

Supplementary Material

Evaluating non-photochemical quenching (NPQ) kinetics and photosynthetic efficiency in cassava (*Manihot esculenta*) subjected to variable high light conditions

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Supplementary Table S1

Table S1a ANOVA table for Figure 3 - Control plants

Variable		Pn	ΦPSII	NPQ
Sree Suvarna	500PAR	21 ± 1.1 ^{ijm}	0.39 ± 0.0058 ^{bc}	0.62 ± 0.013 ^o
	1000PAR	25 ± 1.7 ^{dik}	0.27 ± 0.0033 ^{df}	0.71 ± 0.012 ^{no}
	1500PAR	27 ± 1.8 ^{adi}	0.16 ± 0.0088 ^{ijl}	0.76 ± 0.0058 ^{no}
	2000PAR	28 ± 1.3 ^{adh}	0.13 ± 0.013 ^{klm}	0.79 ± 0.0058 ^{no}
	2500PAR	33 ± 0.69 ^{ab}	0.09 ± 0 ^{npq}	0.86 ± 0.012 ^{no}
	3000PAR	34 ± 1.5 ^a	0.063 ± 0.0088 ^{pr}	0.99 ± 0.0088 ^{ln}
Sree Swarna	500PAR	20 ± 1.6 ^{ikm}	0.42 ± 0.0058 ^b	0.88 ± 0.0088 ^{mno}
	1000PAR	25 ± 1.4 ^{dhikl}	0.29 ± 0.0088 ^d	1 ± 0.0088 ^{kn}
	1500PAR	29 ± 0.76 ^{adf}	0.19 ± 0.0088 ^{ghj}	1.3 ± 0.15 ^{hkl}
	2000PAR	30 ± 0.73 ^{ade}	0.15 ± 0.0033 ^{jl}	1.5 ± 0.15 ^{dhi}
	2500PAR	31 ± 0.57 ^{ad}	0.13 ± 0.0067 ^{klm}	1.6 ± 0.15 ^{dhi}
	3000PAR	32 ± 0.95 ^{abc}	0.08 ± 0 ^{npq}	1.6 ± 0.15 ^{bcdh}
Sree Jaya	500PAR	17 ± 0.61 ^m	0.49 ± 0.0067 ^a	1 ± 0.034 ^{kn}
	1000PAR	18 ± 0.97 ^{lm}	0.28 ± 0.015 ^{de}	1.4 ± 0.064 ^{ghk}
	1500PAR	22 ± 1.2 ^{hikm}	0.21 ± 0.012 ^{ghi}	1.5 ± 0.044 ^{ehi}
	2000PAR	25 ± 0.67 ^{dik}	0.15 ± 0.0033 ^{ilm}	1.6 ± 0.052 ^{cdhi}
	2500PAR	31 ± 1.3 ^{ad}	0.12 ± 0.012 ^{lno}	1.7 ± 0.034 ^{bcdh}
	3000PAR	31 ± 1.5 ^{ad}	0.07 ± 0 ^{opr}	1.8 ± 0.046 ^{adef}
Sree Pavithra	500PAR	18 ± 1.1 ^m	0.27 ± 0.0058 ^{df}	1.6 ± 0.044 ^{dhi}
	1000PAR	19 ± 1.3 ^{km}	0.21 ± 0.022 ^{ghi}	1.7 ± 0.077 ^{bcdeg}
	1500PAR	22 ± 2.6 ^{ghikm}	0.12 ± 0.02 ^{ln}	1.8 ± 0.024 ^{ade}
	2000PAR	27 ± 1.5 ^{bdi}	0.067 ± 0.0033 ^{opr}	1.9 ± 0.029 ^{ad}
	2500PAR	28 ± 0.98 ^{adi}	0.04 ± 0 ^{qr}	1.9 ± 0.017 ^{ad}
	3000PAR	28 ± 0.83 ^{adg}	0.02 ± 0 ^r	2 ± 0.035 ^{ac}
Sree Athulya	500PAR	18 ± 0.55 ^m	0.35 ± 0.018 ^c	1.4 ± 0.038 ^{fghij}
	1000PAR	20 ± 0.86 ^{ikm}	0.22 ± 0.0058 ^{fh}	1.6 ± 0.085 ^{cdh}
	1500PAR	23 ± 0.58 ^{fghikm}	0.16 ± 0.0058 ^{ijl}	1.8 ± 0.11 ^{ade}
	2000PAR	26 ± 0.88 ^{dik}	0.1 ± 0 ^{mnp}	1.9 ± 0.028 ^{ac}
	2500PAR	28 ± 0.72 ^{adi}	0.067 ± 0.0033 ^{opr}	2 ± 0.072 ^{ab}
	3000PAR	33 ± 1.2 ^{abc}	0.05 ± 0 ^{pr}	2.1 ± 0.033 ^a
M4	500PAR	22 ± 1.3 ^{hikm}	0.36 ± 0.0088 ^c	1 ± 0.01 ^{kn}
	1000PAR	23 ± 1.2 ^{efghikm}	0.23 ± 0.018 ^{efg}	1.2 ± 0.023 ^{iklm}
	1500PAR	25 ± 0.9 ^{dik}	0.19 ± 0.0067 ^{ghj}	1.3 ± 0.058 ^{hkl}
	2000PAR	26 ± 1.1 ^{cdhj}	0.18 ± 0.0088 ^{hjk}	1.5 ± 0.033 ^{ehi}
	2500PAR	29 ± 1.3 ^{adg}	0.09 ± 0 ^{npq}	1.6 ± 0.046 ^{cdhi}
	3000PAR	31 ± 0.87 ^{ad}	0.06 ± 0 ^{pr}	1.6 ± 0.081 ^{bcdh}
P-value	Variety	<0.01	<0.01	<0.01
	PAR	<0.01	<0.01	<0.01
	V×P ¹	0.09	<0.01	0.05

Values are means ± SEM, n = 3 per treatment group.

^{a-n}Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by two-way ANOVA and the TUKEY test.

¹V × P = Variety × PAR interaction effect.

Table S1b ANOVA table for Figure 3 - IHL plants.

Variable		Pn	ΦPSII	NPQ
Sree Suvarna	500PAR	16 ± 0.81 ^{gj}	0.31 ± 0.0033 ^b	0.95 ± 0.0033 ^{vw}
	1000PAR	20 ± 1.3 ^{cddegj}	0.22 ± 0.012 ^{def}	1.2 ± 0.013 ^{tu}
	1500PAR	22 ± 1.2 ^{bcdeghi}	0.17 ± 0.017 ^{gj}	1.3 ± 0.0058 ^{rt}
	2000PAR	23 ± 1.3 ^{acd}	0.11 ± 0.0058 ^{klm}	1.4 ± 0.032 ^{nopr}
	2500PAR	26 ± 1.1 ^{acd}	0.08 ± 0 ^{lo}	1.4 ± 0.019 ^{lmp}
	3000PAR	31 ± 1.2 ^a	0.07 ± 0 ^{mno}	1.5 ± 0.018 ^{jlmo}
Sree Swarna	500PAR	17 ± 1.1 ^{fgj}	0.42 ± 0.02 ^a	0.88 ± 0.013 ^w
	1000PAR	21 ± 0.32 ^{bcdeghi}	0.24 ± 0.012 ^{ce}	1 ± 0.0033 ^{uv}
	1500PAR	24 ± 1.5 ^{acef}	0.15 ± 0.0058 ^{gjk}	1.3 ± 0.067 ^{pt}
	2000PAR	25 ± 1.5 ^{ace}	0.12 ± 0.012 ^{jlm}	1.5 ± 0.03 ^{ijmn}
	2500PAR	27 ± 1.2 ^{ac}	0.077 ± 0.0033 ^{lo}	1.6 ± 0.02 ^{hjk}
	3000PAR	28 ± 1 ^{ab}	0.06 ± 0 ^{no}	1.7 ± 0.017 ^{fghi}
Sree Jaya	500PAR	15 ± 1.2 ^{ij}	0.33 ± 0.0088 ^b	1 ± 0.0088 ^{vw}
	1000PAR	19 ± 0.81 ^{degj}	0.19 ± 0.0067 ^{egi}	1.4 ± 0.03 ^{oprs}
	1500PAR	23 ± 1.8 ^{acd}	0.12 ± 0.012 ^{jlm}	1.5 ± 0.077 ^{klmo}
	2000PAR	25 ± 2.7 ^{ace}	0.08 ± 0 ^{lo}	1.6 ± 0.01 ^{hjl}
	2500PAR	24 ± 1.2 ^{ace}	0.063 ± 0.0033 ^{no}	1.7 ± 0.031 ^{ghi}
	3000PAR	25 ± 1.3 ^{ace}	0.06 ± 0 ^{no}	1.8 ± 0.0058 ^{deg}
Sree Pavithra	500PAR	14 ± 0.89 ^{ij}	0.28 ± 0.032 ^{bc}	1.6 ± 0.0058 ^{hjm}
	1000PAR	15 ± 0.83 ^{hj}	0.18 ± 0.0058 ^{fgi}	1.7 ± 0.012 ^{eh}
	1500PAR	21 ± 1.4 ^{bcdeghi}	0.13 ± 0.0067 ^{jl}	1.8 ± 0.0067 ^{cef}
	2000PAR	23 ± 1.2 ^{acd}	0.077 ± 0.0033 ^{lo}	1.8 ± 0.023 ^{ce}
	2500PAR	24 ± 1.4 ^{ace}	0.067 ± 0.0033 ^{no}	1.9 ± 0.015 ^{bcd}
	3000PAR	26 ± 2 ^{acd}	0.06 ± 0 ^{no}	2 ± 0.034 ^{bc}
Sree Athulya	500PAR	20 ± 0.58 ^{degj}	0.3 ± 0.0088 ^b	1.4 ± 0.018 ^{mpq}
	1000PAR	21 ± 1 ^{cddegj}	0.19 ± 0.0058 ^{egh}	1.6 ± 0.021 ^{ghj}
	1500PAR	23 ± 1.2 ^{bcdegh}	0.14 ± 0.0088 ^{ijk}	1.8 ± 0.026 ^{ce}
	2000PAR	26 ± 1 ^{ace}	0.08 ± 0 ^{lo}	1.9 ± 0.026 ^{bc}
	2500PAR	27 ± 0.95 ^{ac}	0.05 ± 0 ^o	2 ± 0.036 ^{ab}
	3000PAR	29 ± 1.5 ^{ab}	0.03 ± 0 ^o	2.1 ± 0.032 ^a
M4	500PAR	14 ± 1.1 ^j	0.25 ± 0.0088 ^{cd}	1 ± 0.015 ^{uv}
	1000PAR	15 ± 1.5 ^{hj}	0.2 ± 0.0033 ^{deg}	1.2 ± 0.012 st
	1500PAR	19 ± 1.4 ^{egj}	0.14 ± 0.015 ^{hijk}	1.3 ± 0.039 ^{qrt}
	2000PAR	20 ± 1.2 ^{cddegj}	0.11 ± 0 ^{klm}	1.5 ± 0.017 ^{klmo}
	2500PAR	21 ± 1.2 ^{cddegj}	0.067 ± 0.0033 ^{no}	1.6 ± 0.022 ^{hjm}
	3000PAR	23 ± 1.6 ^{bcdegh}	0.03 ± 0 ^o	1.6 ± 0.033 ^{ghj}
P-value	Variety	<0.01	<0.01	<0.01
	PAR	<0.01	<0.01	<0.01
	V×P ¹	0.71	<0.01	<0.01

Values are means ± SEM, n = 3 per treatment group.

^{a-n}Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by two-way ANOVA and the TUKEY test.

¹V × P = Variety × PAR interaction effect.

Supplementary Table S2

Table S2a ANOVA table for Figure 4 - Control plants.

Variable		Pn	PhiPS2	NPQ
Sree Suvarna	3000PAR	30 ± 0.36 ^{ab}	0.077 ± 0.0033 ^{jlⁿ}	1.6 ± 0.033 ^{egh}
	2500PAR	30 ± 0.4 ^{ac}	0.1 ± 0.012 ^{fjln}	1.4 ± 0.064 ^{mno}
	2000PAR	28 ± 0.71 ^{acd}	0.12 ± 0.0058 ^{efjln}	1.2 ± 0.026 ^{pr}
	1500PAR	26 ± 2.2 ^{acf}	0.15 ± 0.018 ^{efjl}	1.2 ± 0.022 ^{qr}
	1000PAR	24 ± 2.5 ^{dfh}	0.24 ± 0.034 ^{bc}	1.1 ± 0.0058 ^{rs}
	500PAR	21 ± 0.79 ^{fhi}	0.38 ± 0.025 ^a	1 ± 0.032 ^s
Sree Swarna	3000PAR	29 ± 1.3 ^{acd}	0.04 ± 0 ⁿ	1.9 ± 0.035 ^a
	2500PAR	27 ± 0.56 ^{acde}	0.097 ± 0.013 ^{gijln}	1.8 ± 0.038 ^{ab}
	2000PAR	27 ± 0.44 ^{acde}	0.16 ± 0.01 ^{cfjk}	1.8 ± 0.012 ^{ad}
	1500PAR	25 ± 0.52 ^{acfg}	0.17 ± 0.01 ^{cfhi}	1.7 ± 0.012 ^{dg}
	1000PAR	24 ± 0.62 ^{cfh}	0.19 ± 0.0058 ^{cf}	1.7 ± 0.012 ^{dg}
	500PAR	22 ± 0.67 ^{efh}	0.38 ± 0.027 ^a	1.4 ± 0.044 ^{kmno}
Sree Jaya	3000PAR	31 ± 0.61 ^a	0.037 ± 0.0088 ⁿ	1.4 ± 0.019 ^{jkmn}
	2500PAR	29 ± 0.65 ^{acd}	0.07 ± 0 ^{klⁿ}	1.4 ± 0.024 ^{kmn}
	2000PAR	27 ± 1.2 ^{acde}	0.097 ± 0.026 ^{gijln}	1.4 ± 0.0033 ^{mno}
	1500PAR	25 ± 0.65 ^{bcfg}	0.11 ± 0.024 ^{fjln}	1.4 ± 0.0033 ^{mno}
	1000PAR	21 ± 0.52 ^{fhi}	0.16 ± 0.032 ^{cfj}	1.3 ± 0.023 ^{np}
	500PAR	19 ± 0.61 ^{hj}	0.32 ± 0.022 ^{ab}	1.3 ± 0.0033 ^{opq}
Sree Pavithra	3000PAR	26 ± 0.51 ^{acf}	0.057 ± 0.0033 ^{ln}	1.7 ± 0.01 ^{bdef}
	2500PAR	24 ± 0.78 ^{cfh}	0.08 ± 0.012 ^{ijln}	1.7 ± 0.0067 ^{cdef}
	2000PAR	22 ± 1.1 ^{efh}	0.11 ± 0.0033 ^{fjln}	1.7 ± 0.0067 ^{dg}
	1500PAR	22 ± 0.2 ^{efh}	0.11 ± 0.015 ^{fjln}	1.6 ± 0.019 ^{degh}
	1000PAR	20 ± 0.76 ^{fhi}	0.19 ± 0.019 ^{cfg}	1.5 ± 0.032 ^{im}
	500PAR	19 ± 1.2 ^{hj}	0.22 ± 0.013 ^{cd}	1.4 ± 0.015 ^{mno}
Sree Athulya	3000PAR	28 ± 1.4 ^{acd}	0.04 ± 0 ⁿ	1.8 ± 0.018 ^a
	2500PAR	26 ± 1.9 ^{acf}	0.04 ± 0 ⁿ	1.8 ± 0.012 ^{abc}
	2000PAR	22 ± 0.39 ^{efh}	0.05 ± 0.0058 ^{mn}	1.8 ± 0.0088 ^{abc}
	1500PAR	19 ± 0.8 ^{hj}	0.093 ± 0.018 ^{ghjln}	1.8 ± 0.028 ^{ade}
	1000PAR	18 ± 1.2 ^{hj}	0.17 ± 0.023 ^{cfgh}	1.6 ± 0.012 ^{fgi}
	500PAR	15 ± 1.3 ^j	0.23 ± 0.012 ^{cd}	1.5 ± 0.012 ^{im}
M4	3000PAR	24 ± 0.82 ^{dfh}	0.04 ± 0 ⁿ	1.6 ± 0.023 ^{gij}
	2500PAR	22 ± 0.73 ^{efh}	0.057 ± 0.0033 ^{ln}	1.5 ± 0.025 ^{hik}
	2000PAR	20 ± 0.67 ^{fhi}	0.083 ± 0.012 ^{hjln}	1.5 ± 0.0088 ^{hikl}
	1500PAR	20 ± 0.67 ^{ghj}	0.11 ± 0.018 ^{fjln}	1.4 ± 0.012 ^{lmno}
	1000PAR	20 ± 1.2 ^{ghj}	0.14 ± 0.015 ^{dfjlm}	1.4 ± 0.0058 ^{mno}
	500PAR	16 ± 0.47 ^{ij}	0.21 ± 0.015 ^{cde}	1.1 ± 0.0033 ^{rs}
P-value	Variety	<0.01	<0.01	<0.01
	PAR	<0.01	<0.01	<0.01
	V×P ¹	0.05	<0.01	<0.01

Values are means ± SEM, n = 3 per treatment group.

^{a-n}Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by two-way ANOVA and the TUKEY test.

¹V × P = Variety × PAR interaction effect.

Table S2b ANOVA table for Figure 4 - IHL plants.

Variable		Pn	PhiPS2	NPQ
Sree Suvarna	3000PAR	29 ± 0.86 ^a	0.09 ± 0 ^{hklm}	1.9 ± 0.012 ^{cde}
	2500PAR	28 ± 0.88 ^{ab}	0.09 ± 0.017 ^{hklm}	1.8 ± 0.0067 ^{dgh}
	2000PAR	21 ± 1.1 ^{cd}	0.11 ± 0.01 ^{el}	1.7 ± 0.017 ^{dgh}
	1500PAR	19 ± 0.75 ^{cef}	0.15 ± 0.015 ^{defg}	1.3 ± 0.015 ^{ij}
	1000PAR	19 ± 0.95 ^{ceg}	0.22 ± 0.02 ^c	1.2 ± 0.019 ^j
	500PAR	14 ± 0.37 ^{fghkl}	0.35 ± 0.02 ^a	1.2 ± 0.0058 ^j
Sree Swarna	3000PAR	22 ± 1 ^{bc}	0.06 ± 0.012 ^{ln}	2.3 ± 0.095 ^a
	2500PAR	15 ± 0.62 ^{eghk}	0.06 ± 0 ^{ln}	2.3 ± 0.058 ^a
	2000PAR	11 ± 0.53 ^{hikm}	0.07 ± 0 ^{klm}	2.2 ± 0.017 ^{ab}
	1500PAR	9.6 ± 0.7 ^{km}	0.097 ± 0.019 ^{glm}	1.7 ± 0.017 ^{dgh}
	1000PAR	7.5 ± 0.15 ^{lm}	0.16 ± 0.02 ^{cefg}	1.7 ± 0.012 ^{dgh}
	500PAR	7.3 ± 0.67 ^m	0.28 ± 0.02 ^b	1.6 ± 0.0088 ^{egh}
Sree Jaya	3000PAR	21 ± 0.44 ^{ce}	0.07 ± 0 ^{klm}	1.7 ± 0.024 ^{dgh}
	2500PAR	19 ± 0.64 ^{ceg}	0.11 ± 0.0088 ^{fl}	1.7 ± 0.0058 ^{dgh}
	2000PAR	14 ± 0.61 ^{eghk}	0.11 ± 0.015 ^{el}	1.7 ± 0.0033 ^{dgh}
	1500PAR	11 ± 0.67 ^{hikm}	0.15 ± 0.018 ^{defgh}	1.7 ± 0.0058 ^{dgh}
	1000PAR	9.7 ± 0.76 ^{ikm}	0.12 ± 0.0088 ^{defgk}	1.6 ± 0.0088 ^{gi}
	500PAR	9.8 ± 1.1 ^{ijkm}	0.29 ± 0.022 ^{ab}	1.5 ± 0.0033 ^{hi}
Sree Pavithra	3000PAR	18 ± 0.5 ^{ceg}	0.03 ± 0 ⁿ	1.8 ± 0.0058 ^{def}
	2500PAR	16 ± 0.73 ^{cegh}	0.04 ± 0.0058 ^{mn}	1.8 ± 0.028 ^{dg}
	2000PAR	16 ± 0.55 ^{degi}	0.06 ± 0 ^{ln}	1.8 ± 0.018 ^{dg}
	1500PAR	14 ± 0.87 ^{fghk}	0.08 ± 0 ^{klm}	1.8 ± 0.017 ^{dgh}
	1000PAR	13 ± 0.68 ^{ghkm}	0.11 ± 0 ^{el}	1.7 ± 0.013 ^{dgh}
	500PAR	12 ± 0.41 ^{hikm}	0.17 ± 0.0058 ^{ce}	1.6 ± 0.0058 ^{fgh}
Sree Athulya	3000PAR	22 ± 0.63 ^{bc}	0.03 ± 0 ⁿ	2.3 ± 0.088 ^a
	2500PAR	19 ± 0.66 ^{ceg}	0.04 ± 0 ^{mn}	2.2 ± 0.076 ^a
	2000PAR	18 ± 1.1 ^{ceg}	0.06 ± 0 ^{ln}	2.2 ± 0.15 ^{ab}
	1500PAR	18 ± 1.2 ^{ceg}	0.083 ± 0.0033 ^{iklm}	2.3 ± 0.048 ^a
	1000PAR	16 ± 0.5 ^{deghj}	0.14 ± 0.0088 ^{defghi}	2.1 ± 0.13 ^{abc}
	500PAR	13 ± 1.4 ^{ghkm}	0.17 ± 0.0033 ^{cef}	1.9 ± 0.078 ^{bd}
M4	3000PAR	18 ± 2.4 ^{ceg}	0.04 ± 0 ^{mn}	1.9 ± 0.01 ^{cde}
	2500PAR	16 ± 2.3 ^{degh}	0.12 ± 0.0058 ^{del}	1.9 ± 0.02 ^{def}
	2000PAR	16 ± 2.4 ^{deghk}	0.13 ± 0.0088 ^{defghij}	1.8 ± 0.02 ^{dgh}
	1500PAR	15 ± 0.87 ^{eghk}	0.16 ± 0.0067 ^{cefg}	1.8 ± 0.018 ^{dgh}
	1000PAR	14 ± 1.8 ^{fghk}	0.16 ± 0.0033 ^{cefg}	1.7 ± 0.031 ^{dgh}
	500PAR	11 ± 1.9 ^{hikm}	0.18 ± 0.012 ^{cd}	1.6 ± 0.012 ^{gh}
P-value	Variety	<0.01	<0.01	<0.01
	PAR	<0.01	<0.01	<0.01
	V×P ¹	<0.01	<0.01	<0.01

Values are means ± SEM, n = 3 per treatment group.

^{a-n}Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by two-way ANOVA and the TUKEY test.

¹V × P = Variety × PAR interaction effect.