

Physiological and Biochemical Properties of Potato (*Solanum tuberosum* L.) in Response to Ozone-Induced Oxidative Stress

Ewa Szpunar-Krok, Marta Jańczak-Pieniążek, Dagmara Migut, Karol Skrobacz, Tomasz Piechowiak, Renata Pawlak and Maciej Balawejder

Table S1. Effect of O₃ concentration, exposure time and measurement times on gas exchange parameters in potato leaves (T1 – 1st day after the 1st fumigation, T2 – 7th day after the 1st fumigation, T3 – 1st day after the 2nd fumigation, T4 – 7th day after the 2nd fumigation).

O ₃ concentration	O ₃ exposure	Time 1	Time 2	Time 3	Time 4
Intensity of photosynthesis net (P_N) (μmol (CO₂) m⁻²s⁻¹)					
Control		8.94 ^{deA} ± 2.83	8.90 ^{efA} ± 1.79	7.76 ^{deA} ± 1.81	6.68 ^{efA} ± 0.94
5 ppm	2 min	10.30 ^{eA} ± 1.94	9.73 ^{fA} ± 2.19	9.38 ^{eA} ± 0.92	8.22 ^{fA} ± 1.28
	4 min	9.31 ^{deA} ± 1.45	8.17 ^{efA} ± 1.96	7.77 ^{deA} ± 2.65	5.63 ^{defA} ± 4.42
	8 min	7.12 ^{cdA} ± 1.62	6.77 ^{cdeA} ± 2.72	5.19 ^{cA} ± 1.94	4.25 ^{cdeA} ± 0.52
	12 min	5.49 ^{bcB} ± 1.64	5.44 ^{bcdB} ± 1.44	4.83 ^{bcB} ± 0.99	2.78 ^{abcA} ± 0.84
	16 min	4.12 ^{abB} ± 0.84	3.92 ^{bAB} ± 1.13	3.88 ^{bcAB} ± 0.88	2.61 ^{abcA} ± 1.45
10 ppm	2 min	9.41 ^{deC} ± 2.43	7.91 ^{defBC} ± 0.99	5.81 ^{cdAB} ± 1.86	4.71 ^{cdeA} ± 0.91
	4 min	6.96 ^{bcdB} ± 1.70	6.62 ^{cdeB} ± 0.91	4.79 ^{bcA} ± 0.63	3.76 ^{bcdA} ± 0.90
	8 min	5.02 ^{abcA} ± 1.29	4.96 ^{bcA} ± 0.68	3.94 ^{bcAB} ± 0.39	2.83 ^{abcB} ± 0.64
	12 min	4.81 ^{abcC} ± 1.06	3.01 ^{abB} ± 0.33	2.60 ^{abB} ± 0.40	1.42 ^{abA} ± 0.51
	16 min	2.64 ^{aB} ± 0.87	1.25 ^{aA} ± 0.57	0.83 ^{aA} ± 0.32	0.75 ^{aA} ± 0.20
Transpiration rate (E) (mmol (H₂O)m⁻²s⁻¹)					
Control		2.58 ^{abcC} ± 0.46	2.25 ^{deBC} ± 0.32	2.01 ^{cdAB} ± 0.56	1.72 ^{cdA} ± 0.34
5 ppm	2 min	2.96 ^{cB} ± 0.44	2.55 ^{eAB} ± 0.44	2.19 ^{cB} ± 0.53	2.06 ^{bcdA} ± 0.46
	4 min	2.69 ^{bcB} ± 0.33	2.09 ^{deAB} ± 0.52	1.93 ^{cdAB} ± 0.64	1.39 ^{dA} ± 0.77
	8 min	2.37 ^{abcA} ± 0.44	1.94 ^{deAB} ± 0.87	1.63 ^{cdeAB} ± 0.52	1.31 ^{bcA} ± 0.31
	12 min	2.26 ^{abcC} ± 0.65	1.71 ^{bceBC} ± 0.36	1.57 ^{cdeAB} ± 0.32	0.92 ^{abA} ± 0.48
	16 min	2.08 ^{abB} ± 0.48	1.30 ^{abcA} ± 0.36	1.12 ^{abeA} ± 0.20	0.89 ^{abA} ± 0.44
10 ppm	2 min	2.65 ^{bcC} ± 0.48	2.28 ^{deBC} ± 0.30	1.67 ^{cdeAB} ± 0.61	1.34 ^{bcA} ± 0.44
	4 min	2.50 ^{abcA} ± 0.42	2.11 ^{deB} ± 0.19	1.45 ^{bdeC} ± 0.19	1.07 ^{abcD} ± 0.20
	8 min	1.91 ^{abC} ± 0.49	1.63 ^{ceBC} ± 0.23b	1.21 ^{abeAB} ± 0.15	0.95 ^{abA} ± 0.23
	12 min	2.14 ^{abB} ± 0.53	1.03 ^{acA} ± 0.17	0.92 ^{abA} ± 0.15	0.73 ^{abA} ± 0.27
	16 min	1.82 ^{aB} ± 0.56	0.84 ^{aA} ± 0.37	0.58 ^{aA} ± 0.11	0.41 ^{aA} ± 0.12
Stomatal conductance (g_s) (mmol·m⁻²s⁻¹)					
Control		0.20 ^{bcdD} ± 0.06	0.18 ^{efBC} ± 0.06	0.11 ^{dAB} ± 0.03	0.10 ^{bcA} ± 0.02
5 ppm	2 min	0.22 ^{cB} ± 0.06	0.19 ^{AB} ± 0.05	0.18 ^{eAB} ± 0.04	0.15 ^{cA} ± 0.04
	4 min	0.18 ^{abcA} ± 0.03	0.13 ^{deA} ± 0.06	0.10 ^{cdA} ± 0.06	0.10 ^{bcA} ± 0.09
	8 min	0.19 ^{abcB} ± 0.06	0.10 ^{bcdA} ± 0.06	0.07 ^{abcA} ± 0.03	0.07 ^{abA} ± 0.02
	12 min	0.17 ^{abcB} ± 0.05	0.07 ^{abcdA} ± 0.01	0.06 ^{abcA} ± 0.01	0.04 ^{abA} ± 0.02

10 ppm	16 min	0.12 ^{ab} ± 0.03	0.05 ^{abA} ± 0.01	0.06 ^{abA} ± 0.01	0.05 ^{abA} ± 0.03
	2 min	0.21 ^{bcC} ± 0.05	0.13 ^{cdeB} ± 0.02	0.09 ^{bcdA} ± 0.02	0.06 ^{abA} ± 0.01
	4 min	0.17 ^{abcC} ± 0.05	0.09 ^{bcdB} ± 0.01	0.07 ^{abcAB} ± 0.01	0.05 ^{abA} ± 0.01
	8 min	0.16 ^{abcB} ± 0.04	0.07 ^{abcA} ± 0.01	0.05 ^{abA} ± 0.01	0.05 ^{abA} ± 0.01
	12 min	0.16 ^{abcB} ± 0.04	0.04 ^{abA} ± 0.01	0.04 ^{aA} ± 0.01	0.03 ^{aA} ± 0.01
	16 min	0.13 ^{abB} ± 0.06	0.03 ^{aA} ± 0.01	0.03 ^{aA} ± 0.01	0.02 ^{aA} ± 0.01
Intercellular CO₂ concentration (Ci) (mmol L⁻¹)					
Control		250.6 ^{abB} ± 22.5	223.8 ^{aA} ± 13.0	227.4 ^{aA} ± 20.2	237.5 ^{aB} ± 23.4
5 ppm	2 min	228.1 ^{aA} ± 11.7	226.1 ^{aA} ± 8.5	228.4 ^{aA} ± 20.5	231.3 ^{aA} ± 20.1
	4 min	251.0 ^{abA} ± 11.1	226.0 ^{aA} ± 13.6	230.9 ^{aA} ± 18.4	250.9 ^{abA} ± 29.6
	8 min	271.8 ^{bB} ± 23.0	230.3 ^{aA} ± 28.2	239.3 ^{aA} ± 32.6	245.1 ^{abAB} ± 23.5
	12 min	314.6 ^{cdB} ± 20.1	245.5 ^{abA} ± 23.2	241.4 ^{aA} ± 15.4	245.0 ^{abA} ± 32.9
	16 min	320.3 ^{dB} ± 25.1	245.1 ^{abA} ± 19.1	262.1 ^{abA} ± 29.5	268.5 ^{abCA} ± 29.0
10 ppm	2 min	254.0 ^{abAB} ± 27.5	226.8 ^{aA} ± 18.3	230.9 ^{aA} ± 13.9	272.6 ^{abcdB} ± 29.3
	4 min	284.1 ^{bcB} ± 23.0	240.0 ^{aA} ± 13.8	247.0 ^{aA} ± 8.8	263.5 ^{abcAB} ± 34.2
	8 min	310.4 ^{cdB} ± 26.6	275.1 ^{bcAB} ± 28.1	261.0 ^{aA} ± 6.9	287.9 ^{bcdAB} ± 29.9
	12 min	317.0 ^{cdA} ± 20.6	301.4 ^{cdA} ± 16.9	298.6 ^{bcA} ± 37.7	302.1 ^{cdA} ± 31.7
	16 min	335.9 ^{dB} ± 14.1	308.6 ^{dA} ± 21.1	329.4 ^{cAB} ± 18.9	319.0 ^{dAB} ± 30.5

Lowercase letters indicate significant differences between the means on respective measurement times, capital letters indicate significant differences between means on the measurement times for respective variants of O₃ concentration and exposure time ($p < 0.05$).

Table S2. Effect of O₃ concentration, exposure time and measurement times on relative Chl content (CCI) in potato leaves (T1 – 1st day after the 1st fumigation, T2 – 7th day after the 1st fumigation, T3 – 1st day after the 2nd fumigation, T4 – 7th day after the 2nd fumigation).

O ₃ concentration	O ₃ exposure	Time 1	Time 2	Time 3	Time 4
Control		45.3 ^{cA} ± 10.0	44.6 ^{defgA} ± 13.1	43.8 ^{efA} ± 9.9	43.1 ^{fgA} ± 12.0
5 ppm	2 min	49.3 ^{cA} ± 12.6	50.1 ^{gA} ± 12.8	46.1 ^{fA} ± 19.2	46.3 ^{gA} ± 10.6
	4 min	46.1 ^{cB} ± 10.1	46.0 ^{efgB} ± 10.5	39.0 ^{defAB} ± 8.8	35.7 ^{defA} ± 7.2
	8 min	43.3 ^{bcB} ± 11.8	37.4 ^{cdeAB} ± 6.9	32.7 ^{cdA} ± 10.5	33.0 ^{cdeA} ± 9.5
	12 min	32.9 ^{abBC} ± 7.9	33.5 ^{abC} ± 9.7	25.9 ^{abcAB} ± 6.4	24.4 ^{bcA} ± 9.5
	16 min	32.9 ^{aC} ± 9.3	33.5 ^{abBC} ± 8.1	25.9 ^{abAB} ± 7.5	24.42 ^{abA} ± 7.1
10 ppm	2 min	46.6 ^{cA} ± 10.0	47.8 ^{fgA} ± 8.8	46.6 ^{fA} ± 10.0	41.2 ^{efgA} ± 11.0
	4 min	40.4 ^{bcA} ± 24.1	38.8 ^{cdefA} ± 9.8	34.1 ^{cdeA} ± 11.1	34.8 ^{defA} ± 8.6
	8 min	38.0 ^{abcB} ± 9.4	35.2 ^{bcdAB} ± 9.5	30.2 ^{bcdA} ± 8.2	28.1 ^{cdA} ± 9.6
	12 min	32.3 ^{abC} ± 7.3	26.1 ^{abBC} ± 8.1	23.5 ^{abcAB} ± 9.5	18.3 ^{abA} ± 8.8
	16 min	26.7 ^{aC} ± 7.0	24.2 ^{abC} ± 10.0	18.3 ^{aAB} ± 8.6	13.1 ^{aA} ± 6.0

Lowercase letters indicate significant differences between the means on respective measurement times, capital letters indicate significant differences between means on the measurement times for respective variants of O₃ concentration and exposure time ($p < 0.05$).

Table S3. Effect of O₃ concentration, exposure time and measurement times on Chl fluorescence parameters in potato leaves (T1 – 1st day after the 1st fumigation, T2 – 7th day after the 1st fumigation, T3 – 1st day after the 2nd fumigation, T4 – 7th day after the 2nd fumigation).

O ₃ concentration	O ₃ exposure	Time 1	Time 2	Time 3	Time 4
Maximal photochemical efficiency of PSII (F _v /F _m)					
Control		0.82 ^{cdB} ± 0.02	0.84 ^{cC} ± 0.01	0.79 ^{efA} ± 0.01	0.79 ^{eA} ± 0.01
5 ppm	2 min	0.83 ^{dB} ± 0.01	0.84 ^{cB} ± 0.01	0.80 ^{fA} ± 0.01	0.80 ^{eA} ± 0.01
	4 min	0.82 ^{cdB} ± 0.01	0.83 ^{cB} ± 0.01	0.78 ^{efA} ± 0.02	0.79 ^{deA} ± 0.02
	8 min	0.81 ^{bcdB} ± 0.01	0.84 ^{cC} ± 0.01	0.77 ^{efA} ± 0.02	0.78 ^{deA} ± 0.02
	12 min	0.79 ^{bcdC} ± 0.03	0.82 ^{cC} ± 0.02	0.70 ^{cdA} ± 0.01	0.74 ^{cB} ± 0.02
	16 min	0.73 ^{baB} ± 0.09	0.77 ^{bcB} ± 0.03	0.64 ^{bcA} ± 0.08	0.72 ^{cAB} ± 0.04
10 ppm	2 min	0.83 ^{cdB} ± 0.01	0.83 ^{cB} ± 0.01	0.74 ^{defA} ± 0.01	0.76 ^{cdA} ± 0.01
	4 min	0.81 ^{bcdB} ± 0.01	0.83 ^{cC} ± 0.01	0.74 ^{defA} ± 0.01	0.75 ^{cA} ± 0.01
	8 min	0.78 ^{bcdB} ± 0.04	0.80 ^{bcB} ± 0.03	0.73 ^{deA} ± 0.01	0.74 ^{cA} ± 0.01
	12 min	0.74 ^{bcB} ± 0.07	0.74 ^{abB} ± 0.10	0.61 ^{abA} ± 0.02	0.67 ^{baB} ± 0.03
	16 min	0.62 ^{aaB} ± 0.11	0.68 ^{aA} ± 0.12	0.53 ^{aA} ± 0.08	0.58 ^{aAB} ± 0.01
Maximum quantum yield of primary photochemistry (F _v /F ₀)					
Control		4.52 ^{deA} ± 0.58	5.24 ^{dB} ± 0.38	4.70 ^{cdAB} ± 0.27	4.76 ^{efAB} ± 0.32
5 ppm	2 min	4.93 ^{eA} ± 0.28	5.32 ^{dA} ± 0.22	5.04 ^{dA} ± 0.37	5.04 ^{fA} ± 0.29
	4 min	4.70 ^{deAB} ± 0.33	5.02 ^{cdB} ± 0.27	4.40 ^{cdA} ± 0.46	4.78 ^{efAB} ± 0.30
	8 min	4.31 ^{deAB} ± 0.39	5.15 ^{cdC} ± 0.22	4.06 ^{cA} ± 0.52	4.54 ^{defB} ± 0.38
	12 min	3.97 ^{bcdA} ± 0.78	4.61 ^{cdA} ± 0.50	3.88 ^{cA} ± 0.36	4.02 ^{cdA} ± 0.55
	16 min	2.90 ^{abA} ± 0.88	3.50 ^{bA} ± 0.67	2.95 ^{bA} ± 1.19	3.72 ^{bcA} ± 0.76
10 ppm	2 min	4.72 ^{eAB} ± 0.21d	4.89 ^{cdC} ± 0.49	4.29 ^{cdA} ± 0.42	4.74 ^{defAB} ± 0.35
	4 min	4.18 ^{cdeA} ± 0.36	4.86 ^{cdB} ± 0.40	4.23 ^{cdA} ± 0.37	4.38 ^{cdefAB} ± 0.37
	8 min	3.72 ^{bcdA} ± 0.72	4.09 ^{bcA} ± 0.61	3.89 ^{cA} ± 0.30	4.04 ^{cdeA} ± 0.29
	12 min	3.12 ^{bcA} ± 1.06	3.20 ^{abA} ± 1.34	2.68 ^{abA} ± 0.38	3.24 ^{baA} ± 0.54
	16 min	1.85 ^{aA} ± 1.00	2.28 ^{aA} ± 1.12	1.82 ^{aA} ± 0.80	2.04 ^{aA} ± 0.52
Performance index (PI)					
Control		8.47 ^{deA} ± 2.45	13.65 ^{eB} ± 2.91	10.47 ^{deAB} ± 2.81	11.74 ^{efAB} ± 3.56
5 ppm	2 min	11.94 ^{fA} ± 1.84	15.53 ^{eB} ± 2.65	13.17 ^{eAB} ± 2.84	13.16 ^{fAB} ± 2.26
	4 min	8.59 ^{deA} ± 1.40	12.22 ^{deB} ± 2.29	8.77 ^{cdA} ± 2.28	12.74 ^{efB} ± 3.18
	8 min	6.29 ^{cdA} ± 1.51	11.06 ^{deC} ± 1.39	6.99 ^{cdAB} ± 2.52	9.35 ^{cdeBC} ± 3.02
	12 min	5.60 ^{bcdA} ± 2.26	8.39 ^{bcdB} ± 1.48	5.73 ^{bcB} ± 1.65	6.99 ^{bcdAB} ± 1.44
	16 min	3.03 ^{abA} ± 1.43	4.25 ^{abA} ± 1.70	3.45 ^{abA} ± 2.74	5.20 ^{abA} ± 2.23
10 ppm	2 min	9.78 ^{efA} ± 1.53	12.22 ^{deA} ± 5.22	7.86 ^{cdA} ± 2.49	12.07 ^{efA} ± 1.35
	4 min	6.83 ^{cdeA} ± 1.56	8.29 ^{bcdAB} ± 3.08	7.04 ^{cdA} ± 1.87	9.96 ^{defB} ± 1.10
	8 min	5.43 ^{bcdA} ± 2.15	6.82 ^{abcA} ± 1.97	5.46 ^{bcA} ± 1.10	6.17 ^{bcA} ± 1.45
	12 min	3.67 ^{abcA} ± 2.84	4.42 ^{abA} ± 3.42	2.34 ^{abA} ± 0.69	5.58 ^{baA} ± 2.09
	16 min	1.80 ^{aA} ± 1.73	2.52 ^{aA} ± 2.59	1.29 ^{aA} ± 0.90	1.71 ^{aA} ± 0.91

Lowercase letters indicate significant differences between the means on respective measurement times, capital letters indicate significant differences between means on the measurement times for respective variants of O₃ concentration and exposure time ($p < 0.05$).

Table S4. Effect of O₃ concentration, exposure time and measurement times on antioxidant activity (AA) in potato leaves (T1 – 1st day after the 1st fumigation, T2 – 7th day after the 1st fumigation, T3 – 1st day after the 2nd fumigation, T4 – 7th day after the 2nd fumigation).

O ₃ concentration	O ₃ exposure	Time 1	Time 2	Time 3	Time 4
Method with ABTS^{•+} radical					
Control		173.1 ^{cdA} ± 10.9	181.6 ^{dA} ± 9.9	186.0 ^{deA} ± 4.7	181.3 ^{efA} ± 14.1
5 ppm	2 min	217.9 ^{fA} ± 2.3	258.1 ^{gA} ± 12.7	224.0 ^{fgA} ± 4.9	216.4 ^{fA} ± 34.1
	4 min	206.4 ^{efA} ± 2.9	227.0 ^{fB} ± 6.6	217.8 ^{fAB} ± 6.0	208.3 ^{fA} ± 5.6
	8 min	175.5 ^{cdA} ± 15.1	209.8 ^{efC} ± 6.2	200.2 ^{efBC} ± 9.3	184.2 ^{efAB} ± 1.8
	12 min	153.4 ^{bcA} ± 2.8	190.3 ^{deB} ± 6.5	179.4 ^{dB} ± 8.3	154.0 ^{deA} ± 7.5
	16 min	141.9 ^{bbB} ± 7.0	151.6 ^{cB} ± 7.3	147.9 ^{cB} ± 4.3	112.0 ^{bcA} ± 4.1
10 ppm	2 min	204.9 ^{efA} ± 11.6	254.0 ^{gB} ± 6.4	239.8 ^{gB} ± 4.5	202.2 ^{fA} ± 4.2
	4 min	192.9 ^{deA} ± 9.1	192.4 ^{deA} ± 1.2	197.4 ^{eA} ± 5.9	186.0 ^{efA} ± 5.5
	8 min	140.9 ^{baA} ± 6.1	130.3 ^{baA} ± 6.2	155.1 ^{cA} ± 7.6	143.0 ^{cdA} ± 14.8
	12 min	116.4 ^{aB} ± 7.4	114.2 ^{abB} ± 1.4	114.0 ^{bbB} ± 4.1	101.3 ^{abA} ± 3.5
	16 min	93.5 ^{aB} ± 5.2	106.4 ^{aB} ± 1.7	94.5 ^{aB} ± 1.5	68.1 ^{aA} ± 7.6
Method with DPPH^{•+} radical					
Control		6.49 ^{gC} ± 0.01	5.98 ^{efB} ± 0.01	5.76 ^{fA} ± 0.02	5.91 ^{efB} ± 0.01
5 ppm	2 min	7.65 ^{iB} ± 0.01	6.69 ^{gA} ± 0.14	6.79 ^{iA} ± 0.07	6.60 ^{gA} ± 0.14
	4 min	6.98 ^{hiC} ± 0.01	5.70 ^{deA} ± 0.21	6.97 ^{iC} ± 0.03	6.28 ^{fgB} ± 0.01
	8 min	6.85 ^{hB} ± 0.01	5.59 ^{deA} ± 0.07	5.54 ^{eA} ± 0.00	5.44 ^{deA} ± 0.14
	12 min	5.45 ^{dD} ± 0.01	4.72 ^{cC} ± 0.14	3.68 ^{cA} ± 0.09	4.17 ^{cbB} ± 0.07
	16 min	4.78 ^{bcC} ± 0.01	4.15 ^{bbB} ± 0.07	3.19 ^{baA} ± 0.03	3.11 ^{baA} ± 0.07
10 ppm	2 min	7.02 ^{iB} ± 0.01	6.41 ^{fgA} ± 0.07	6.55 ^{hA} ± 0.07	6.34 ^{fgA} ± 0.14
	4 min	6.21 ^{fA} ± 0.07	5.47 ^{dA} ± 0.14	6.13 ^{gA} ± 0.07	5.38 ^{dA} ± 0.28
	8 min	5.82 ^{cC} ± 0.07	4.96 ^{cbB} ± 0.01	4.79 ^{dB} ± 0.07	4.19 ^{cA} ± 0.07
	12 min	5.63 ^{dC} ± 0.07	4.05 ^{bbB} ± 0.07	3.13 ^{baA} ± 0.01	3.19 ^{baA} ± 0.07
	16 min	4.31 ^{aC} ± 0.01	3.11 ^{abB} ± 0.14	2.80 ^{abB} ± 0.06	2.09 ^{aaA} ± 0.07

Lowercase letters indicate significant differences between the means on respective measurement times, capital letters indicate significant differences between means on the measurement times for respective variants of O₃ concentration and exposure time ($p < 0.05$).