

COMPUTER CROP MODELS AS A MANAGEMENT TOOL

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Scope

- Crop modelling History
 - CANEGRO sugarcane model
 - Evolution of a benchmarking tool
 - Models as a management tool
 - Harvest Planning
 - Performance monitoring
 - Replant Planning
 - Irrigation scheduling
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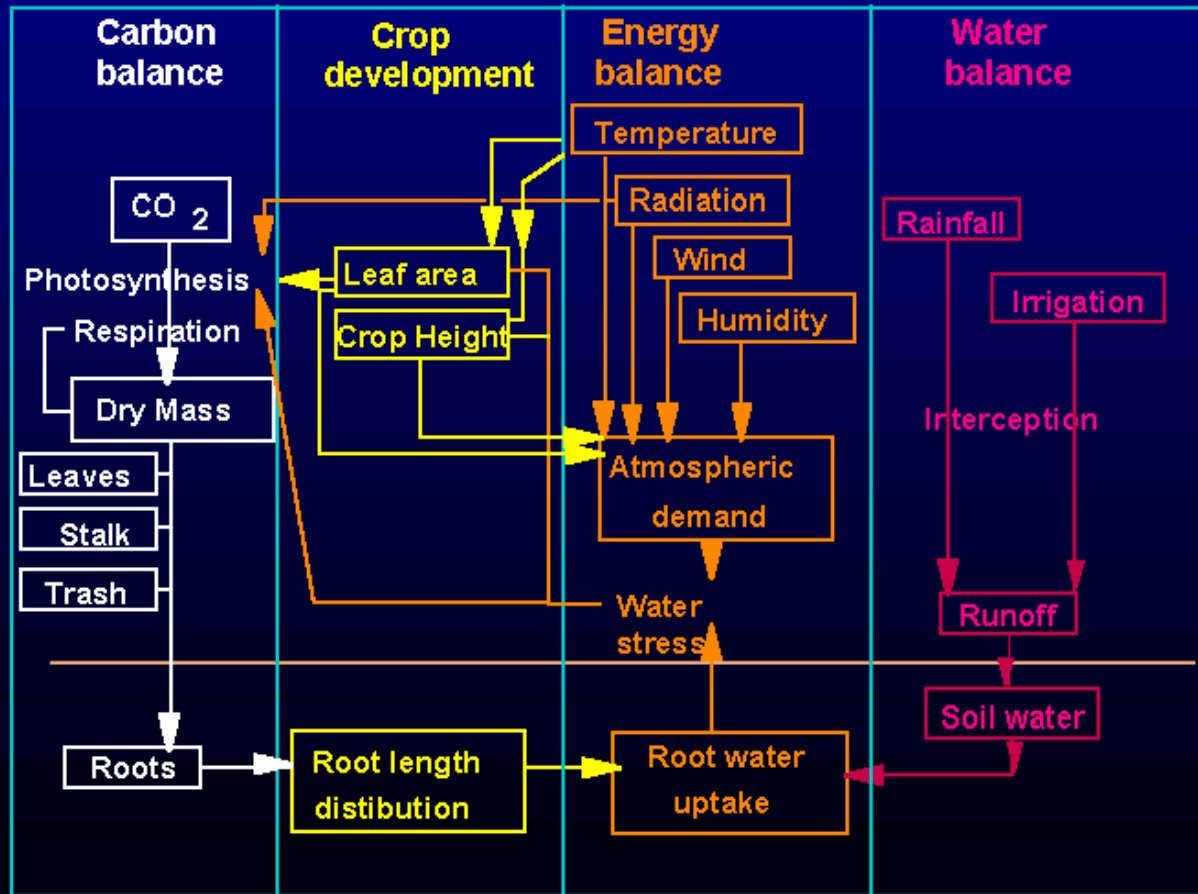
History

- Development started during the 70's
 - Initially of Maize, Wheat, Sorghum
 - Development on Sugarcane models began during early 80's
 - South Africa – CANEGRO
 - Australia – AusCane, Qcane, APSIM
 - Many others throughout the world
 - Initially a research tool to compliment conventional experimentation
 - Pressure to use models to assist agri-business
 - Development continues today
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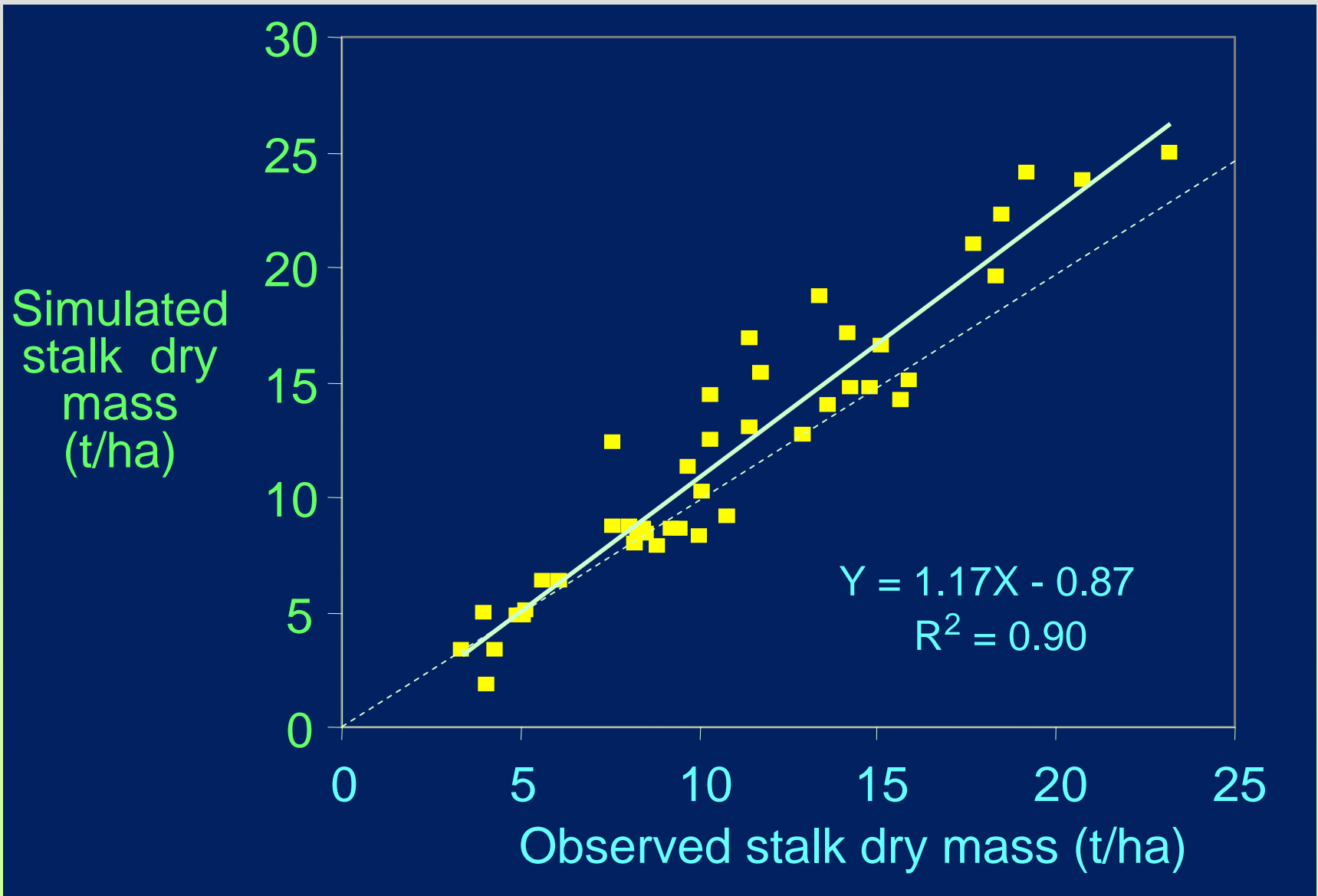
The CANEGRO crop model

- Developed primarily in South Africa
 - International consortium – DSSAT
 - Primarily climate-driven
 - Features
 - Hesketh-McCree RUE-based Carbon Balance
 - Water balance – multi-layer single dimension model
 - Energy Balance – Sugarcane-specific Penman-Monteith
 - Mechanistic canopy development routine
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CANEGRO - Conceptual Basis

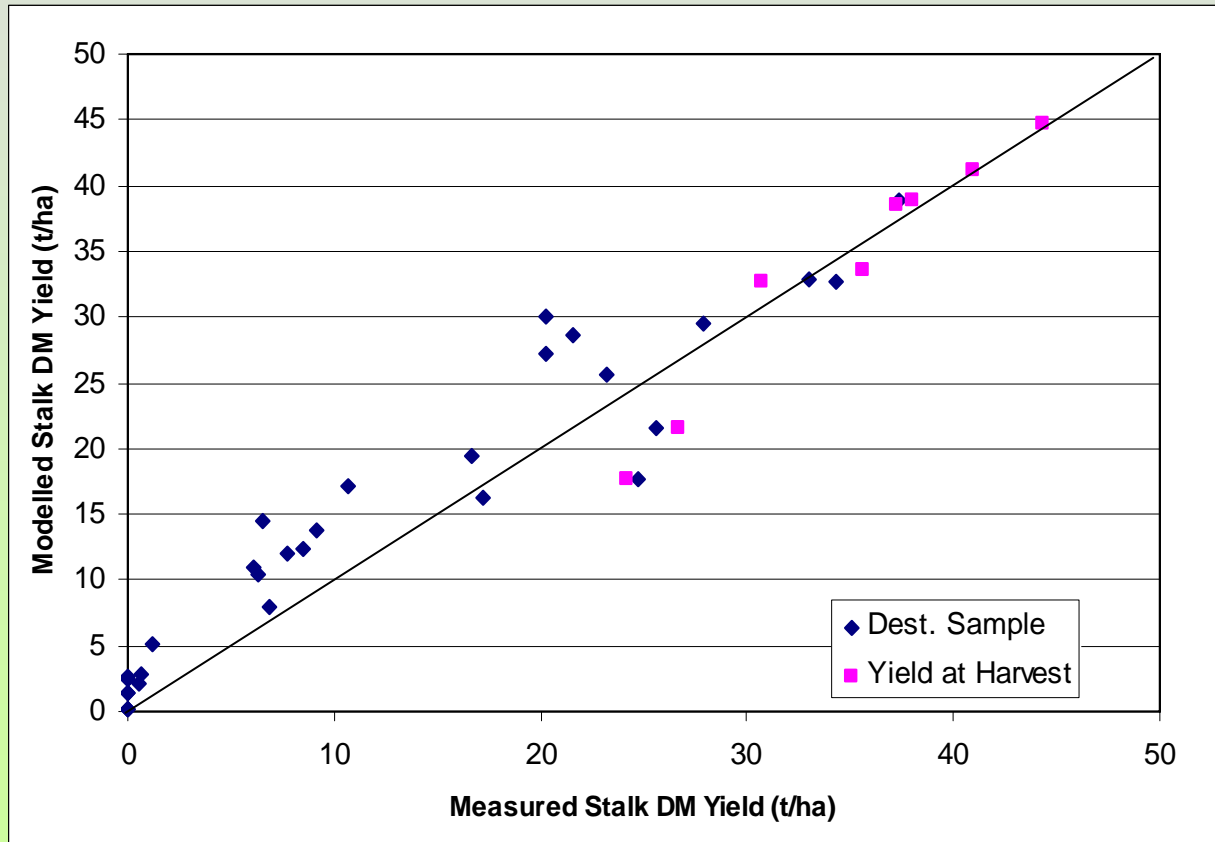


Model Validation – South Africa

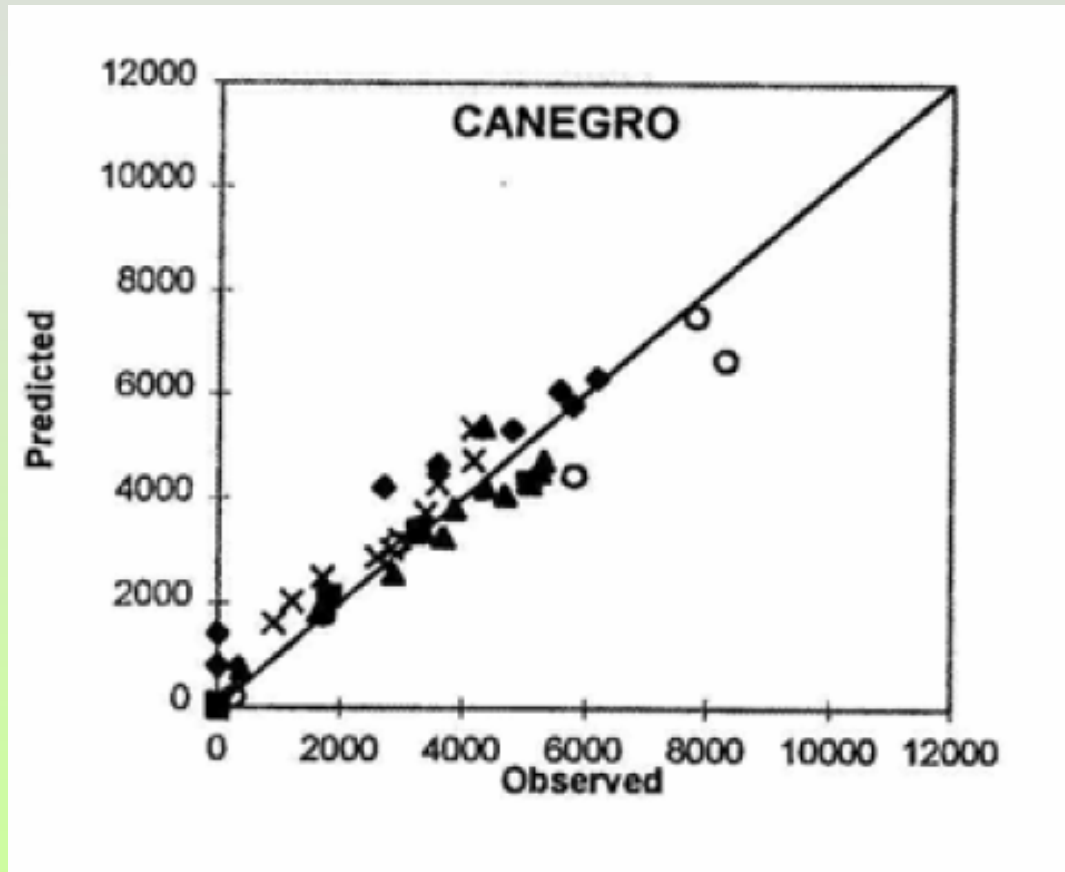


Model Validation - Swaziland

- Stress Trial – 4 levels of stress, 4 seasons
- Destructive sampling – 2 monthly intervals and
- Yield at Harvest



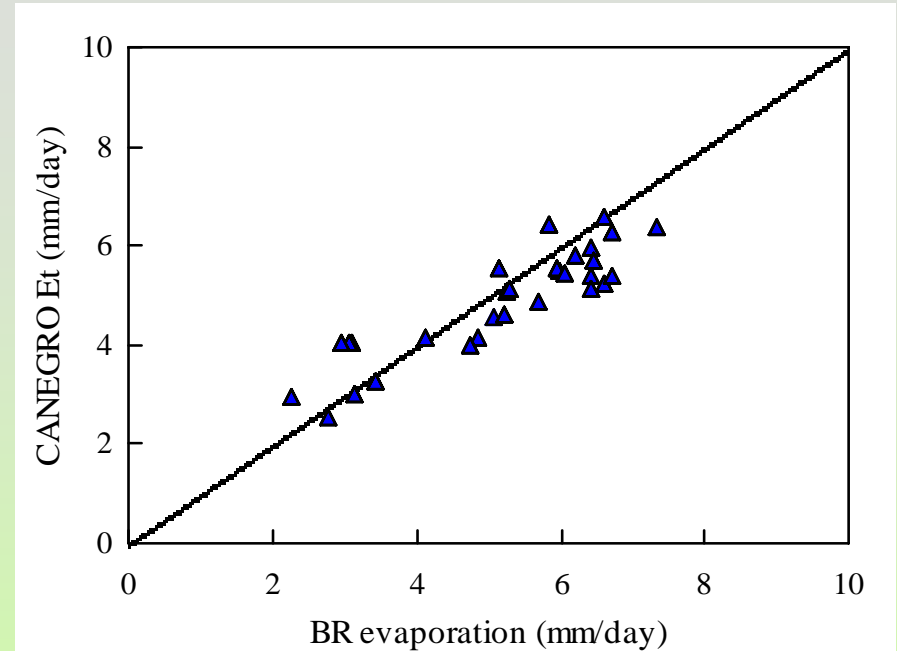
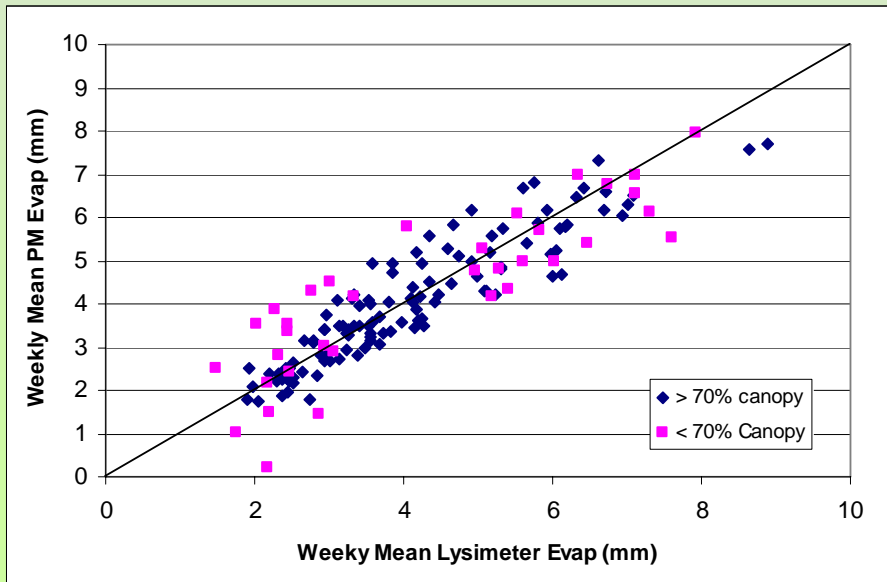
CANEGRO Validation - International



- 4 sites in Australia
- 1 site in Hawaii

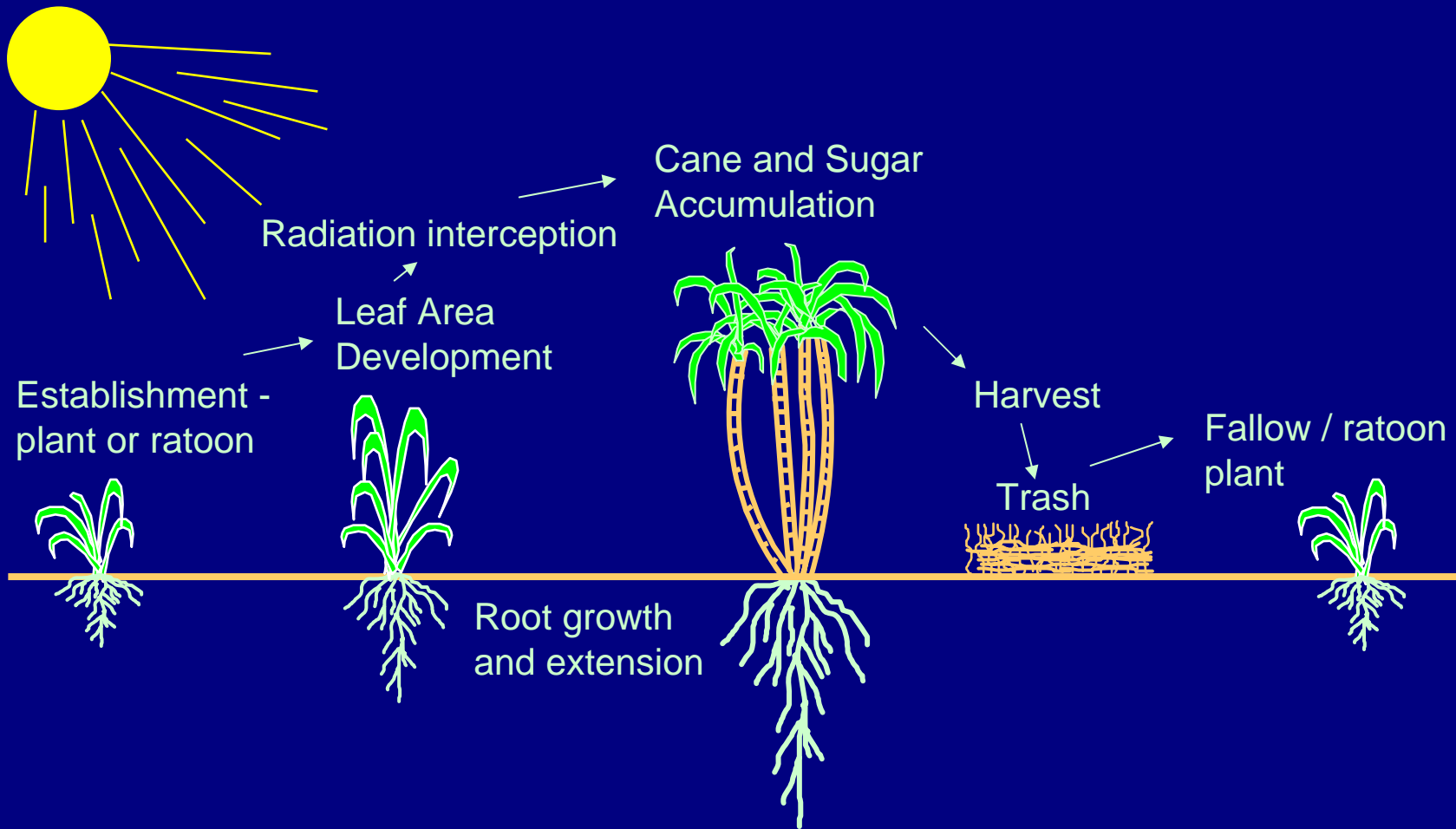
CANEGRO Validation – Evapotranspiration Estimate

- Penman-Monteith sugarcane reference Et approach
- Original Validation – Three years Lysimeter data – Pongola, South Africa

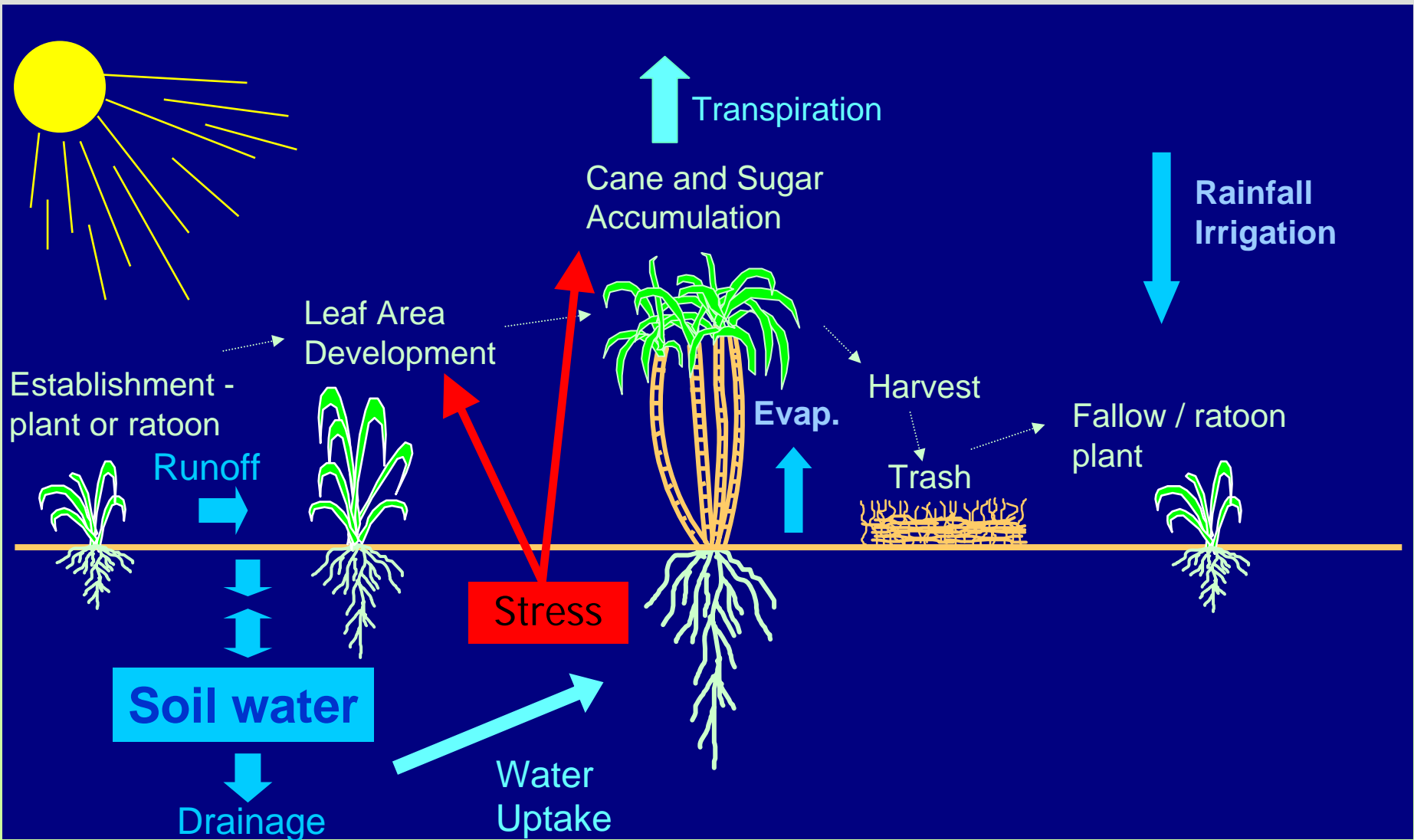


- Et Validation
- Bowen ratio Measurements, Swaziland

Potential Yield Calculation



Water Limited Yield Calculation

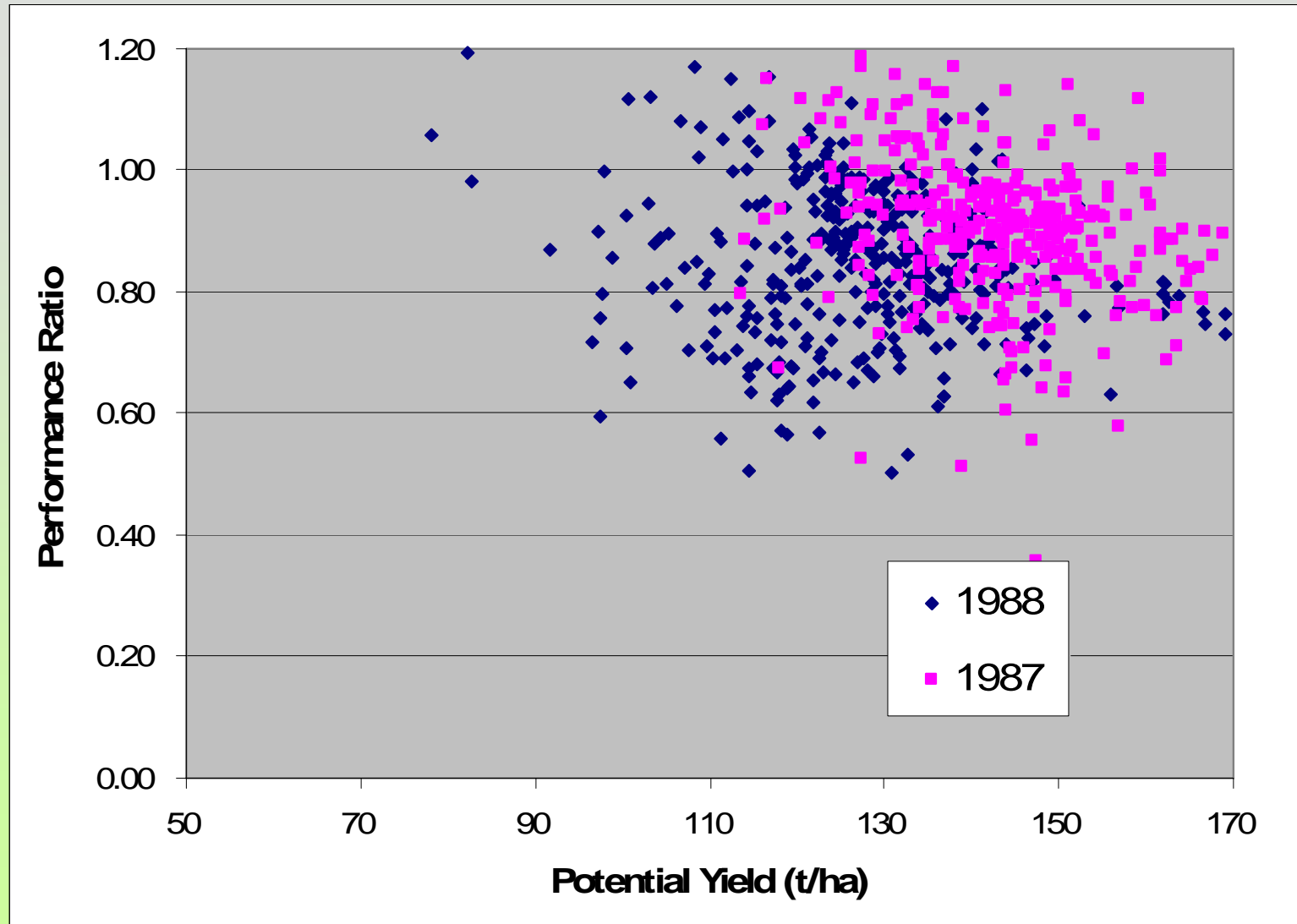


Evolution of a Benchmarking Tool

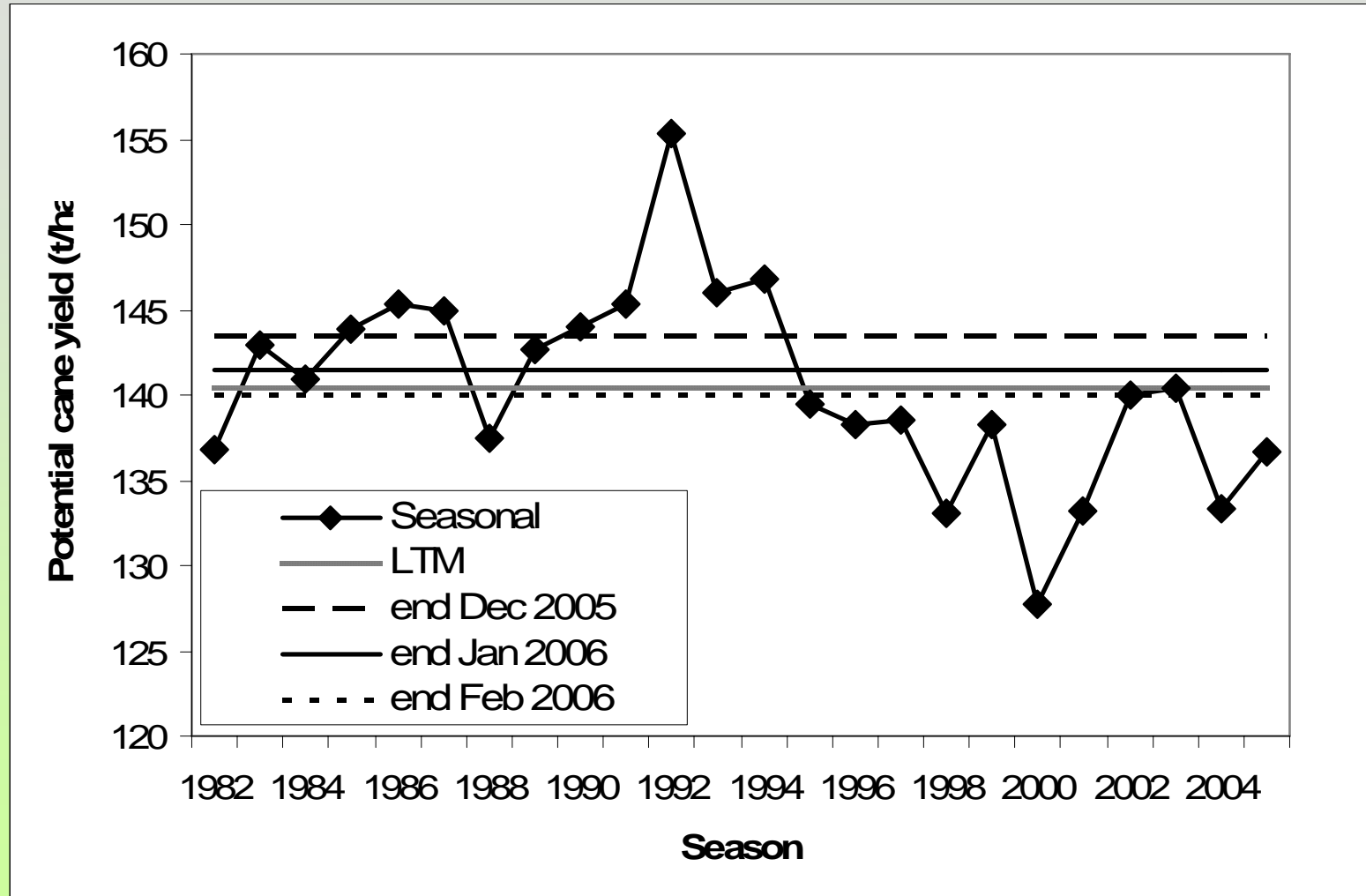
Step 1 – Potential Yield

- Questions raised regarding performance at RSSC, Swaziland during the late 80's
 - 1987/88 season avg yield = 130 t/ha
 - 1988/89 season avg yield = 107 t/ha
 - Why the big drop?
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Season Potential and Performance



Potential Yield - Season Benchmarking



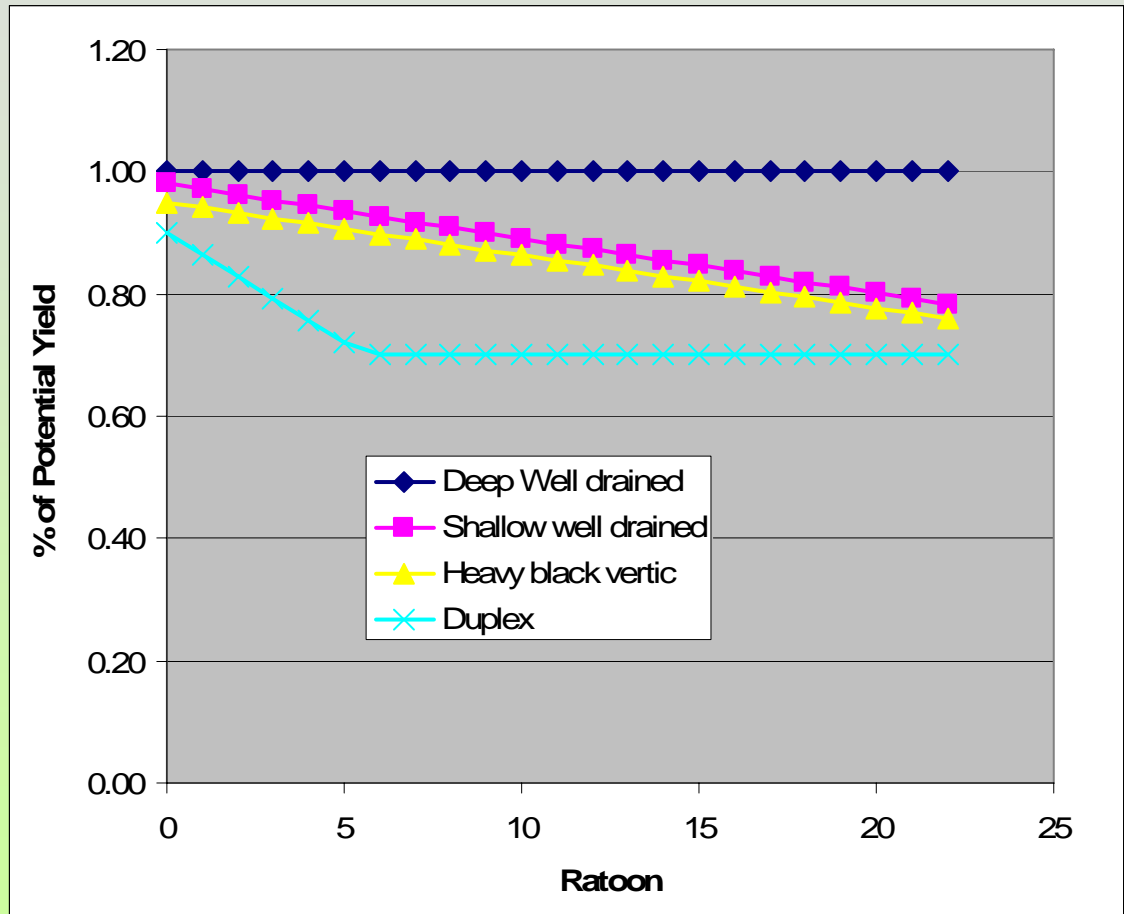
Evolution of a Benchmarking Tool

Step 2 – Attainable Yield

- Questions regarding field performance comparisons raised
 - Potential yield concept able to cope with seasonal variability
 - Need to consider other agronomic constraints
 - Led to development of Attainable Yield concept
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Attainable Yield Concept

- Identified the soil/ratoon interaction as the most important agronomic consideration



Attainable Yield Concept

- Soil/Ratoon matrix combined with other agronomic factors in a simple multiplicative model of the form:
 - $\text{AttYld} = \text{PotYld} * \text{Soil/Rat fac} * \text{Variety fac} * \text{Irrig fac}$
 - Eg. Shallow well drained soil, 6th ratoon, NCo376, Drag-line irrigation system
 - $\text{AttYld} = 140 \text{ t/ha/an} * 0.94 * 1.00 * 1.00 = 132 \text{ t/ha/an}$
-

Examples of model use in commercial operations – CanePro Cane Management Software

1. Harvest Planning and Yield Estimates



The Problem

- Large Estates
 - 3500 ha – 21000 ha
 - 100 – 1000 fields
 - Supplying 1 – 2 mills
 - Complex harvest planning decisions
 - Need for accurate estimates
 - Usually majority or only mill supply
 - Implications for season start and duration
 - Need for in-season revision of estimate
-

Estate Practice – Prior to CanePro

- Estimate largely based on 5-year mean productivity
 - Realise the effect of age and climate on yield but unsure how to incorporate into early estimates
 - Rely on Section Managers subjective yield assessment
 - Yield revisions 2 - 4 times per season
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The Need

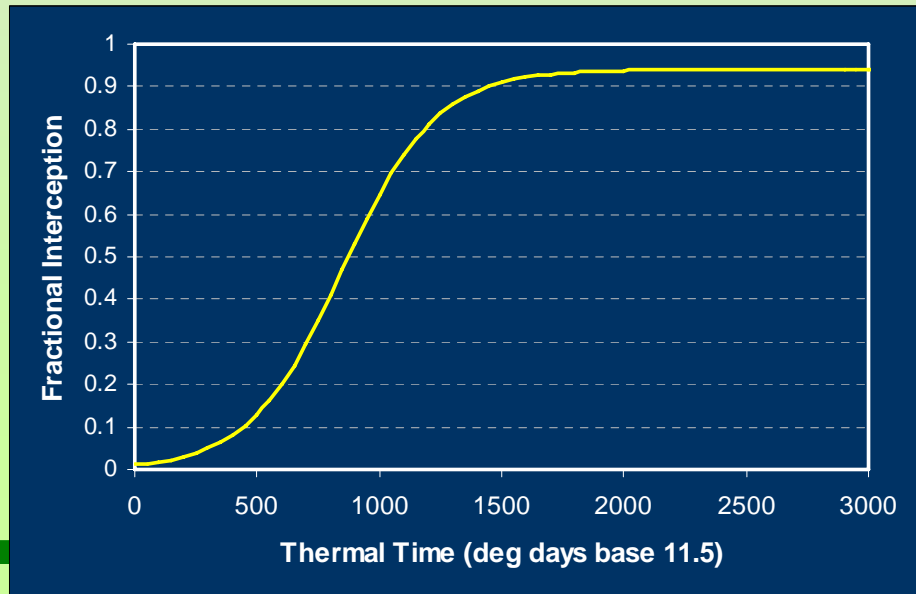
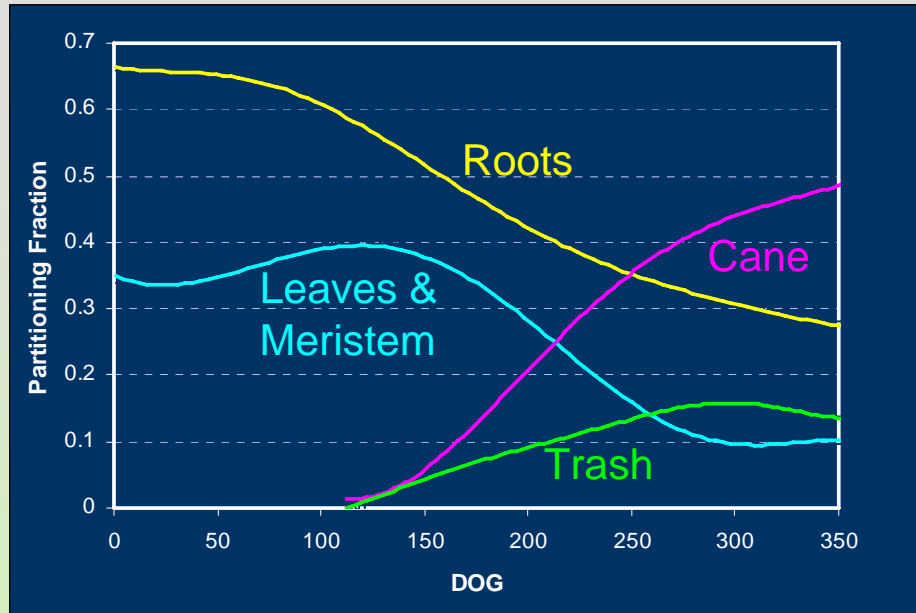
- Easy-to-use harvest planning tool which:
 - Is flexible
 - Integrates the effect of climate and age on yield
 - Provides real-time in-season revisions
 - Model inputs simple and easy to obtain

How?

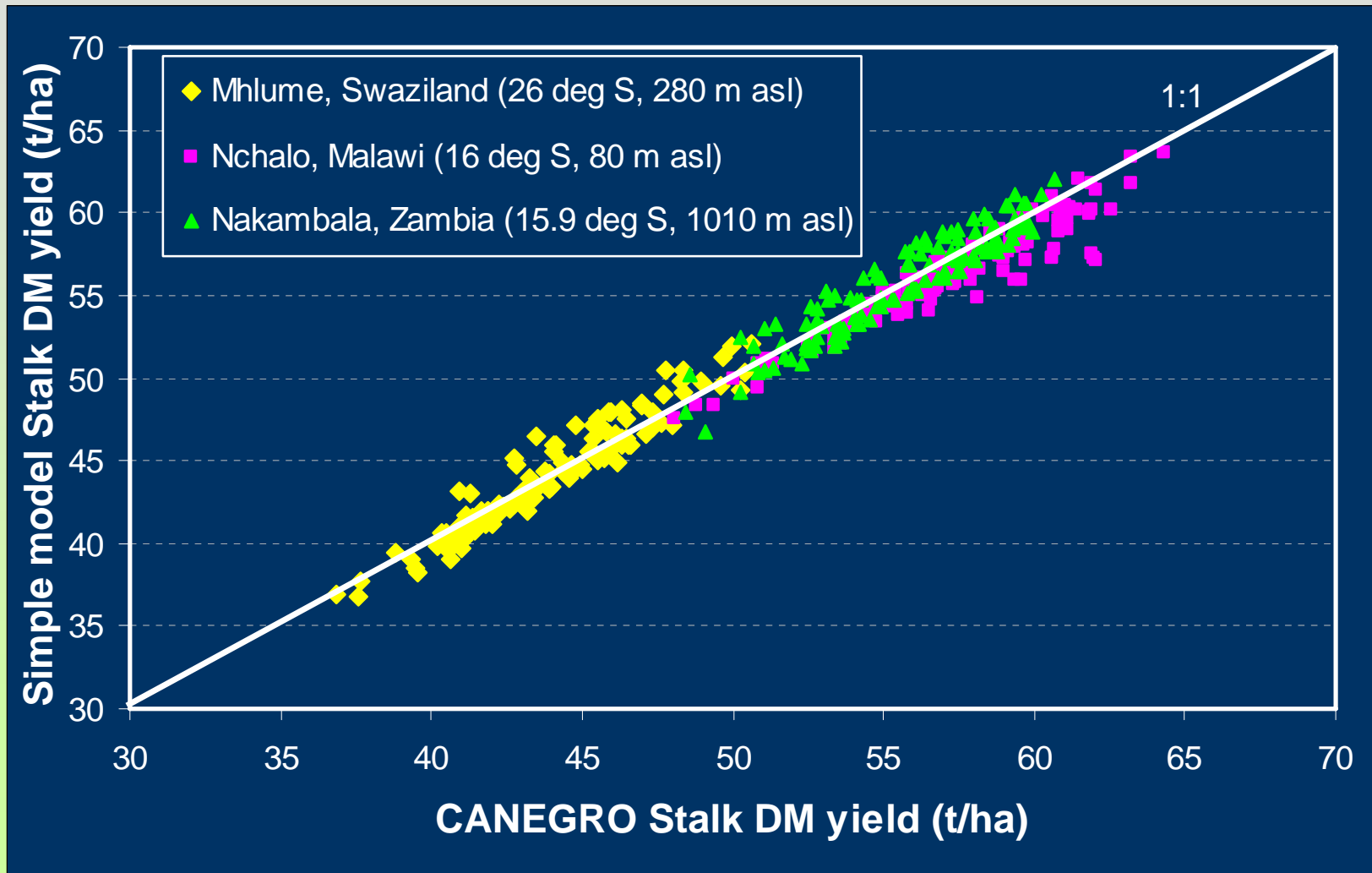
- Combine commercially available harvest planning engine with a simplified yield simulation model and performance ratio concept
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Simplified Yield model

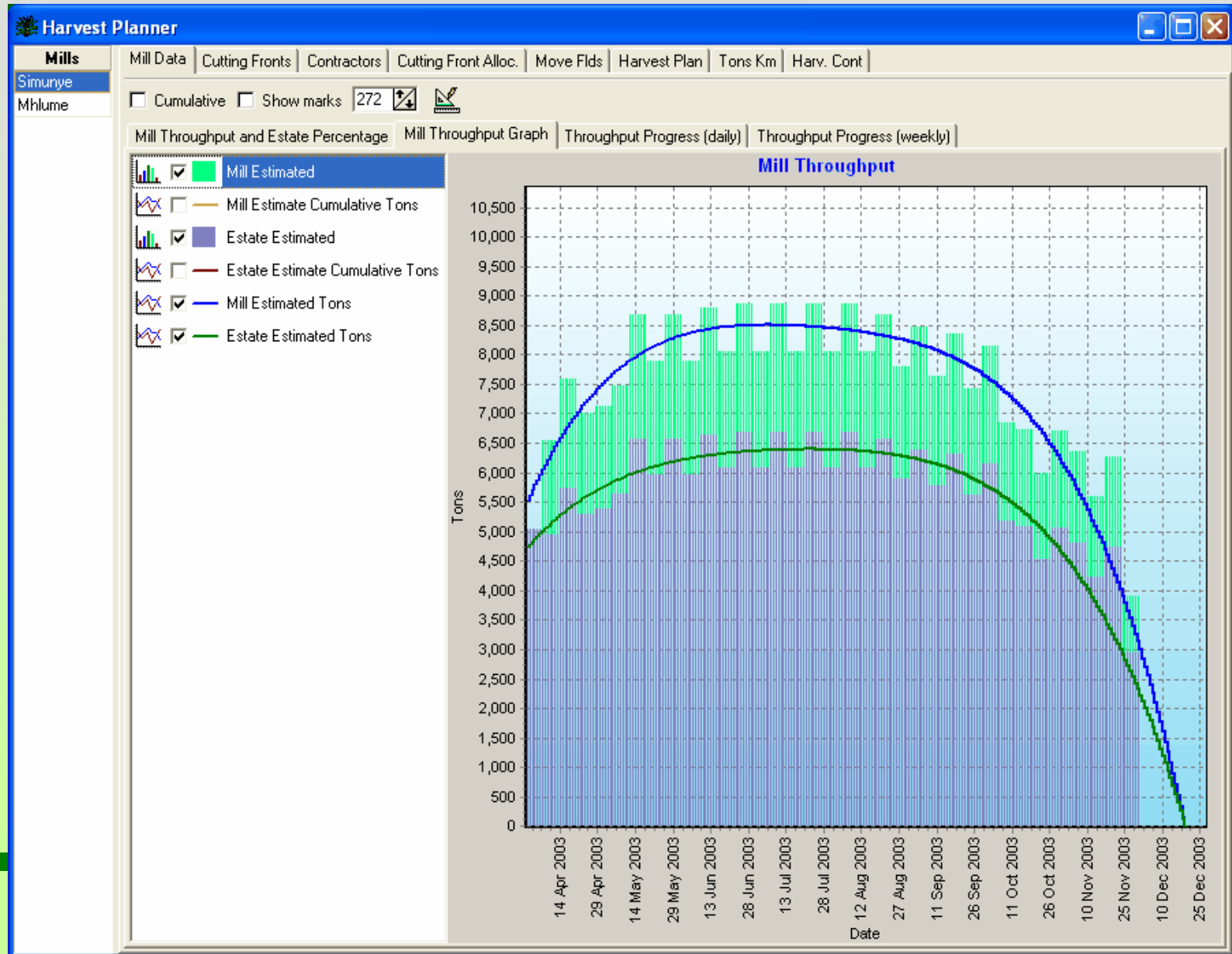
- Potential yield model developed using CANEGRO RUE model (McCree & Hesketh) and DM partitioning algorithms
- Empirical temperature based radiation interception curve (base 11.5)



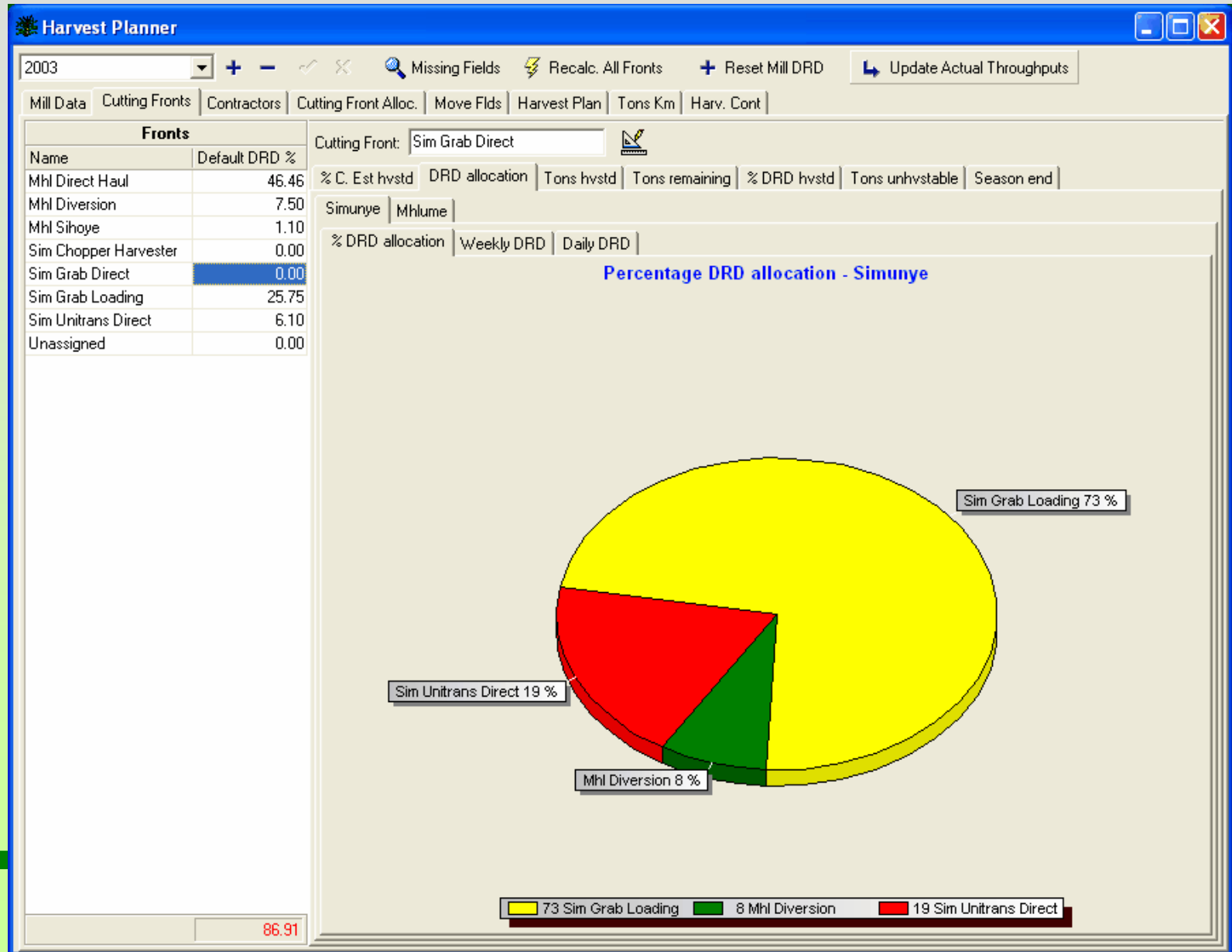
Model Validation



Step 1- Crush Programme



Step 2 – Cutting Fronts



Step 3 – Field Harvest Order

Harvest Planner

2003

Missing Fields
 Recalc. All Fronts
 View Editor
 Reset Mill DRD
 Update Actual Throughputs

Mill Data
Cutting Fronts
Contractors
Cutting Front Alloc.
Move Flds
Harvest Plan
Tons Km
Harv. Cont

From cutting front: Mhl Direct Haul

		Cutting Sequence Data			Area (ha)		Estim...	
Name	Seq. ...	Grow start	Cut date	Carried over	Actual	To Harvest	Current	To
215010	1	28/02/2002	10/04/2003	0.00	13.50	13.50	121.9	
215020	2	01/03/2002	10/04/2003	0.00	10.80	10.80	121.6	
215030	3	27/02/2002	10/04/2003	0.00	8.10	8.10	116.8	
402011	4	12/05/2002	10/04/2003	0.00	2.00	2.00	123.3	
402012	5	12/05/2002	11/04/2003	0.00	1.80	1.80	141.5	
403010	6	08/03/2002	11/04/2003	0.00	15.20	15.20	122.4	
403020	7	09/03/2002	11/04/2003	0.00	13.10	13.10	122.1	
403030	8	27/02/2002	11/04/2003	0.00	10.60	10.60	122.5	
416010	9	02/03/2002	12/04/2003	0.00	10.80	10.80	121.9	
416020	10	05/03/2002	12/04/2003	0.00	6.20	6.20	122.3	
416030	11	28/02/2002	12/04/2003	0.00	7.00	7.00	122.5	
416040	12	04/03/2002	13/04/2003	0.00	10.90	10.90	122.6	
520010	13	28/04/2002	13/04/2003	0.00	18.60	18.60	155.4	
520020	14	25/04/2002	14/04/2003	0.00	19.00	19.00	157.2	
521010	15	01/05/2002	14/04/2003	0.00	19.40	19.40	154.7	
521020	16	01/05/2002	15/04/2003	0.00	19.70	19.70	154.9	
222010	17	04/03/2002	16/04/2003	0.00	4.60	4.60	120.3	
222020	18	06/03/2002	16/04/2003	0.00	6.80	6.80	120.9	
222030	19	05/03/2002	16/04/2003	0.00	10.50	10.50	120.0	
222040	20	07/03/2002	17/04/2003	0.00	11.30	11.30	120.6	
222050	21	09/03/2002	17/04/2003	0.00	10.90	10.90	120.4	
223010	22	20/03/2002	17/04/2003	0.00	10.60	10.60	119.7	
223020	23	15/03/2002	18/04/2003	0.00	13.20	13.20	119.9	
223030	24	18/03/2002	18/04/2003	0.00	10.00	10.00	120.6	
223040	25	19/03/2002	18/04/2003	0.00	7.00	7.00	120.3	

To cutting front:

General Details

Name
Cut date
Carried over
S...

Multiple items can be selected on the left hand side.
The selected items have a blue background.
Ctrl + Click adds an item to the selection.
Shift + Click adds a range to the selection.

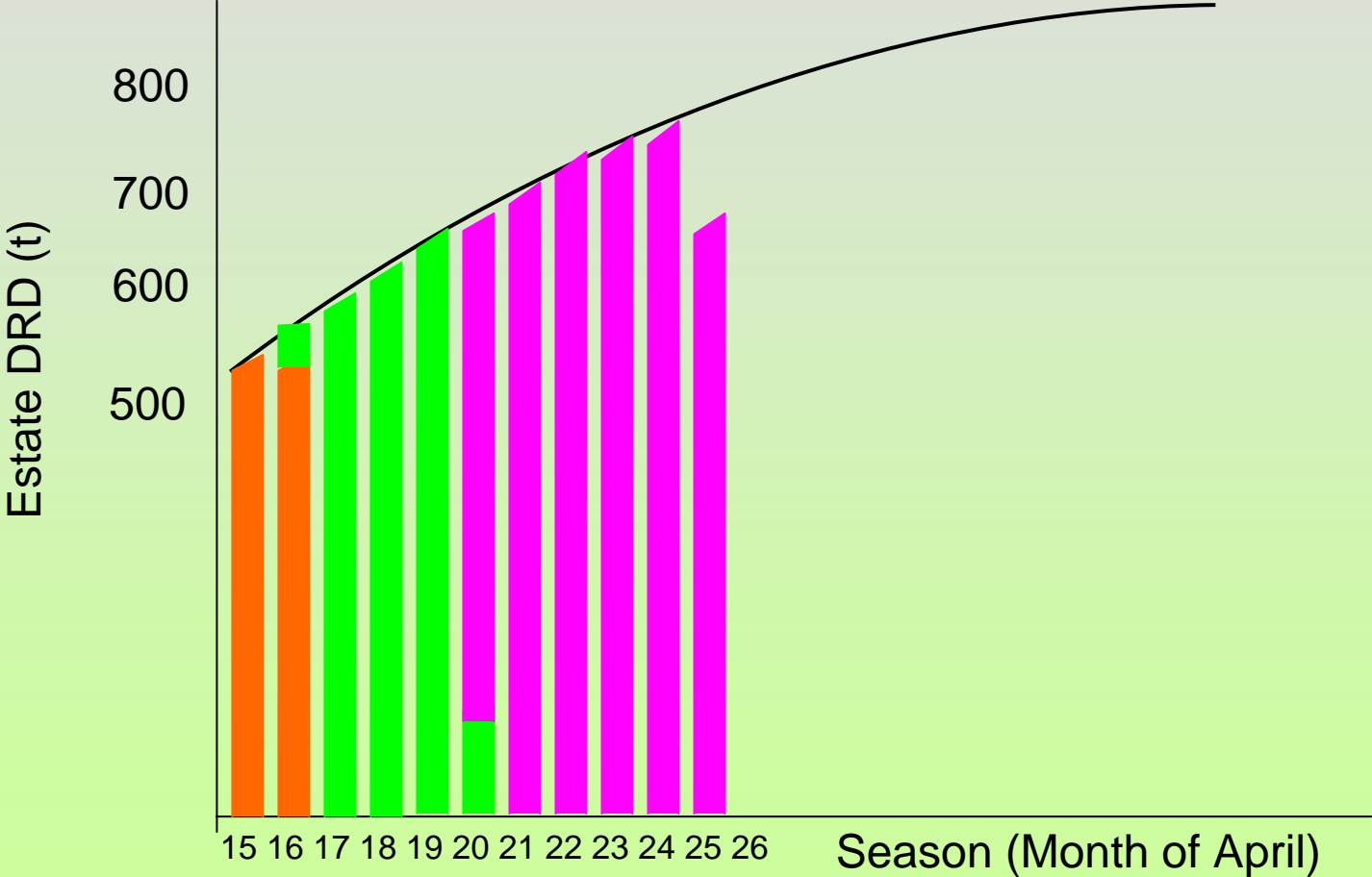
Only one item can be selected as the target on the right hand side.
The target item has a darker background.
Press on the arrow in the central

Field status colours:

Time frame:

Step 4 – Harvest Plan

Order	Field	Size	Cut Start	Perf ratio	Potential yld	Yield (tons)	Cut End
1.	Field A – 10ha	15/4	0.7	140	980	16/4	
2.	Field B – 20ha	16/4	0.8	140	2240	20/4	
3.	Field C – 40ha	20/4	0.9	140	5040	25/4	



Step 4 (contd...) – Harvest Plan

Harvest Planner

2003

Missing Fields Recalc. Front Recalc. All Fronts Show Selected Front Reset Mill DRD

Update Actual Throughputs

Mill Data Cutting Fronts Contractors Cutting Front Alloc. Move Flds **Harvest Plan** Tons Km Harv. Cont

Cutting front

- Mhl Direct Haul
- Mhl Diversion
- Mhl Sihoye
- Sim Chopper Harveste
- Sim Grab Direct
- Sim Grab Loading
- Sim Unitrans Direct
- Unassigned

Drag a column header here to group by that column

Field	Cut date	End cut date	Estimated Cane Yield					Est to
			Tons cane/ha	Total Tons	Tons hvstd	Tons to hvst	Tons unharvestable	
906020	26/07/2003	30/07/2003	107.8	2059.43		2059.43	0.00	
125010	26/07/2003	26/07/2003	97.1	1787.41		1787.41	0.00	
125020	26/07/2003	27/07/2003	83.5	1879.78		1879.78	0.00	
1404	27/07/2003	27/07/2003	142.1	3893.54		3893.54	0.00	
1411	27/07/2003	28/07/2003	135.7	2511.11		2511.11	0.00	
204	27/07/2003	30/07/2003	96.0	3176.95		3176.95	0.00	
131010	27/07/2003	27/07/2003	70.0	553.17		553.17	0.00	
131030	27/07/2003	27/07/2003	82.7	678.02		678.02	0.00	
131040	27/07/2003	28/07/2003	54.3	548.10		548.10	0.00	
131020	27/07/2003	27/07/2003	67.9	800.83		800.83	0.00	
1412	28/07/2003	29/07/2003	134.3	3343.41		3343.41	0.00	
5033	28/07/2003	29/07/2003	136.3	4389.88		4389.88	0.00	
1413	29/07/2003	30/07/2003	140.3	3324.12		3324.12	0.00	
1418	29/07/2003	29/07/2003	139.3	1630.09		1630.09	0.00	
1419	29/07/2003	29/07/2003	142.4	840.42		840.42	0.00	
5032	29/07/2003	30/07/2003	136.6	2746.59		2746.59	0.00	
1414	30/07/2003	31/07/2003	140.4	2106.13		2106.13	0.00	
5012	30/07/2003	31/07/2003	113.1	2623.77		2623.77	0.00	
5031	30/07/2003	30/07/2003	136.9	1341.83		1341.83	0.00	
4012	30/07/2003	02/08/2003	178.0	2865.34		2865.34	0.00	
847010	30/07/2003	04/08/2003	103.0	2440.06		2440.06	0.00	
1415	31/07/2003	31/07/2003	139.8	2824.74		2824.74	0.00	
1416	31/07/2003	01/08/2003	139.2	1531.63		1531.63	0.00	
143010	31/07/2003	31/07/2003	89.2	544.04		544.04	0.00	
143020	31/07/2003	31/07/2003	89.1	882.03		882.03	0.00	
143030	31/07/2003	01/08/2003	86.9	860.72		860.72	0.00	
1,304				2,104,203.4	0.00	2,104,203.45	0.00	

Estimate Detail

Yield Data for Field: 315

- Current season Details

Grow Start Date	25/05/2002
Cut Date	23/04/2003
Estimator Method	Current Estima
Area to Harvest	19.50
Orig. Area to Harvest	19.50
Tons/ha/mnth Est.	8.20
Current Estimate	91.87
Original Estimate	90.53
Official Estimate	0.00
Current Tons	1,791.47
Original Tons	1,765.43
TCHA	100.75
Ratoon	12
Cut Age	10.9
Perf. Ratio	

- Previous Seasons Yields (TCHA)

2002	93.08
2001	93.62
2000	103.55

- Previous Seasons Ratoons

2002	11
2001	10
2000	9

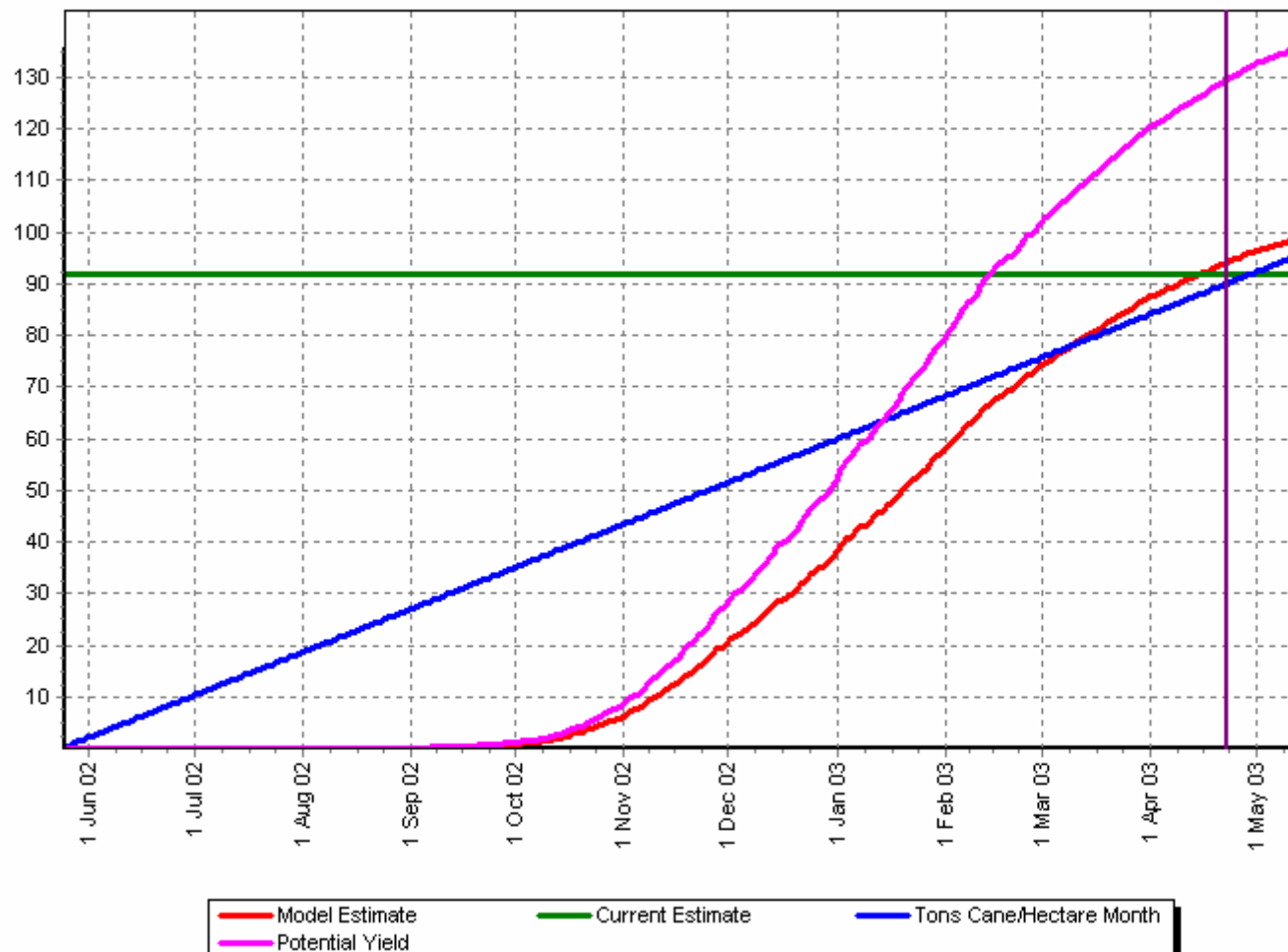
- Previous Seasons Cut Dates

2002	24/05/2002
2001	30/05/2001
2000	10/06/2000

- Previous 3 Seasons Perf. Ratios

2002	.68
2001	.69
2000	.81

Graph of Various Estimator Yields (TCH) for 20 Days Past the Cut Date



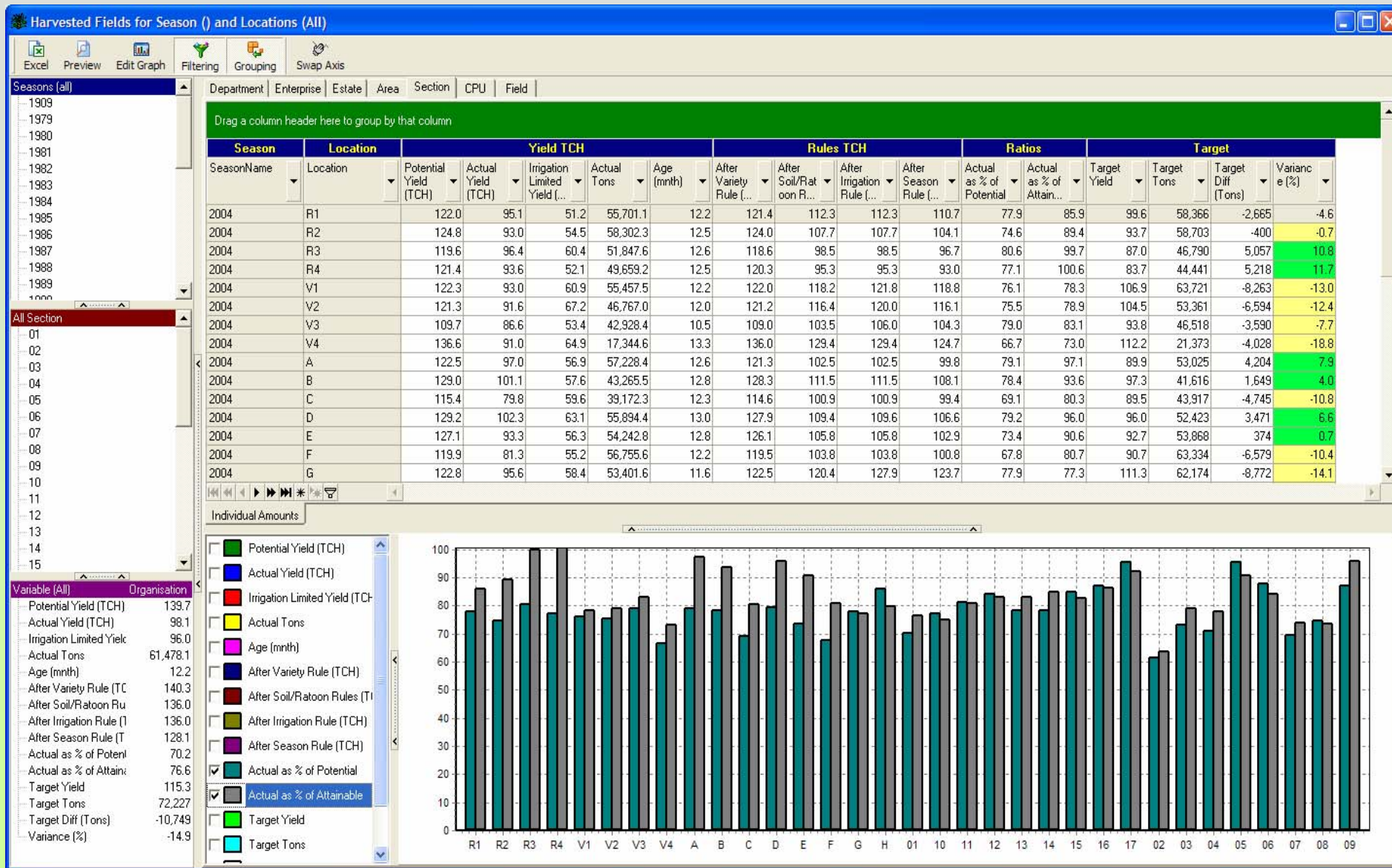
Advantages

- Flexibility
 - Harvest date and estimate re-calculated if field harvest sequence changed
- Captures climate and age effects
- Live in-season
 - Harvest plan continually updated and estimate refreshed
- Better control of other operations linked to harvest date e.g. ripening
- What-if analysis w.r.t. season start and duration

Examples of model use in commercial operations – CanePro Cane Management Software

2. Performance Monitoring

Performance Monitoring



Advantages

- Allows for comparisons between/within season
 - Allows benchmarking between estates
 - Allows benchmarking between different environments/countries
 - Used to assess manager performance
 - Crucial part of replant planning decisions
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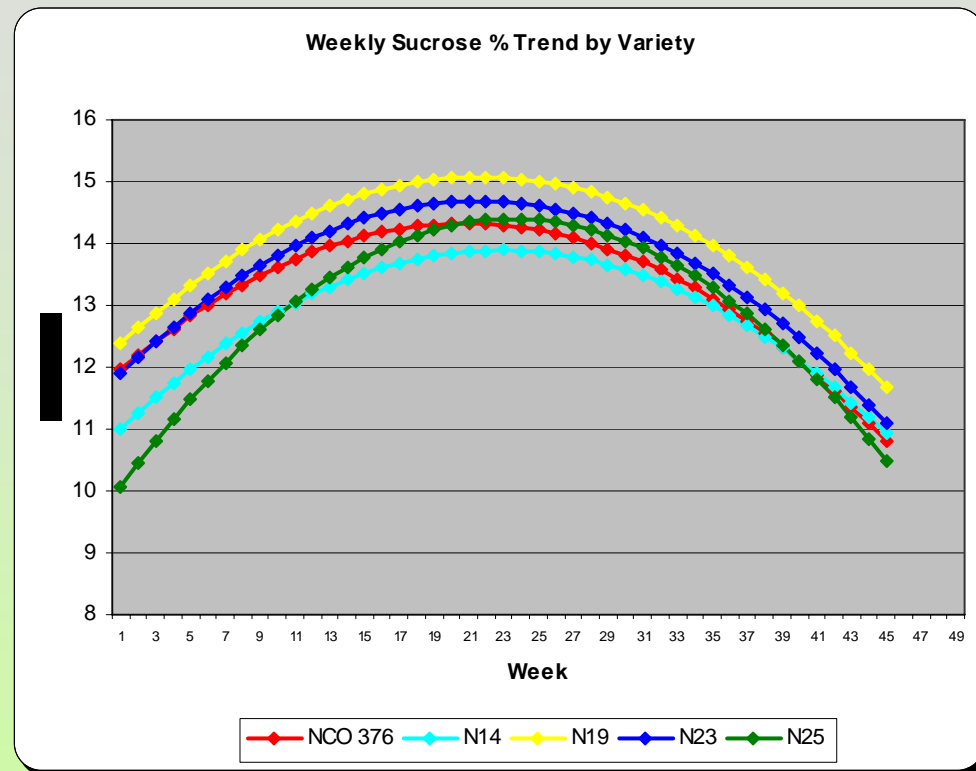
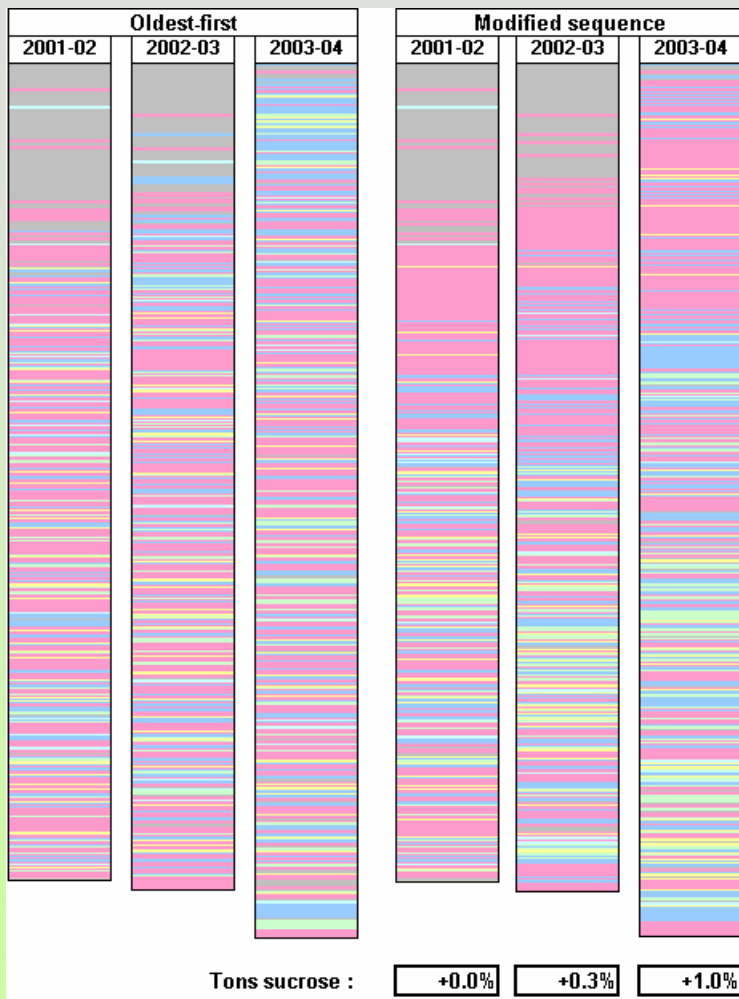
Examples of model use in commercial operations – CanePro Cane Management Software

3. Harvest Sequencing

Harvest Planner Developments

- Optimise harvest sequence using knowledge of sugarcane physiology
 - Seasonal growth characteristics
 - Seasonal cane moisture profile
 - Seasonal cane sucrose curve





Quickly realised that to optimise harvest sequence one cannot ignore replanting and the need to accommodate the movement of fields to be replanted



Examples of model use in commercial operations – CanePro Cane Management Software

4. Replant Planning

Replant Planning Concepts

- Identify fields to be replanted and when over a selected number of cutting seasons.
 - Identify which varieties should be used to replant each field to obtain an ideal variety mix.
 - Integrate a knowledge of replant dates into the harvest plan to optimise field sequencing over the chosen cutting seasons.
-

Replant Planner Algorithm

Setup

Mill Specific Planting Seasons

- Duration
- Mill Crush Rate

Planting Periods

- Duration
- Planting Capacity

Yield Adjustment Factors

- Soil/Ratoon Matrix
- Irrigation Factors
- Variety Factors

Sucrose Curves

- Variety, soil and mill specific

Select Fields to Replant

1. Establish Field performance ranking using attainable yield concept over last 5 ratoons
2. Allow User to Modify Ranking
3. Estimate ideal replant ratoon for each field using:
 - 5 year mean field performance ratio
 - Subsequent soil/ratoon matrix
 - Planting capacity
4. Assign planting season based on ratio of current to ideal replant ratoon
5. Assign planting period based on relative advantage of moving forward or back in the replant period

Ideal Variety Mix

1. Identify highest yielding variety for each day of season [tons sucrose]
2. Establish ideal estate variety composition
3. Establish adjusted ideal estate variety composition of each replant period based on:
 - Current variety composition
 - Variety exception constraints
 - Variety area constraints

Final Output

1. Replant Plan
 - Plant Date
 - Variety
1. Adjusted Harvest Plan

Step 1- Setup - Seasons

Replant Setup

Excel Preview

Seasons Potential Yields Sucrose Curves

Cutting Season			DRD Source		DRD % Increase		
Name	Start date	End date	Use season	Days shift	CARGO CHOPPER	CARGO WHOLESTICK	UBOMBO CANE TRANSPORT
2008-09	1/04/2008	31/12/2008	2007-08	0	-15.0	5.0	10.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2007-08	1/02/2008	25/03/2008	31.0	239.1	9		
Spring 2008-09	1/07/2008	15/09/2008	80.0	880.0	6		
2009-10	1/04/2009	31/12/2009	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2008-09	1/02/2009	25/03/2009	31.0	234.7	9		
Spring 2009-10	1/07/2009	15/09/2009	80.0	880.0	6		
2010-11	1/04/2010	31/12/2010	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2009-10	1/02/2010	25/03/2010	31.0	234.7	9		
Spring 2010-11	1/07/2010	15/09/2010	80.0	880.0	6		
2011-12	1/04/2011	31/12/2011	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2010-11	1/02/2011	25/03/2011	31.0	234.7	9		
Spring 2011-12	1/07/2011	15/09/2011	80.0	880.0	6		
2012-13	1/04/2012	31/12/2012	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2011-12	1/02/2012	24/03/2012	31.0	234.7	9		
Spring 2012-13	1/07/2012	15/09/2012	80.0	880.0	6		
2013-14	1/04/2013	31/12/2013	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2012-13	1/02/2013	25/03/2013	31.0	234.7	9		
Spring 2013-14	1/07/2013	15/09/2013	80.0	880.0	6		
2014-15	1/04/2014	31/12/2014	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2013-14	1/02/2014	25/03/2014	31.0	234.7	9		
Spring 2014-15	1/07/2014	15/09/2014	80.0	880.0	6		
2015-16	1/04/2015	31/12/2015	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2014-15	1/02/2015	25/03/2015	31.0	234.7	9		
Spring 2015-16	1/07/2015	15/09/2015	80.0	880.0	6		
2016-17	1/04/2016	31/12/2016	2007-08	0	-15.0	5.0	20.0
Planting period	Start date	End date	Max ha/week	Total area (ha)	Min weeks fallow		
Autumn 2015-16	1/02/2016	24/03/2016	31.0	234.7	9		
Spring 2016-17	1/07/2016	15/09/2016	80.0	880.0	6		

+ Add - Delete

Step 1- Setup – Soil/Ratoon matrix

Replant Setup

Excel
 Preview
 ☒ ☐

Seasons
 Potential Yields
 Sucrose Curves

Soil Ratoon Matrix																	
Soil Category	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
B Set	0.921	0.901	0.882	0.862	0.842	0.822	0.802	0.783	0.763	0.743	0.723	0.703	0.684	0.664	0.644	0.624	0.604
C Set	0.982	0.975	0.969	0.962	0.955	0.949	0.942	0.935	0.928	0.922	0.915	0.908	0.902	0.895	0.888	0.882	0.875
D Set	0.938	0.927	0.916	0.905	0.894	0.883	0.872	0.861	0.851	0.840	0.829	0.818	0.807	0.796	0.785	0.774	0.763
F Set	0.938	0.927	0.916	0.905	0.894	0.883	0.872	0.861	0.851	0.840	0.829	0.818	0.807	0.796	0.785	0.774	0.763
I Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552
K Set	0.983	0.968	0.952	0.937	0.922	0.907	0.892	0.877	0.862	0.842	0.832	0.817	0.801	0.786	0.771	0.756	0.741
L Set	0.947	0.938	0.929	0.920	0.911	0.902	0.893	0.884	0.875	0.866	0.857	0.848	0.839	0.830	0.821	0.812	0.803
N Set	0.947	0.938	0.929	0.920	0.911	0.902	0.893	0.884	0.875	0.866	0.857	0.848	0.839	0.830	0.821	0.812	0.803
R Set	1.000	0.992	0.985	0.977	0.970	0.962	0.954	0.947	0.939	0.932	0.924	0.917	0.909	0.901	0.894	0.886	0.879
S Set	0.948	0.943	0.938	0.933	0.928	0.923	0.918	0.913	0.908	0.903	0.898	0.893	0.888	0.883	0.878	0.873	0.868
T Set	0.972	0.963	0.955	0.946	0.938	0.929	0.921	0.912	0.904	0.895	0.887	0.878	0.870	0.861	0.853	0.844	0.836
U Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552
V Set	0.907	0.882	0.857	0.832	0.807	0.782	0.757	0.732	0.706	0.681	0.656	0.631	0.606	0.581	0.556	0.531	0.506
W Set	0.921	0.901	0.882	0.862	0.842	0.822	0.802	0.783	0.763	0.743	0.723	0.703	0.684	0.664	0.644	0.624	0.604
Y Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552

Additional Factors

Irrigation System

Center Pivot	1.000
Flood	1.000
Floppy	0.890
Furrow 1-5	0.920
Furrow 11-15	0.840
Furrow 6-10	0.860
Overhead	1.000
Portable Pipe Spl	1.000
Semi Solid-Set Spl	1.000
Sprinkler 1-5	0.890
Sprinkler 11-15	0.840
Sprinkler 6-10	0.870
Step-Down furrows	1.000
other furrows	0.000

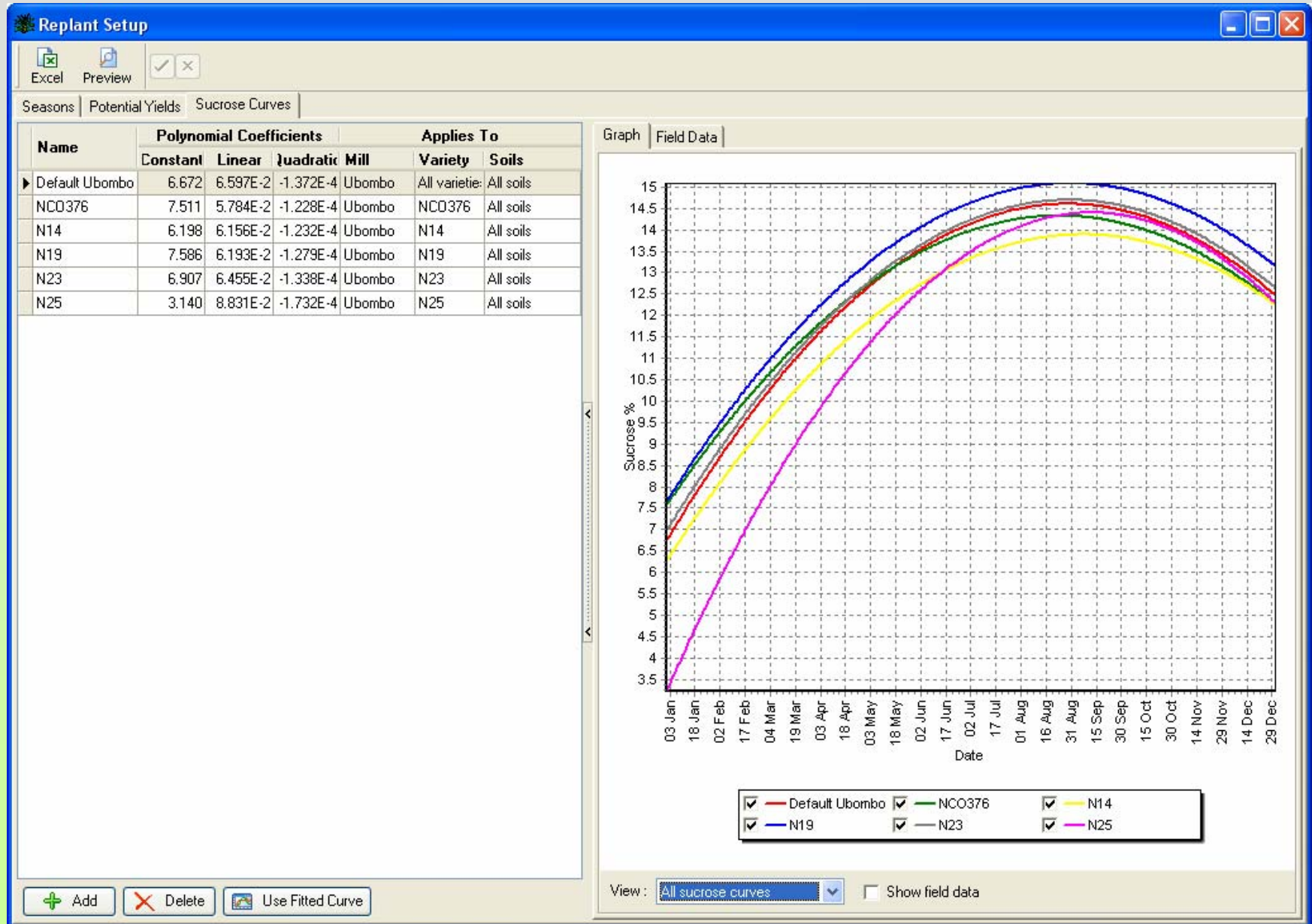
Variety

CP66	1.000
MIX	1.000
N14	0.960
N15	1.000
N17	1.000
N19	0.950
N22	0.830
N23	1.050
N24	0.850

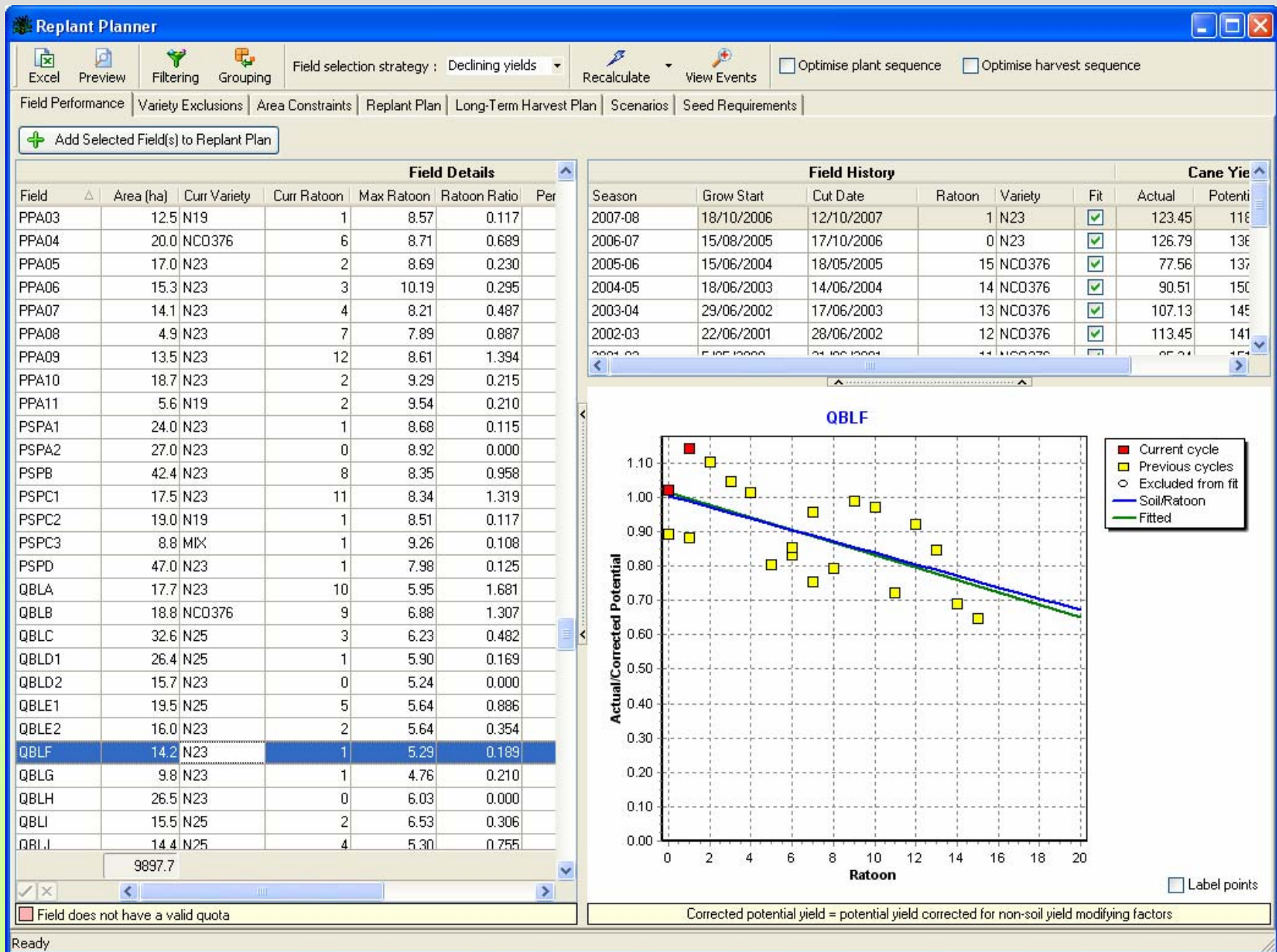
Factors In Use

Factor	Active
Irrigation System	<input checked="" type="checkbox"/>
Variety	<input checked="" type="checkbox"/>

Step 1- Setup – Variety Quality Curves



Step 2- Field Performance



Step 2- Variety Constraints

Replant Planner

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events ☐ Optimise plant sequence ☐ Optimise harvest sequence

Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

By Plant Variety By Location

Variety			Autumn 2007-08 (ha)			Spring 2008-09 (ha)			Autumn 2008-09 (ha)			Spring 2009-10 (ha)		
Name	Current Area (%)	Planned (%)	Min	Max	Planned	Min	Max	Planned	Min	Max	Planned	Min	Max	Planned
CP66														
MIX	3.1													
N14	0.4													
N15														
N17														
N19	8.3	6.7	30.0	120.0		250.0	1200.0	89.9	250.0	1200.0	40.1	250.0	1200.0	
N22														
N23	36.1	24.7	60.0	260.0		250.0	1200.0	116.4	250.0	1200.0	59.9	250.0	1200.0	2
N24														
N25	22.4	38.7		0.0		250.0	1200.0	386.5		0.0		250.0	1200.0	4
N26														
N28														
N30														
N32														
N36		11.6				50.0	100.0	54.1				50.0	150.0	
N52/219														
N52\219														
NC0376	29.7	18.4	40.0	120.0		250.0	1200.0	236.4	250.0	1200.0	147.3	250.0	1200.0	
TOTAL	100.0	100.0	130.0		0.0	1050.0		883.3	750.0		247.3	1050.0		8
CAPACITY					239.1			880.0			234.7			8

Ready

Step 3- Replant Plan

Replant Planner

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events ☐ Optimise plant sequence ☐ Optimise harvest sequence

Field Performance Variety Exclusions Area Constraints **Replant Plan** Long-Term Harvest Plan Scenarios Seed Requirements

Field Details					Replant Details				
Field	Area (Ha)	Current Ratoon	Current Variety	Season	Plant Period	Period Locked	New Variety	Variety Locked	Plant Date
LMH03	9.2	9	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	1/07/2008
LMH04	5.5	4	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	1/07/2008
LMH07	7.2	7	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	2/07/2008
LMU09	6.7	13	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	2/07/2008
LMU10	6.8	7	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	25/07/2008
LTA02	31.0	11	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	3/07/2008
LTA03	21.0	11	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	6/07/2008
LTA10	12.4	6	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	28/07/2008
LWV04	16.7	8	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	8/07/2008
QCO02	23.5	7	MIX	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	9/07/2008
TTJ02D	16.2	1	N25	2009-10	Autumn 2008-09	<input type="checkbox"/>	N19	<input type="checkbox"/>	1/02/2009
TTJ12	8.4	13	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	11/07/2008
TTJ22A	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	4/02/2009
TTJ22B	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	7/02/2009
TTJ22D	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	10/02/2009
VML01	10.7	7	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	N19	<input checked="" type="checkbox"/>	13/02/2009
VNZ02	11.2	10	N25	2008-09	Spring 2008-09	<input type="checkbox"/>	N19	<input type="checkbox"/>	12/07/2008
VSH02	34.0	4	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	13/07/2008
LMH06	8.0	10	N19	2008-09	Spring 2008-09	<input type="checkbox"/>	N25	<input type="checkbox"/>	16/07/2008
LMU03	10.2	11	NCO376	2008-09	Spring 2008-09	<input type="checkbox"/>	N25	<input type="checkbox"/>	23/07/2008
568	8258.2								

Remove from Plan Select All Set Selected Update Plant Sequence Update Field History...

Ready

Step 3- Long Term Harvest Plan

Replant Planner

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events ☐ Optimise plant sequence ☐ Optimise harvest sequence

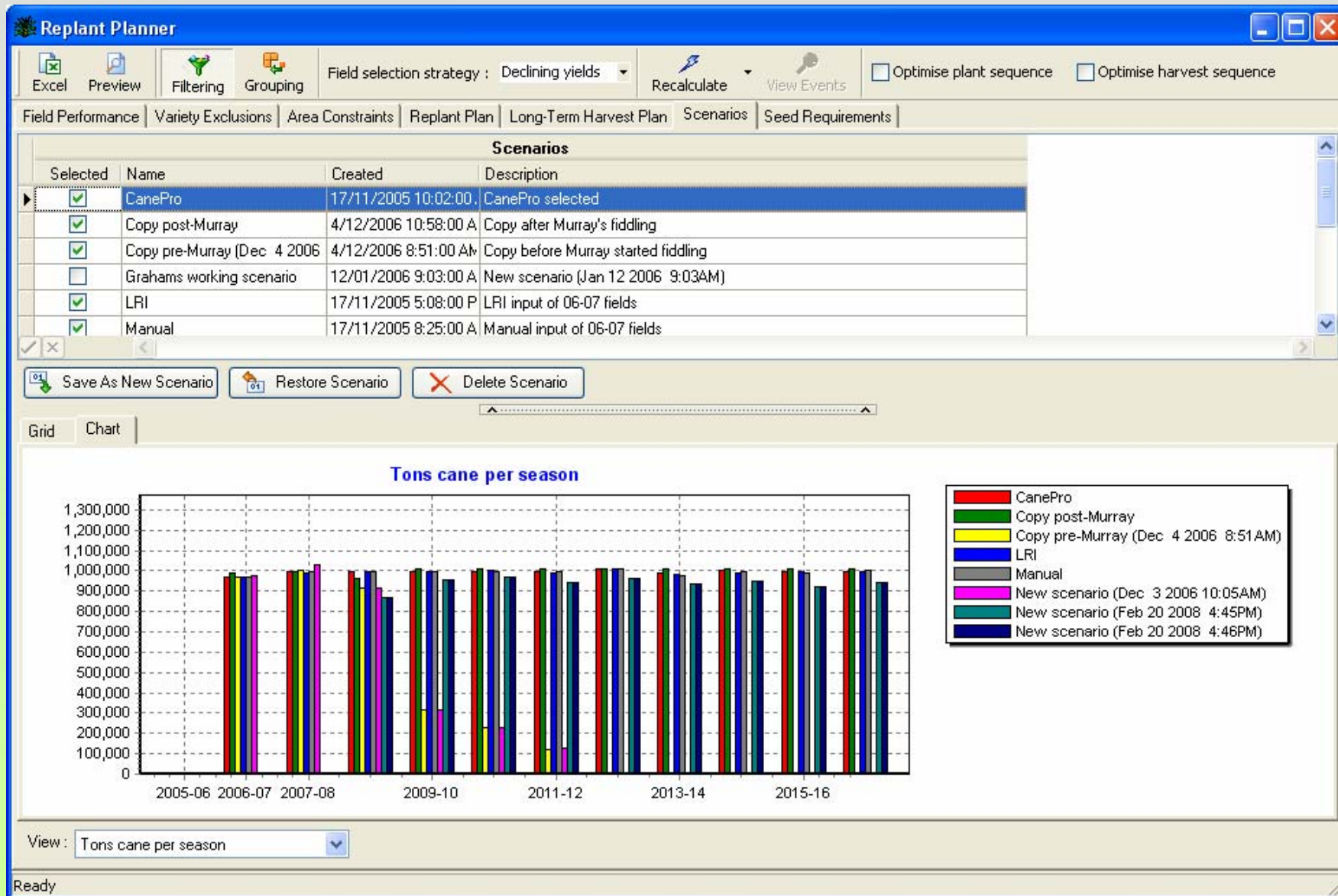
Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

Harvestings Fields Carried Over Cut Front Utilisation % of Area Harvested By Variety % of Area Harvested By Ratoon Age Distribution Monthly Area Harvested By Variety

Field Details								Harvest Details		
Field Name	Area (Ha)	Ratoon	Variety	Grow Start	Mill	Cutting Front	Cut Date	Cut Age	Season	Tons Ca
VGI02	15.5	6	N23	18/05/2007	Ubombo	CARGO WHOLESTICK	29/07/2008	14.39	2008-09	
SFIW	33.0	6	N23	10/09/2007	Ubombo	UBOMBO CANE TRANS	29/07/2008	10.61	2008-09	
PMR14	3.3	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRANS	31/07/2008	10.61	2008-09	
HSO05	17.3	0	N25	12/09/2007	Ubombo	UBOMBO CANE TRANS	31/07/2008	10.61	2008-09	
VGI03	14.1	9	NCO376	16/05/2007	Ubombo	CARGO WHOLESTICK	31/07/2008	14.52	2008-09	
PMR15	4.7	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRANS	31/07/2008	10.61	2008-09	
VGI07	10.0	5	NCO376	27/08/2007	Ubombo	CARGO WHOLESTICK	1/08/2008	11.17	2008-09	
PMR16	1.0	4	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRANS	1/08/2008	10.65	2008-09	
TTJ01D	13.2	13	NCO376	14/09/2007	Ubombo	CARGO CHOPPER	1/08/2008	10.58	2008-09	
PMR23C	18.0	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRANS	1/08/2008	10.65	2008-09	
PMR23A	12.5	4	N23	12/09/2007	Ubombo	UBOMBO CANE TRANS	1/08/2008	10.65	2008-09	
SFLE	29.0	2	NCO376	13/09/2007	Ubombo	UBOMBO CANE TRANS	2/08/2008	10.65	2008-09	
MSL04	44.8	4	N23	2/07/2007	Ubombo	CARGO CHOPPER	2/08/2008	13.05	2008-09	
VML04	11.6	2	NCO376	15/05/2007	Ubombo	CARGO WHOLESTICK	2/08/2008	14.62	2008-09	
HPA21	11.6	3	NCO376	15/09/2007	Ubombo	UBOMBO CANE TRANS	3/08/2008	10.61	2008-09	
VDR01	36.5	18	NCO376	4/07/2007	Ubombo	CARGO WHOLESTICK	3/08/2008	13.01	2008-09	
SFU	29.7	5	N25	14/09/2007	Ubombo	UBOMBO CANE TRANS	3/08/2008	10.65	2008-09	
HPA12	8.8	1	N23	15/09/2007	Ubombo	UBOMBO CANE TRANS	4/08/2008	10.65	2008-09	
SHS02	23.0	2	N23	17/09/2007	Ubombo	UBOMBO CANE TRANS	4/08/2008	10.58	2008-09	
4327	80437.3							12.10		

Ready

Step 4- Scenarios



Advantages

- Improves replant field selection decisions
- Place varieties in the right time of the season to optimise overall season yield
- Optimise long-term harvest plan to minimize age effects
- Scenarios allow evaluation of decisions on overall sucrose yield



Examples of model use in commercial operations – CanePro Cane Management Software

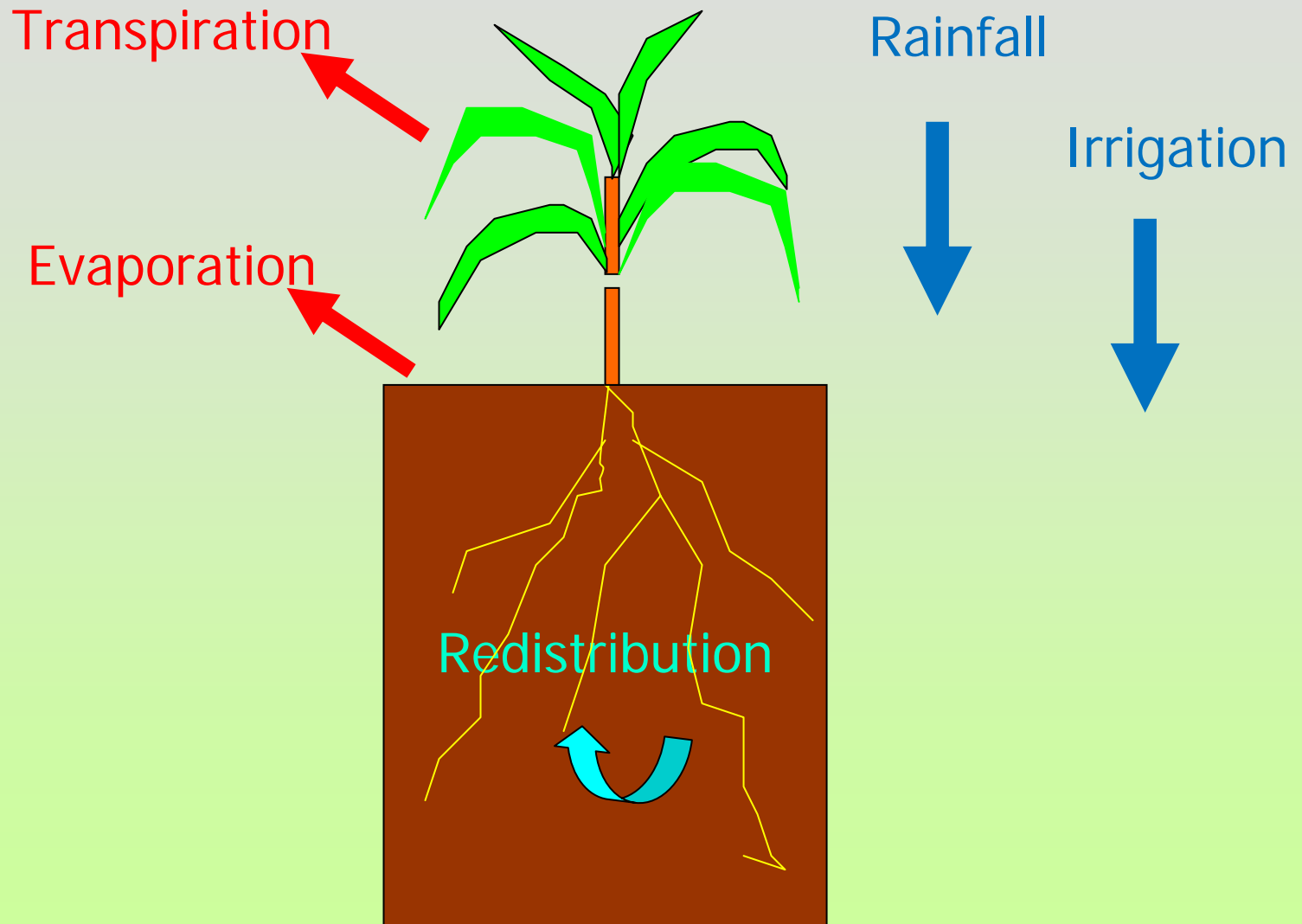
5. Irrigation Scheduling

Irrigation Scheduling Concept

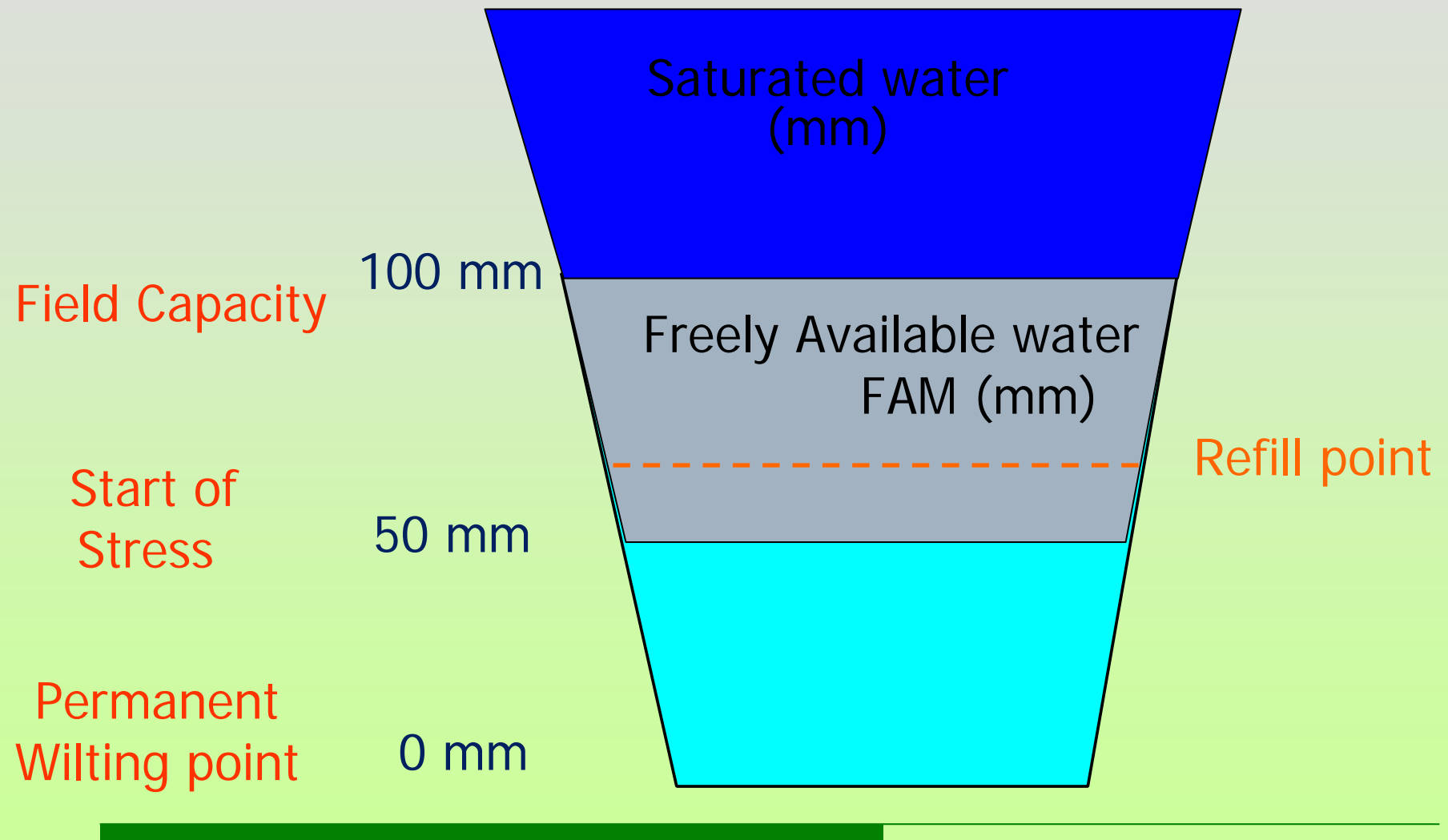
- Water balance
- Soil water concepts
- Estimating components of the water balance



Water Balance



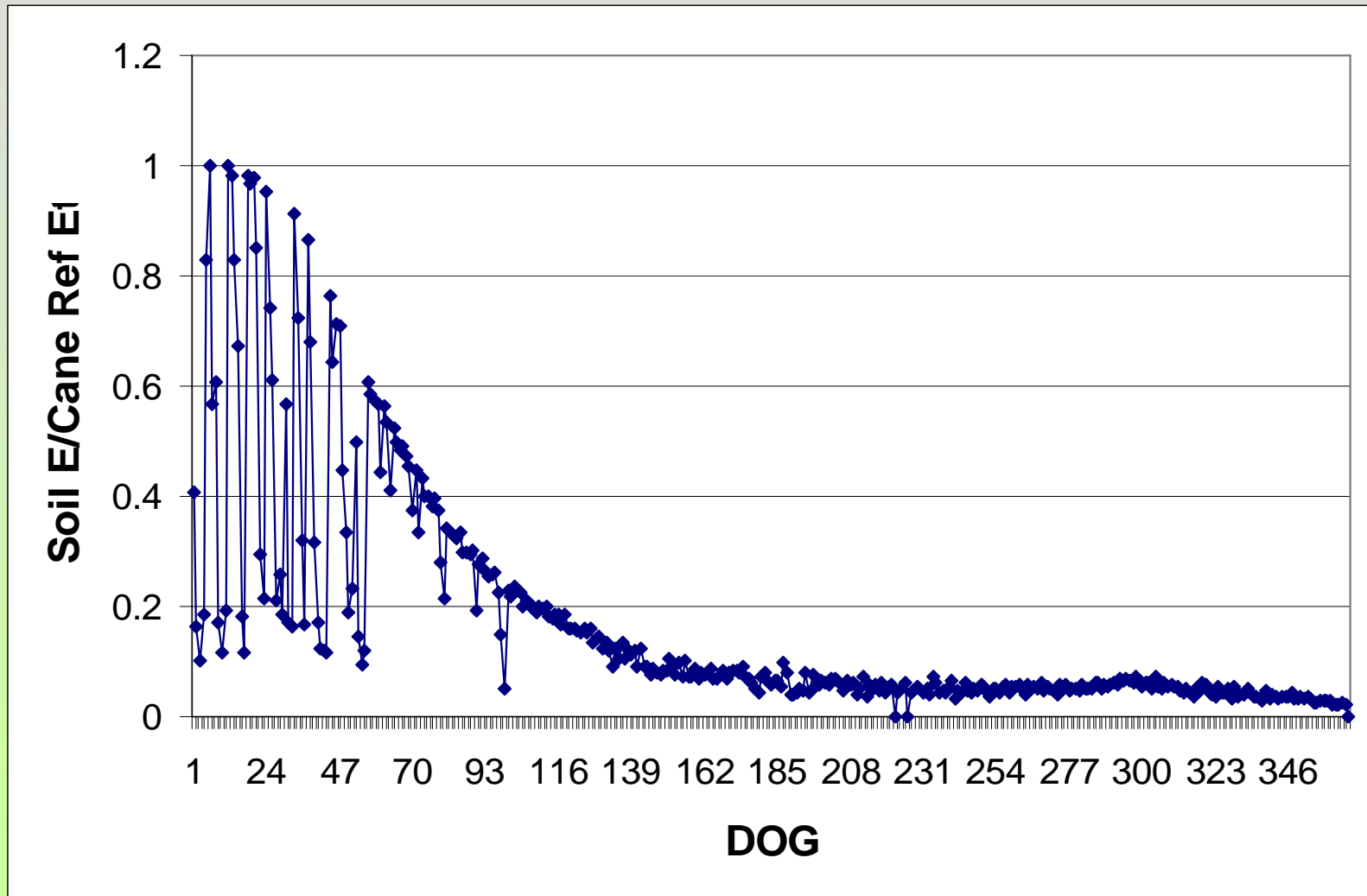
Soil Water Concepts



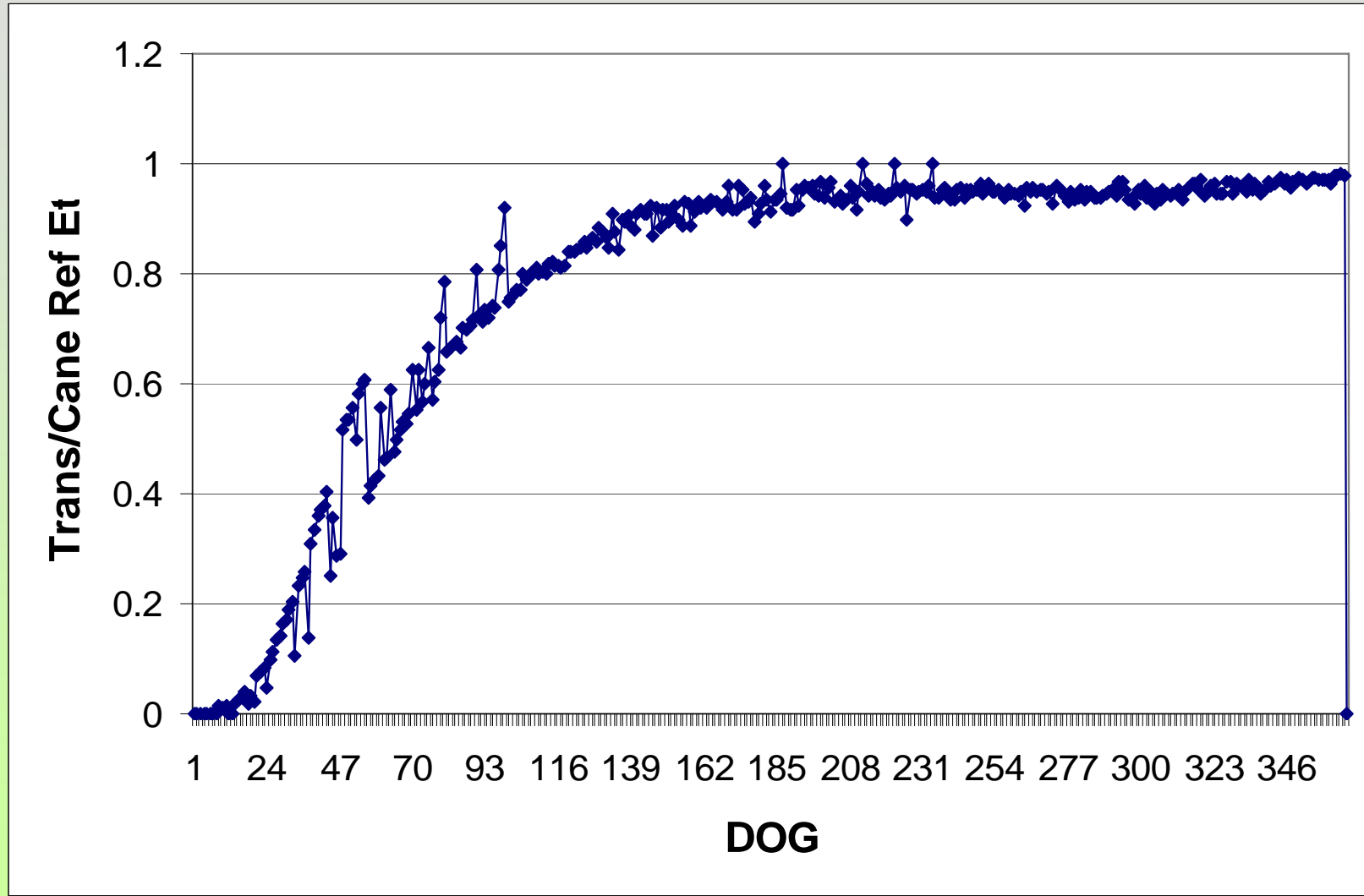
Estimating components of the water balance

- Evaporation + transpiration – Potential E_t calculated using Penman-Monteith
 - Soil evaporation calculated separately from transpiration
 - Rainfall and estimate of net irrigation as direct inputs
-

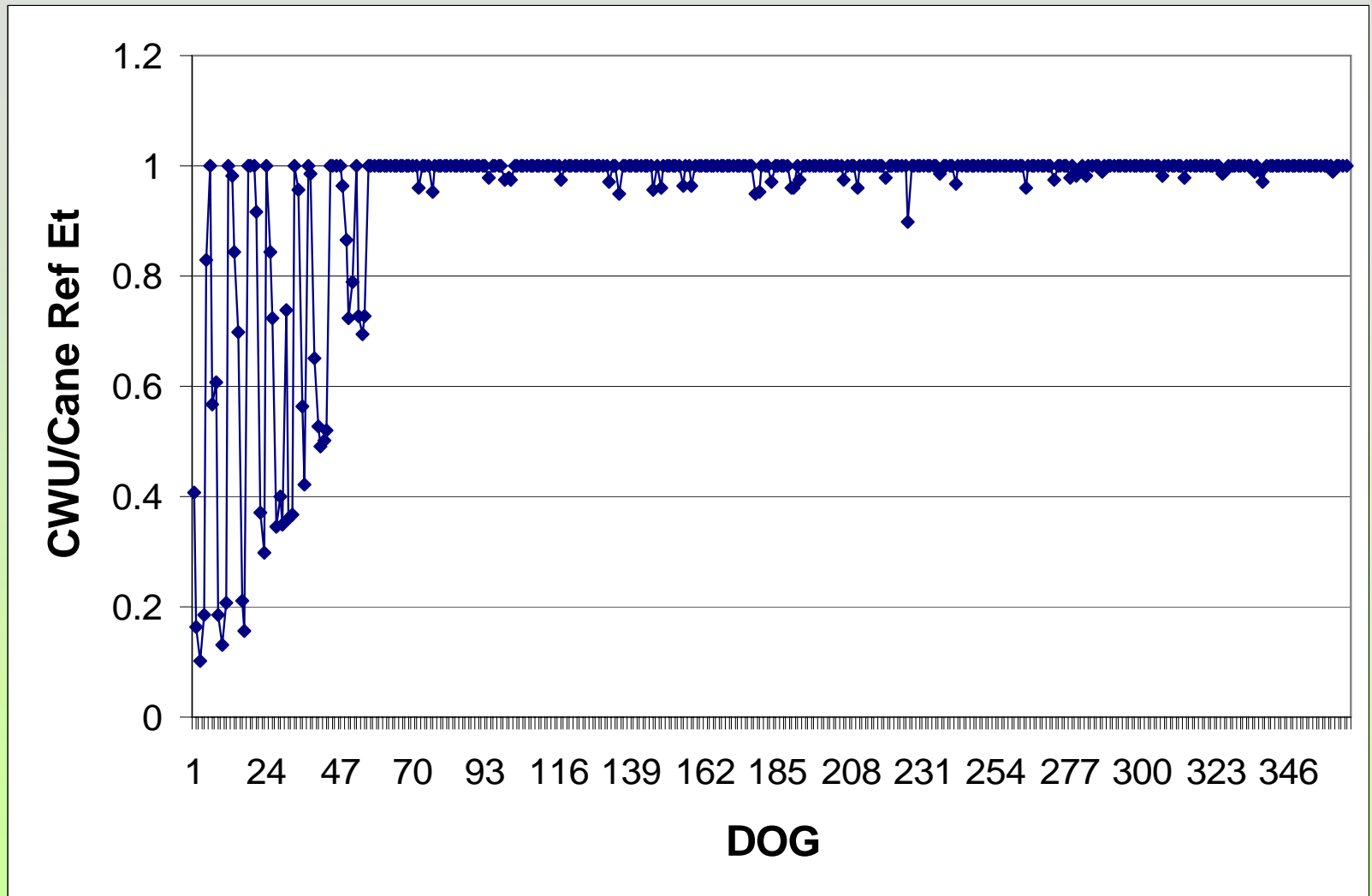
Soil Evap. as a % of Pot Et



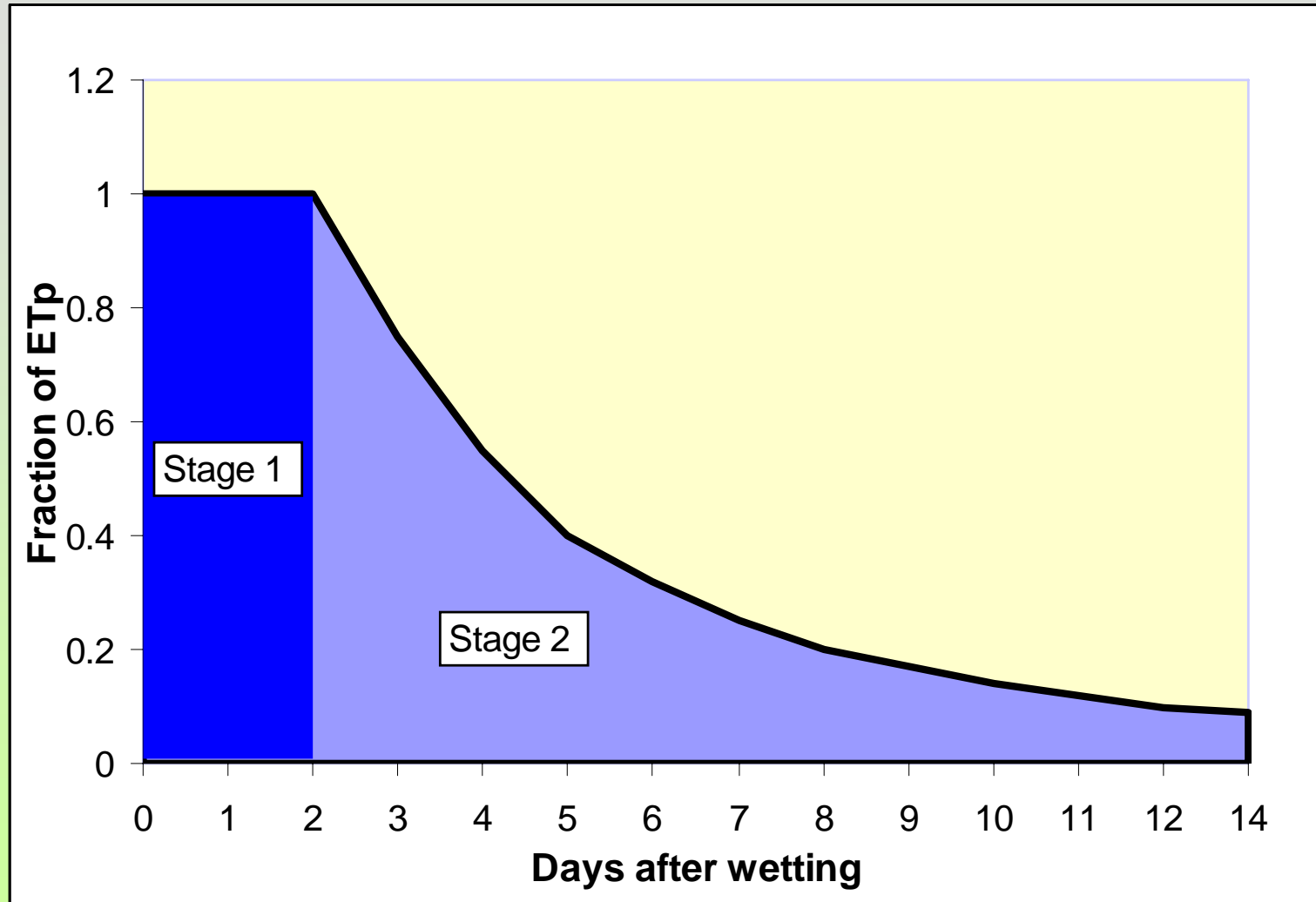
Transpiration as a % of Pot Et



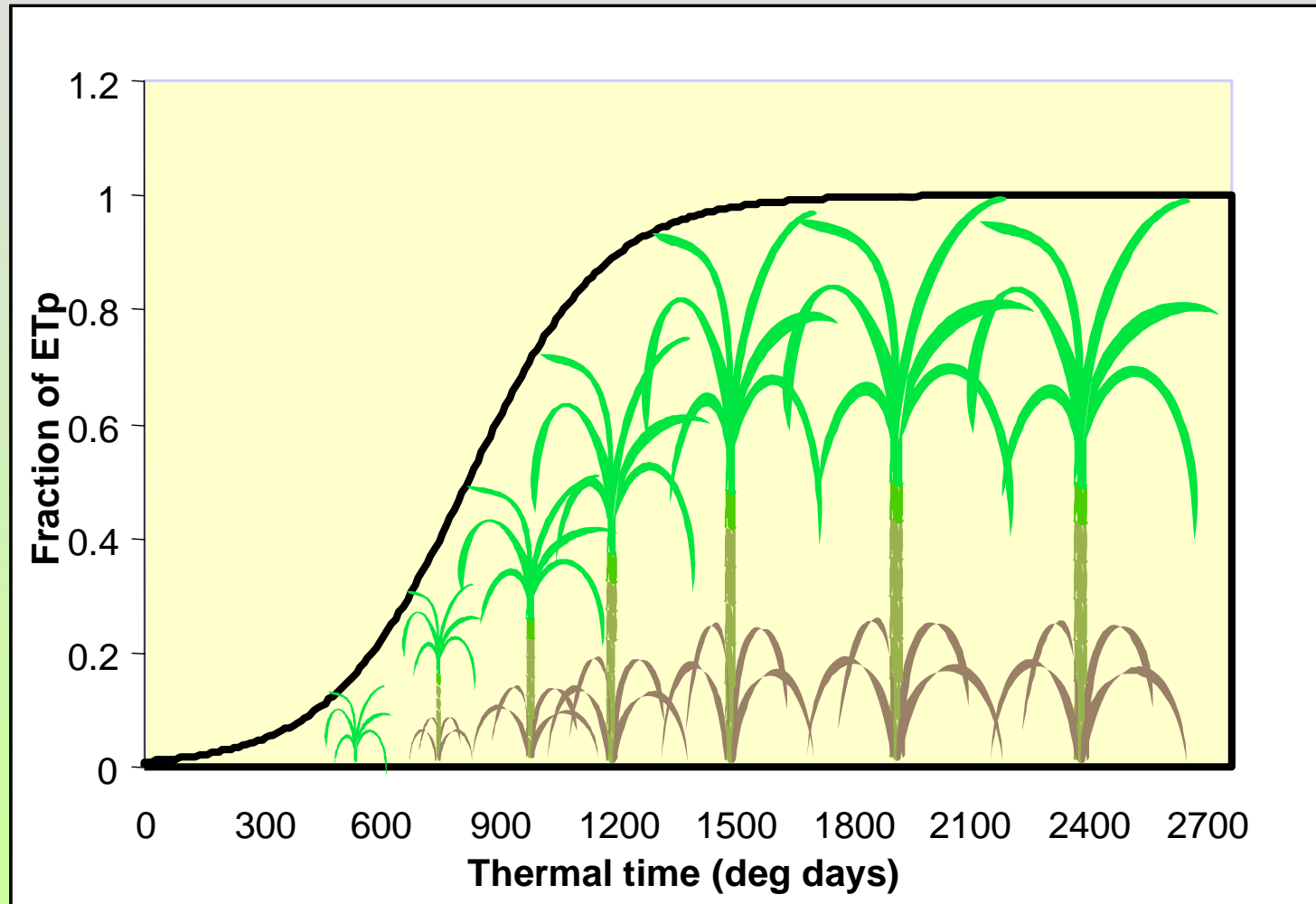
CWU as a % of Pot Et



Two-Stage Soil Evaporation Model



Transpiration – Thermal Time-based Canopy Development Model



Field soil details

Irrigation Scheduling for Season Current under Location Section - 01

Excel Preview Edit Graph ☐ Show cum. Rainfall Drag Curve Edit Comments Hide Grids + - ✓ x

General Rainfall Irrigation Canopy development Daily WB Graph Graph data

Location

01

- S00501
- S00502
- S00503
- S00504
- S00505
- S00506
- S00701
- S00702
- S00703
- S00704
- S00801
- S00802
- S00803
- S00804
- S00805
- S00806
- S00807
- S00808

Field Details - General

Field Name	S00501
Ratoon	1
Grow Start Date	30/08/2007
Harvest Date	6/08/2008
Met. Site	Mlaula AWS
Rain Gauge	ML01-Gauge 1
Irrigation System	Sprinkler (24 mm)

Irrigation System Details

Irrigation System	Sprinkler (24 mm)
Wetted Area(%)	100
Typical Net App. (mm)	24
Minimum Cycle Time (days)	3
Typical App. Efficiency (%)	75

Soil Details

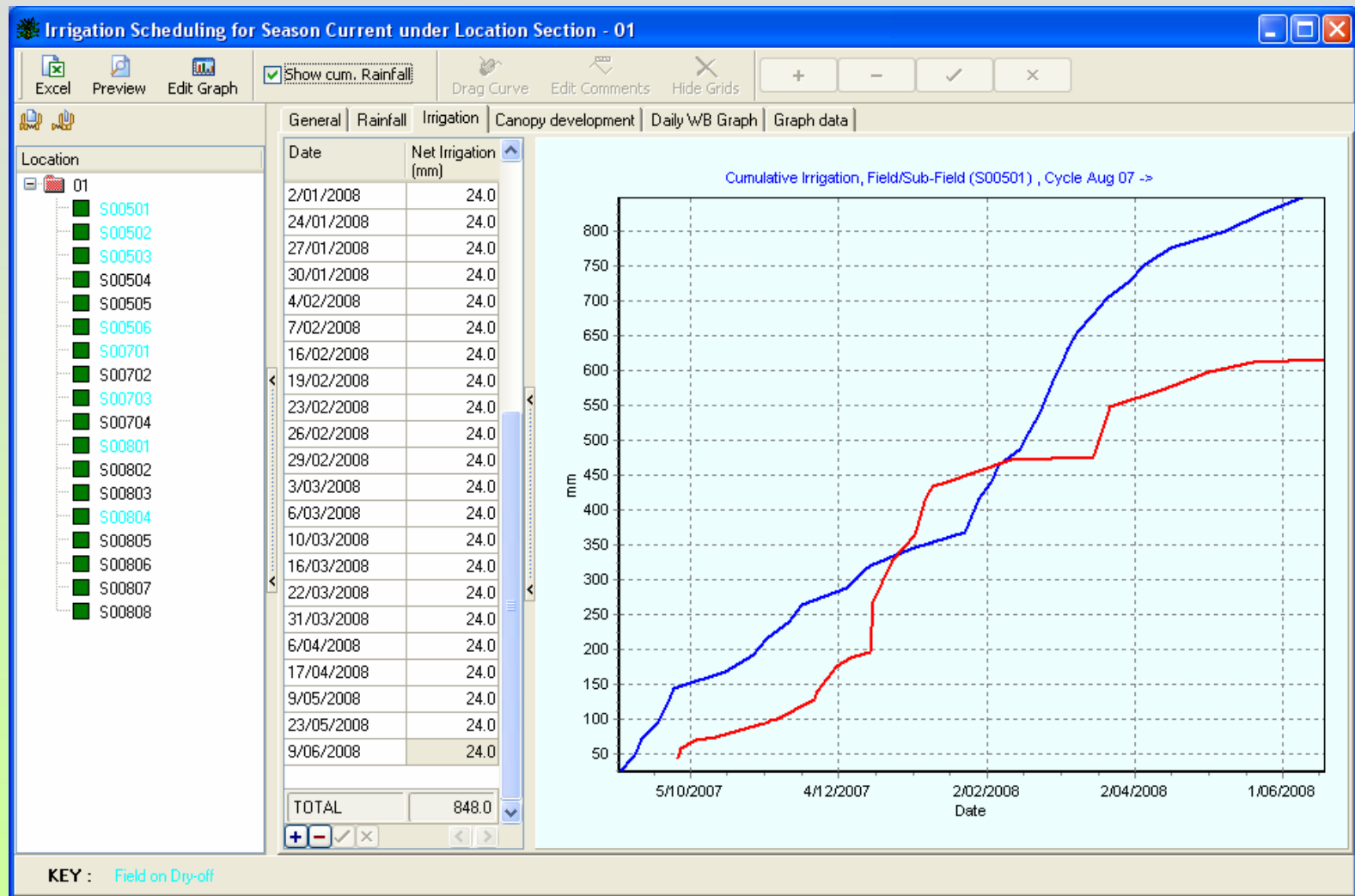
TAM (mm)	70
FAM(mm)	35
Refill Point (mm)	35
Starting SWB (mm)	0
Drain Days	2

Dry-Off Details

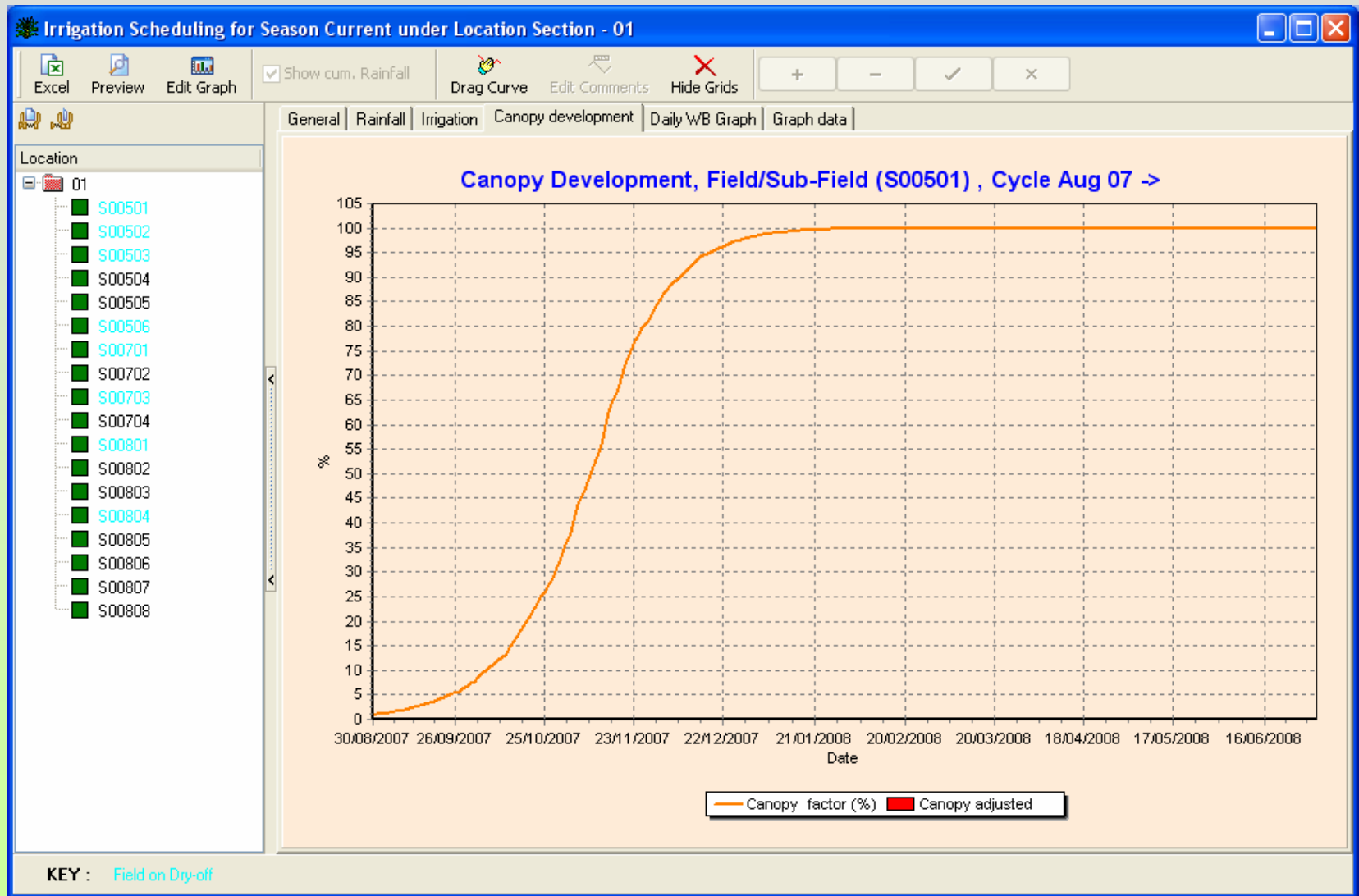
Dry-off Date	20/06/2008
Multiple of TAM	2.5
Dry-off TAM (mm)	70
Link Dry-off to Last Spray Date?	<input type="checkbox"/>

KEY : Field on Dry-off

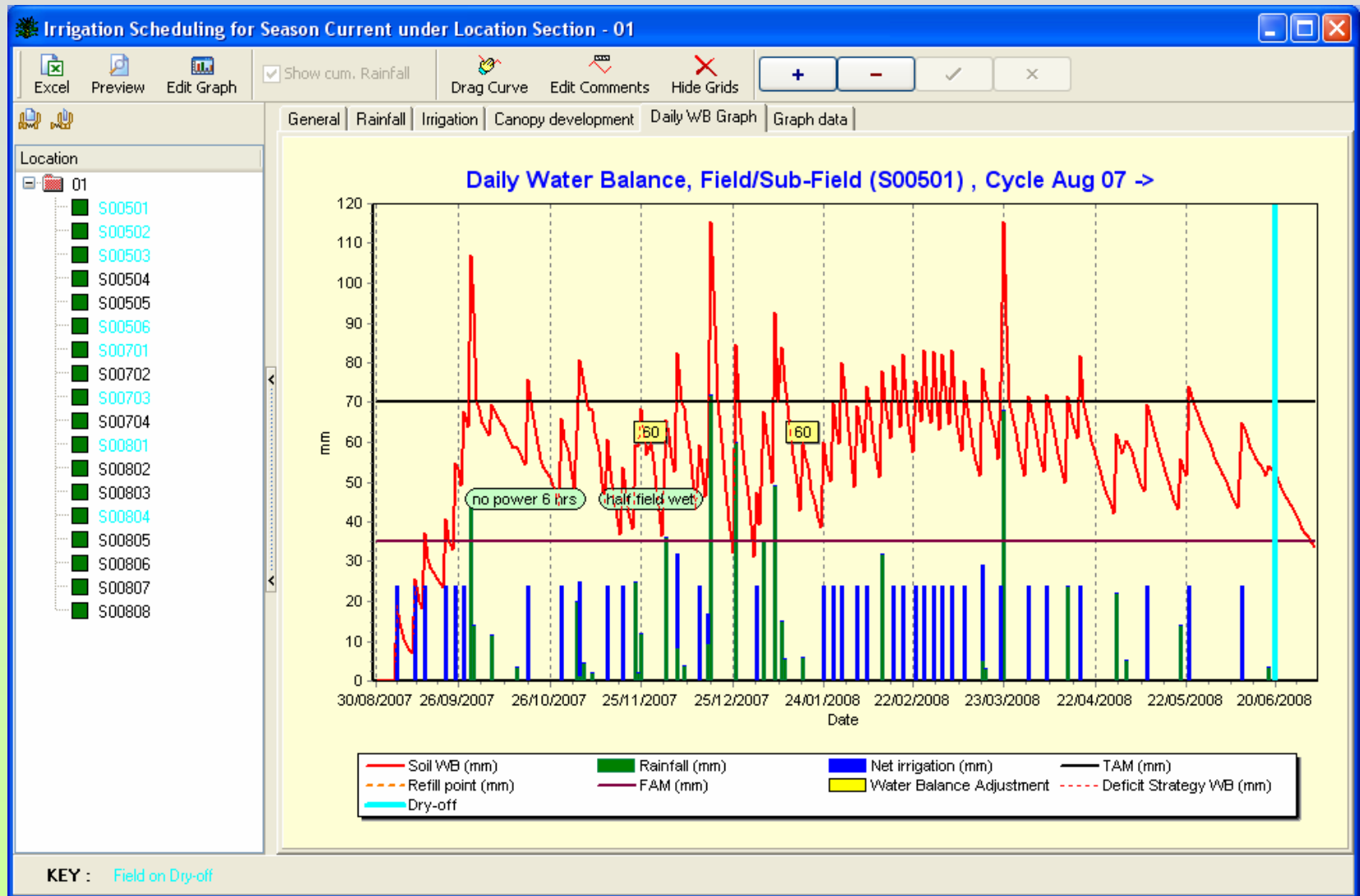
Irrigation & Rainfall



Canopy Development



Water balance



Weekly Schedule

Schedule Week at a Time Starting 3/07/2008 and Location

</

Advantages

- Improve water use efficiency
- Raise awareness of irrigation on the estate
- Improve logistics of water-ordering



Conclusions

- Models have the ability to provide physiologically based decision-support tools to commercial operations
 - Allows for wide adoption of new technology through client base
 - Improve yields through better decisions
 - Save costs through better monitoring and control
-