

SUPPLEMENTARY INFORMATION

Growth, physiological, nutrient-uptake-efficiency and shade-tolerance responses of cacao genotypes under different shades

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Table S1. Growth parameters (mean values per plant) of cacao genotypes from different origins subjected to two levels of shade (50% and 80%).

Genotype		SL (cm)*		SD (mm)		LA (cm ²)		RA (cm ²)		RDW (g)		BDW (g)		S/R	
		50%	80%	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%
PWC															
AYP-15		33.33 c**	45.27 b	10.72 b	8.19 d	706.92 b	860.25 b	239.83 d	208.15 d	3.75 e	1.14 e	25.49 d	11.91 g	6.22 b	9.41 a
AYP-20		38.27 c	51.27 b	10.84 b	8.90 c	388.71 b	701.45 b	108.34 d	151.63 d	6.13 d	2.64 e	30.97 c	16.03 f	4.07 c	5.25 b
AYP-22		37.50 c	48.77 b	8.94 c	7.88 d	1245.41 a	1032.92 a	306.99 c	325.15 c	5.06 d	1.94 e	26.02 d	6.63 g	4.39 b	2.47 d
PAS-100		27.67 c	36.80 c	9.91 c	7.49 d	845.88 b	959.96 b	190.21 d	222.01 d	5.72 d	1.93 e	29.19 d	13.37 g	4.48 b	5.96 b
PAS-105		32.67 c	36.13 c	9.57 c	8.07 d	596.09 b	937.02 b	300.61 c	388.76 b	4.97 d	1.40 e	28.44 d	9.57 g	4.74 b	5.97 b
PAS-91		31.63 c	46.90 b	11.84 a	8.05 d	1173.48 a	1228.88 a	290.09 c	433.64 a	10.71 b	2.72 e	42.38 a	13.33 g	3.07 d	4.19 c
PAS-93		43.37 c	59.97 a	11.38 b	8.39 d	722.72 b	1045.25 a	197.86 d	315.98 c	9.17 c	2.22 e	28.71 d	12.68 g	2.18 d	4.71 b
UGU-112		31.43 c	44.37 b	10.08 c	7.75 d	531.56 b	838.70 b	239.69 d	337.40 b	6.92 c	1.31 e	29.12 d	9.78 g	3.93 c	6.57 b
UGU-126		30.57 c	41.03 c	10.97 b	7.67 d	733.08 b	1057.4 a	210.60 d	281.22 c	5.91 d	1.41 e	32.25 c	14.17 g	4.71 b	9.18 a
UGU-130		23.37 c	35.77 c	8.64 d	6.45 d	666.84 b	1152.7 a	214.62 d	209.03 d	3.57 e	1.64 e	21.34 e	13.19 g	5.19 b	7.34 a
UNG-53		35.60 c	42.87 c	9.09 c	7.64 d	990.34 b	1040.46 a	251.17 c	361.67 b	6.46 c	2.65 e	26.13 d	11.37 g	3.04 d	3.27 c
UNG-73		31.83 c	45.07 b	10.63 b	7.24 d	658.56 b	1235.49 a	324.58 c	365.62 b	9.76 b	3.30 e	39.59 a	18.07 f	3.16 c	4.75 b
UNG-76		36.60 c	49.33 b	10.39 b	7.10 d	559.94 b	944.88 b	192.31 d	352.97 d	9.15 c	3.37 e	39.42 a	21.75 e	3.42 c	5.48 b
UNG-77		36.90 c	40.87 c	9.39 c	9.55 c	1108.74 a	1300.43 a	314.03 c	190.42 b	9.93 b	5.67 d	32.28 c	21.70 e	2.32 d	2.83 d
PFC															
ICT-1026		45.00 b	50.73 b	12.43 a	9.03 c	749.85 b	1246.95 a	261.78 c	376.03 b	10.41 b	2.50 e	36.27 b	11.78 g	2.59 d	4.49 b
ICT-1087		45.87 b	51.83 b	12.63 a	10.30 b	904.52 b	1102.92 a	295.09 c	496.99 a	10.04 b	5.59 d	41.94 a	26.77 d	3.22 c	3.87 c
ICT-1092		35.40 c	68.47 a	13.00 a	9.06 c	1040.10 a	1202.26 a	287.74 c	373.28 b	9.03 c	2.78 e	40.35 a	17.19 f	3.65 c	5.29 b
ICT-1112		42.27 c	55.10 a	12.03 a	7.88 d	985.50 b	1392.01 a	342.00 b	391.44 b	12.65 a	5.37 d	40.01 a	20.91 e	2.16 d	2.89 d
ICT-1189		38.93 c	50.67 b	12.90 a	10.04 c	1207.02 a	1253.8 a	292.81 c	341.51 b	12.64 a	4.31 d	40.61 a	20.04 e	2.22 d	3.65 c
ICT-1251		38.53 c	51.60 b	11.47 b	9.72 c	812.41 b	1162.32 a	346.18 b	416.42 a	9.14 c	3.20 e	33.01 c	16.04 f	2.62 d	4.09 c
ICT-1281		36.93 c	37.27 c	11.02 b	8.22 d	656.73 b	1221.94 a	360.48 b	379.81 b	9.78 b	2.59 e	34.20 b	16.46 f	2.54 d	5.72 b
ICT-1292		43.03 c	54.90 a	13.15 a	9.02 c	968.91 b	1057.95 a	293.15 c	371.26 b	12.05 a	3.96 e	37.69 b	15.65 g	2.16 d	3.03 d
ICT-1506		38.97 c	49.00 b	11.42 b	10.88 b	776.12 b	1038.42 a	304.42 c	460.27 a	9.42 b	3.67 e	31.95 c	21.17 e	2.48 d	4.77 b
ICT-2142		34.90 c	46.20 b	11.20 b	9.26 c	776.68 b	822.84 b	322.66 c	449.18 a	10.17 b	3.37 e	28.95 d	19.44 e	1.87 d	4.89 b
ICT-2161		35.00 c	46.10 b	11.78 a	10.13 c	616.93 b	983.81 b	257.92 c	472.67 a	10.04 b	3.60 e	32.34 c	16.35 f	2.22 d	3.88 c
ICT-2171		41.53 c	55.10 a	13.27 a	8.58 d	881.30 b	999.13 a	285.55 c	336.09 b	12.46 a	5.54 d	35.91 b	22.19 e	1.89 d	3.00 d
ICT-2172		37.60 c	65.43 a	13.65 a	8.70 d	1437.02 a	1412.61 a	249.74 c	307.74 c	12.27 a	4.64 d	34.35 b	22.83 e	1.80 d	3.92 c
ICT-2173		47.40 b	48.93 b	10.27 b	8.49 d	785.07 b	1255.67 a	277.44 c	349.77 b	7.54 c	4.18 d	28.69 d	21.09 e	2.98 d	4.04 c
ICT-2653		32.10 c	47.23 b	11.93 a	9.76 c	879.42 b	1035.99 a	337.94 b	307.94 c	11.57 a	3.67 e	37.41 b	13.43 g	2.24 d	2.67 d
BCC															
BN-34		37.70 c	35.57 c	8.54 d	6.65 d	763.10 b	1058.05 a	334.53 b	340.96 b	9.25 c	3.63 e	32.60 c	16.18 f	2.53 d	3.49 c
BS-01		34.50 c	41.73 c	8.72 d	9.83 c	879.54 b	1079.15 a	338.36 b	402.63 a	7.60 c	3.38 e	31.68 c	15.64 g	3.29 c	3.63 c
CA-14		36.73 c	33.07 c	9.65 c	7.66 d	818.76 b	834.93 b	272.47 c	361.36 b	6.47 c	2.49 e	26.66 d	17.44 f	3.43 c	6.07 b
CEPEC-2002		36.20 c	40.43 c	10.72 b	8.25 d	632.53 b	970.48 b	302.44 c	288.82 c	7.95 c	3.27 e	29.00 d	10.96 g	2.60 d	2.31 d
CP-49-C10		36.27 c	35.23 c	10.52 b	7.58 d	763.34 b	1118.17 a	332.71 b	390.72 b	7.69 c	3.00 e	34.63 b	12.96 g	3.51 c	3.37 c
CP-53-C10		31.40 c	37.13 c	9.79 c	7.62 d	812.02 b	950.53 b	290.11 c	343.77 b	7.25 c	2.62 e	32.38 c	11.66 g	3.64 c	3.60 c
IPIRANGA-1		31.73 c	56.00 a	10.05 c	7.93 d	1117.13 a	1166.97 a	340.01 b	345.07 b	7.41 c	2.87 e	30.37 c	10.88 g	3.62 c	3.71 c
PH-09		23.07 c	46.63 b	9.92 c	8.33 d	687.77 b	1002.07 a	307.15 c	270.79 c	8.20 c	1.30 e	33.86 b	9.39 g	3.19 c	6.54 b
PH-144		45.33 b	54.07 a	11.99 a	9.63 c	977.80 b	1016.84 a	252.06 c	343.32 b	7.66 c	3.03 e	34.97 b	21.61 e	3.59 c	6.19 b
PH-15		34.73 c	51.40 b	9.79 c	8.56 d	872.39 b	969.05 b	439.71 a	450.62 a	5.22 d	2.55 e	25.58 d	13.40 g	4.01 c	4.33 b
PH-16		29.53 c	34.07 c	9.62 c	7.53 d	817.56 b	980.65 b	368.82 b	371.42 b	9.13 c	3.21 e	29.15 d	14.06 g	2.29 d	3.36 c
PH-17		31.20 c	35.57 c	9.09 c	7.16 d	801.06 b	1115.94 a	251.80 c	257.28 c	7.50 c	3.52 e	25.56 d	12.82 g	2.48 d	2.65 d
PH-21		39.97 c	53.20 a	9.34 c	8.27 d	791.30 b	1077.63 a	302.73 c	221.90 d	4.24 d	3.06 e	26.84 d	17.85 f	5.33 b	4.87 b
PH-990		35.47 c	40.30 c	9.41 c	7.83 d	943.25 b	1185.36 a	318.69 c	332.32 b	5.43 d	2.99 e	27.45 d	17.21 f	4.73 b	5.09 b
NIC															
CCN-10		31.27 c	41.33 c	13.43 a	10.48 b	1024.44 a	1184.12 a	298.51 c	442.30 a	11.02 a	3.63 e	34.39 b	17.13 f	2.14 d	3.77 c
CCN-51		40.10 c	45.33 b	12.06 a	10.56 b	1294.43 a	1393.24 a	404.42 a	494.13 a	11.30 a	5.70 d	40.18 a	22.28 e	2.61 d	2.91 d
EET-400		39.27 c	50.03 b	10.93 b	8.55 d	965.54 b	988.93 b	240.07 d	308.90 c	9.76 b	3.07 e	32.60 c	17.21 f	2.38 d	4.69 b
H-10		50.05 b	63.10 a	12.26 a	8.05 d	720.73 b	1335.75 a	474.94 a	372.16 b	8.15 c	3.81 e	27.16 d	13.09 g	2.31 d	2.52 d
ICS-1		41.30 c	42.93 c	12.14 a	9.32 c	917.33 b	1140.95 a	272.13 c	407.49 a	8.67 c	4.18 d	29.37 d	22.22 e	2.38 d	4.35 b
ICS-39		41.47 c	53.90 a	12.40 a	8.53 d	816.56 b	1054.92 a	305.41 c	372.95 b	7.33 c	3.34 e	32.80 c	20.93 e	3.53 c	5.63 b
ICS-6		36.40 c	45.57 b	12.14 a	8.21 d	801.38 b	914.53 b	328.02 c	453.16 a	7.56 c	3.91 e	29.79 d	15.83 g	2.96 d	3.06 d
ICS-95		44.80 b	37.93 c	11.03 b	8.32 d	967.35 b	1182.73 a	284.28 c	345.16 b	8.20 c	2.63 e	31.51 c	15.46 g	2.86 d	5.09 b
IMC-67		42.27 c	44.83 b	13.49 a	8.78 c	1022.91 a	1281.34 a	364.60 b	472.07 a	11.37 a	3.07 e	33.77 b	14.30 g	2.07 d	3.75 c
POUND-12		42.07 c	45.97 b	12.00 a	9.55 c	1038.90 a	1117.07 a	341.77 b	452.85 a	7.03 c	3.80 e	28.47 d	17.28 f	3.07 d	3.56 c
SCA-6		35.77 c	39.83 c	11.01 b	10.22 b	943.69 b	1315.00 a	269.91 c	412.50 a	7.27 c	2.80 e	28.18 d	13.68 g	2.98 d	4.15 c
TSH-1188		35.83 c	44.40 b	12.36 a	8.74 c	737.38 b	1054.80 a	345.92 b	430.10 a	10.29 b	3.49 e	32.50 c	17.62 f	2.19 d	4.10 c
TSH-565		33.77 c	42.07 c	11.86 a	9.17 c	902.88 b	1262.33 a	289.53 c	433.21 a	9.52 b	3.00 e	35.75 b	12.18 g	2.75 d	4.10 c
UF-613		33.27 c	38.87 c	11.79 a	8.36 d	815.09 b	1070.66 a	303.36 c	442.48 a	7.51 c	3.77 e	28.87 d	18.53 f	2.85 d	3.95 c
UF-667		38.17 c	43.33 c	11.63 b	8.63 d	1319.35 a	1527.33 a	395.79 b	434.70 a	10.39 b	3.80 e	35.91 b	19.70 e	2.52 d	4.21 c
Media PWC		33.62 (d)	44.60 (b)	10.17 (b)	7.88 (d)	780.59 (d)	1023.99 (b)	241.50 (d)	295.97 (c)	6.94 (c)	2.38 (e)	30.81 (b)	13.83 (d)	3.92 (b)	5.53 (a)
Media BCC		39.56 (c)	51.90 (a)	12.14 (a)	9.27 (c)	898.51 (c)	1145.91 (a)	300.99 (c)	388.69 (c)	10.61 (a)	2.93 (d)	35.58 (a)	18.76 (c)	2.44 (d)	4.01 (b)
Media PFC		34.56 (d)	42.46 (b)	9.80 (b)	8.06 (d)	834.11 (d)	1037.56 (b)	317.97 (b)	337.21 (b)	7.21 (c)	2.92 (e)	30.05 (b)	14.43 (d)	3.45 (c)	4.23 (b)
Media NIC		39.05 (c)	45.30 (b)	12.04 (a)	9.03 (c)	952.53 (c)	1188.25 (a)	327.91 (b)	418.28 (a)	9.02 (b)	3.60 (d)	32.08 (b)	17.16 (c)	2.64 (d)	3.99 (b)
Media Total		36.79 B***	46.15 A	11.07 A	8.58 B	868.47 B	1110.27 A	297.69 B	361.54 A	8.50 A	3.23 B	32.19 A	16.11 B	3.09 B	4.42 A
Source of															
P _v															
Shade (S)	1	0.0004		0.0001		0.0001		<0.0001		<0.0001		<0.0001		0.0001	
Genotype (G)	57	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	
G*S	57	0.0072		0.0003		0.6657		0.0008		<0.0001		<0.0001		0.0006	

(*) SL: shoot length, SD: stem diameter, LA: leaf area, RA: root area, RDW: root dry weight, BDW: total dry weight, S/R: shoot/root rate. (**) Average of three replicates; different lower case letters on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, $P \leq 0.05$). (***) Average of 58 genotypes; different capital letters on the right of each value in line of each variable indicate a significant difference between shade level (Scott & Knott test, $P \leq 0.05$). PWC: wild cacao from river basins of Peruvian Amazon collection (n=14), PFC: Peruvian farmers' collection (n=15), BCC: Brazilian cacao collection (n=14), NIC: national and international cacao collection (n=15). Different lower case letters in parenthesis on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, $P \leq 0.05$).

Table S2. Physiological parameters (mean values)- and Shade Tolerance Index (STI) for 58 cacao genotypes subjected to two levels of shade (50 and 80%).

Genotype	CHL (SPAD)*		gs (mmol m ⁻² s ⁻¹)		WUE (g l ⁻¹)		STI
	50%	80%	50%	80%	50%	80%	
PWC							
AYP-15	33.10 b**	34.50 a	245.10 a	51.54 b	1.21 b	0.92 c	47.06 c
AYP-20	33.30 b	33.93 a	179.10 b	54.47 b	1.38 b	1.14 b	51.78 c
AYP-22	33.03 b	33.97 a	226.13 a	81.30 b	1.16 b	0.40 d	25.72 d
PAS-100	33.80 a	33.43 b	237.53 a	84.63 b	1.30 b	0.98 c	46.51 c
PAS-105	33.33 b	33.70 b	125.13 b	78.10 b	1.30 b	0.70 d	33.54 d
PAS-91	34.63 a	33.20 b	107.23 b	58.20 b	1.76 a	0.91 c	30.28 d
PAS-93	34.60 a	33.20 b	151.80 b	102.20 b	1.09 c	0.89 c	28.43 d
UGU-112	33.57 b	33.40 b	104.57 b	49.73 b	1.23 b	0.72 d	34.07 d
UGU-126	33.57 b	33.20 b	142.63 b	47.33 b	1.46 a	1.09 c	44.67 c
UGU-130	34.70 a	33.47 b	127.03 b	62.30 b	0.99 c	0.99 c	61.65 b
UNG-53	32.90 b	34.07 a	259.70 a	84.37 b	1.09 c	0.75 d	43.35 c
UNG-73	34.43 a	33.23 b	140.33 b	73.70 b	1.66 a	1.26 b	44.46 c
UNG-76	34.30 a	33.47 b	261.33 a	97.00 b	1.68 a	1.57 a	50.53 c
UNG-77	33.07 b	33.00 b	329.97 a	62.97 b	1.24 b	1.37 b	68.64 b
PFC							
ICT-1026	27.80 g	31.07 d	218.80 a	166.33 b	1.44 a	0.79 d	31.30 d
ICT-1087	29.10 e	30.40 d	159.23 b	122.47 b	1.77 a	1.81 a	72.79 a
ICT-1092	28.33 f	30.40 d	189.17 a	158.63 b	1.74 a	1.23 b	42.29 c
ICT-1112	27.40 g	30.50 d	229.80 a	150.93 b	1.52 a	1.33 b	52.41 c
ICT-1189	28.57 f	30.17 d	249.50 a	181.60 a	1.55 a	1.34 b	50.74 c
ICT-1251	29.23 e	28.97 f	146.67 b	173.77 b	1.33 b	1.10 c	48.59 c
ICT-1281	30.47 d	29.93 e	210.97 a	142.67 b	1.36 b	1.19 b	48.52 c
ICT-1292	28.63 f	31.37 d	131.80 b	166.83 b	1.42 a	1.00 c	41.60 c
ICT-1506	24.60 h	31.60 c	145.83 b	210.20 a	1.25 b	1.50 a	61.18 b
ICT-2142	33.03 b	31.67 c	131.73 b	190.40 a	1.04 c	1.37 b	67.97 b
ICT-2161	30.13 d	29.50 e	280.97 a	168.87 b	1.24 b	1.09 c	51.18 c
ICT-2171	28.57 f	30.30 d	146.77 b	150.17 b	1.30 b	1.42 a	61.58 b
ICT-2172	29.27 e	29.90 e	148.67 b	108.50 b	1.23 b	1.55 a	82.18 a
ICT-2173	32.60 c	31.53 c	109.47 b	217.90 a	1.18 b	1.44 a	73.90 a
ICT-2653	27.80 g	31.07 d	260.83 a	231.83 a	1.44 a	0.83 d	35.56 d
BCC							
BN-34	29.80 e	29.27 e	208.97 a	85.20 b	1.30 b	1.07 c	50.21 c
BS-01	30.90 d	33.53 b	274.73 a	88.37 b	1.34 b	1.05 c	49.98 c
CA-14	33.07 b	34.50 a	264.50 a	147.93 b	1.12 c	1.28 b	65.56 b
CEPEC-2002	30.43 d	32.50 c	157.37 b	123.17 b	1.17 b	0.66 d	37.92 d
CP-49-C10	30.47 d	31.70 c	241.07 a	164.60 b	1.50 a	0.85 d	37.46 d
CP-53-C10	32.97 b	33.67 b	212.03 a	71.43 b	1.40 a	0.77 d	36.00 d
IPIRANGA-1	32.33 c	33.77 a	119.83 b	73.30 b	1.28 b	0.68 d	36.04 d
PH-09	32.73 c	33.57 b	198.03 a	183.27 a	1.43 a	0.69 d	24.41 d
PH-144	30.67 d	31.37 d	139.57 b	94.80 b	1.52 a	1.59 a	61.72 b
PH-15	30.63 d	33.57 b	225.30 a	145.40 b	1.13 c	0.93 c	51.37 c
PH-16	33.20 b	34.47 a	240.67 a	175.93 b	1.11 c	0.93 c	46.80 c
PH-17	30.47 d	33.83 a	256.60 a	149.37 b	1.00 c	0.79 d	48.12 c
PH-21	31.00 d	34.05 a	363.03 a	47.83 b	1.26 b	1.26 b	65.62 b
PH-990	32.93 b	33.97 a	274.30 a	60.00 b	1.22 b	1.22 b	71.27 a
NIC							
CCN-10	32.13 c	34.00 a	144.27 b	82.25 b	1.30 b	1.15 b	50.05 c
CCN-51	30.53 d	30.87 d	158.07 b	76.37 b	1.60 a	1.42 a	55.69 c
EET-400	28.30 f	31.00 d	258.13 a	149.07 b	1.27 b	1.21 b	52.62 c
H-10	28.60 f	30.47 d	175.93 b	260.67 a	1.06 c	0.79 d	49.20 c
ICS-1	30.40 d	30.73 d	152.13 b	127.57 b	1.15 b	1.54 a	74.90 a
ICS-39	25.53 h	31.70 c	169.50 b	128.53 b	1.42 a	1.50 a	73.86 a
ICS-6	27.10 g	31.90 c	239.43 a	237.60 a	1.24 b	1.02 c	53.26 c
ICS-95	27.87 g	31.43 d	141.77 b	150.70 b	1.29 b	1.10 c	50.72 c
IMC-67	28.30 f	32.23 c	279.97 a	157.17 b	1.24 b	0.96 c	36.80 d
POUND-12	30.47 d	30.47 d	154.17 b	126.43 b	1.19 b	1.15 b	60.83 b
SCA-6	30.70 d	31.07 d	192.17 a	91.90 b	1.16 b	0.93 c	49.20 c
TSH-1188	30.60 d	30.80 d	169.40 b	118.90 b	1.23 b	1.21 b	54.26 c
TSH-565	28.00 g	31.07 d	115.60 b	94.77 b	1.46 a	0.78 d	33.62 d
UF-613	27.70 g	31.77 c	219.07 a	148.43 b	1.19 b	1.26 b	79.71 a
UF-667	30.50 d	31.10 d	187.13 a	146.67 b	1.42 a	1.36 b	54.87 c
Media PWC	33.74 (a)	33.55 (a)	188.40 (b)	70.56 (d)	1.33 (a)	0.98 (c)	43.62 (c)
Media PFC	29.17 (e)	30.44 (d)	184.01 (b)	169.41 (b)	1.39 (a)	1.27 (a)	54.77 (a)
Media BCC	31.71 (b)	33.46 (a)	226.86 (a)	115.04 (c)	1.27 (a)	0.98 (c)	48.75 (b)
Media NIC	28.66 (e)	31.19 (c)	183.78 (b)	139.80 (c)	1.28 (a)	1.16 (b)	55.31 (a)
Media Total	30.75 B***	32.12 A	195.35 A	124.77 B	1.31 A	1.09 B	50.77
S. variation	df	Pv					
Shade (S)	1	<0.0001		0.0001		0.0003	
Genotype (G)	57	<0.0001		0.0002		<0.0001	
G*S	57	<0.0001		0.0007		<0.0001	

(*)CHL: leaf chlorophyll content, gs: stomatal conductance, WUE: water use efficiency, STI: shade tolerance index. (**) Average of three replicates; different lower case letters on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P \leq 0.05$)). (***) Average of 58 genotypes; different capital letters on the right of each value in line of each variable indicate a significant difference between shade level (Scott & Knott test, $P \leq 0.05$). PWC: wild cacao from river basins of Peruvian Amazon collection (n=14), PFC: Peruvian farmers' collection (n=15), BCC: Brazilian cacao collection (n=14), NIC: national and international cacao collection (n=15). Different lower case letters in parenthesis on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P \leq 0.05$)).

Table S3. Mean concentrations of macronutrients (g kg⁻¹) in shoots of 58 cacao genotypes subjected to two levels of shade (50 and 80%).

Genotype	N		K		Ca		Mg		P	
	g kg ⁻¹									
	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%
PWC										
AYP-15	17.44 b*	20.77 a	29.40 a	23.16 b	16.03 c	18.51 b	5.93 b	6.35 b	1.77 a	0.81 d
AYP-20	18.45 b	22.83 a	30.40 a	21.62 b	10.67 f	16.96 c	6.03 b	6.47 b	0.90 d	0.69 e
AYP-22	11.10 d	13.49 c	24.47 b	22.56 b	11.87 e	22.72 a	5.03 c	7.63 a	1.10 c	0.60 e
PAS-100	19.97 a	15.77 b	27.23 a	24.28 b	17.37 c	18.85 b	6.43 b	6.57 b	1.47 b	0.83 d
PAS-105	14.80 c	16.40 b	27.93 a	20.96 c	16.77 c	17.87 b	6.77 b	5.92 b	1.23 b	0.81 d
PAS-91	18.45 b	22.83 a	26.47 a	20.91 c	12.07 e	16.20 c	6.03 b	6.20 b	0.87 d	0.67 e
PAS-93	17.45 b	20.95 a	19.67 c	18.39 c	15.70 c	17.23 c	7.17 a	6.35 b	1.00 c	0.69 e
UGU-112	10.83 d	23.32 a	20.90 c	21.71 b	9.53 f	17.39 c	4.43 c	6.20 b	1.10 c	0.81 d
UGU-126	11.81 d	11.09 d	28.63 a	22.70 b	13.27 e	16.80 c	6.20 b	5.74 b	1.10 c	0.78 d
UGU-130	11.88 d	18.10 b	26.00 a	21.03 c	16.37 c	15.10 d	5.61 b	6.60 b	1.10 c	0.67 e
UNG-53	17.48 b	21.64 a	29.90 a	23.11 b	16.10 c	20.77 a	7.30 a	7.50 a	1.10 c	0.63 e
UNG-73	16.65 b	20.60 a	18.57 c	19.72 c	8.93 g	14.99 d	4.30 c	5.76 b	0.72 d	0.80 d
UNG-76	10.56 d	16.42 b	19.80 c	23.19 b	16.33 c	15.74 c	6.03 b	5.72 b	1.33 b	0.78 d
UNG-77	17.86 b	22.10 a	29.60 a	22.16 b	12.37 e	15.47 d	6.00 b	6.59 b	1.40 b	0.83 d
PFC										
ICT-1026	20.60 a	23.06 a	20.90 c	23.54 b	5.17 h	16.95 c	2.23 d	6.71 b	1.33 b	0.75 d
ICT-1087	17.39 b	21.52 a	19.43 c	26.79 a	4.43 h	16.44 c	1.87 d	6.81 b	1.30 b	0.83 d
ICT-1092	14.24 c	17.63 b	21.70 b	22.14 b	4.20 h	17.47 c	2.10 d	7.84 a	1.17 c	0.77 d
ICT-1112	18.85 b	23.79 a	20.17 c	22.87 b	4.47 h	17.61 c	1.97 d	8.65 a	1.43 b	0.78 d
ICT-1189	18.03 b	22.31 a	18.83 c	24.27 b	14.87 d	16.59 c	5.50 b	6.21 b	1.27 b	0.84 d
ICT-1251	17.46 b	21.61 a	21.50 b	26.06 a	5.00 h	18.81 b	2.23 d	6.25 b	1.10 c	0.75 d
ICT-1281	18.86 b	27.12 a	19.83 c	24.87 b	13.17 e	16.67 c	6.07 b	6.69 b	1.00 c	0.99 c
ICT-1292	18.62 b	23.05 a	21.50 b	26.89 a	4.87 h	18.89 b	2.43 d	7.70 a	1.30 b	0.84 d
ICT-1506	14.55 c	18.01 b	21.87 b	26.66 a	4.47 h	18.45 b	2.07 d	7.43 a	1.17 c	0.88 d
ICT-2142	18.18 b	22.35 a	21.90 b	22.37 b	12.87 e	17.13 c	6.77 b	6.76 b	1.10 c	0.81 d
ICT-2161	16.53 b	20.46 a	21.47 b	20.87 c	12.10 e	16.01 c	6.23 b	7.10 a	0.77 d	0.57 e
ICT-2171	18.76 b	23.57 a	21.10 c	23.97 b	4.77 h	19.61 b	2.17 d	8.23 a	1.18 c	0.81 d
ICT-2172	17.41 b	22.30 a	23.57 b	27.92 a	5.13 h	18.77 b	2.33 d	7.58 a	1.37 b	0.77 d
ICT-2173	19.40 b	24.00 a	22.03 b	26.74 a	14.03 d	16.42 c	6.47 b	7.10 a	1.30 b	0.96 c
ICT-2653	18.77 b	23.22 a	21.73 b	23.96 b	7.60 g	19.28 b	2.00 d	6.90 a	0.83 d	0.61 e
BCC										
BN-34	22.59 a	23.83 a	22.10 b	24.55 b	12.70 e	19.1 b	5.70 b	7.41 a	1.03 c	0.68 e
BS-01	18.86 b	22.92 a	22.70 b	20.12 c	15.23 d	19.65 b	6.23 b	9.72 a	0.97 c	0.30 e
CA-14	17.86 b	22.11 a	23.17 b	24.34 b	13.10 e	15.88 c	5.27 b	6.87 a	1.00 c	0.69 e
CEPEC-2002	18.38 b	22.12 a	26.07 a	23.59 b	11.77 e	22.82 a	5.43 b	8.12 a	1.07 c	0.53 e
CP-49-C10	18.86 b	23.29 a	21.53 b	20.78 c	12.90 e	18.92 b	5.77 b	8.03 a	0.77 d	0.49 e
CP-53-C10	19.72 a	24.40 a	21.63 b	25.03 b	12.53 e	18.85 b	5.60 b	7.74 a	0.97 c	0.60 e
IPIRANGA-1	17.18 b	21.26 a	22.37 b	22.59 b	10.70 f	16.49 c	5.40 b	6.94 a	0.94 d	0.42 e
PH-09	17.94 b	21.95 a	22.37 b	19.06 c	11.33 f	20.99 a	5.67 b	7.47 a	1.08 c	0.53 e
PH-144	20.06 a	24.83 a	21.97 b	20.57 c	13.27 e	18.32 b	5.83 b	7.34 a	0.97 c	0.60 e
PH-15	17.97 b	22.72 a	26.05 a	21.33 b	12.75 e	17.57 c	5.75 b	7.12 a	0.95 c	0.62 e
PH-16	18.45 b	22.83 a	20.53 c	19.10 c	14.40 d	21.81 a	6.30 b	7.70 a	1.30 b	0.50 e
PH-17	17.22 b	21.28 a	22.67 b	19.54 c	13.87 d	18.77 b	5.77 b	7.42 a	0.70 d	0.48 e
PH-21	18.28 b	23.93 a	23.97 b	17.54 c	11.70 e	19.16 b	5.57 b	7.74 a	0.93 d	0.55 e
PH-990	18.35 b	28.83 a	24.87 b	23.12 b	10.93 f	18.73 b	4.46 c	7.72 a	0.83 d	0.63 e
NIC										
CCN-10	17.63 b	21.81 a	12.37 d	17.19 c	7.23 g	14.28 d	4.03 c	4.69 c	0.63 e	0.84 d
CCN-51	18.73 b	23.18 a	13.87 d	17.81 c	8.33 g	12.53 e	3.80 c	4.92 c	1.10 c	0.80 d
EET-400	17.64 b	21.83 a	24.93 b	19.81 c	15.13 d	18.46 b	7.93 a	6.60 b	0.93 d	0.78 d
H-10	14.97 c	18.52 b	12.20 d	18.98 c	6.70 g	17.51 c	3.70 c	6.42 b	0.25 e	0.62 e
ICS-1	18.04 b	26.54 a	13.43 d	16.44 d	7.57 g	12.36 e	3.50 c	5.72 b	1.10 c	0.89 d
ICS-39	17.24 b	21.33 a	17.70 c	19.68 c	10.47 f	15.39 d	4.06 c	6.18 b	0.63 e	0.91 d
ICS-6	15.22 c	21.20 a	26.03 a	21.18 c	13.23 e	15.75 c	7.43 a	6.35 b	0.97 c	0.83 d
ICS-95	17.54 b	21.71 a	24.13 b	18.97 c	13.43 e	13.72 d	7.13 a	4.66 c	0.93 d	0.90 d
IMC-67	18.26 b	22.60 a	16.46 d	22.13 b	9.33 f	17.68 b	5.42 b	6.95 a	1.45 b	0.72 d
POUND-12	17.60 b	21.82 a	22.35 b	19.63 c	14.35 d	14.88 d	6.70 b	5.97 b	0.80 d	0.84 d
SCA-6	16.17 b	20.01 a	13.17 d	18.25 c	8.43 g	16.87 c	4.87 c	6.37 b	0.60 e	0.72 d
TSH-1188	17.27 b	21.37 a	24.70 b	14.72 d	12.9 e	11.86 e	7.33 a	4.64 c	0.87 d	0.89 d
TSH-565	16.83 b	20.82 a	23.40 b	16.27 d	14.70 d	14.66 d	7.73 a	5.11 b	0.97 c	0.77 d
UF-613	18.26 b	22.59 a	13.60 d	17.22 c	9.20 f	16.55 c	4.20 c	6.39 b	1.20 c	0.98 c
UF-667	16.64 b	20.61 a	23.53 b	19.73 c	14.10 d	14.67 d	7.90 a	5.61 b	0.83 d	0.96 c
Media PWC	15.09 (d)	19.02 (b)	25.64 (a)	21.82 (c)	13.81 (d)	17.47 (b)	6.02 (c)	6.40 (b)	1.18 (a)	0.74 (c)
Media PFC	17.45 (c)	21.78 (a)	21.17 (c)	24.66 (a)	7.81 (f)	17.67 (b)	3.60 (d)	7.20 (a)	1.14 (a)	0.80 (c)
Media BCC	18.26 (b)	22.53 (a)	23.00 (b)	21.52 (c)	12.66 (d)	19.08 (a)	5.69 (c)	7.52 (a)	0.93 (b)	0.54 (d)
Media NIC	17.20 (c)	21.45 (a)	18.79 (d)	18.53 (d)	11.01 (e)	15.14 (c)	5.78 (c)	5.69 (c)	0.87 (b)	0.83 (c)
Media Total	17.01 B**	21.21 A	22.08 B	21.63 A	11.26 B	17.31 A	5.25 B	6.69 A	1.03 A	0.73 B
S. variation	df	pv								
Shade (S)	1	<0.0001		0.1034		<0.0001		<0.0001		0.0002
Genotype (G)	57	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001
G*S	57	0.002		<0.0001		<0.0001		<0.0001		<0.0001

(*) Average of three replicates, different lower case letters on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P < 0.05$)). (**) Average of 58 genotypes, different capital letters on the right of each value in line of each variable indicate a significant difference between shade level (Scott & Knott test, ($P < 0.05$)). PWC: wild cacao from river basins of Peruvian Amazon collection, PFC: Peruvian farmers' collection, BCC: Brazilian cacao collection, NIC: National and International cacao collection. Different lower case letters in parenthesis on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P < 0.05$)).

Table S4. Mean concentration of micronutrients (mg kg⁻¹) in shoots of 58 cacao genotypes subjected to two levels of shade (50 and 80%).

Genotype	Fe		Zn		Mn		Cu	
	mg kg ⁻¹							
	50%	80%	50%	80%	50%	80%	50%	80%
PWC								
AYP-15	247.80 b*	259.18 b	46.57 b	42.23 c	84.29 b	63.46 c	4.42 c	8.89 c
AYP-20	169.84 c	278.63 a	31.88 d	45.01 c	54.25 c	84.93 b	6.74 c	9.35 c
AYP-22	187.13 c	222.38 b	33.66 d	76.39 a	28.37 d	84.18 b	6.88 c	16.50 b
PAS-100	275.73 a	225.13 b	43.36 c	50.00 b	70.38 b	100.18 b	9.54 c	7.50 c
PAS-105	151.18 c	239.34 b	43.24 c	55.80 b	49.54 c	131.91 a	8.09 c	12.92 b
PAS-91	149.98 c	225.64 b	41.47 c	47.31 b	53.07 c	115.15 a	5.09 c	6.54 c
PAS-93	122.26 d	225.84 b	38.96 c	47.19 b	65.03 c	75.48 b	6.65 c	14.33 b
UGU-112	131.94 d	226.99 b	32.82 d	50.12 b	22.63 d	64.79 c	6.01 c	4.92 c
UGU-126	168.27 c	245.70 b	39.73 c	42.50 c	46.85 c	80.83 b	5.17 c	6.78 c
UGU-130	166.49 c	225.14 b	47.72 b	47.03 b	55.25 c	78.62 b	7.77 c	6.47 c
UNG-53	177.41 c	182.02 c	44.73 c	42.59 c	58.87 c	50.23 c	9.44 c	9.13 c
UNG-73	107.39 d	260.63 b	31.31 d	41.17 c	18.52 d	79.68 b	6.84 c	7.77 c
UNG-76	120.68 d	303.51 a	42.18 c	41.53 c	40.11 d	77.83 b	8.06 c	5.95 c
UNG-77	247.09 b	241.41 b	47.89 b	41.85 c	61.22 c	90.83 b	7.89 c	14.99 b
PFC								
ICT-1026	98.48 d	176.44 c	35.25 d	48.75 b	58.83 c	50.67 c	9.66 c	24.26 a
ICT-1087	109.82 d	173.16 c	26.16 d	41.61 c	47.81 c	82.21 b	9.80 c	16.01 b
ICT-1092	80.33 d	185.94 c	30.58 d	50.88 b	50.24 c	105.24 a	5.87 c	10.70 c
ICT-1112	84.37 d	141.48 d	40.87 c	44.44 c	28.94 d	54.33 c	6.64 c	8.38 c
ICT-1189	72.04 d	142.24 d	26.86 d	42.41 c	52.35 c	62.81 c	5.32 c	8.69 c
ICT-1251	177.47 c	135.31 d	45.55 c	51.08 b	63.69 c	92.37 b	6.56 c	8.21 c
ICT-1281	109.77 d	134.68 d	29.39 d	45.75 c	42.80 c	67.15 c	5.02 c	10.97 c
ICT-1292	127.43 d	155.29 c	30.19 d	47.28 b	43.96 c	62.06 c	6.75 c	16.72 b
ICT-1506	133.08 d	151.98 c	37.90 c	44.51 c	40.41 d	74.93 b	7.90 c	9.44 c
ICT-2142	127.25 d	156.95 c	25.04 d	39.70 c	39.12 d	50.95 c	7.61 c	16.54 b
ICT-2161	112.34 d	138.54 d	22.86 d	46.56 b	31.96 d	81.67 b	9.06 c	9.38 c
ICT-2171	123.40 d	188.00 c	42.32 c	50.65 b	45.54 c	81.72 b	8.18 c	19.50 b
ICT-2172	92.32 d	162.03 c	33.01 d	45.42 c	36.20 d	70.56 b	8.39 c	9.03 c
ICT-2173	110.90 d	131.38 d	27.19 d	48.07 b	47.83 c	74.68 b	8.72 c	9.02 c
ICT-2653	100.76 d	168.58 c	30.75 d	52.14 b	41.33 d	81.71 b	6.85 c	9.49 c
BCC								
BN-34	108.44 d	207.65 b	29.92 d	38.60 c	31.76 d	72.46 b	5.19 c	9.42 c
BS-01	258.90 b	205.16 b	24.13 d	40.69 c	34.11 d	57.58 c	4.41 c	5.84 c
CA-14	126.32 d	155.77 c	26.11 d	38.29 c	18.42 d	52.78 c	5.17 c	7.01 c
CEPEC-2002	159.11 c	119.81 d	38.74 c	49.70 b	21.80 d	34.36 d	6.04 c	9.20 c
CP-49-C10	97.20 d	141.37 d	22.02 d	48.66 b	33.31 d	38.69 d	4.13 c	7.74 c
CP-53-C10	345.71 a	179.01 c	21.64 d	46.34 b	38.32 d	78.28 b	5.72 c	9.93 c
IPIRANGA-1	121.31 d	234.17 b	21.06 d	44.22 c	25.86 d	95.32 b	5.45 c	7.17 c
PH-09	213.20 b	171.92 c	25.17 d	43.18 c	26.35 d	122.81 a	6.11 c	9.18 c
PH-144	243.08 b	189.39 c	23.46 d	41.19 c	32.13 d	56.63 c	4.48 c	5.20 c
PH-15	116.92 d	198.69 b	27.91 d	40.08 c	21.31 d	48.97 c	6.78 c	7.81 c
PH-16	329.32 a	211.58 b	21.59 d	53.52 b	30.70 d	147.17 a	6.02 c	7.29 c
PH-17	135.13 d	156.04 c	34.53 d	60.42 b	49.64 c	155.58 a	6.77 c	13.69 b
PH-21	194.97 b	200.87 b	29.07 d	36.85 c	22.05 d	52.47 c	6.30 c	6.82 c
PH-990	274.37 a	167.23 c	43.07 c	41.27 c	24.12 d	64.56 c	7.39 c	10.27 c
NIC								
CCN-10	262.12 b	205.56 b	43.74 c	43.83 c	84.95 b	101.23 b	9.07 c	12.96 b
CCN-51	261.34 b	230.53 b	26.89 d	37.04 c	21.36 d	88.85 b	9.78 c	12.86 b
EET-400	239.43 b	256.67 b	44.05 c	55.18 b	82.36 b	73.81 b	15.63 b	15.86 b
H-10	122.26 d	152.02 c	44.78 c	39.49 c	27.82 d	65.85 c	8.38 c	17.54 b
ICS-1	199.54 b	183.69 c	34.11 d	37.63 c	21.10 d	103.17 b	9.71 c	11.77 c
ICS-39	140.60 d	167.99 c	45.35 c	45.45 c	74.68 b	109.90 a	10.9 c	9.02 c
ICS-6	165.72 c	206.67 b	36.59 c	40.83 c	55.47 c	75.83 b	12.58 b	15.83 b
ICS-95	198.72 b	205.77 b	41.87 c	42.48 c	78.05 b	126.84 a	18.79 b	29.92 a
IMC-67	247.17 b	203.83 b	38.20 c	44.21 c	26.75 d	79.31 b	9.43 c	12.93 b
POUND-12	184.32 c	183.17 c	41.13 c	41.83 c	59.54 c	64.34 c	7.64 c	7.23 c
SCA-6	134.50 d	219.24 b	40.45 c	44.61 c	70.05 b	66.24 c	11.68 c	20.08 b
TSH-1188	189.65 c	226.59 b	38.94 c	46.50 b	54.22 c	115.98 a	7.16 c	8.87 c
TSH-565	236.09 b	213.47 b	36.34 c	47.32 b	83.48 b	76.51 b	8.08 c	12.44 b
UF-613	174.97 c	229.17 b	37.61 c	43.42 c	18.86 d	93.03 b	14.56 b	14.16 b
UF-667	286.85 a	388.64 a	38.00 c	37.94 c	100.10 b	82.76 b	9.44 c	10.78 c
Media PWC	173.09 (b)	240.11 (a)	40.39 (c)	47.91 (a)	50.60 (b)	84.15 (a)	7.04 (d)	9.43 (c)
Media PFC	110.65 (d)	156.13 (c)	32.26 (d)	46.62 (a)	44.73 (b)	72.87 (a)	7.49 (d)	12.42 (b)
Media BCC	194.57 (b)	181.33 (b)	27.74 (e)	44.50 (b)	29.28 (c)	76.98 (a)	5.71 (d)	8.33 (c)
Media NIC	202.88 (b)	218.20 (a)	39.20 (c)	43.18 (b)	57.25 (b)	88.24 (a)	10.85 (b)	14.15 (a)
Media Total	169.83 B**	198.54 A	34.93 B	45.53 A	45.66 B	80.56 A	7.82 B	11.16 A
<i>S. variation</i>	<i>df</i>	<i>pv</i>						
Shade (S)	1	0.0017	<0.0001		0.0006		<0.0001	
Genotype (G)	57	<0.0001	<0.0001		<0.0001		<0.0001	
G*S	57	<0.0001	<0.0001		<0.0001		0.0017	

(*) Average of three replicates, different lower case letters on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P < 0.05$)). (**) Average of 58 genotypes, different capital letters on the right of each value in line of each variable indicate a significant difference between shade level (Scott & Knott test, ($P < 0.05$)). PWC: wild cacao from river basins of Peruvian Amazon collection, PFC: Peruvian farmers' collection, BCC: Brazilian cacao collection, NIC: National and International cacao collection. Different lower case letters in parenthesis on the right of each value in both columns of each variable indicate a significant difference between genotypes and shade level, (Scott & Knott test, ($P < 0.05$)).

