Supplementary online material:
Evaluating process-based sugarcane models for simulating genotypic and environmental effects observed in an international dataset

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1. INTRODUCTION

This document provides supplementary online material to:

Jones et al. (2020) “Evaluating process-based sugarcane models for simulating genotypic and environmental effects observed in an international dataset”, Field Crops Research.

Section 2 provides details of the soil profiles used for the simulations, while Section 3 lists the phenotypic parameter data used for deriving model input parameter values. Additional results are shown in Section 4.

Acronyms used in this supplementary material document are listed in Table S1.

Table S1. Acronyms used in this Supplementary Online Material document, excluding phenotypic parameters (listed in Table S3).

Acronym	Units	Description
ADM	t/ha	Above-ground dry biomass
E		Environment or Experiment
FIPARa	%	Seasonal average fractional interception of photosynthetically-active radiation by green leaves
G		Genotype
P		Plant crop
PAR	MJ/m^2	Incident photosynthetically-active radiation
R1		First ratoon crop
RUEa	g/MJ	Seasonal average apparent radiation use efficiency, calculated as above ground dry biomass at harvest divided by seasonal intercepted photosynthetically-active radiation

2. SOIL DESCRIPTIONS FOR SIMULATIONS

Table S2 shows soil profile data as used in the model simulations.

Table S2. Soil information used as input for simulations for each experiment.

Soil layer lower boundary depth (cm)	Lower limit (cm^3/cm^3)	Drained upper limit (cm^3/cm^3)	Saturation (cm^3/cm^3)	Bulk density (g/cm^3)
La Mare				
5	0.137	0.298	0.402	1.03
20	0.137	0.298	0.402	1.03
40	0.142	0.306	0.414	1.03
80	0.305	0.453	0.456	1.24
120	0.305	0.453	0.456	1.24
Pongola				
5	0.101	0.261	0.368	1.39
17	0.101	0.261	0.368	1.39
32	0.101	0.261	0.368	1.39
47	0.16	0.282	0.371	1.43
62	0.16	0.282	0.371	1.43
92	0.151	0.304	0.399	1.34
122	0.151	0.304	0.399	1.34
152	0.151	0.304	0.399	1.34
182	0.151	0.304	0.399	1.34
272	0.151	0.304	0.399	1.34
Belle Glade				
5	0.150	0.250	0.500	0.35
15	0.150	0.250	0.500	0.35
30	0.150	0.250	0.500	0.35
60	0.150	0.250	0.500	0.35
100	0.150	0.250	0.500	0.35
170	0.150	0.250	0.500	0.35
179	0.026	0.058	0.402	1.53
Chiredzi (P)				
5	0.231	0.335	0.431	1.42
10	0.237	0.345	0.437	1.40
15	0.231	0.335	0.431	1.42
20	0.231	0.338	0.431	1.42
25	0.266	0.374	0.432	1.42
35	0.262	0.367	0.426	1.44
45	0.232	0.333	0.415	1.48
60	0.189	0.299	0.419	1.47
75	0.130	0.226	0.397	1.54
90	0.059	0.116	0.383	1.58
105	0.053	0.105	0.407	1.51
120	0.054	0.099	0.406	1.51
Chiredzi (R1)				
5	0.143	0.232	0.384	1.57
10	0.124	0.309	0.463	1.35

15	0.053	0.084	0.134	1.57
20	0.160	0.248	0.384	1.57
25	0.168	0.263	0.391	1.55
30	0.186	0.277	0.387	1.56
40	0.204	0.295	0.387	1.56
55	0.224	0.324	0.395	1.54
70	0.214	0.312	0.391	1.55
85	0.204	0.301	0.391	1.55
100	0.186	0.283	0.391	1.55
120	0.142	0.240	0.395	1.54
140	0.160	0.253	0.391	1.55
160	0.136	0.221	0.380	1.58

3. OBSERVED PHENOTYPIC PARAMETER VALUES

The main article makes reference to phenotypic parameter values from Jones et al. (2019). These parameter values are summarised in Table S3.

Table S3. Values for observed phenotypic parameter values for each cultivar, as reported by Jones et al. (2019).

Parameter name	Definition	N41	R570	CP88-1762
TT_EM50 (Plant crops)	Thermal time (TT10[1], °Cd) from planting to 50% primary shoot emergence.	443	491	459
TT_EM50 (ratoon crops)	Thermal time (TT10[1], °Cd) from ratooning to 50% primary shoot emergence.	250	428	260
PI	Average leaf phyllocron interval (thermal time required for the production of one fully expanded leaf) over first 30 leaves (TT10[1], °Cd)	134	152	129
PFINAL	Final shoot population, stalks/m^2	12.4	8.7	10.4
PPOP	Peak shoot population, shoots/m^2			
RUEmax	Apparent radiation use efficiency, maximum of four biomass sampling periods (g/MJ)	2.92	3.07	3.34
ADM_OSG	Above-ground dry biomass at the start of stalk growth, t/ha	5.58	5.67	4.64
STKPF	Fraction of daily above-ground dry biomass increments allocated to stalks, t/t	0.80	0.80	0.80
TT_OSG	Cumulative thermal time (TT10[1]) since 50% primary shoot emergence at start of stalk growth, °Cd	964	926	842
TT_Fi50	Thermal time (TT16[2]) from 50% shoot emergence to 50% canopy cover (in terms of photosynthetically-active radiation interception), °Cd	381	362	312
FiPARavg	Seasonal average fractional interception of photosynthetically-active radiation	0.70	0.68	0.72

[1]TT10: cumulative thermal time from crop start calculated using a base temperature of 10 °C, with optimal and upper temperatures as specified in Jones and Singels, 2018.

[2]TT16: cumulative thermal time from crop start calculated using a base temperature of 16 °C, with optimal and upper temperatures as specified in Jones and Singels, 2018.

4. ADDITIONAL RESULTS

Mean and coefficient of variation per genotype G (across environments (Es)) and per E (across Gs) were calculated for Seasonal average fractional interception of photosynthetically-active radiation by green leaves (FIPARa, %), Seasonal average apparent radiation use efficiency, calculated as above ground dry biomass at harvest divided by seasonal intercepted photosynthetically-active radiation (RUEa, g/MJ) and Above-ground dry biomass (ADM, t/ha). Rankings (G per E, highest value = 1, lowest value = 3) were calculated, along with mean and coefficient of variation of these rankings. This ranking scheme was intended as a pragmatic means to make the data easier to interpret. These data are shown in Tables S4-S6, along with values per G and E, G effects, E effects and rankings of GxE effects for each G per E (the calculations for which are shown in the main article).

Table S4. Seasonal average fractional interception of radiation (FIPARa, %) values per dataset (Observed and simulated by three models) per cultivar G and experiment (environment) E, along with averages ('All') and coefficient of variation (CV%) of G values per E; G values rankings per E; the additive E effect per E; the additive GxE effects per G and E, with additive G effects per G shown in italicized text in the 'Average' rows; and the rankings of the additive GxE effects for each G per E. Average values are shown, as well as the CV% of values and additive effects per G or for all Gs and Es.

	Values (%)					G value rankings per E				Additive GxE and *G* effects			GxE effect: G ranking per E		
Experiment	**N41**	**R570**	**CP88-1762**	**All**	**CV%**	**N41**	**R570**	**CP88-1762**	**Additive E effects**	**N41**	**R570**	**CP88-1762**	**N41**	**R570**	**CP88-1762**
Observed															
Belle Glade, P	61	60	68	63.0	6.9	2	3	1	-7.00	-1.80	-1.00	2.80	3	2	1
Belle Glade, R1	73	66	76	71.7	7.2	2	3	1	1.67	1.60	-3.70	2.10	2	3	1
La Mare, R1	79	81	77	79.0	2.5	2	1	3	9.00	0.20	4.00	-4.20	2	1	3
Pongola, P	66	65	68	66.3	2.3	2	3	1	-3.67	-0.10	0.70	-0.60	2	1	3
Average	69.8	68.0	72.2	70.0	10.00	2.00	2.50	1.50	0.00	*-0.25*	*-2.00*	*2.25*	2.25	1.75	2.00
CV%	11.3	13.3	6.8	10.0	26.9	0.0	40.0	66.7					22.2	54.7	57.7
DSSAT-Canegro															
Belle Glade, P	63	61	63	62.3	1.9	1	3	2	-6.25	0.00	0.20	-0.30	2	1	3
Belle Glade, R1	66	64	68	66.0	3.0	2	3	1	-2.58	-0.70	-0.40	1.10	3	2	1
La Mare, R1	79	77	77	77.7	1.5	1	2	3	9.08	0.70	0.90	-1.60	2	1	3
Pongola, P	69	66	70	68.3	3.0	2	3	1	-0.25	0.00	-0.80	0.80	2	3	1

Average	69.2	67.0	69.5	68.6	8.90	1.50	2.80	1.80	0.00	*0.67*	*-1.58*	*0.92*	2.25	1.75	2.00
CV%	10.0	10.4	8.3	9.6	8.6	38.5	17.9	53.2					22.2	54.7	57.7
Mosicas															
Belle Glade, P	69	68	72	69.7	3.0	2	3	1	-4.00	-0.20	0.50	-0.20	2	1	3
Belle Glade, R1	75	72	78	75.0	4.0	2	3	1	1.33	0.40	-0.80	0.40	1	3	2
La Mare, R1	87	85	89	87.0	2.3	2	3	1	13.33	0.40	0.20	-0.60	1	2	3
Pongola, P	62	61	66	63.0	4.2	2	3	1	-10.67	-0.60	0.20	0.40	3	2	1
Average	73.2	71.5	76.2	73.7	12.80	2.00	3.00	1.00	0.00	*-0.42*	*-2.17*	*2.58*	1.75	2.00	2.25
CV%	14.5	14.1	12.9	13.8	6.9	0.0	0.0	0.0					54.7	40.8	42.6
APSIM															
Belle Glade, P	71	69	70	70.0	1.4	1	3	2	0.92	0.60	0.30	-0.90	1	2	3
Belle Glade, R1	70	67	71	69.3	3.0	2	3	1	0.25	0.20	-1.00	0.80	2	3	1
La Mare, R1	66	66	69	67.0	2.6	2	3	1	-2.08	-1.40	0.30	1.10	3	2	1
Pongola, P	71	69	70	70.0	1.4	1	3	2	0.92	0.60	0.30	-0.90	1	2	3
Average	69.5	67.8	70.0	69.1	2.70	1.50	3.00	1.50	0.00	*0.42*	*-1.33*	*0.92*	1.75	2.25	2.00
CV%	3.4	2.2	1.2	2.1	30.5	38.5	0.0	38.5					54.7	22.2	57.7

Table S5. Seasonal apparent radiation use efficiency (calculated from above-ground dry biomass and fractional interception of photosynthetically-active radiation, RUEa, MJ/m^2) values per dataset (Observed and simulated by three models) per cultivar G and experiment (environment) E, along with averages ('All') and coefficient of variation (CV%) of G values per E; G values rankings per E; the additive E effect per E; the additive GxE effects per G and E, with additive G effects per G shown in italicized text in the 'Average' rows; and the rankings of the additive GxE effects for each G per E. Average values are shown, as well as the CV% of values and additive effects per G or for all Gs and Es.

	Values					G value rankings per E				G and GxE effects			GxE effect: G ranking per E		
Experiment	**N41**	**R570**	**CP88-1762**	**All**	**CV%**	**N41**	**R570**	**CP88-1762**	**E effect**	**N41**	**R570**	**CP88-1762**	**N41**	**R570**	**CP88-1762**
Observed															
Belle Glade, P	2.09	2.66	2.80	2.52	14.9	3	2	1	0.37	-0.30	0.02	0.27	3	2	1
Belle Glade, R1	1.47	2.19	1.96	1.87	19.7	3	1	2	-0.27	-0.28	0.20	0.08	3	1	2
La Mare, R1	2.36	2.40	2.00	2.25	9.8	2	1	3	0.11	0.23	0.03	-0.26	1	2	3
Pongola, P	2.16	1.81	1.86	1.94	9.8	1	3	2	-0.20	0.34	-0.25	-0.09	1	3	2
Average	2.02	2.27	2.15	2.15	17.30	2.25	1.75	2.00	*0.00*	*-0.13*	*0.12*	*0.01*	2.00	2.00	2.00
CV%	19.0	15.8	20.2	13.9	27.5	42.6	54.7	40.8					57.7	40.8	40.8
DSSAT-Canegro															
Belle Glade, P	1.93	2.08	2.37	2.13	10.5	3	2	1	0.05	-0.02	-0.01	0.03	3	2	1
Belle Glade, R1	1.84	1.96	2.24	2.01	10.2	3	2	1	-0.06	0.00	-0.02	0.02	2	3	1
La Mare, R1	1.86	1.98	2.15	2.00	7.3	3	2	1	-0.08	0.04	0.02	-0.06	1	2	3
Pongola, P	1.96	2.14	2.38	2.16	9.8	3	2	1	0.09	-0.02	0.01	0.01	3	1	2
Average	1.90	2.04	2.29	2.07	8.90	3.00	2.00	1.00	*0.00*	*-0.18*	*-0.03*	*0.21*	2.25	2.00	1.75
CV%	3.0	4.2	4.8	4.0	16.4	0.0	0.0	0.0					42.6	40.8	54.7
Mosicas															
Belle Glade, P	1.98	2.05	2.11	2.05	3.2	3	2	1	0.17	0.00	-0.02	0.02	2	3	1
Belle Glade, R1	1.93	2.02	2.04	2.00	2.9	3	2	1	0.12	0.00	0.00	0.00	3	1	2
La Mare, R1	1.61	1.67	1.68	1.65	2.3	3	2	1	-0.23	0.02	0.00	-0.01	1	2	3
Pongola, P	1.75	1.87	1.86	1.83	3.6	3	1	2	-0.05	-0.01	0.02	-0.01	3	1	2
Average	1.82	1.90	1.92	1.88	9.00	3.00	1.75	1.25	*0.00*	*-0.06*	*0.02*	*0.04*	2.25	1.75	2.00
CV%	9.3	9.2	10.0	9.6	6.1	0.0	28.6	40.0					42.6	54.7	40.8
APSIM															

Belle Glade, P	2.14	2.31	2.49	2.31	7.6	3	2	1	0.09	-0.04	0.00	0.04	3	2	1
Belle Glade, R1	2.09	2.24	2.42	2.25	7.3	3	2	1	0.02	-0.03	-0.01	0.03	3	2	1
La Mare, R1	2.20	2.36	2.54	2.37	7.2	3	2	1	0.14	-0.03	0.00	0.04	3	2	1
Pongola, P	1.94	1.99	2.01	1.98	1.8	3	2	1	-0.25	0.09	0.01	-0.11	1	2	3
Average	2.09	2.23	2.37	2.23	9.00	3.00	2.00	1.00	*0.00*	*-0.13*	*0.00*	*0.14*	2.50	2.00	1.50
CV%	5.3	7.4	10.2	7.7	31.0	0.0	0.0	0.0					40.0	0.0	66.7

Table S6. Final harvest above-ground dry biomass (t/ha) values per dataset (observed and simulated by three models) per cultivar G and experiment (environment) E, along with averages ('All') and coefficient of variation (CV%) of G values per E; G values rankings per E; the additive E effect per E; the additive GxE effects per G and E, with additive G effects per G shown in italicized text in the 'Average' rows; and the rankings of the additive GxE effects for each G per E. Average values are shown, as well as the CV% of values and additive effects per G or for all Gs and Es. For observations, superscripts a-d indicate significant difference (calculated using Fisher, alpha=0.05) between cultivars per experiment; w-z indicate significant difference between experiments; and A-B indicate significant difference between cultivars across all experiments.

	Values					G value rankings per E				G and GxE effects			GxE effect: G ranking per E		
Experiment	**N41**	**R570**	**CP88-1762**	**All**	**CV%**	**N41**	**R570**	**CP88-1762**	**E effect**	**N41**	**R570**	**CP88-1762**	**N41**	**R570**	**CP88-1762**
Observed															
Belle Glade, P	41.9^{b}	52.3^{ab}	62.4^{a}	52.2^{x}	19.6	3	2	1	2.80	-7.70	-0.90	8.50	3	2	1
Belle Glade, R1	34.7^{b}	46.6^{a}	48.1^{a}	43.1^{yz}	17.0	3	2	1	-6.29	-5.80	2.50	3.30	3	2	1
Chiredzi, R1	45.8^{a}	45.7^{a}	50.0^{a}	47.2^{xy}	5.3	2	3	1	-2.23	1.20	-2.40	1.20	1	3	2
La Mare, R1	68.3^{a}	71.2^{a}	56.4^{b}	65.3^{w}	12.0	2	1	3	15.88	5.60	5.00	-10.60	1	2	3
Pongola, P	43.4^{a}	35.9^{a}	38.4^{a}	39.2^{z}	9.8	1	3	2	-10.16	6.70	-4.30	-2.50	1	3	2
Average	46.8^{A}	50.3^{A}	51.1^{A}	52.2^{x}	22.30	2.20	2.20	1.60	*0.00*	*-2.58*	*0.92*	*1.66*	1.80	2.40	1.80
CV%	27.1	26.0	17.7	20.5	25.5	38.0	38.0	55.9					60.9	22.8	46.5
DSSAT-Canegro															
Belle Glade, P	39.90	41.80	49.20	43.60	11.3	3	2	1	-4.85	-0.50	0.00	0.50	3	2	1
Belle Glade, R1	39.60	40.90	49.20	43.20	12.0	3	2	1	-5.26	-0.40	-0.50	0.90	2	3	1
Chiredzi, R1	50.80	50.80	57.30	53.00	7.1	2	3	1	4.47	1.00	-0.30	-0.70	1	2	3
La Mare, R1	54.30	56.20	61.00	57.20	6.1	3	2	1	8.71	0.30	0.90	-1.20	2	1	3
Pongola, P	41.80	43.50	51.00	45.40	10.9	3	2	1	-3.08	-0.50	-0.10	0.50	3	2	1
Average	45.30	46.60	53.60	48.50	14.30	2.80	2.20	1.00	*0.00*	*-3.20*	*-1.86*	*5.06*	2.20	2.00	1.80
CV%	15.0	14.2	10.0	12.9	18.8	16.0	20.3	0.0					38.0	35.4	60.9
Mosicas															
Belle Glade, P	44.90	46.00	49.70	46.90	5.3	3	2	1	-0.05	-0.40	0.00	0.40	3	2	1
Belle Glade, R1	46.90	47.00	51.20	48.40	5.0	3	2	1	1.46	0.20	-0.60	0.40	2	3	1
Chiredzi, R1	50.20	50.60	53.80	51.60	3.8	3	2	1	4.65	0.30	-0.10	-0.20	1	2	3
La Mare, R1	51.60	52.00	54.60	52.80	3.1	3	2	1	5.85	0.40	0.10	-0.50	1	2	3

Pongola, P	32.90	34.70	37.30	35.00	6.3	3	2	1	-11.92	-0.50	0.60	-0.10	3	1	2
Average	45.30	46.10	49.30	46.90	14.50	3.00	2.00	1.00	*0.00*	*-1.60*	*-0.82*	*2.42*	2.00	2.00	2.00
CV%	16.4	14.8	14.2	15.1	8.7	0.0	0.0	0.0					50.0	35.4	50.0
APSIM															
Belle Glade, P	49.20	51.40	56.50	52.40	7.1	3	2	1	1.56	-1.00	0.30	0.70	3	2	1
Belle Glade, R1	47.30	48.30	55.60	50.40	9.0	3	2	1	-0.39	-1.00	-0.80	1.70	3	2	1
Chiredzi, R1	50.50	48.00	51.40	50.00	3.6	2	3	1	-0.85	2.70	-0.70	-2.00	1	2	3
La Mare, R1	53.80	57.50	64.60	58.60	9.4	3	2	1	7.84	-2.70	0.20	2.50	3	2	1
Pongola, P	42.50	42.20	43.20	42.60	1.2	2	3	1	-8.16	2.00	0.90	-2.90	1	2	3
Average	48.70	49.50	54.30	50.80	12.10	2.60	2.40	1.00	*0.00*	*-2.15*	*-1.32*	*3.47*	2.20	2.00	1.80
CV%	8.6	11.3	14.4	11.3	29.4	21.1	22.8	0.0					49.8	0.0	60.9

5. REFERENCES

Jones, M., Singels, A., Chinorumba, S., Patton, A., Poser, C., Singh, M., Martiné, J., Christina, M., Shine, J., Annandale, J., Hammer, G.L., 2019. Exploring process-level genotypic and environmental effects on sugarcane yield using an international experimental dataset. Field Crop. Res. 244, 107622.