Trait modelling with APSIM

[1] Geoff Inman-Bamber, [2]Phillip Jackson, [3]Chris Stokes, [4]Shaun Verrall, [5]Prakash Lakshmanan, [6]Jaya Basnayake
+ Justin Sexton

[1] College of Science, Technology and Engineering, **James Cook University**, Townsville, Australia.
[2] CSIRO Agriculture, Australian Tropical Science and Innovation Precinct, Townsville, Australia
[3] CSIRO Land and Water, Australian Tropical Science and Innovation Precinct, Townsville, Australia
[4] CSIRO Agriculture, Biosciences Precinct, Dutton Park, Australia
[5] **Sugar Research Australia**, 50 Meiers Road, Indooroopilly, Australia
[6] Sugar Research Australia, Bruce Highway, Brandon, Australia

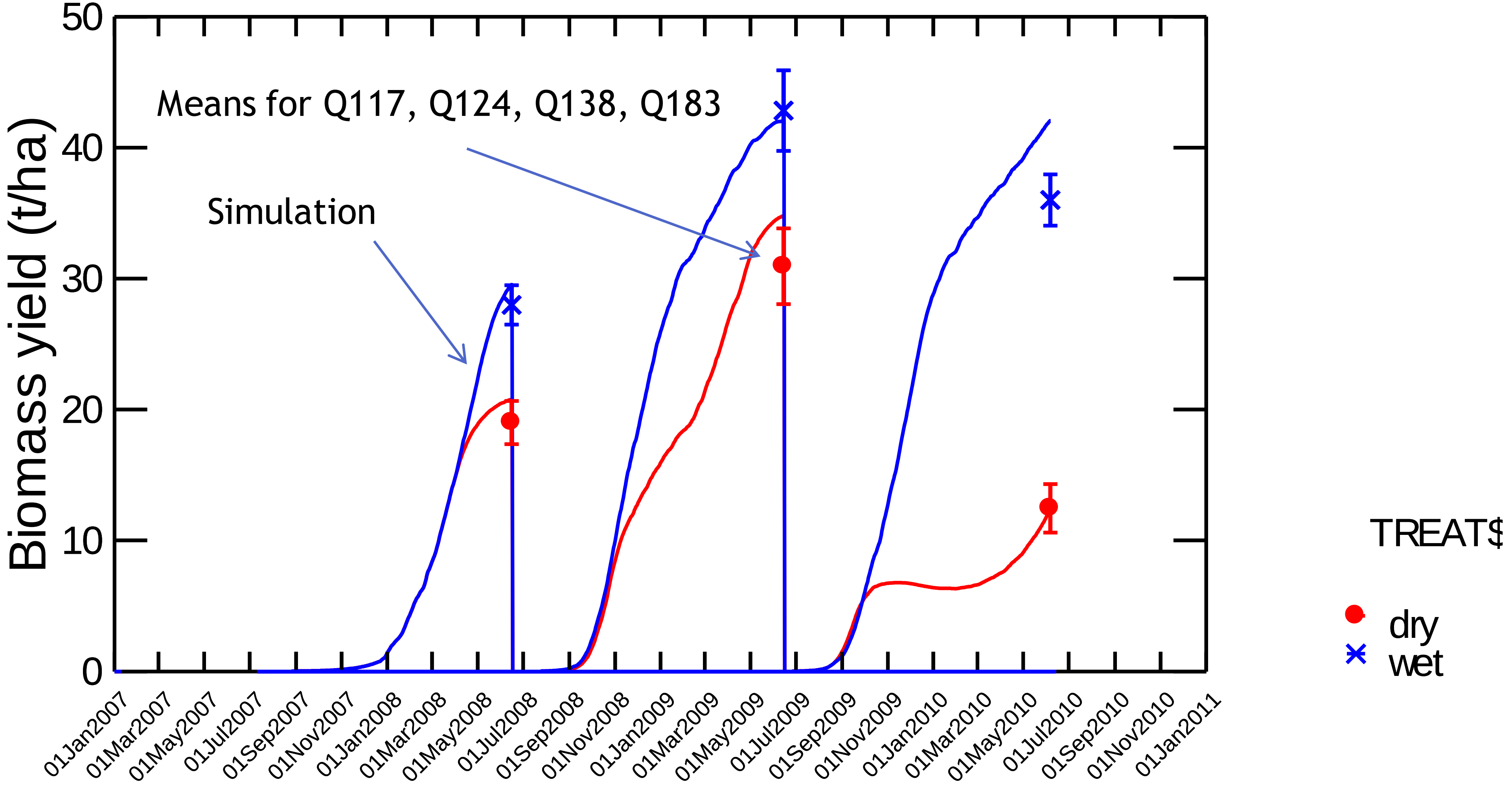
Part 1. Modelling traits for yield and drought resistance in sugarcane

- Serve as framework for the field and glasshouse research in MCPD
  - *Help with unravelling interactions in the data*
  - *Help in research design*
- To determine where and when traits will be most successful for increased sugar yield
- To improve knowledge of the physiology of yield and drought resistance

Site characterisation

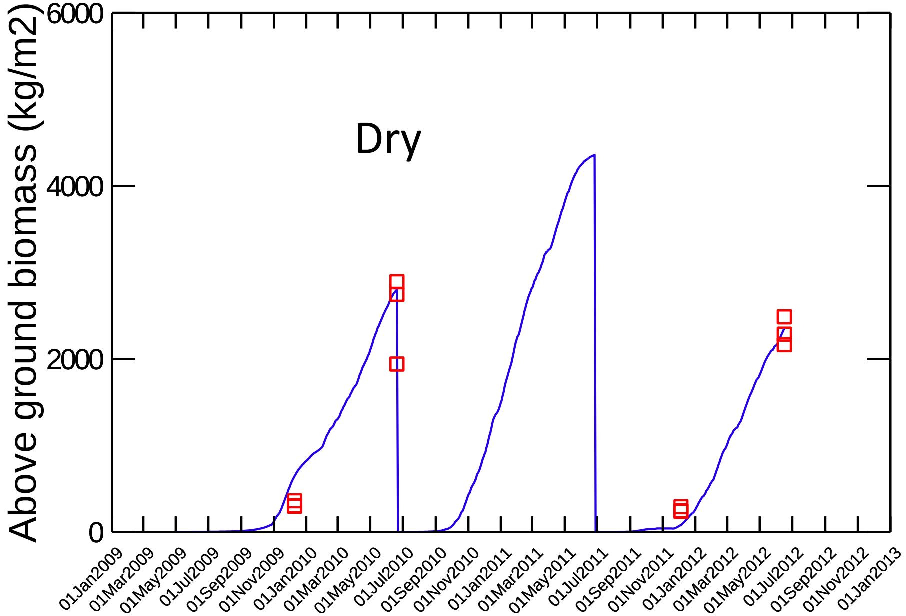
- *Home Hill*
  - Plant, 1st and 2nd ratoon
  - Well irrigated
  - Dry
- *Dalbeg*
  - Plant and 2nd ratoon
  - Well irrigated
  - Semi-dry
  - Dry

Home Hill



Means for Q117, Q124, Q138, Q183
Simulation
Biomass yield (t/ha)
0
10
20
30
40
50
01Jan2007
01Mar2007
01May2007
01Jul2007
01Sep2007
01Nov2007
01Jan2008
01Mar2008
01May2008
01Jul2008
01Sep2008
01Nov2008
01Jan2009
01Mar2009
01May2009
01Jul2009
01Sep2009
01Nov2009
01Jan2010
01Mar2010
01May2010
01Jul2010
01Sep2010
01Nov2010
01Jan2011
TREAT$
dry
wet

Dalbeg


Dry
Above ground biomass (kg/m2)
6000
4000
2000
0
01Jan2009
01Mar2009
01May2009
01Jul2009
01Sep2009
01Nov2009
01Jan2010
01Mar2010
01May2010
01Jul2010
01Sep2010
01Nov2010
01Jan2011
01Mar2011
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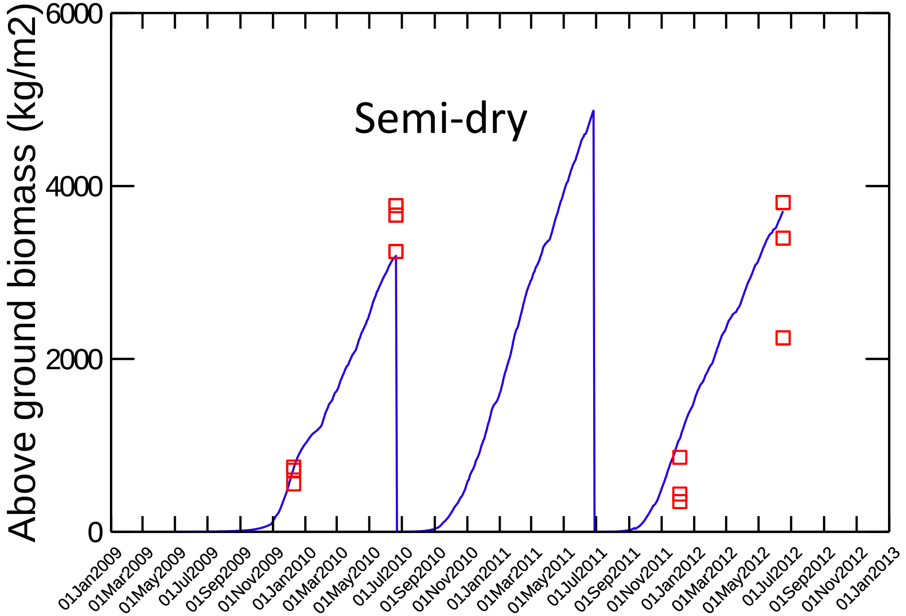
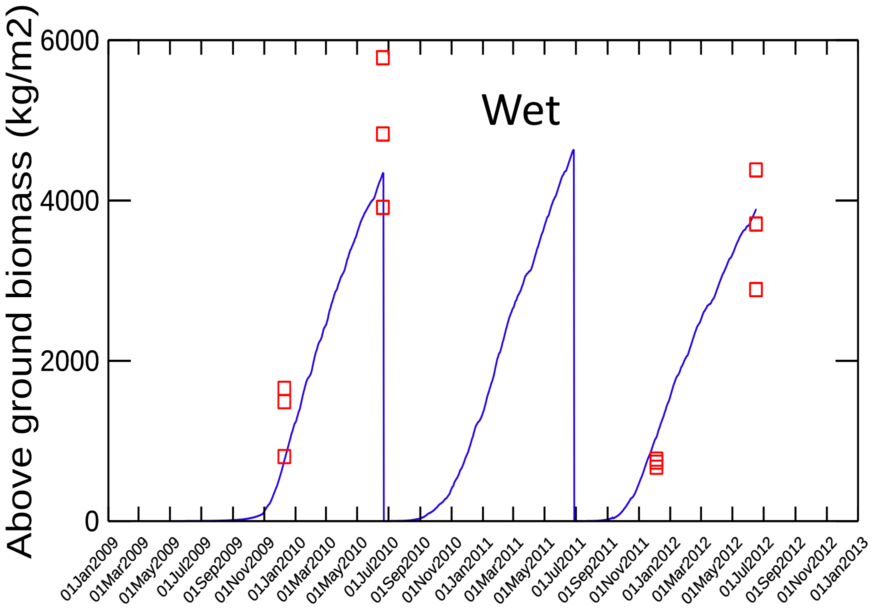
01Jul2011
01Sep2011
01Nov2011
01Jan2012
01Mar2012
01May2012
01Jul2012
01Sep2012
01Nov2012
01Jan2013

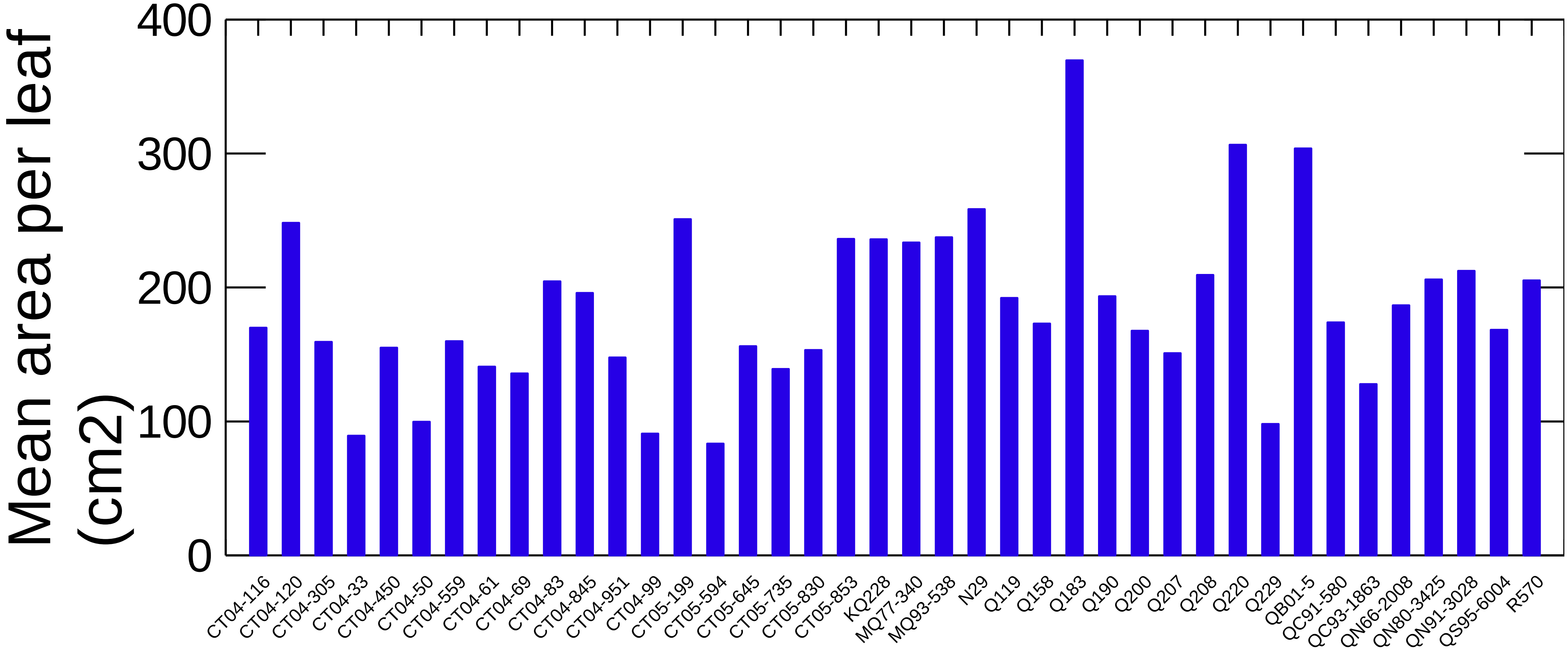

Semi-dry
Above ground biomass (kg/m2)
6000
4000
2000
0
01Jan2009
01Mar2009
01May2009
01Jul2009
01Sep2009
01Nov2009
01Jan2010
01Mar2010
01May2010
01Jul2010
01Sep2010
01Nov2010
01Jan2011
01Mar2011
01May2011
01Jul2011
01Sep2011
01Nov2011
01Jan2012
01Mar2012
01May2012
01Jul2012
01Sep2012
01Nov2012
01Jan2013


Wet
Above ground biomass (kg/m2)
6000
4000
2000
0
01Jan2009
01Mar2009
01May2009
01Jul2009
01Sep2009
01Nov2009
01Jan2010
01Mar2010
01May2010
01Jul2010
01Sep2010
01Nov2010
01Jan2011
01Mar2011
01May2011
01Jul2011
01Sep2011
01Nov2011
01Jan2012
01Mar2012
01May2012
01Jul2012
01Sep2012
01Nov2012
01Jan2013

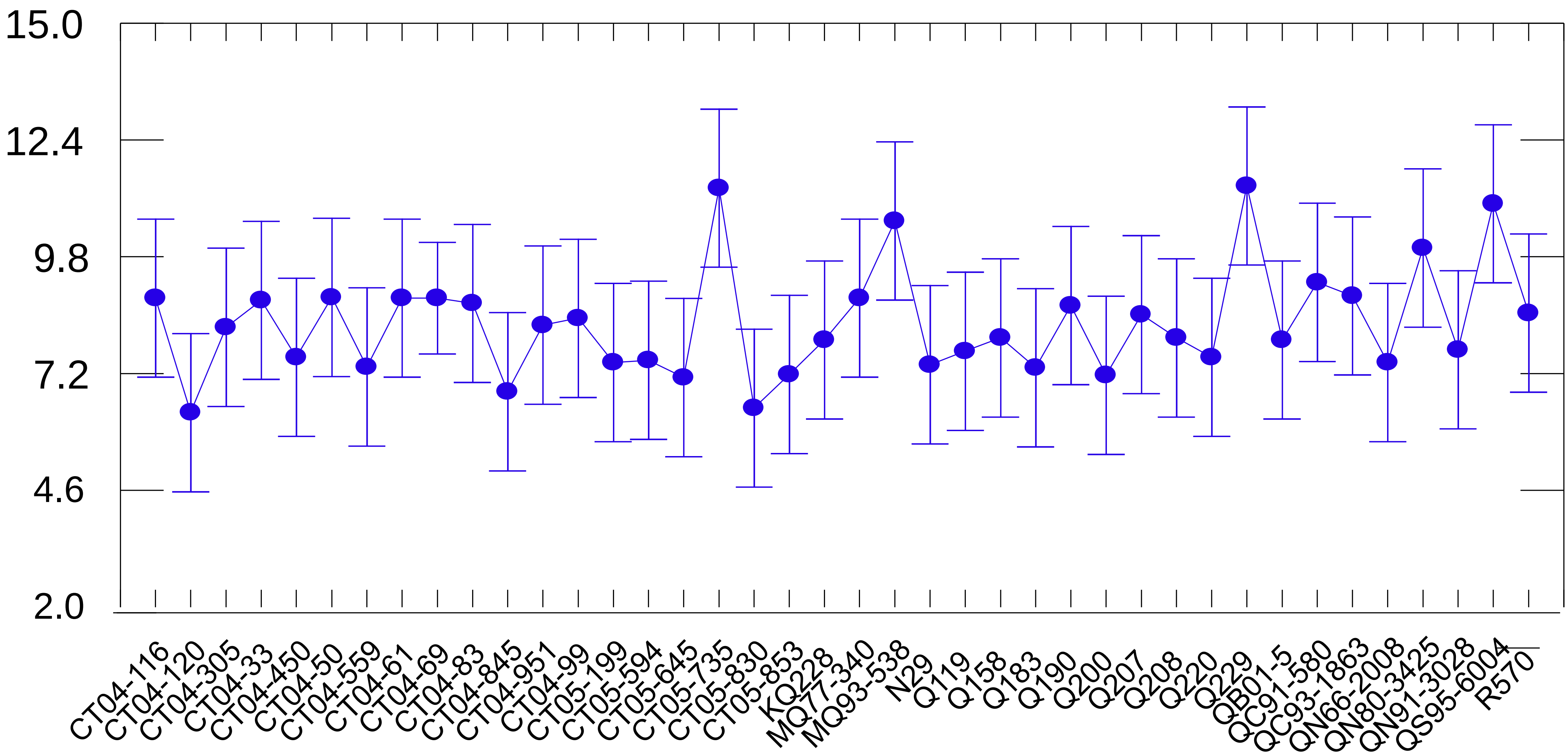
- Clone characterisation
  - 40 clones in common at Dalbeg and Home Hill
    - Canopy
      - Stalk population
      - Area per leaf
      - Green leaf number per stalk
    - RUE
    - Conductance (Kl)
    - Extractible soil water (10 clones)
    - Transpiration efficiency (18 clones)

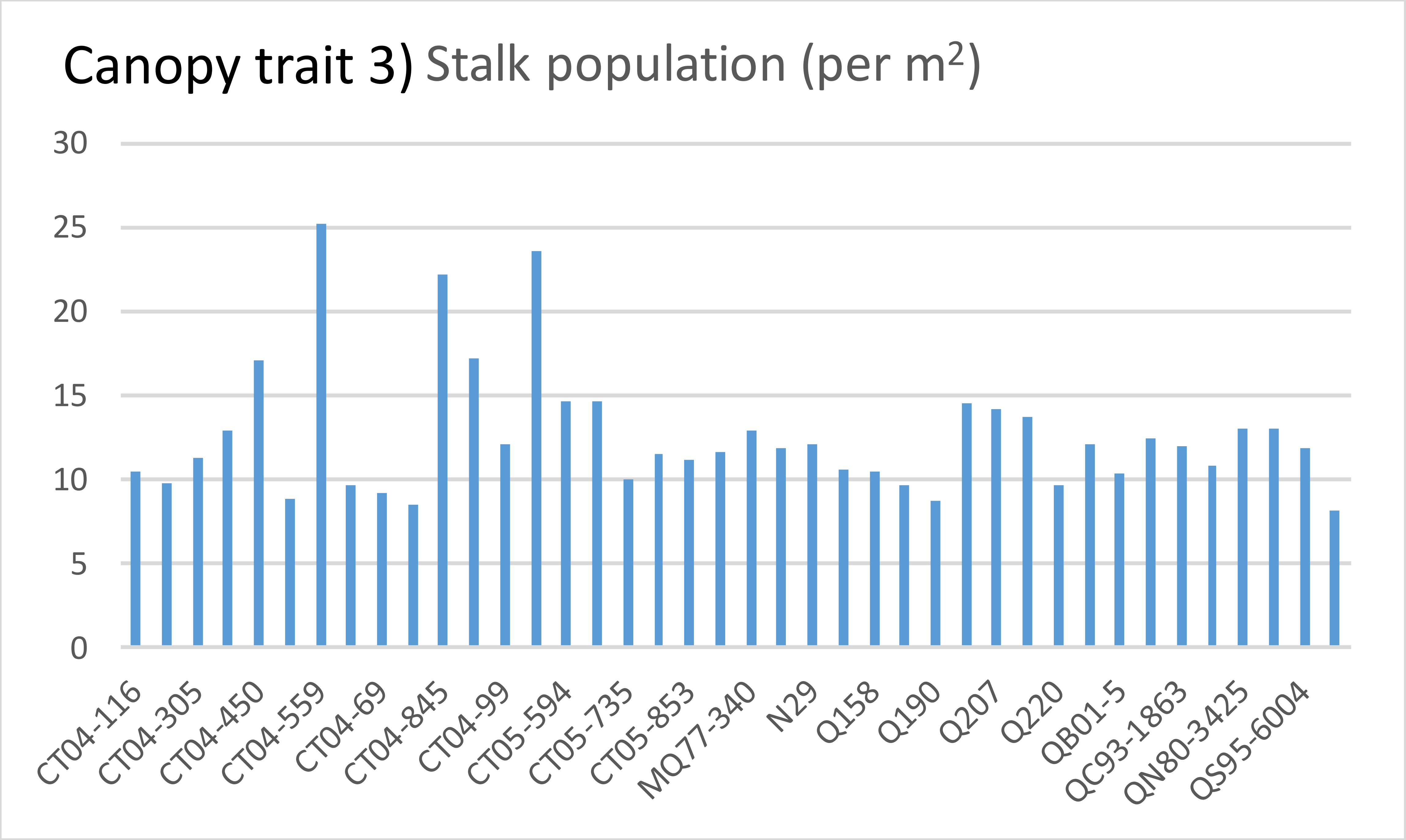
Canopy trait 1) Area per leaf

Area per plant was determined for the DB 2nd ratoon crop and green leaf number for the three HH crops.



Canopy trait 2) Green leaf number per stalk





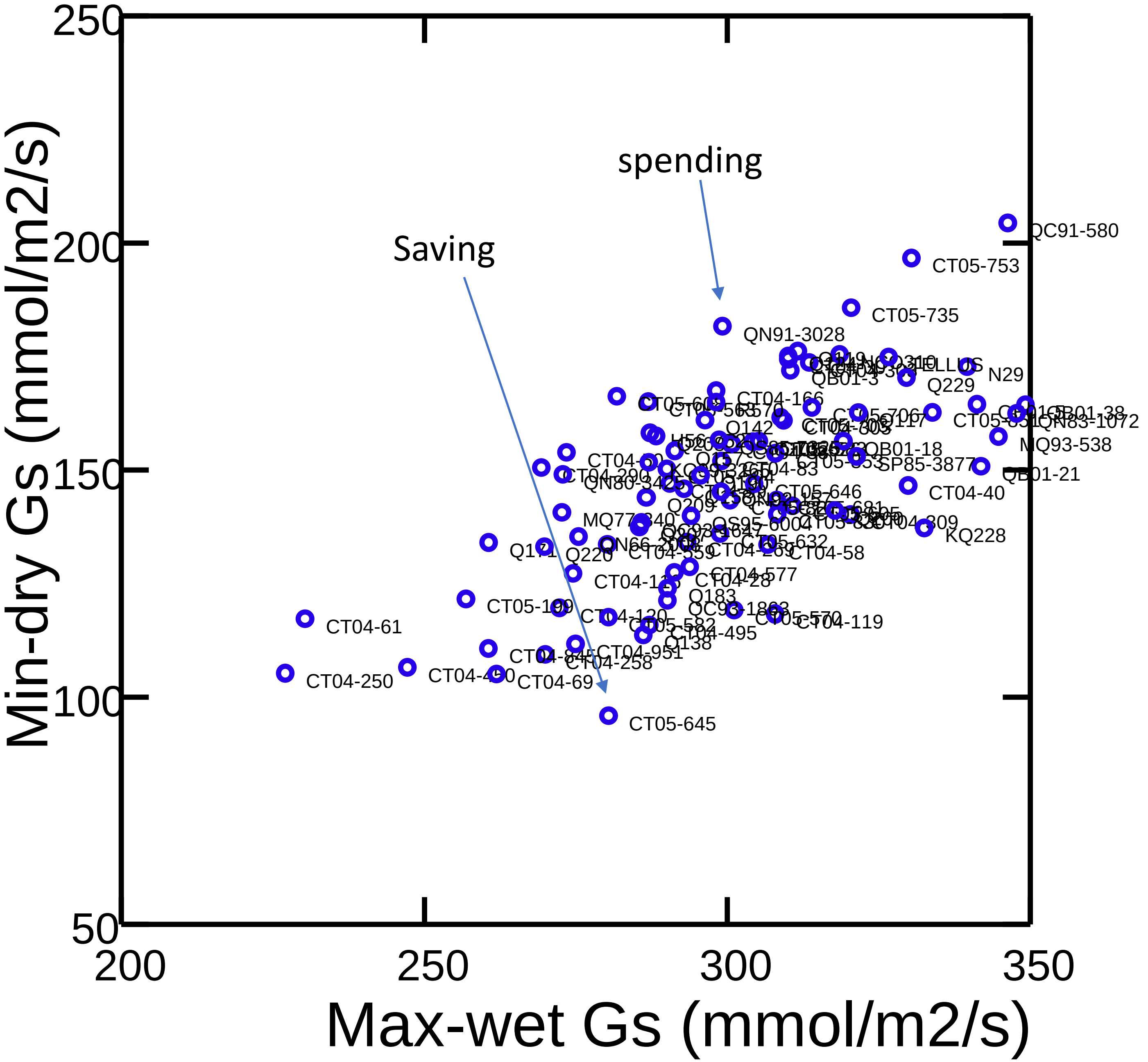
Canopy trait 3) Stalk population (per m2)
30
25
20
15
10
5
0
CT04-116
CT04-305
CT04-450
CT04-559
CT04-69
CT04-845
CT04-99
CT05-594
CT05-735
CT05-853
MQ77-340
N29
Q158
Q190
Q207
Q220
QB01-5
QC93-1863
QN80-3425
QS95-6004

RUE

Table 4. Stomatal conductance measured under favourable soil moisture conditions at Home Hill and conductance relative the standard variety, Q117

Clone	Irrigated conductance (mmol/m^2/s)	Relative to Q117 (322 mmol/m^2/s	Clone	Irrigated conductance (mmol/m^2/s)	Relative to Q117 (322 mmol/m^2/s
CT04-116	275	0.854	MQ93-538	345	1.072
CT04-120	273	0.847	N29	340	1.056
CT04-305	310	0.962	Q119	312	0.969
CT04-33	301	0.935	Q158	293	0.911
CT04-450	248	0.769	Q183	291	0.902
CT04-50	274	0.851	Q190	296	0.919
CT04-559	281	0.871	Q200	318	0.988
CT04-61	231	0.717	Q207	286	0.888
CT04-69	262	0.815	Q208	289	0.897
CT04-83	299	0.930	Q220	270	0.839
CT04-845	261	0.811	Q229	330	1.025
CT04-951	275	0.855	QB01-5	342	1.061
CT04-99	291	0.903	QC91-580	347	1.077
CT05-199	257	0.799	QC93-1863	290	0.902
CT05-594	290	0.902	QN66-2008	276	0.857
CT05-645	281	0.872	QN80-3425	273	0.849
CT05-735	321	0.996	QN91-3028	300	0.930
CT05-830	309	0.959	QS95-6004	294	0.914
CT05-853	308	0.958	R570	299	0.927
KQ228	333	1.034	MQ93-538	345	1.072
MQ77-340	273	0.848	N29	340	1.056

Conductance

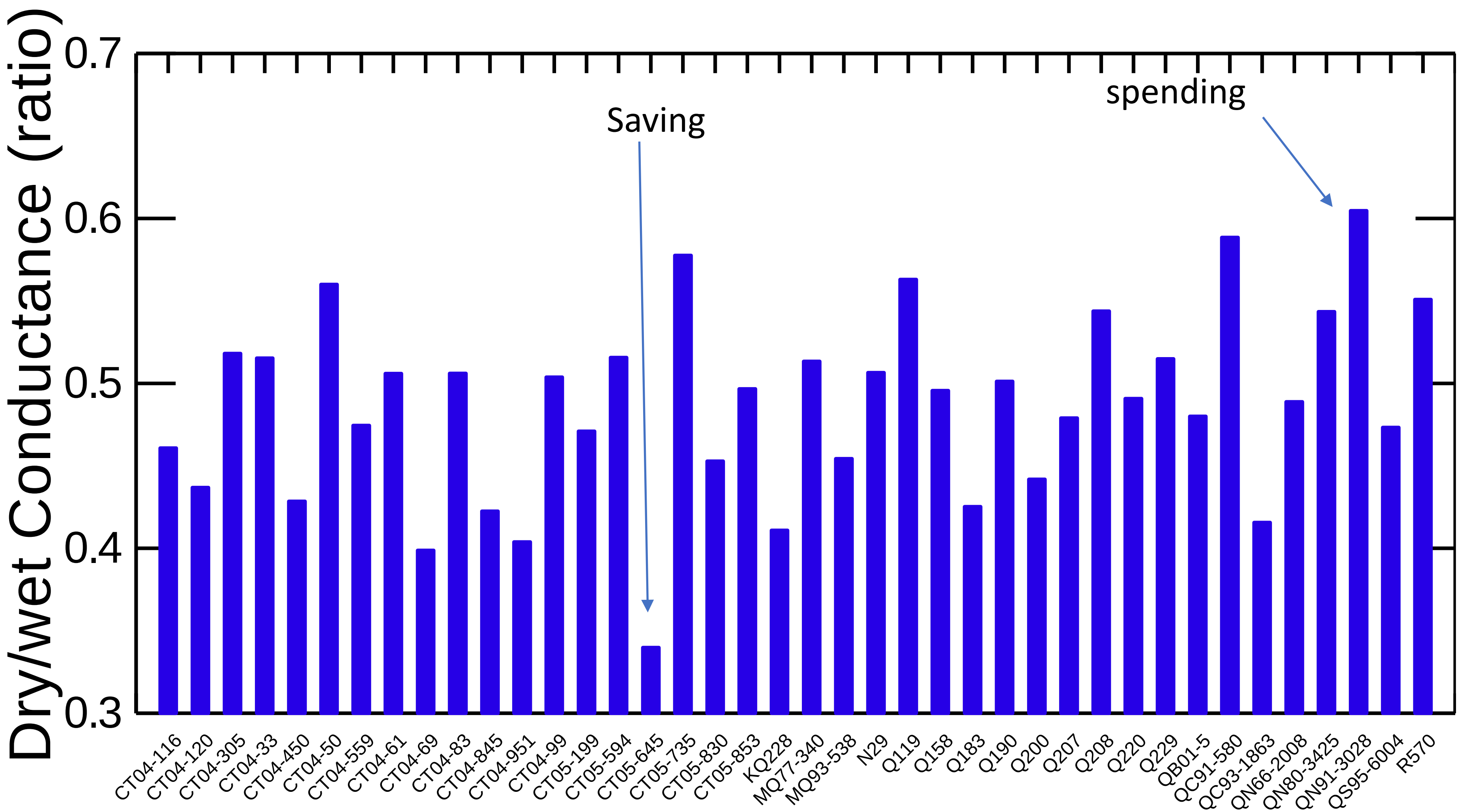


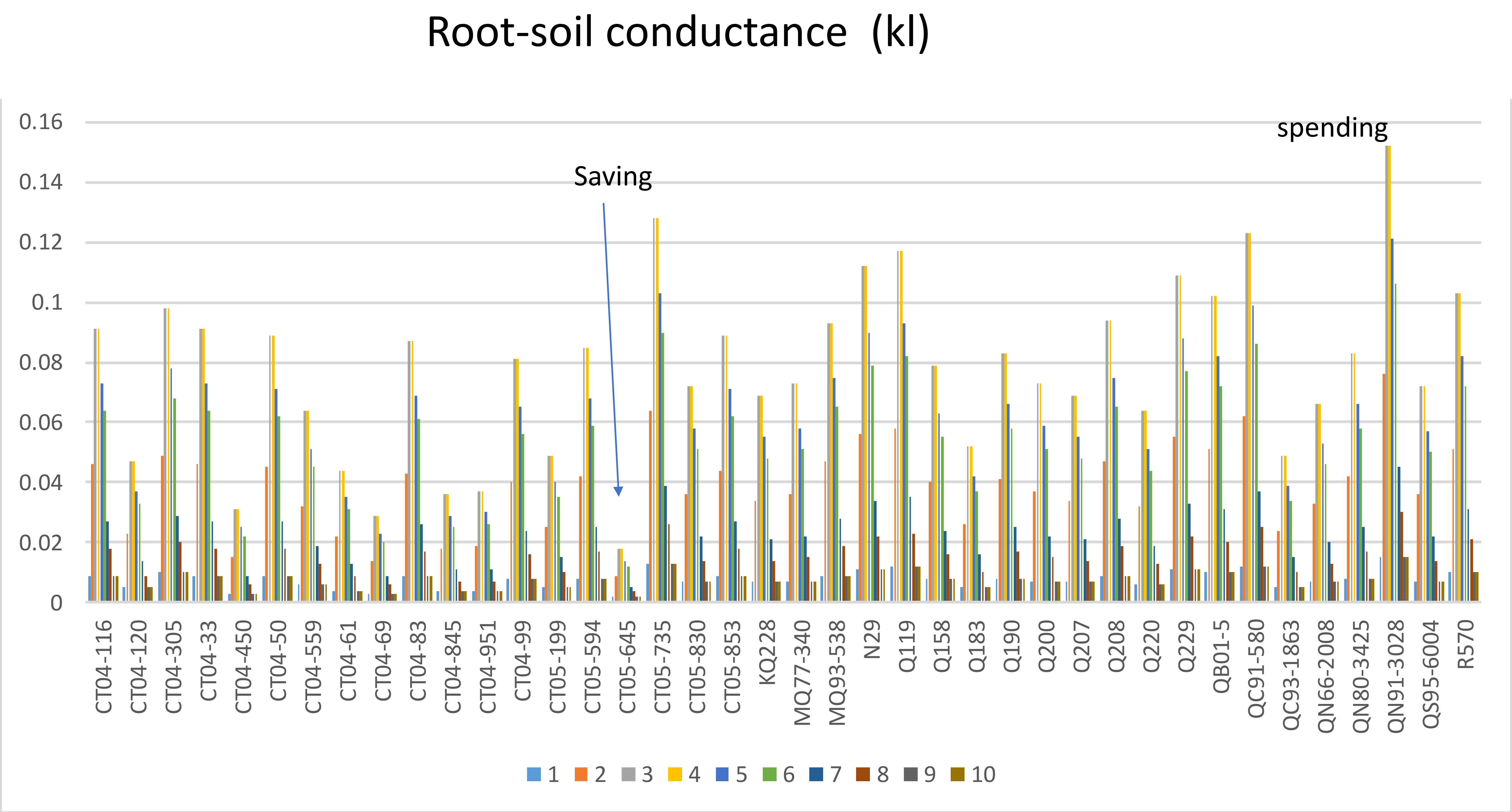
APSIM user interface: soil water screen

Root soil conductance (kl)

Depth (cm)		sugar LL (mm/mm)	sugar PAWC 220.2	sugar KL (/day)	sugar XF (0-1)
0-15	0	0.200	28.7	0.01	1.0
15-30	0	0.133	26.7	0.05	1.0
30-45	0	0.197	24.6	0.10	1.0
45-60	0	0.230	19.7	0.10	1.0
60-90	0	0.316	28.2	0.08	1.0
90-120	4	0.349	21.3	0.07	1.0
120-150	4	0.353	29.7	0.03	1.0
150-180	0	0.393	20.7	0.02	1.0
180-210	0	0.393	20.7	0.01	1.0
210-240	0	0.382	0.0	0.01	0.0

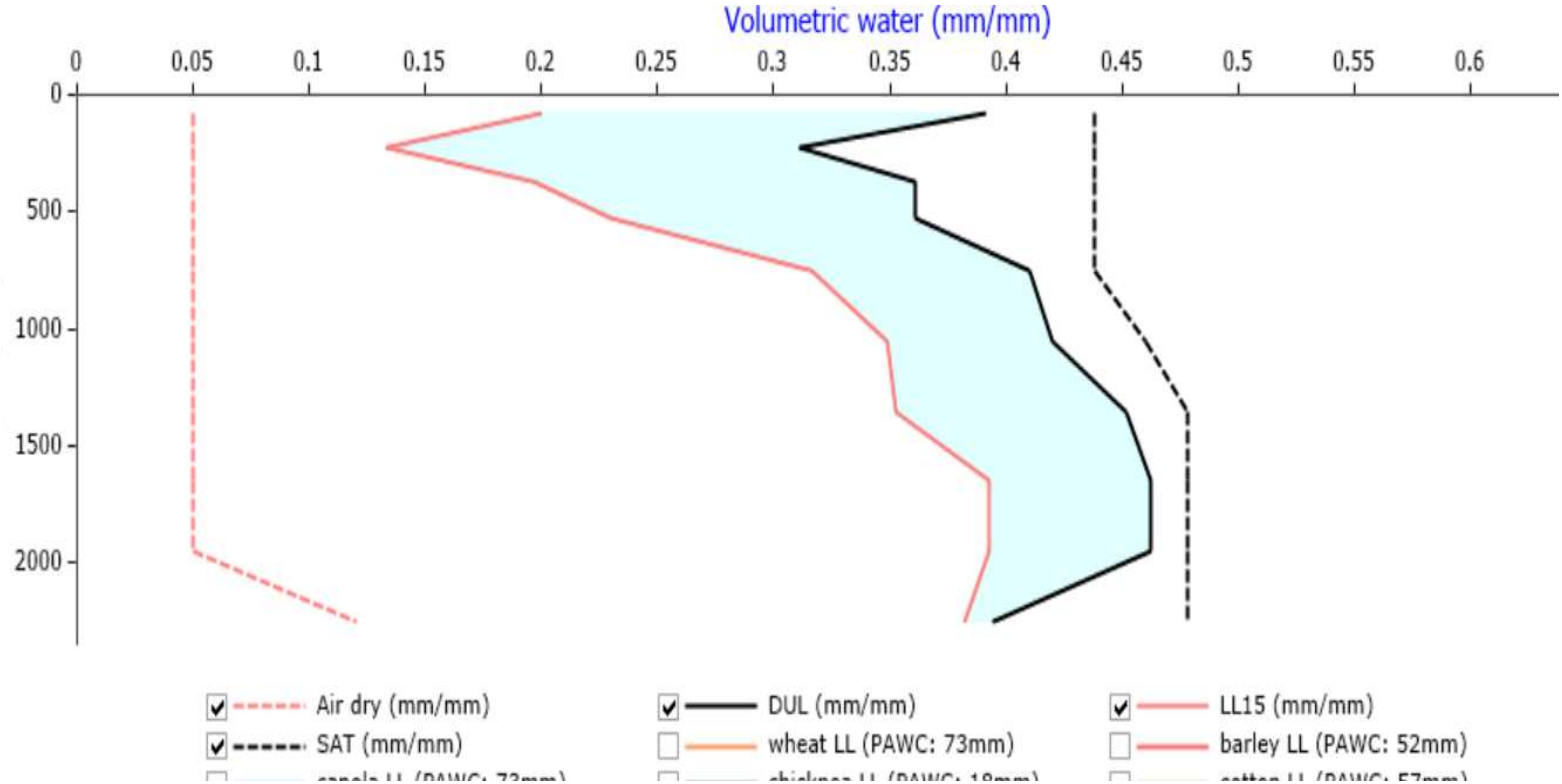
Root soil conductance multiplier = Gsdry/Gswet



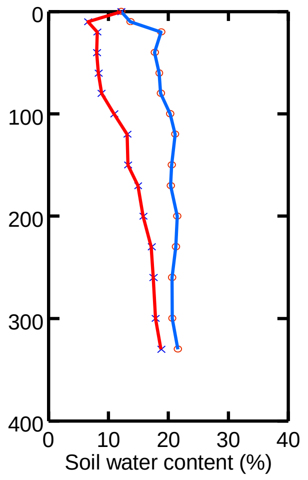


Root-soil conductance (kl)
Saving
spending
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
CT04-116
CT04-120
CT04-305
CT04-33
CT04-450
CT04-50
CT04-559
CT04-61
CT04-69
CT04-83
CT04-845
CT04-951
CT04-99
CT05-199
CT05-594
CT05-645
CT05-735
CT05-830
CT05-853
KQ228
MQ77-340
MQ93-538
N29
Q119
Q158
Q183
Q190
Q200
Q207
Q208
Q220
Q229
QB01-5
QC91-580
QC93-1863
QN66-2008
QN80-3425
QN91-3028
QS95-6004
R570
1 2 3 4 5 6 7 8 9 10

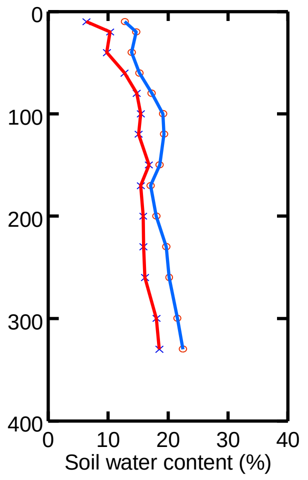
APSIM user interface soil water screen for soil hydraulic properties



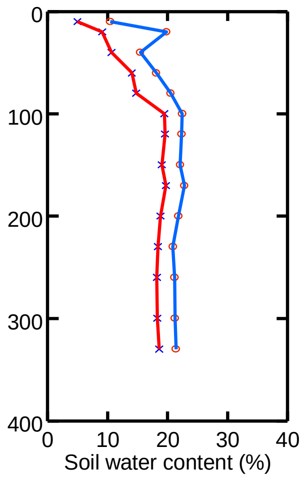
Total extractible soil water



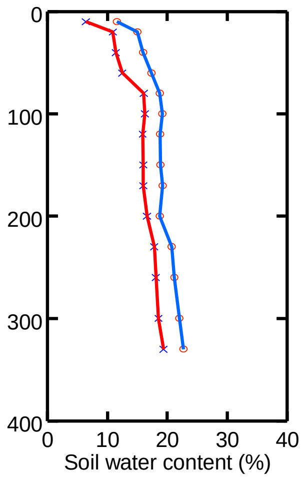
Q190



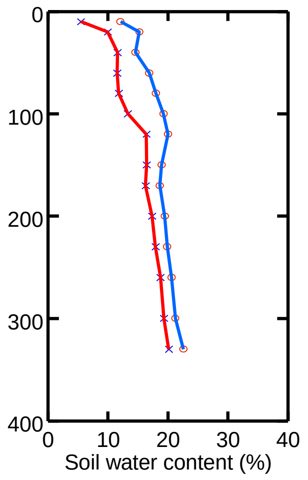
QB01 -5



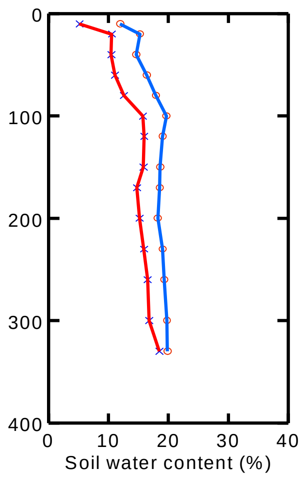
CT04 -69



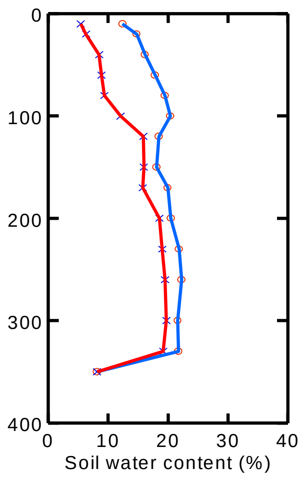
CT04 -951



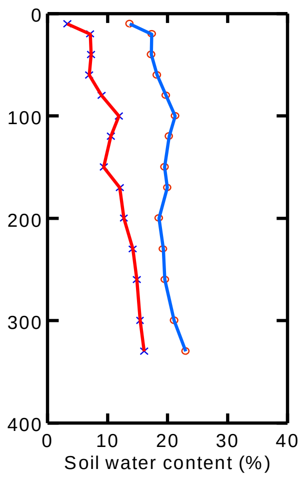
CT05 -645



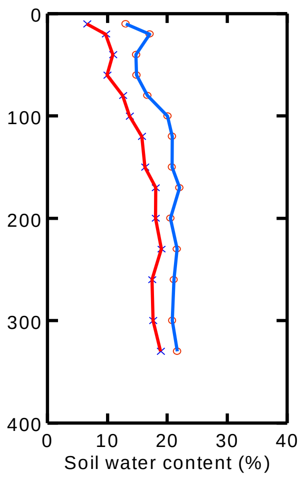
CT05 -735



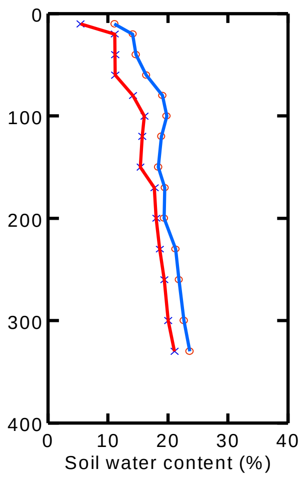
CT05 -830



KQ228



Q183



QC91 -580

Transpiration efficiency (TE)

Aerial biomass gain (g)/ Water transpired (kg)

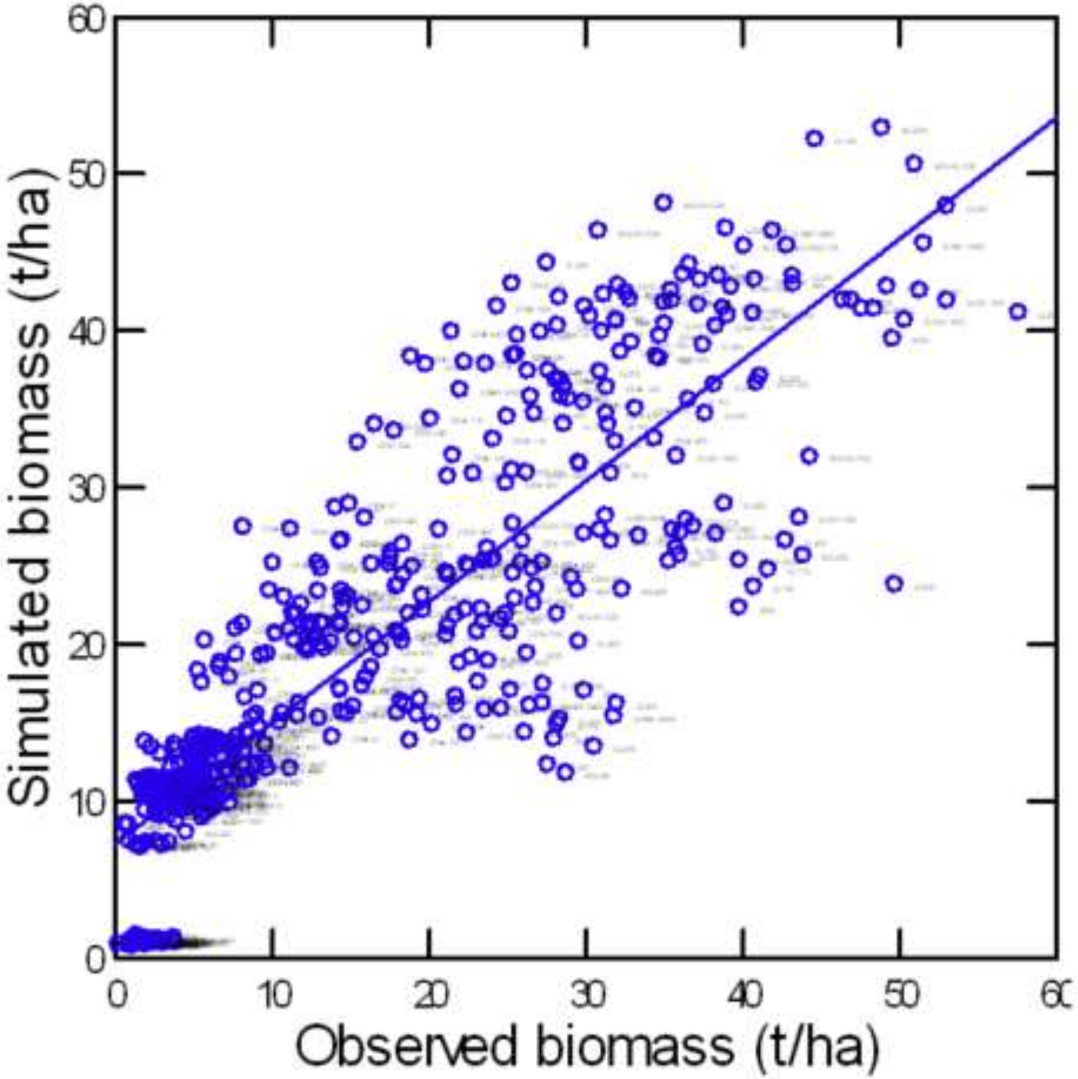
Clone	TE dry treat-ment	TE wet treat-ment	TE relative to Q183 dry	TE relative to Q183 wet	Transpiration efficiency coefficient when RWS/T_0 = 0	0.25	0.5	1
CT04-50	8.3	5.6	86.5	97.4	5.5	15.9	12.0	7.7
CT04-559	7.6	5.4	78.6	94.7	4.9	14.1	10.6	8.2
CT04-951	8.5	5.4	88.5	94.7	5.1	14.8	11.2	7.7
CT05-583	7.7	5.1	80.2	88.6	5.4	15.7	11.8	8.2
CT05-735	7.0	5.6	72.9	97.4	5.1	14.7	11.0	8.4
CT05-853	8.7	5.5	90.1	96.5	5.8	16.8	12.7	8.6
KQ228	7.4	5.1	76.6	89.5	5.0	14.4	10.9	8.0
MQ239	8.7	6.2	90.6	107.9	5.4	15.7	11.8	8.8
N29	7.4	5.3	77.1	92.1	4.9	14.2	10.7	7.5
Q119	6.6	5.2	68.2	90.4	4.8	13.8	10.4	8.1
Q183	9.6	5.7	100.0	100.0	6.0	17.4	13.1	8.7
Q190	7.8	5.6	81.3	98.2	5.2	14.9	11.3	8.5
Q200	7.5	5.9	77.6	103.5	5.0	14.6	11.0	8.7
Q208	7.9	5.1	82.3	88.6	5.2	15.1	11.3	7.9
Q229	8.0	5.4	83.3	93.9	5.5	15.9	11.9	8.2
QB01-5	6.8	5.2	70.3	91.2	4.7	13.7	10.3	7.6
QC91-580	7.3	6.1	76.0	106.1	4.9	14.3	10.7	8.9
QN66-2008	9.4	5.4	97.9	94.7	6.6	19.3	14.5	7.8
QS95-6004	7.7	5.7	80.2	99.1	5.4	15.5	11.7	8.5
R570	6.3	5.2	65.6	90.4	4.3	12.4	9.4	8.2

Simulation of biomass yields from traits- no calibration

- Dalbeg
- Homehill

Dalbeg

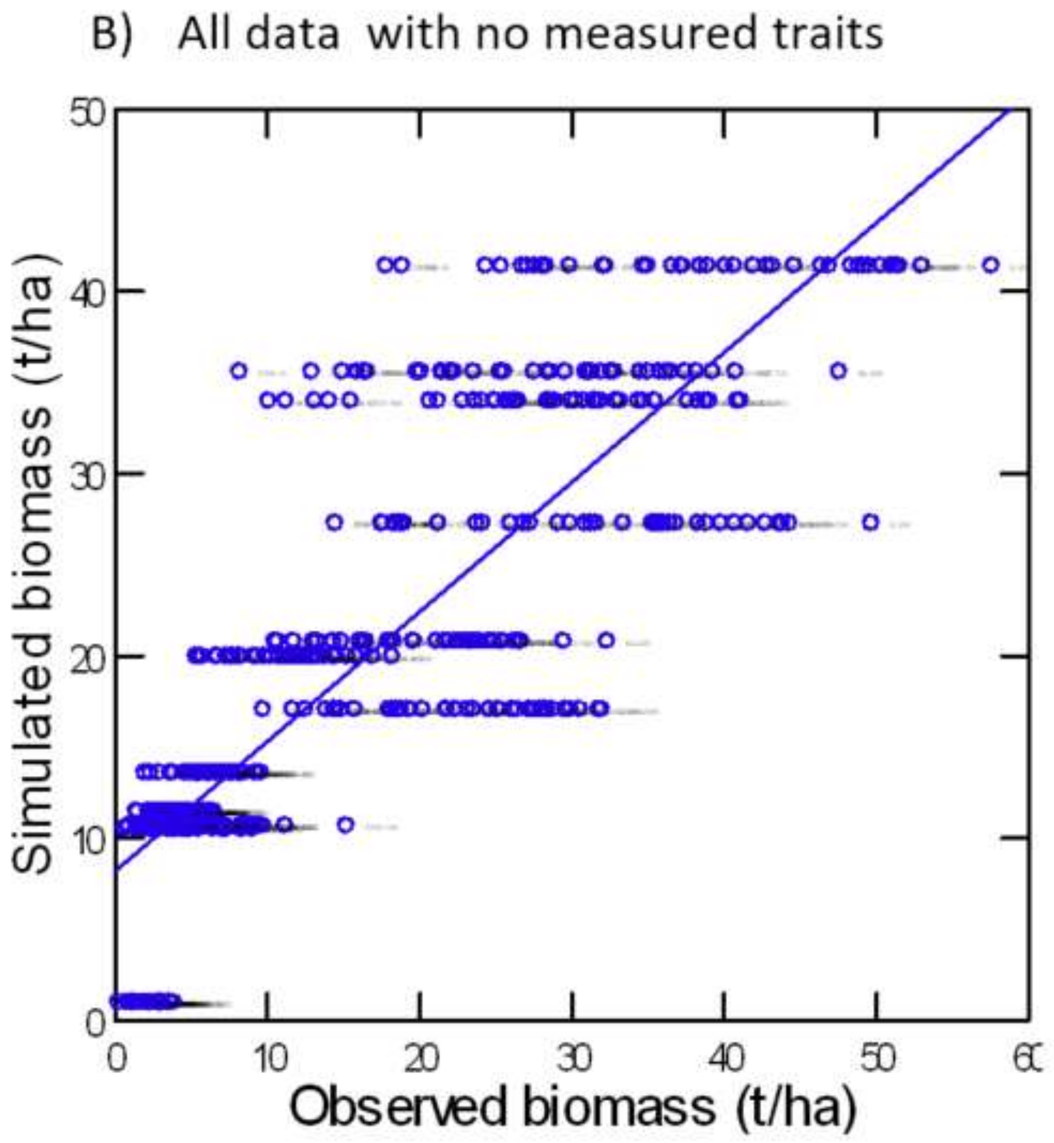
A) All data (plant and R2) with all measured traits



Dependent Variable	¦	BIOMASS
N	¦	480
Multiple R	¦	0.855
Squared Multiple R	¦	0.731
Adjusted Squared Multiple R	¦	0.730
Standard Error of Estimate	¦	6.397

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error
CONSTANT	7.283	0.465
TDM	0.772	0.021



Dependent Variable		BIOMASS
N		480
Multiple R		0.836
Squared Multiple R		0.699
Adjusted Squared Multiple R		0.699
Standard Error of Estimate		6.364

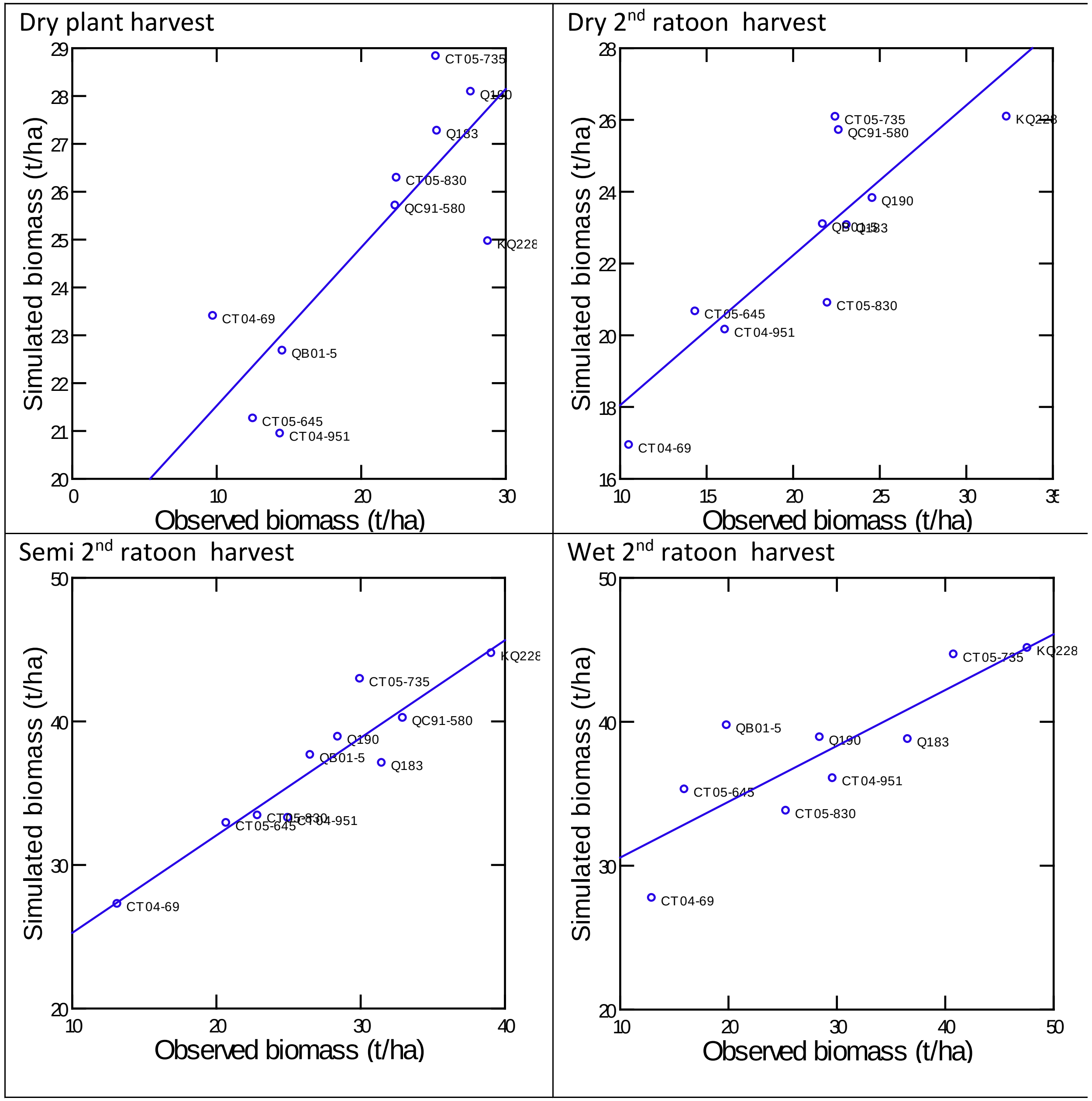
Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error
CONSTANT	8.234	0.463
TDM	0.711	0.021

R^2 for the plant (0) and second ratoon crop (2) at Dalbeg, for simulated versus biomass measured at harvest and prior to the wet season (6 months) for three irrigation treatments; dry, semi-dry (sem) and well irrigated (wet).

			All clones (n=40)	n=7	n=18	n=10
Traits included in model			All traits	+ESW+TE	+TE	+ESW
Treat	Crop	Stage				
dry	0	Harvest	0.235**	0.659*	0.133	0.661**
dry	0	6 months	0.272**	0.234	0.377**	0.18
dry	2	Harvest	0.438**	0.52	0.240*	0.715**
dry	2	6 months	0.085	0.047	0.045	0.078
sem	0	Harvest	0.207**	0.289	0.104	0.441*
sem	0	6 months	0.335**	0.224	0.097	0.373
sem	2	Harvest	0.479**	0.633*	0.180	0.867**
sem	2	6 months	0.468**	0.046	0.389**	0.284
wet	0	Harvest	0.282**	0.376	0.114	0.494*
wet	0	6 months	0.329**	0.165	0.192*	0.35
wet	2	Harvest	0.433**	0.463	0.239*	0.707**
wet	2	6 months	0.555**	0.012	0.314*	0.239

-Negative slope, * = significant with p=0.05, ** = significant with p=0.01 or less



Dry plant harvest
Simulated biomass (t/ha)
Observed biomass (t/ha)
CT05-735
Q190
Q183
CT05-830
QC91-580
KQ228
CT04-69
QB01-5
CT05-645
CT04-951
Dry 2nd ratoon harvest
Simulated biomass (t/ha)
Observed biomass (t/ha)
CT05-735
QC91-580
KQ228
Q190
Q183
CT05-830
CT05-645
CT04-951
CT04-69
Semi 2nd ratoon harvest
Simulated biomass (t/ha)
Observed biomass (t/ha)
KQ228
CT05-735
QC91-580
Q190
QB01-5
Q183
CT05-830
CT04-951
CT05-645
CT04-69
Wet 2nd ratoon harvest
Simulated biomass (t/ha)
Observed biomass (t/ha)
CT05-735
KQ228
QB01-5
Q190
Q183
CT04-951
CT05-645
CT05-830
CT04-69

R^2 for a plant (0) and two ratoon crops (1 and 2) at Home Hill, for simulated versus biomass measured at harvest for two irrigation treatments; dry and well irrigated (wet).

Number of clones			All dones (n=40)			n=7	n=18	n=10
Traits included in model			All traits	-ESW	-ESW-TE	+ESW+TE	+TE	+ESW
Treat	Crop	Stage						
dry	0	Harvest	0.062	0.281**	0.268**	0.002	0.004	0.013
dry	1	Harvest	0.249**	0.355**	0.358**	0.517	0.114	0.425*
dry	2	Harvest	0.053-	0.049-	0.032-	0.342-	-0.060	0.256
wet	0	Harvest	0.282**	0.237**	0.224**	0.546	0.272*	0.561**
wet	1	Harvest	0.441**	0.457**	0.452**	0.215	0.303**	0.542**
wet	2	Harvest	0.331**	0.294**	0.310**	0.522	0.361**	0.428**

-Negative slope, * = significant with p=0.05, ** = significant with p=0.01 or less

Conclusions

- Significant variation in biomass yield between 40 clones was explained by variation in traits measured
- Vigour traits (RUE and LAI) alone can explain a lot of variation when yields are moderate to high
- Extractible soil water helped to some extent
- TE did not explain much clone variation
- GxE not explained when E=very dry

Part 2: New APSIM Sugar features

- TEC (transpiration efficiency coefficient)
  = f(water stress and CO_2)
- Hourly from daily Radiation, temperature and VPD
- Hourly transpiration limited by root water supply (RWS)
- Hourly transpiration limited by max transpiration set by user
- Root water supply = f(root length volume)
- Respiration of sugars
- RUE defined by leaf not growth stage

APSIM Sugar – new features

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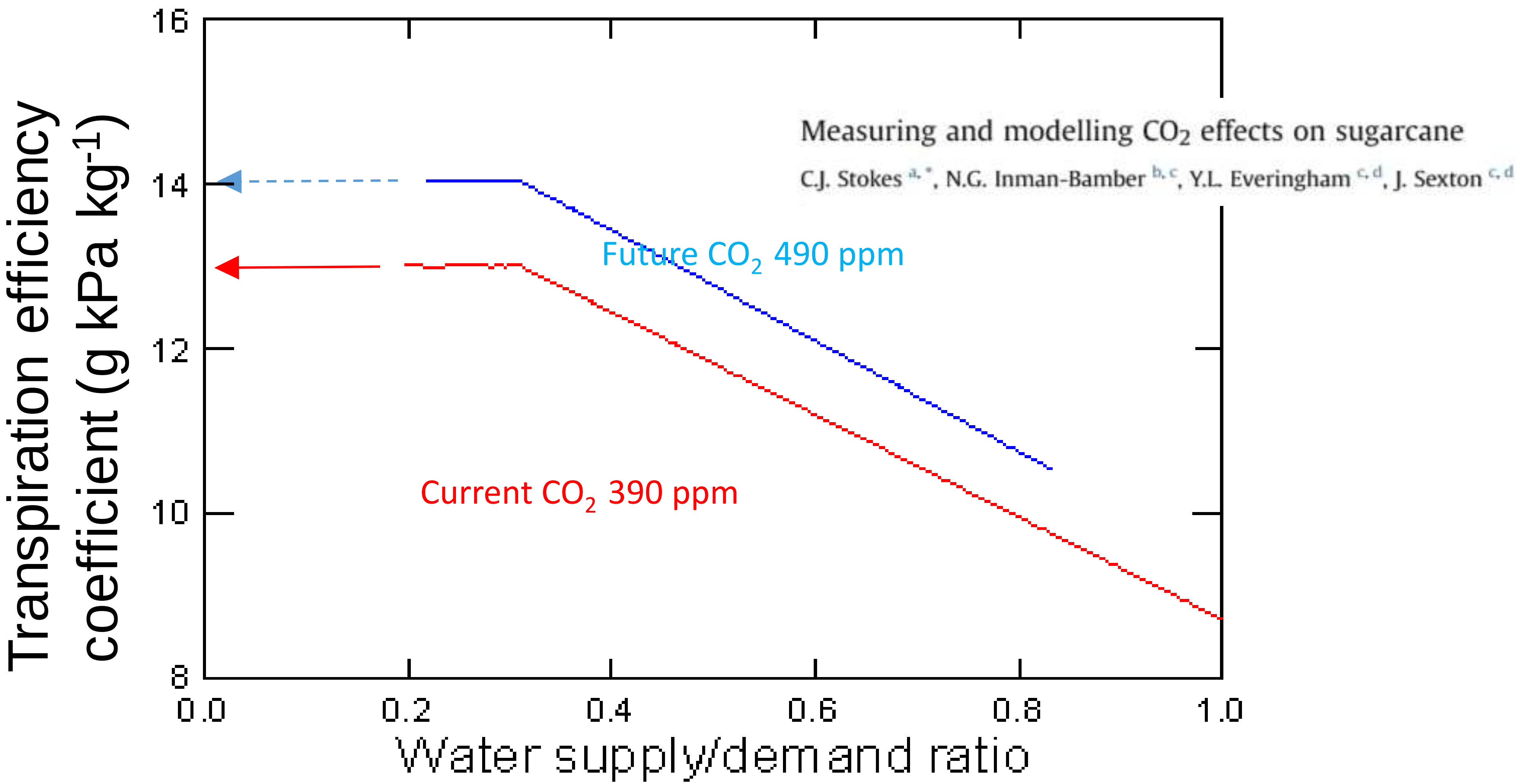
Sugarcane for water-limited environments: Enhanced capability of the APSIM sugarcane model for assessing traits for transpiration efficiency and root water supply

N.G. Inman-Bamber[a,*], P.A. Jackson[b], C.J. Stokes[c], S. Verrall[d], P. Lakshmanan[e], J. Basnayake[f]

[a] College of Science, Technology and Engineering, James Cook University, Townsville, Australia
[b] CSIRO Agriculture, Australian Tropical Science and Innovation Precinct, Townsville, Australia
[c] CSIRO Land and Water, Australian Tropical Science and Innovation Precinct, Townsville, Australia
[d] CSIRO Agriculture, Biosciences Precinct, Dutton Park, Australia
[e] Sugar Research Australia, 50 Meiers Road, Indooroopilly, Australia
[f] Sugar Research Australia, Bruce Highway, Brandon, Australia

Transpiration efficiency coefficient (TEC) and water stress and CO_2



Potential transpiration = Intercepted radiation * RUE * VPD_i / TEC

				Transpiration		Biomass
Hour	**VPD**	**Radiation incoming**		**limit**	**actual**	**gain**
	kPa	**(W/m2)**	**(MJ/m2)**	**mm/h**	**mm/h**	**g/m2**
6	0.10	50	0.18	2.00	0.00	0.24
7	0.20	200	0.72	2.00	0.02	0.95
8	0.50	500	1.80	2.00	0.14	2.38
9	1.00	800	2.88	2.00	0.44	3.81
10	1.50	1000	3.60	2.00	0.82	4.77
11	2.00	1050	3.78	2.00	1.15	5.00
12	2.50	1100	3.96	2.00	1.51	5.24
13	2.00	1050	3.78	2.00	1.15	5.00
14	1.50	1000	3.60	2.00	0.82	4.77
15	1.00	800	2.88	2.00	0.44	3.81
16	0.50	500	1.80	2.00	0.14	2.38
17	0.20	200	0.72	2.00	0.02	0.95
18	0.10	50	0.18	2.00	0.00	0.24
Totals			**29.88**		**6.65**	**39.56**
				TE		**5.95** g/kg

LAI = 3.5
TEC = 8.7 g kPa/kg
RUE = 1.8 g/MJ

$$\text{Potential transpiration} = \text{Intercepted radiation} * \text{RUE} * \text{VPD}_i \;/\; \text{TEC}$$

				Transpiration		Biomass
Hour	**VPD**	**Radiation incoming**		**limit**	**actual**	**gain**
	kPa	**(W/m2)**	**(MJ/m2)**	**mm/h**	**mm/h**	**g/m2**
6	0.10	50	0.18	0.80	0.00	0.24
7	0.20	200	0.72	0.80	0.02	0.95
8	0.50	500	1.80	0.80	0.14	2.38
9	1.00	800	2.88	0.80	0.44	3.81
10	1.50	1000	3.60	0.80	0.80	4.64
11	2.00	1050	3.78	0.80	0.80	3.48
12	2.50	1100	3.96	0.80	0.80	2.78
13	2.00	1050	3.78	0.80	0.80	3.48
14	1.50	1000	3.60	0.80	0.80	4.64
15	1.00	800	2.88	0.80	0.44	3.81
16	0.50	500	1.80	0.80	0.14	2.38
17	0.20	200	0.72	0.80	0.02	0.95
18	0.10	50	0.18	0.80	0.00	0.24
Totals			**29.88**		**5.20**	**33.80**
				TE		**6.50**

g/kg

LAI = 3.5

TEC = 8.7 g kPa/kg

RUE = 1.8 g/MJ

Root water supply (RWS)

Combined soil hydraulic conductivity – root length coefficient

Extractible soil water (mm) in layer n

- *Old*

$$RWS_n = kl_n * ESW_n \quad (\text{mm d}^{-1})$$

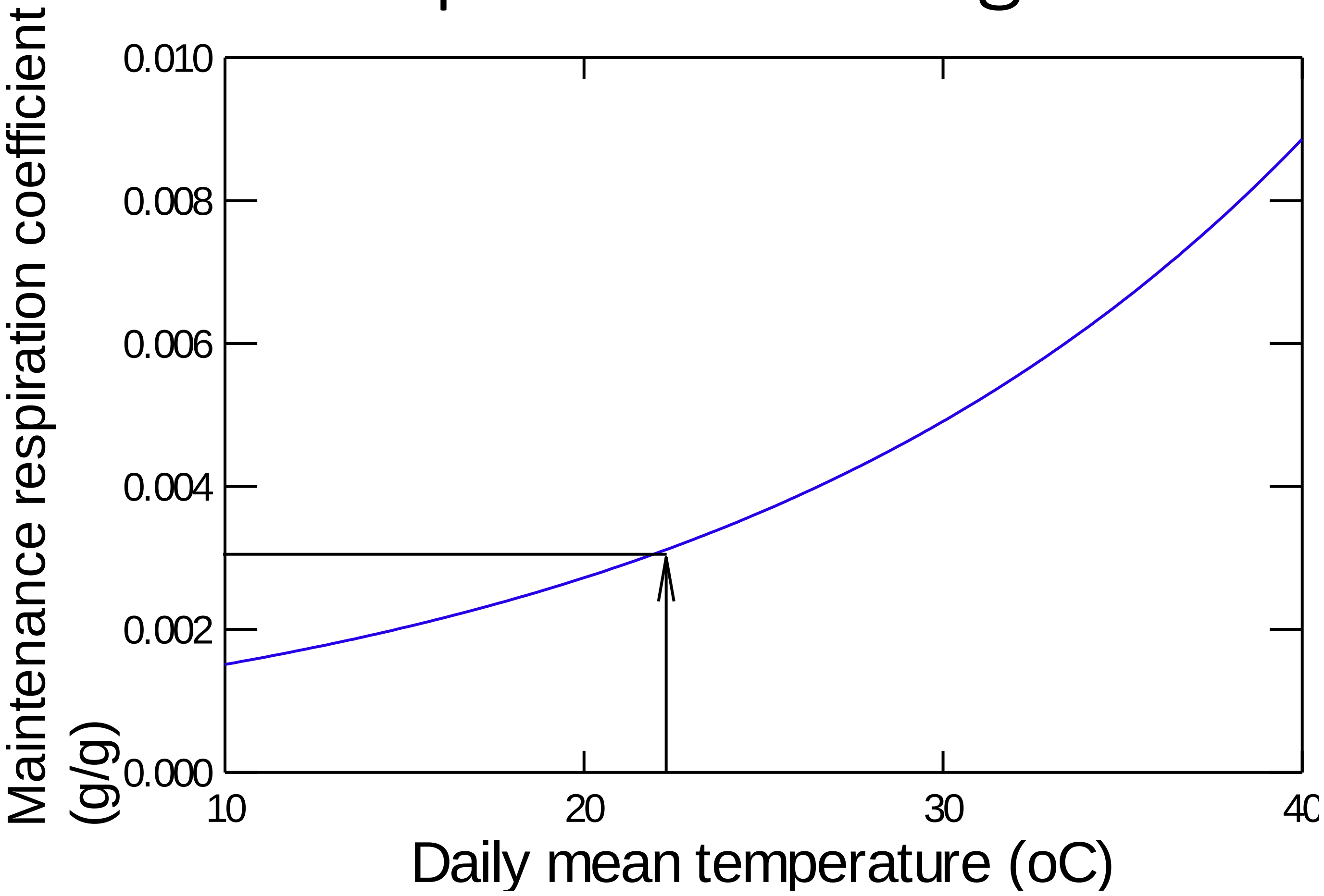
- *New*

$$RWS_n = RLV_n * 100 * k_n * ESW_n \quad (\text{mm d}^{-1})$$

Soil hydraulic conductivity coefficient

Root length per mm^3

Respiration of sugars



Maintenance respiration coefficient from Liu and Bull (2001) in response to daily mean temperature.

<x_tmean units="oC">   10   15   20   25   30   35</x_tmean>
<y_suc_resp_fr units="0-1">0.0015 0.0020 0.0027 0.0036 0.0049 0.0066 </y_suc_resp_fr>

RUE by leaf stage (growth slowdown)

- Old

  <stage_names>sowing sprouting emergence begin_cane flowering end_crop</stage_names>

  <rue> 0 0 1.8 1.8 1.8 0.0 </rue>

- New

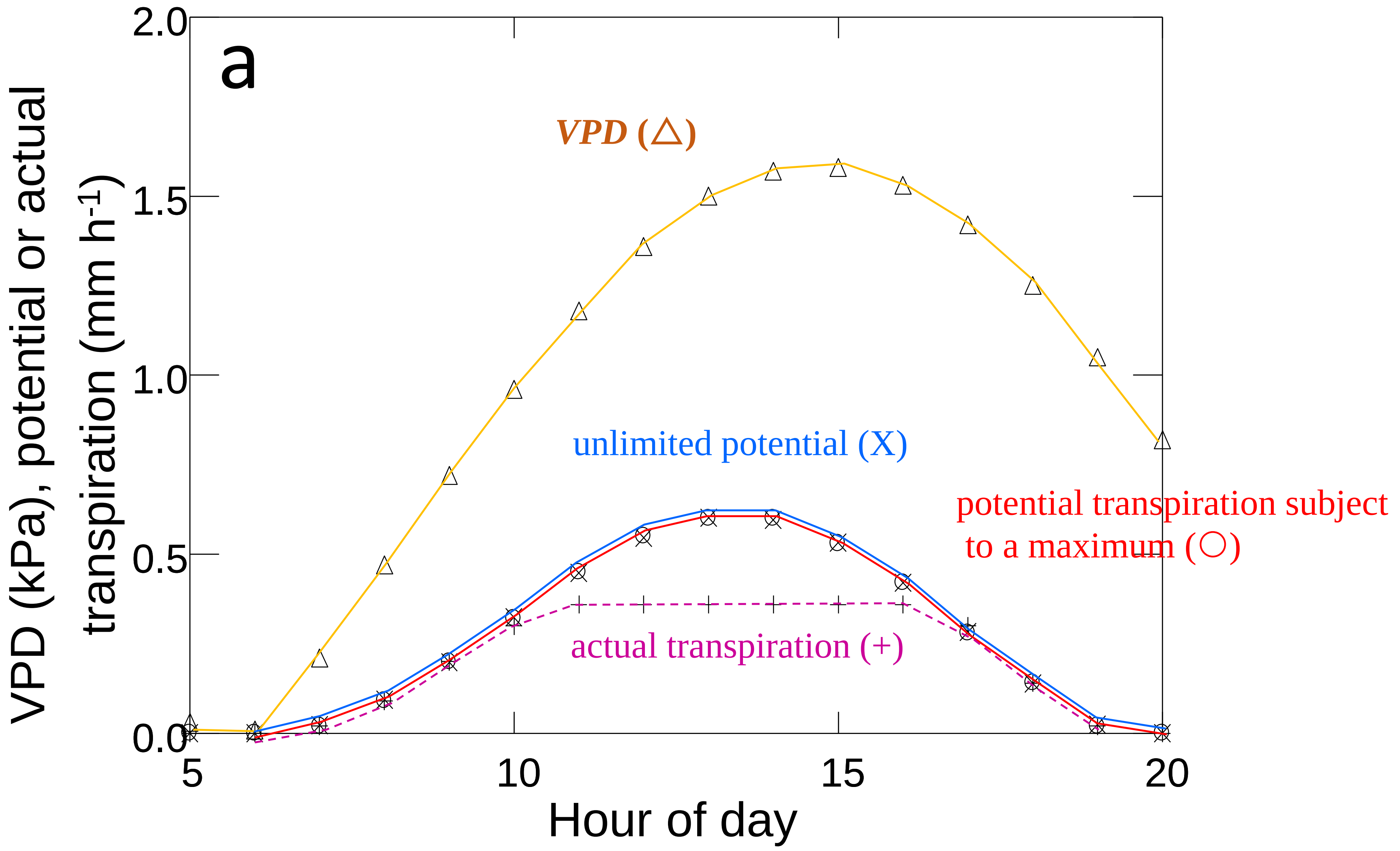
  <x_leaf_no> 1 10 24 </x_leaf_no>

  <y_rue_leaf_no_fact> 1.0 1.0 0.85 </y_rue_leaf_no_fact>

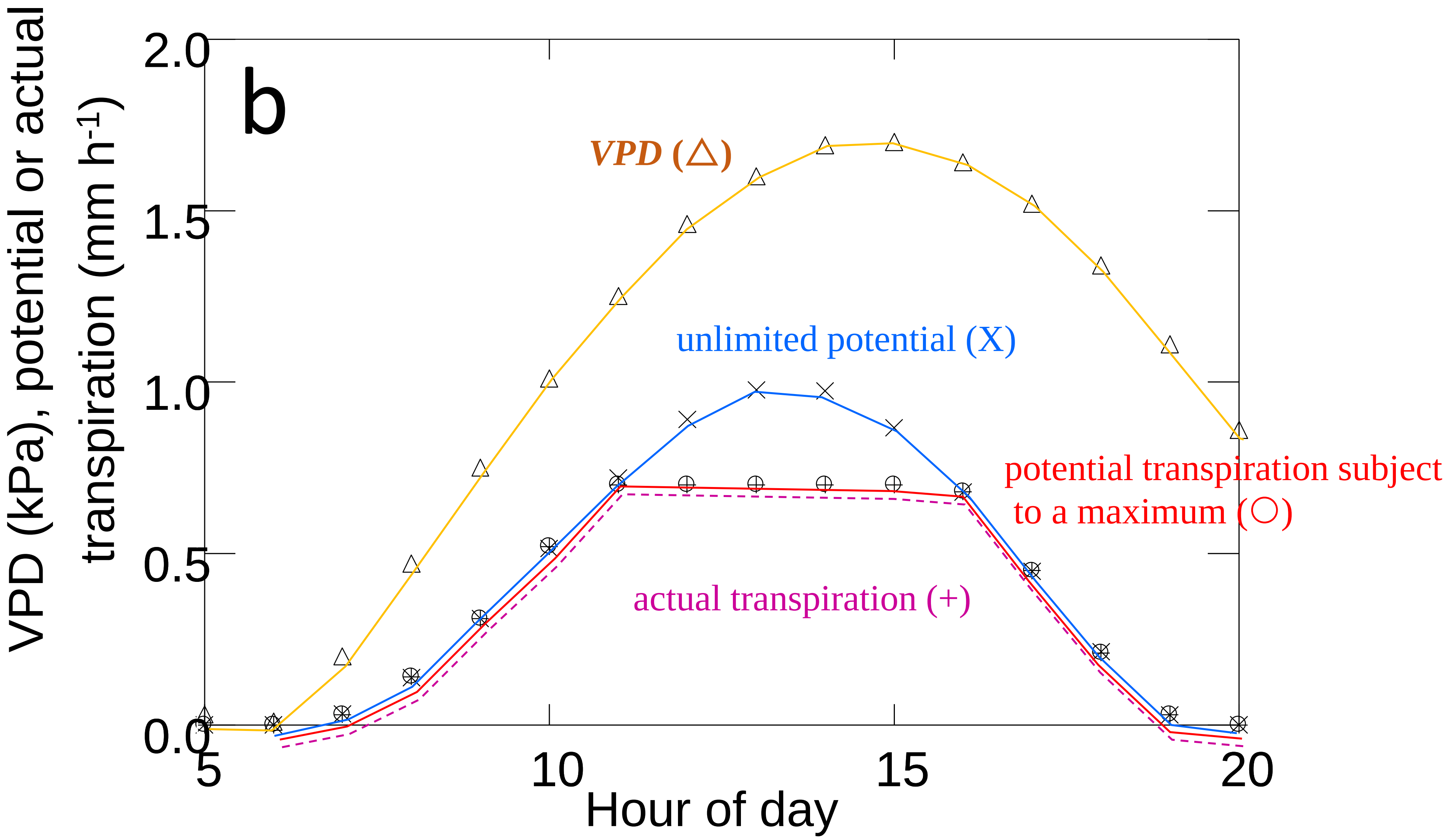
Keating et al (1999) dataset used for validation 13 of the 19 experiments

Exp (treat)	Region	Variety	Crop class	Treatment	Irrig (mm)	N_1
1	Harwood	Q117	Plant	None	1275	16
2	Ingham	Q117	Plant	None	698	11
3	Ingham	Q117	1st ratoon	None	662	11
5	Ayr	Q96	Plant	None	3400	10
6	Ayr	Q117	1st ratoon	None	4913	13
7	Pongola	N14	Plant	None	725	5
8(c)	Bundaberg	CP51-21	1st ratoon	340 kg N ha^{-1}	479	7
8(c)	Bundaberg	CP51-21	2nd ratoon	170 kg N ha^{-1}	201	3
9(a)	Bambaroo	Q124	Plant	1) Fully irrigated	481	4
9(b)	Bambaroo	Q124	Plant	2) Limited	349	4
9(c)	Bambaroo	Q124	Plant	3) Rainfed	0	4
10(a)	La Mercy	NCo376	1st ratoon	None	0	0
10(b)	La Mercy	NCo376	1st ratoon	Irrigation 1	909	0
10(c)	La Mercy	NCo376	1st ratoon	Irrigation 2	782	0
10(d)	La Mercy	NCo376	1st ratoon	Irrigation 3	801	0
10(e)	La Mercy	NCo376	1st ratoon	Irrigation 4	348	0
Total						182

Results from added features



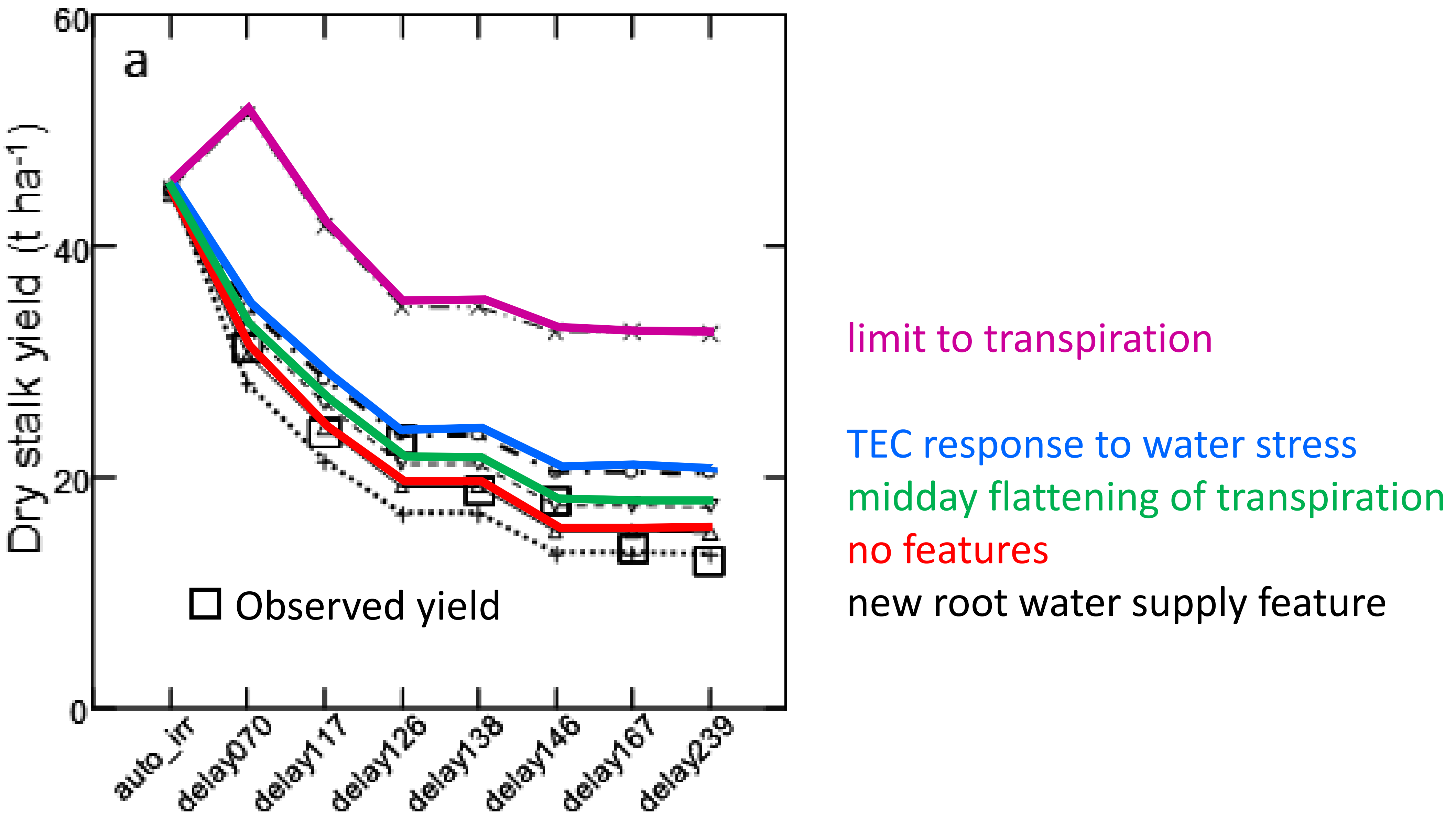
on a day when root water supply was limiting (RWS/T_0=0.77)



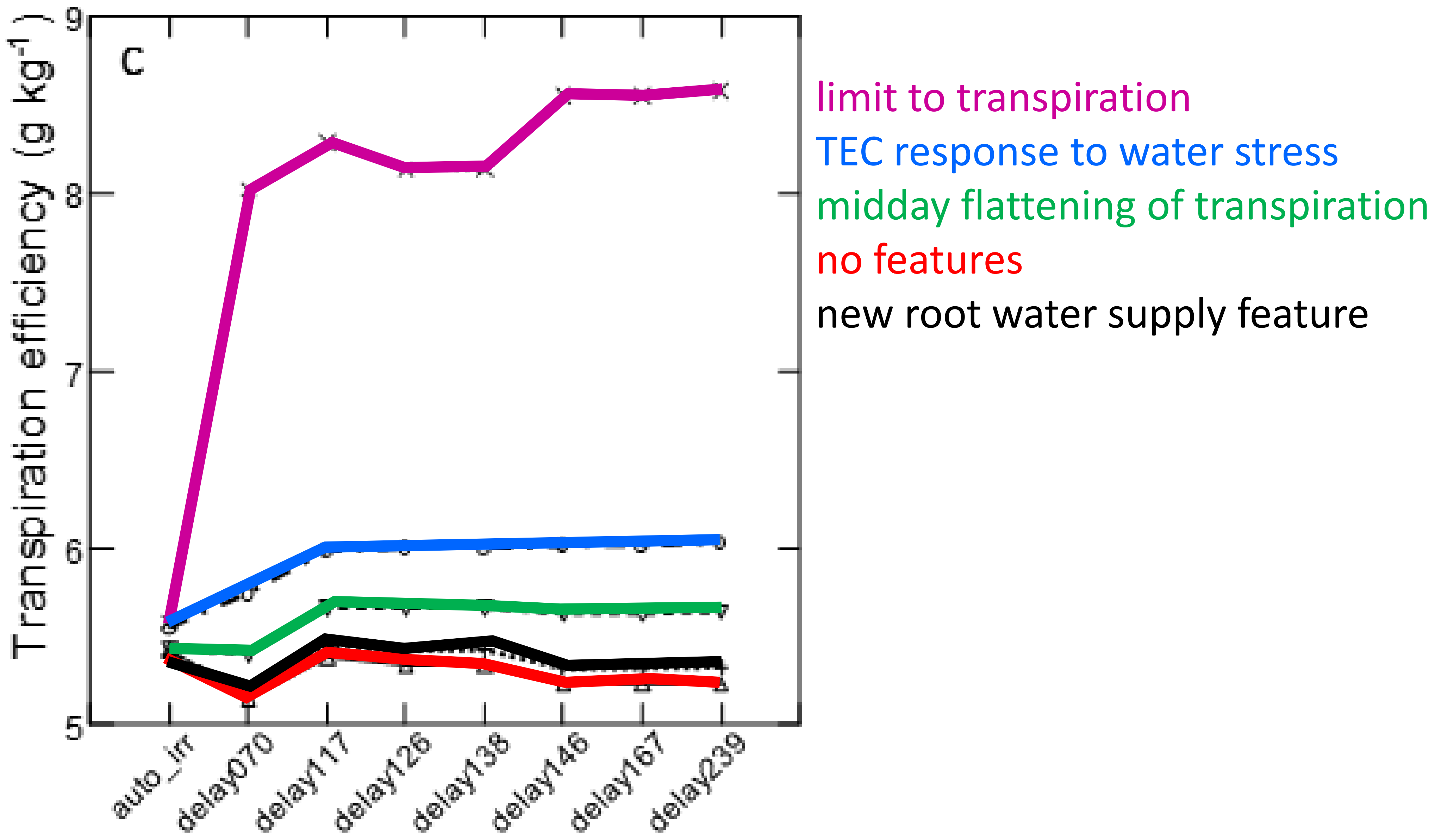
on a day when root water supply was adequate (RWS/T_0=1, maximum transpiration = 0.7 mm h^{-1}).

Regression and Willmott's statistics for 13 experiments (182 observations)

TEC response to water stress	Midday flattening of trans-piration	Limit to trans-piration	Separate *k* and *l*	R^2	Cons-tant ($t\ ha^{-1}$)	Slope	D	Syste-matic RMSE ($t\ ha^{-1}$)
X	X	X	X	0.867	-0.37	1.07	0.959	2.31
✓	X	X	X	0.862	-0.52	1.08	0.956	2.69
X	✓	X	X	0.864	-0.67	1.08	0.957	2.51
✓	✓	X	X	0.858	-0.80	1.09	0.954	2.87
X	✓	✓	X	0.831	-0.35	1.00	0.952	0.33
X	X	X	✓	0.868	-0.52	1.07	0.960	2.07
✓	X	X	✓	0.862	-0.63	1.08	0.956	2.53
X	✓	X	✓	0.865	-0.63	1.08	0.958	2.35
✓	✓	X	✓	0.858	-1.07	1.09	0.955	2.53
X	✓	✓	✓	0.830	-0.20	1.00	0.952	0.22



a
Dry stalk yield (t ha-1)
60
40
20
0
auto_irr
delay070
delay117
delay126
delay138
delay146
delay167
delay239
Observed yield
limit to transpiration
TEC response to water stress
midday flattening of transpiration
no features
new root water supply feature



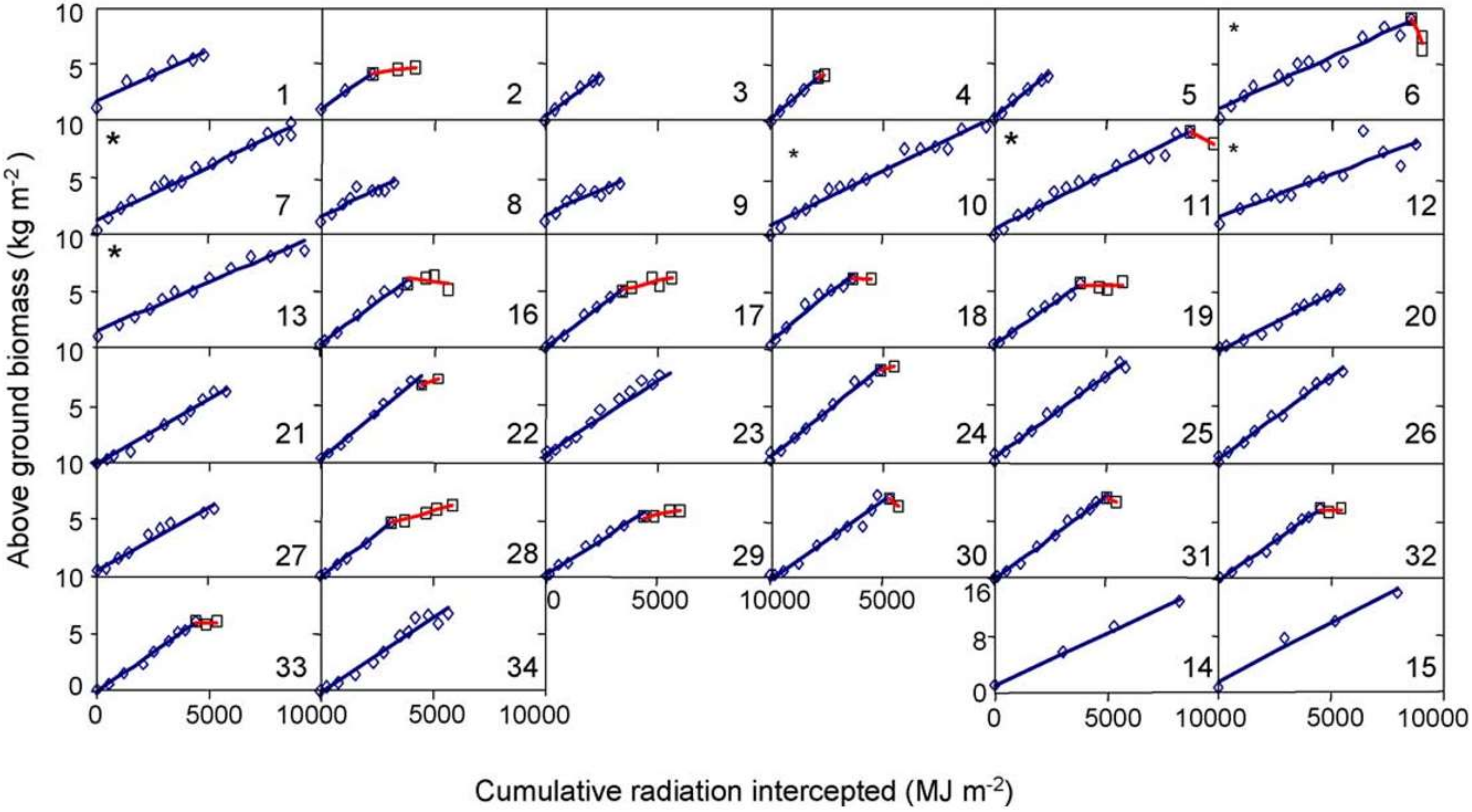
c
Transpiration efficiency (g kg^{-1})
9
8
7
6
5
auto_irr
delay070
delay117
delay126
delay138
delay146
delay167
delay239
limit to transpiration
TEC response to water stress
midday flattening of transpiration
no features
new root water supply feature

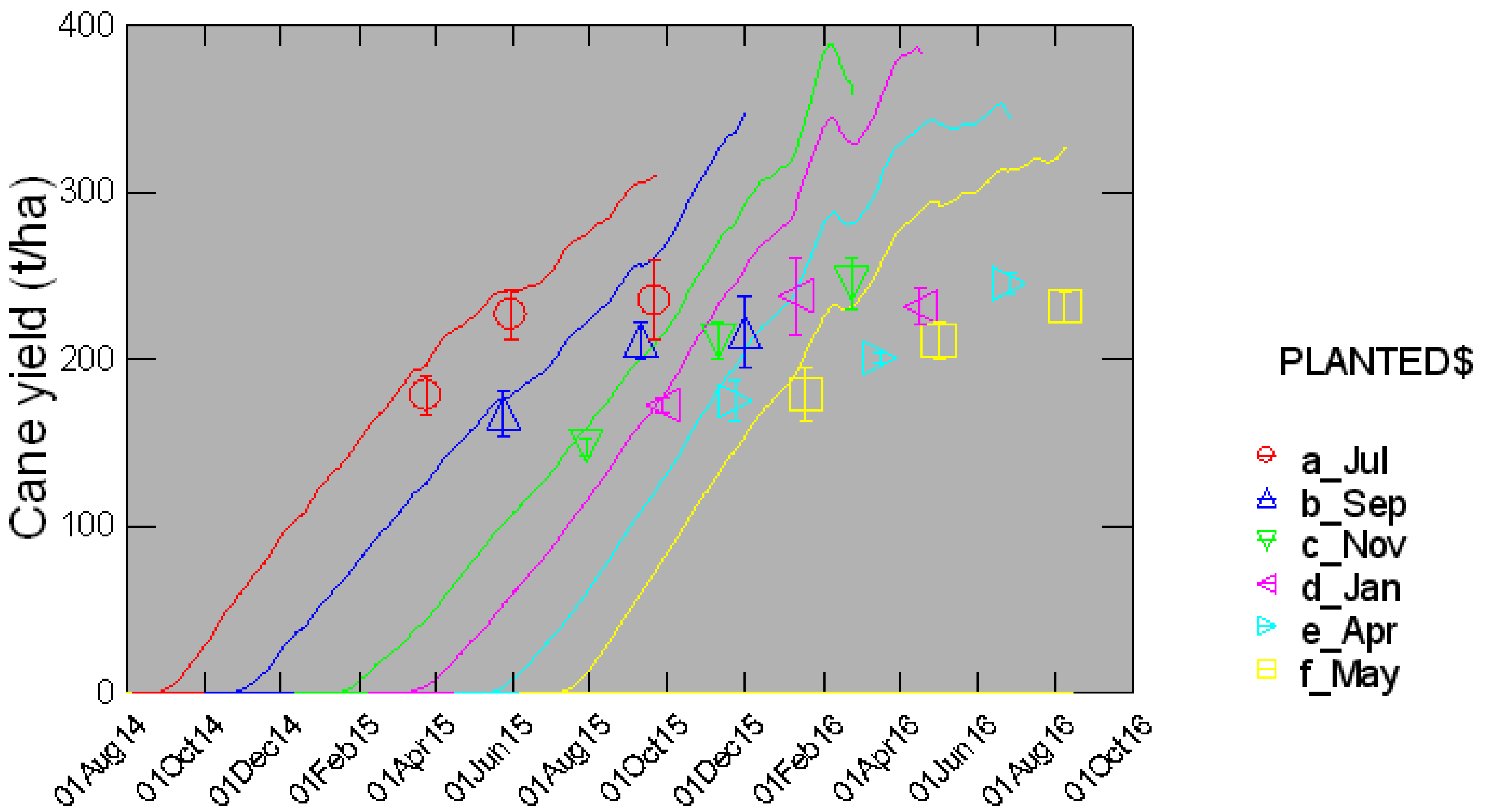
Effect of setting a maximum hourly transpiration rate (0.5 to 0.7 mm h^{-1} for S = 0 to 1) on biomass yield and transpiration efficiency (TE) for a 12-month plant crop simulation (planted on 1st September) at Kalamia and Bundaberg.

Location	PAWC (mm)	Max transpiration (mm h^{-1})	Biomass yield (t ha^{-1})	TE (g Kg^{-1})	Stress-days
Kalamia with full irrigation	287	No maximum	74.1	4.06	13.1
	287	0.5 to 0.7	61.9	4.17	0.0
	76	No maximum	48.5	4.28	74.7
	76	0.5 to 0.7	55.2	4.84	44.7
Bundaberg with no irrigation	287	No maximum	49.9	7.20	50.0
	287	0.5 to 0.7	59.8	8.60	43.9
	76	No maximum	32.9	7.53	82.2
	76	0.5 to 0.7	46.7	10.61	79.7

RUE by leaf stage - slowdown

- Growth analysis experiment 2014 to 2016, plant crop only
  - Brazil, Piaui, Guadalupe
  - Six varieties
  - Six planting dates at ~ 2 month intervals
  - Harvesting at 8, 11.5 and 15 months for yield and quality (ATR)
  - Ceptometer PAR interception et al
  - Four replications, fully randomized.
- Variety trial Cn1 plant and ratoon crop
- Kind permission from **Terracal Alimentos e Bioenergia**

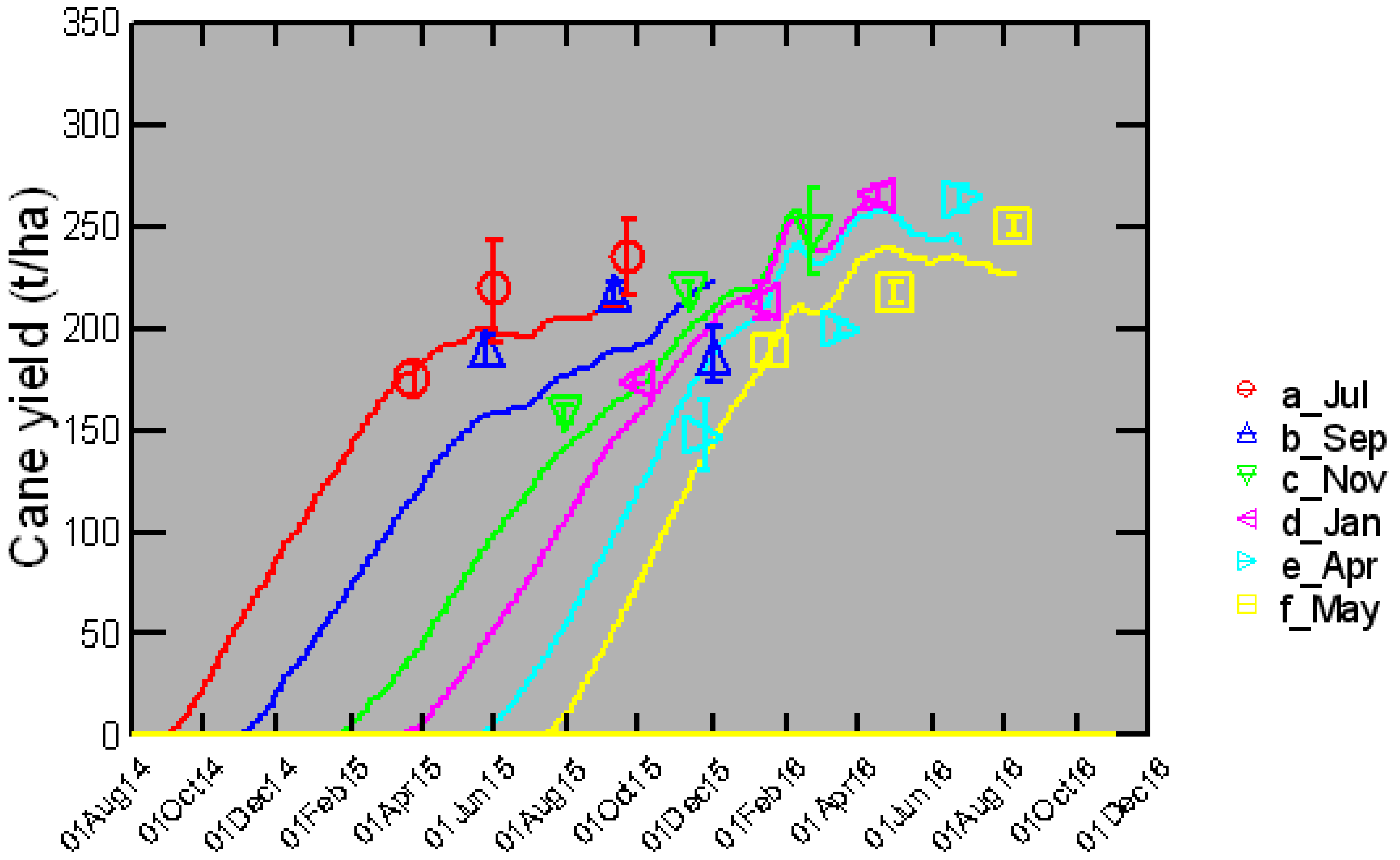

Above ground biomass (kg m-2)
Cumulative radiation intercepted (MJ m-2)
1
2
3
4
5
6
7
8
9
10
11
12
13
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
14
15
0
5
10
8
16
0
5000
10000



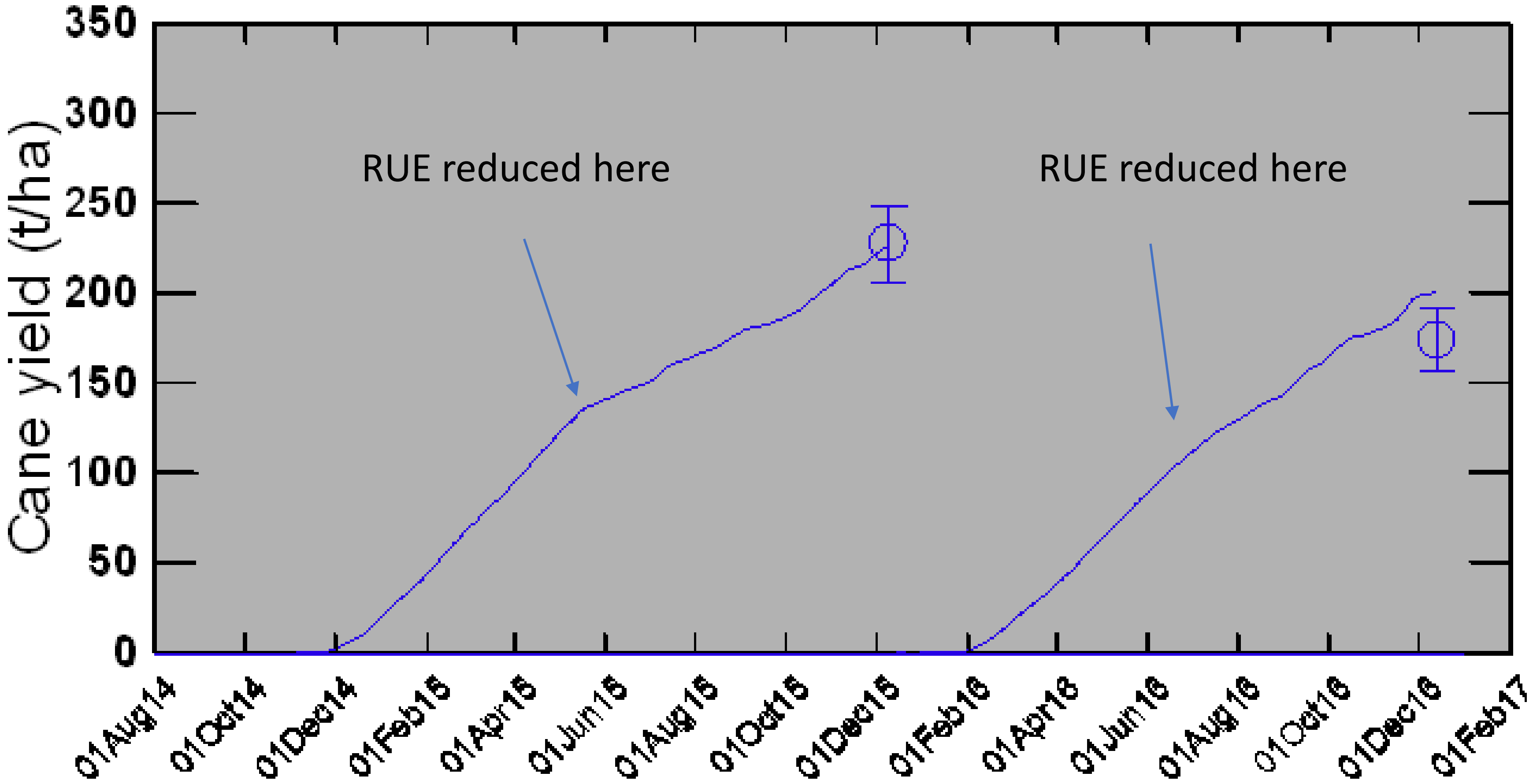
Measured and simulated* cane yield of variety RB867515 planted on six occasions time series with lines representing simulated yields and symbols the observed yields. * Simulated with modifications for accurate simulation of PAR interception

Table 1. Growth reduction (slow-down) factors applied to radiation use efficiency (1.8 g/MJ) at distinct growth stages defined by the number of fully emerged leaves on primary stalks.

Leaf stage	1	20	25	30	35	40	45	50	60	80
RB867515	1.00	1.00	1.00	1.00	0.90	0.60	0.50	0.50	0.40	0.40
RB98710	1.00	1.00	0.90	0.80	0.60	0.50	0.40	0.30	0.30	0.30
RB92579	1.00	1.00	1.00	1.00	0.90	0.60	0.50	0.50	0.50	0.50
RB961003	1.00	1.00	1.00	0.95	0.90	0.70	0.70	0.70	0.70	0.70
SP94-3206	1.00	1.00	1.00	1.00	0.90	0.60	0.50	0.50	0.40	0.40
RB931003	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.50	0.40	0.40



Cane yield (t/ha)
350
300
250
200
150
100
50
0
01Aug14
01Oct14
01Dec14
01Feb15
01Apr15
01Jun15
01Aug15
01Oct15
01Dec15
01Feb16
01Apr16
01Jun16
01Aug16
01Oct16
01Dec16
a_Jul
b_Sep
c_Nov
d_Jan
e_Apr
f_May



Mean cane yield over three varieties (RB867515, RB931003 and RB92579), simulated (lines) and measured (symbols) for test Cn1 at Guadalupe, for the plant and 1st ratoon crops.

APSIM new features conclusions 1

- Parameter settings for the new features were based on the best evidence available
- accuracy of the simulation of observed biomass, changed only to a minor extent
- Separating *k* and *l* had the most consistent effect on improving model performance.
- The simulation of two new experiments was remarkably accurate regardless of which features were used in the simulation.
- Dry stalk yields reported for the third new experiment were simulated accurately with
  - no new features
  - midday flattening of transpiration
  - separate *k* and *l* enabled

APSIM new features conclusions 2

- Effects of conductance on TE can now be simulated by limiting maximum hourly transpiration at the leaf level or *k* and specific root length at the root level.
- Better discrimination between sugarcane cultivars, now that vigour traits such leaf area development and radiation use efficiency are linked to root water uptake.
- Credible method for avoiding simulation of excessive yields

Publications

- Inman-Bamber, N.G., Lakshmanan, P., Park, S., 2012. Sugarcane for water-limited environments: Theoretical assessment of suitable traits. Field Crops Research, 134, 95-104.
- Basnayake, J., Jackson, P.A., Inman-Bamber, N.G., Lakshmanan, P., 2012a. Sugarcane for water-limited environments. Genetic variation in cane yield and sugar content in response to water stress. Journal of Experimental Botany, 63, 6023-6033.
- Sexton, J., Inman-Bamber, N. G., Everingham, Y., Basnayake, J., Lakshmanan, P., Jackson, P., 2014. Detailed trait characterisation is needed for simulation of cultivar responses to water stress. Proceedings Australian Society of Sugar Cane Technologists, 36, CD-ROM.
- Jackson, P., Basnayake, J., Inman-Bamber, G., Lakshmanan, P., 2014. Selecting sugarcane varieties with higher transpiration efficiency. Proceedings Australian Society of Sugar Cane Technologists, 36, CD-ROM.
- Basnayake, J., Jackson, P.A., Inman-Bamber, N.G., Lakshmanan, P., 2015. Sugarcane for water-limited environments. Variation in stomatal conductance and its genetic correlation with crop productivity. Journal of Experimental Botany, 66, 3945-3958
- Jackson, P., Basnayake, J., Inman-Bamber, G., Lakshmanan, P., Stokes, C., 2016. Genetic variation in whole plant transpiration efficiency in sugarcane, and relationships with leaf gas exchange measurements. Journal Experimental Botany, 67, 861-871.

Midday flattening of transpiration under stress

- *R* = Radiation (MJ m^{-2})
- *E* = extinction coefficient
- *RUE* = radiation use efficiency (g MJ^{-1})
- *LAI* = leaf area index
- *VPD* = vapour pressure deficit (kPa)
- *TEC* = for the previous day (g kPa kg^{-1})
- T_0 = potential transpiration
- T_A = actual transpiration (mm or kg/m^2)
- *B* = biomass gain (g/m2)
- TE = transpiration efficiency
- *i* = i^{th} hour of day

- $T_{Oi} = R_i(1-exp(-E.LAI)) * RUE * VPD_i / TEC$
- $T_{Ai} = min(T_{Oi}, RWS_i)$
- $B_i = T_{Ai} * TEC/VPD_i$
- $TE = \left(\sum_i^l B_i\right)/\left(\sum_i^l T_{Ai}\right)$

Association between Ps, Gs and Ci in sugarcane