0.0908
Root GSSG	0.9583	-0.0977	-0.0594	-0.1758
Root GSH/(GSH + GSSG)	-0.9759	0.1101	0.0178	0.1214
Leaf glutathione				
Leaf GSH + GSSG	0.7477	-0.3619	-0.4187	0.3379
Leaf GSH	0.7159	-0.4568	-0.1348	0.4652
Leaf GSSG	0.4943	-0.0046	-0.8434	-0.0783
Leaf GSH/(GSH + GSSG)	-0.3012	-0.1385	0.8715	0.2413
Eigen value	48.588	3.898	2.442	1.517
Variation percent (%)	80.979	6.497	4.071	2.529

Table S2. Principal component analysis (PCA) for physiological parameters of *Citrus sinensis* seedlings

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Superoxide anion production, MDA and MG						
Root superoxide anion production rate	0.9747	-0.0213	0.0932	-0.0529	-0.0845	0.0208
Root MDA	0.9867	0.0743	0.0374	-0.1014	-0.0275	0.0081
Root MG	0.8970	-0.1357	0.1259	-0.1314	-0.1784	-0.2078
Leaf superoxide anion production rate	0.9206	-0.1293	0.2020	0.2018	0.0864	0.1522
Leaf MDA	0.8714	0.1824	0.3308	-0.0599	0.1987	-0.0296
Leaf MG	0.8446	-0.2473	0.0461	0.1639	0.2815	-0.1033
Root antioxidant enzymes						
Root APX	0.9939	-0.0684	-0.0462	0.0238	0.0198	-0.0176
Root MDHAR	0.9819	0.1403	0.0892	-0.0642	0.0003	-0.0023
Root DHAR	0.9892	0.0514	0.0124	0.0929	0.0108	0.0131
Root GR	0.9963	0.0128	-0.0434	0.0033	0.0000	-0.0201
Root SOD	0.9822	0.0520	-0.0414	-0.1427	-0.0219	0.0163
Root CAT	0.9137	0.0482	0.2166	0.1846	0.1279	-0.1230
Root GuPX	0.9104	0.0404	0.2904	-0.0093	0.1288	-0.0198
Leaf antioxidant enzymes						
Leaf APX	0.4417	0.0621	0.7737	-0.0601	-0.1019	0.1891
Leaf MDHAR	0.9133	-0.0730	-0.1750	-0.0981	0.2744	0.0996
Leaf DHAR	0.9204	0.2284	0.2552	-0.0767	0.0117	-0.0936
Leaf GR	-0.7548	-0.0518	0.0260	-0.5077	0.3155	0.1587
Leaf SOD	0.6028	0.2579	-0.4838	0.2027	-0.0744	-0.2593
Leaf CAT	0.9075	-0.2352	-0.0623	-0.0080	-0.0331	0.0517
Leaf GuPX	-0.0529	0.6953	0.5958	-0.1570	0.0756	0.1288
Root S metabolism-related enzymes						
Root ATPS	-0.9844	0.0933	0.0414	-0.0676	0.0431	-0.0219
Root CS	-0.9652	0.1406	0.1187	-0.0928	0.0139	0.0076
Root GST	0.9924	-0.0755	-0.0569	0.0158	0.0015	0.0108
Root GlPX	0.9970	-0.0124	0.0537	0.0155	0.0188	-0.0050
Root APR	0.9086	0.2604	0.1742	0.1070	-0.0889	-0.0931
Root SiR	0.8248	0.2130	0.0921	-0.2888	0.0794	-0.2703
Root γGCS	0.9420	0.0619	-0.0316	-0.1739	0.2009	0.0943
Root GS	-0.9743	0.0991	-0.0568	0.0855	0.0108	0.0106
Leaf S metabolism-related enzymes						
Leaf ATPS	-0.4305	0.1489	0.1549	0.4821	0.5505	-0.0299
Leaf CS	0.2940	-0.5058	0.3660	0.4768	-0.4308	-0.3129
Leaf GST	-0.9578	0.0901	0.0077	-0.1421	-0.1597	0.0881
Leaf GlPX	0.9746	-0.0137	-0.1303	-0.0205	0.0223	0.0963
Leaf APR	-0.9485	0.0448	0.0478	-0.0094	0.0389	-0.1314
Leaf SiR	-0.7258	-0.3193	-0.4516	-0.1474	0.2203	-0.1437
Leaf γGCS	0.9833	0.1262	0.0372	0.0169	-0.0367	0.0829
Leaf GS	0.7682	-0.0100	-0.0549	-0.2934	0.4937	-0.1521
Root Gly I and Gly II						
Root Gly I	-0.9806	0.0374	-0.1355	0.0133	-0.0216	-0.0459
Root Gly II	-0.9744	-0.0038	-0.0519	0.0653	0.0533	-0.0410
Root Gly I and Gly II						
Leaf Gly I	0.9766	-0.0825	0.0041	-0.0065	0.0443	0.0965
Leaf Gly II	0.9565	0.0595	-0.1470	0.1116	-0.0868	0.0768

Root ascorbate and related enzymes						
Root ASC + DHA	-0.9945	0.0456	0.0310	0.0139	0.0202	-0.0434
Root ASC	-0.9952	0.0405	0.0120	0.0237	0.0372	-0.0263
Root DHA	-0.8935	0.0923	0.2197	-0.0861	-0.1535	-0.2115
Root ASC/(ASC + DHA)	-0.8709	0.1647	-0.0209	0.3468	0.1904	0.1568
Root AO	-0.9938	0.0458	0.0078	0.0084	-0.0080	-0.0274
Root PMI	-0.9916	0.0150	0.0020	0.0411	0.0217	-0.0050
Leaf ascorbate and related enzymes						
Leaf ASC + DHA	-0.8802	-0.2437	0.2529	0.1500	-0.1980	0.0720
Leaf ASC	-0.9059	-0.1268	0.2303	0.1854	-0.1848	0.0902
Leaf DHA	0.1006	-0.8858	0.1924	-0.2452	-0.1171	-0.1264
Leaf ASC/(ASC + DHA)	-0.5686	0.7017	-0.0584	0.3463	0.0028	0.1227
Leaf AO	0.8681	0.2998	0.0650	0.2762	0.0831	0.1751
Leaf PMI	-0.5207	-0.3004	-0.0285	-0.1961	-0.1960	0.6808
Root glutathione						
Root GSH + GSSG	-0.7166	-0.0853	-0.1610	0.2704	0.3766	0.0134
Root GSH	-0.9555	0.0424	0.1429	0.2158	0.0540	-0.0771
Root GSSG	0.9185	-0.0997	-0.0894	0.3139	0.0207	0.1356
Root GSH/(GSH + GSSG)	-0.9483	0.0489	0.0759	-0.2164	0.0555	-0.0847
Leaf glutathione	0.8449	-0.2291	-0.3017	0.1662	-0.0791	0.1561
Leaf GSH + GSSG	0.7525	-0.4708	-0.1990	0.2140	0.0406	0.1764
Leaf GSH	0.6394	0.5202	-0.4096	-0.0455	-0.3485	0.0211
Leaf GSSG	-0.4375	-0.7048	0.3559	0.1168	0.3822	0.0419
Leaf GSH/(GSH + GSSG)						
Eigen value	44.870	4.055	2.802	2.099	1.895	1.256
Variation percent (%)	74.784	6.759	4.670	3.499	3.159	2.093

Table S3. Principal component analysis (PCA) for physiological parameters of leaves and roots

Variables	Leaves					Roots	
	PC1	PC2	PC3	PC4	PC5	PC1	PC2
Superoxide anion production, MDA and MG							
Superoxide anion production rate	0.8750	-0.1877	0.1742	-0.0272	0.1438	0.8774	-0.3985
MG	0.8846	-0.1439	0.2324	0.0797	-0.0485	0.9291	-0.2069
MDA	0.8909	-0.0227	-0.1609	0.2006	0.2160	0.9560	-0.1328
Antioxidant enzymes							
APX	0.7121	0.4887	-0.2193	0.3413	-0.1448	0.9786	-0.0627
CAT	0.3660	-0.8242	0.1717	-0.1977	0.2298	0.7209	0.6432
SOD	0.6947	0.5889	-0.1216	0.2315	-0.1617	0.9488	-0.2457
MDHAR	0.7505	-0.5919	-0.0891	0.0276	0.0453	0.9469	0.2260
GuPX	0.5813	-0.1084	-0.5345	0.4313	-0.2466	0.5905	0.7225
GR	-0.5563	-0.6068	0.2422	-0.1158	-0.3099	0.9234	0.3538
DHAR	0.7923	-0.2086	-0.2917	0.2070	0.3713	0.9414	-0.1755
S metabolism-related enzymes							
GS	0.7899	-0.3515	0.2102	0.1119	-0.0230	-0.9482	-0.1956
GST	-0.7094	-0.5695	-0.2157	-0.0337	-0.2409	0.9881	-0.0789
SiR	-0.4032	0.7895	0.3331	-0.0599	-0.1649	0.7781	-0.4135
CS	0.7510	-0.2014	0.1112	0.1058	-0.3745	-0.9768	0.0252
γGCS	0.9315	0.1393	-0.0293	0.0110	0.2494	0.9236	-0.1699
ATPS	-0.5143	0.7697	0.0558	0.1554	0.1885	-0.9738	-0.0269
APR	-0.9647	-0.0145	-0.0936	-0.0092	0.0345	0.8781	0.3084
GlPX	0.9346	-0.2119	0.1227	-0.0505	-0.1812	0.9933	0.0061
Gly I and II							
Gly II	0.9090	0.0852	0.1084	-0.2859	0.1688	-0.9486	-0.2026
Gly I	0.8656	0.3597	0.1858	-0.0381	0.1677	-0.5716	0.7709
Ascorbate and related enzymes							
DHA	-0.4175	-0.0441	0.5453	0.1806	0.4284	-0.8876	-0.0198
ASC/(ASC + DHA)	-0.7602	0.0409	-0.4497	-0.0878	0.1651	-0.7707	0.1750
ASC + DHA	-0.9170	0.0748	-0.0551	0.1071	0.2837	-0.9825	-0.0062
ASC	-0.9192	0.0808	-0.0978	0.0975	0.2620	-0.9830	-0.0048
PMI	-0.4405	0.5014	0.2230	-0.2359	-0.2922	-0.9893	-0.0707
AO	0.8330	0.3494	-0.2414	0.2292	-0.0302	-0.9402	0.2177
Glutathione							
GSSG	0.6112	0.2458	-0.3849	-0.6127	0.0292	0.9406	0.0950
GSH/(GSH + GSSG)	-0.4049	-0.1775	0.5831	0.6347	-0.0596	-0.9645	-0.0963
GSH + GSSG	0.8118	0.3066	0.2458	-0.3017	-0.0011	-0.8122	-0.2063
GSH	0.7543	0.2788	0.4593	-0.1241	-0.0132	-0.9725	0.0717
Eigen value	16.7606	4.6533	2.3078	1.6922	1.3314	24.7262	2.5519
Variation percent (%)	55.8687	15.5110	7.6926	5.6408	4.4380	82.4205	8.5063