Appendix 8: Summary of the SINATA Tool
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The SINATA model

The purpose of this report is to provide a summary of how the SINATA (**S**trategic **I**rrigation and **N**itrogen **A**ssessment **T**ool for **A**pples) model comes together.

What is SINATA?

SINATA is a decision support tool, formulated in Excel^{TM}, to provide a guide for advisors and growers on optimization of irrigation and nitrogen application for the major apple-growing growing regions of Australia. The tool works at the block scale to determine water and nitrogen fertilizer needs based on local soil and climate conditions, tree age and anticipated crop yields. Being in Excel allows the model to be made more widely accessible, with the added potential to serve as a repository of knowledge that is already captured or may be advanced in the future.

The SINATA model in EXCEL™ comprises a number of worksheets that enable the USER to set inputs e.g. to describe details of the orchard block with appropriate soil and climate attributes (Fig. 1), and to view outputs and outcomes of management decisions e.g. annual and monthly water and nutrient balances in response to irrigation and N-fertilizer use.

What is the main purpose of SINATA?

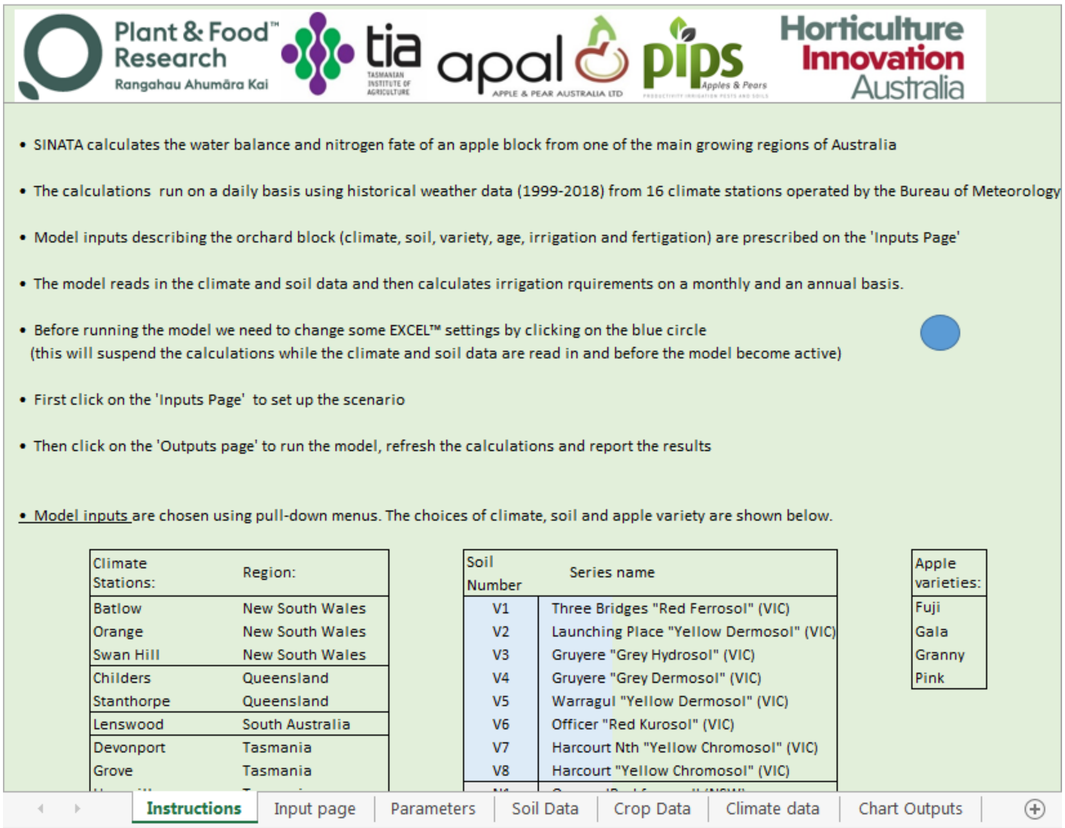
The primary goal of SINATA is to understand how water and fertilizer application (rates, timings) can be managed to satisfy the tree’s requirements, mitigating leaching and optimising productivity without cost to fruit quality.

What goes into the model?

The model includes local climate and soil data, and includes functional relations for different apple varieties (phenology and yield) to assess irrigation and N-fertilizer needs. The following list outlines what goes into the model.

- Inputs – soil (hydraulic and physio-chemial properties), plant (crop factors and productivity), atmosphere (long term climate including ETo and rainfall) data
- Processes – water (uptake, runoff, drainage, storage) and nitrogen (uptake, soil transformation, leaching, runoff) balances
- Functional descriptions of tree productivity (variety and age relationships including phenology and yield)
- Outputs – monthly and annual water and nitrogen balances

A number of factors e.g. associated with location, variety, irrigation and fertigation, are selected using pull-down menus from the tools ‘Input page’ worksheet (Fig. 2). The remaining factors are set internally, by default, and are from within a set of linked worksheets (‘Parameters’, ‘soil’, ‘crop’ and ‘climate’ data) that are normally hidden from the User’s view.



- SINATA calculates the water balance and nitrogen fate of an apple block from one of the main growing regions of Australia
- The calculations run on a daily basis using historical weather data (1999-2018) from 16 climate stations operated by the Bureau of Meteorology
- Model inputs describing the orchard block (climate, soil, variety, age, irrigation and fertigation) are prescribed on the 'Inputs Page'
- The model reads in the climate and soil data and then calculates irrigation rquirements on a monthly and an annual basis.
- Before running the model we need to change some EXCEL™ settings by clicking on the blue circle
(this will suspend the calculations while the climate and soil data are read in and before the model become active)
- First click on the 'Inputs Page' to set up the scenario
- Then click on the 'Outputs page' to run the model, refresh the calculations and report the results
- Model inputs are chosen using pull-down menus. The choices of climate, soil and apple variety are shown below.

Climate Stations:	Region:
Batlow	New South Wales
Orange	New South Wales
Swan Hill	New South Wales
Childers	Queensland
Stanthorpe	Queensland
Lenswood	South Australia
Devonport	Tasmania
Grove	Tasmania

Soil Number	Series name
V1	Three Bridges "Red Ferrosol" (VIC)
V2	Launching Place "Yellow Dermosol" (VIC)
V3	Gruyere "Grey Hydrosol" (VIC)
V4	Gruyere "Grey Dermosol" (VIC)
V5	Warragul "Yellow Dermosol" (VIC)
V6	Officer "Red Kurosol" (VIC)
V7	Harcourt Nth "Yellow Chromosol" (VIC)
V8	Harcourt "Yellow Chromosol" (VIC)

Apple varieties:
Fuji
Gala
Granny
Pink

Figure 1. Instructions worksheet from the SINATA (**S**trategic **I**rrigation and **N**itrogen **A**ssessment **T**ool for **A**pples) model. The tool includes local climate and soils data. Functional relations are used to calculate dry-matter production and nitrogen demands for four of the commercial apple varieties. Several worksheets that are normally hidden (‘Parameters’, ‘soil data’, ‘crop data’ and ‘climate data”) contain default parameter values derived from the experimental findings of the PIPS (Production Irrigation pests and Soils) project.

What can the SINATA tool do?

The following list outlines what SINATA can do.

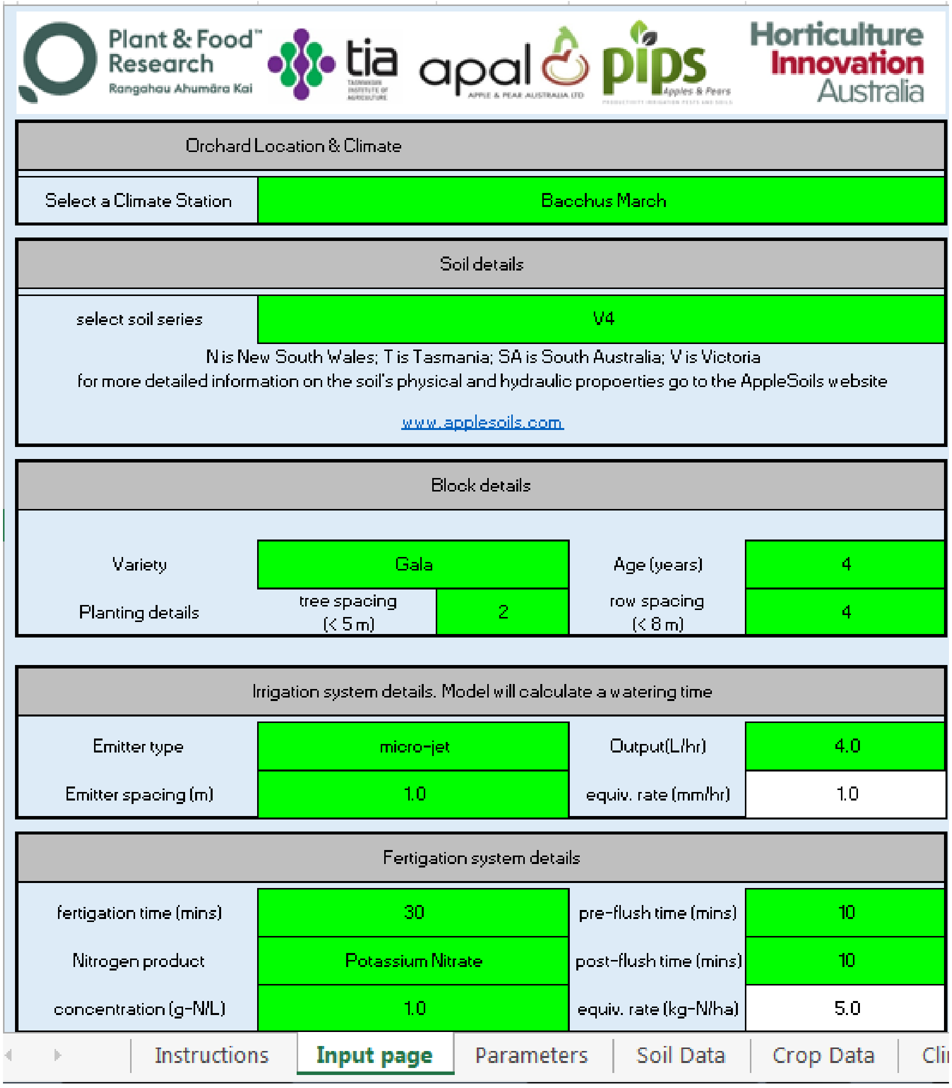
- Calculate a soil water balance – to provide advice on crop water use and irrigation
- Simulate crop growth, dry matter allocation, nitrogen distribution – to advise on tree nitrogen demands and returns of organic matters (leaves and prunings)
- Simulates N turnover in the soil – to advise how much nitrogen is mineralization fom soil organic matter
- Calculates a soil nitrogen balance – to provide advice on fate of surface applied fertilizer

- Estimate the environmental impact in terms of nitrogen losses

What can't the SINATA tool do?

The following list outlines some, but not all, of the things that SINATA can't do.

- simulate future scenarios (i.e. climate change, warmer, drier, etc)
- simulate fruit quality (size, colour etc)
- accommodate unknown soils or climates or apple varieties, without additional data
- make management decisions for the current year (uses historical rather than real-time climate data
- handle the 2- or 3-dimensional nature of an orchard such as mounding and contouring



Orchard Location & Climate

Select a Climate Station	Bacchus March

Soil details

select soil series	V4

N is New South Wales; T is Tasmania; SA is South Australia; V is Victoria
for more detailed information on the soil's physical and hydraulic propoerties go to the AppleSoils website

www.applesoils.com

Block details

Variety	Gala		Age (years)	4
Planting details	tree spacing (< 5 m)	2	row spacing (< 8 m)	4

Irrigation system details. Model will calculate a watering time

Emitter type	micro-jet	Output(L/hr)	4.0
Emitter spacing (m)	1.0	equiv. rate (mm/hr)	1.0

Fertigation system details

fertigation time (mins)	30	pre-flush time (mins)	10
Nitrogen product	Potassium Nitrate	post-flush time (mins)	10
concentration (g-N/L)	1.0	equiv. rate (kg-N/ha)	5.0

Figure 2. A screen image of the "Input page" worksheet from the SINATA (**S**trategic **I**rrigation and **N**itrogen **A**ssessment **T**ool for **A**pples) model. The tool includes local climate and soils data. Functional relations are used to calculate the dry-matter production and nitrogen demands for four of the

commercial apple varieties. Values in the green boxes are selected using a pull-down menu. All other cells are locked from entry.

What are the assumptions behind the calculations?

Tree water use

The daily climate variables from BOM include a value for the reference evaporation rate, ET_0 [mm/d], which defines the potential rate of evaporation from an extensive surface of green grass cover, of a short, uniform height, that is actively growing, completely shading the ground, and is not short of water or nutrients. On the other hand, the potential water use of the apple trees, ET_C, is calculated using a crop factor, K_C, as:

$$ET_\mathrm{C} = K_\mathrm{C}\, ET_\mathrm{O} \qquad \text{[Eq. 1]}$$

For this calculation, the daily value of ET_C is represented by the tree water use (T, L/d), which we have measured with sap flow sensors for a ranges of tree ages and canopy sizes, divided by the ground area per tree (e.g. A_G = 3.85m^2 at a spacing of 1.1 m by 3.5 m (Fig. 3). A functional relationship has been derived for Kc in order to calculate the seasonal transpiration rate of apple trees, including adjustments for tree ages and different varieties.

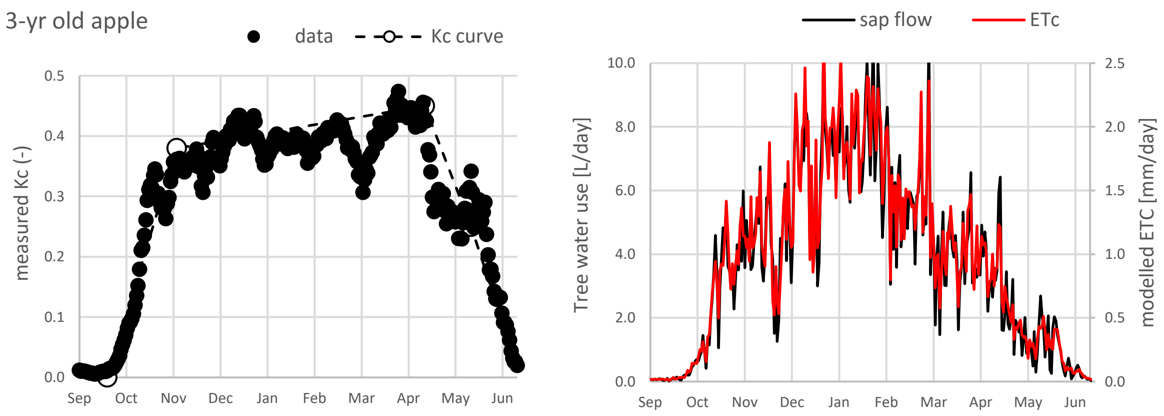


Figure 3. The top panel shows the seasonal pattern of the crop factor, *K*c, used to calculate the water use of Envy™ apple trees (*Malus* x *domestica* var. 'Scilate'), as derived from measured sap flow and the local ETo value from climate data. The broken line represents a stylised envelope curve used by SINATA to represent the influence of leaf development on transpiration losses from these young apple trees. The bottom panel shows the seasonal pattern of daily transpiration (n=6) of 3-year-old Envy™ apple trees (*Malus* x *domestica* var. 'Scilate') at Lucaston Park Orchards, Tasmania, as measured using the compensation heat-pulse method. The red line shows the tree water use as calculated from the FAO-56 model using the seasonal crop factor from the top panel.

The ‘Parameter’ worksheet in SINATA holds a number of functional relationships used by the tool. For example, the left panel of Fig. 4 shows the mid-season crop factor as a function of time since planting, or tree age. Older trees tend to transpire more water than younger trees due to the increased size of the leaf canopy, if all other factors are equal. However, as the trees develop towards full canopy the leaf area stabilizes and the crop factor reaches a plateau with a maximum close to 1.0. The crop factor – tree age relationship in Fig. 4 comes from an extensive series of trunk sap-flow measurements on different-ages apple trees, carried out under the PIPS-I & PIPS-II research programmes in Victoria and Tasmania.

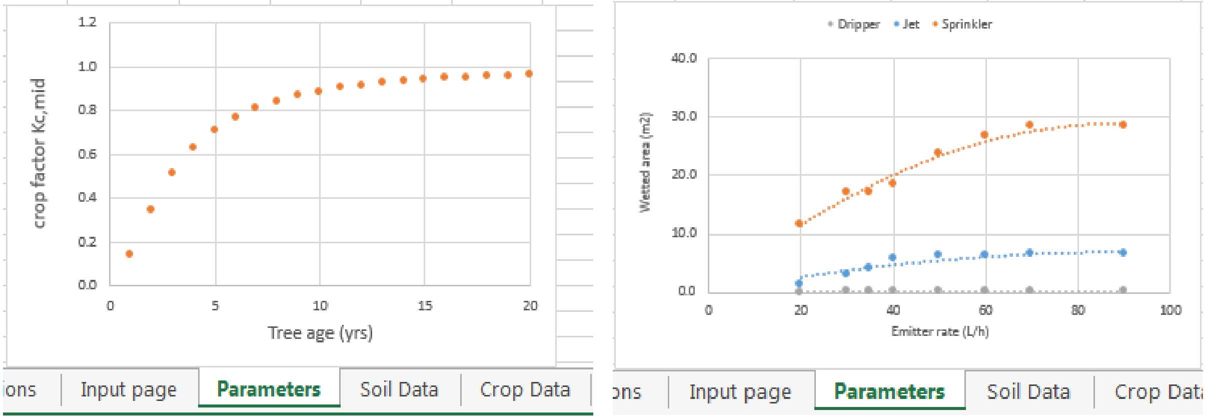


Figure 4. The left panel shows the assumed relationship between the mid-season crop factor and the tree age, as determined from the ratio of measured tree water use (L/day) per unit ground area (m2/tree) divided by potential evapotranspiration (ETo, mm/day). The right panel shows the assumed relationship between the size of the wetted area (m^2) and the emitter output (L/hr) for drippers (grey line), jets (blue line) and sprinklers (orange line) (Source: Netafim product guide downloaded from www.netafirm.com).

Irrigation

The fractional wetted area of the orchard block is important for determining how much of the recently-applied irrigation is lost to the atmosphere as surface evaporation. The right panel of Fig. 4 shows the relationship employed by SINATA to determine the area wetted by an emitter as a function of output rate. This relationship comes directly from manufacturer’s specification sheets and it is ‘hard-coded’ into SINATA.

Daily irrigation volumes are determined on the basis of need, by adding sufficient irrigation to maintain soil water contents above a strategic set-point curve which is illustrated by the grey line of Fig. 5. The default strategy is to raise soil moisture levels between budburst and flowering, then reduce soil moisture levels (with minimum water stress) between flowering through to harvest, then to allow for a gradual decline in soil moisture until leaf fall, and finally to halt irrigation until the next budburst occurs. Three other lines are shown in Fig.5. These are the field capacity (or the upper drained limit of the soil profile), the refill point and wilting point (FC = soil water content at a matric potential of 0.1 kPa) which are integrated soil properties (see next section) summed from the soil surface to the bottom of the root-zone.

By default, SINATA employs the irrigation strategy of Fig. 5 to determine the irrigation demands. However, the USER can also change the set points for irrigation, to simulate a revised irrigation strategy and then assess the outcome in terms of changed water demands.

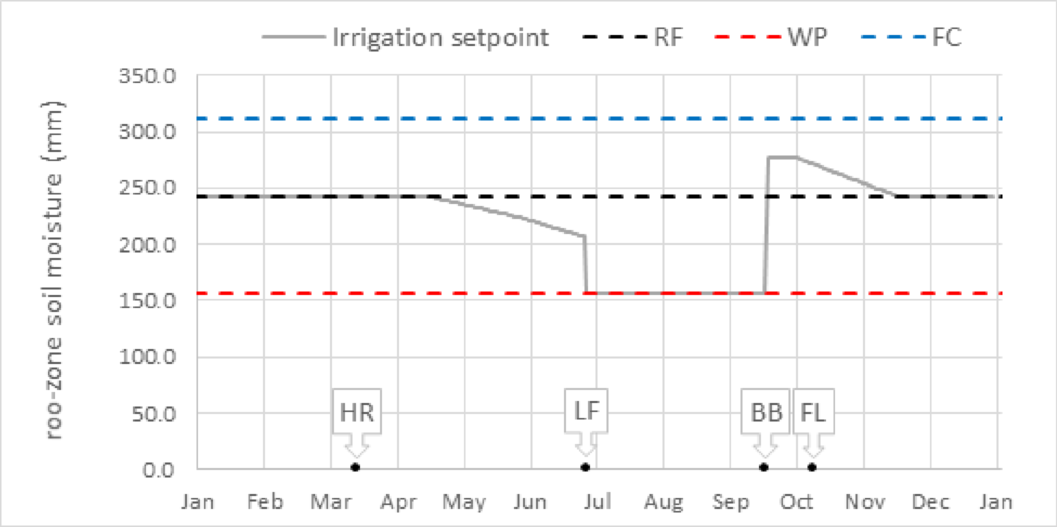


Figure 5. SINATA defines the irrigation strategy using a number of ‘set-points’ to maintain the root-zone water at critical times. These set points are defined by the soils water holding capacity at field capacity (FC) and wilting point (WP). The refill point (FP) represents the soil water content where trees begin to show signs of water stress. Boxes on the lower axis represent key phenological times of Budburst (BB), flowering (FL), harvest (HR) and leaf fall (LF).

Soil properties

A total of 57 soils are incorporated into SINATA. The soil’s hydraulic properties are characterized by the water retention curve (WRC) and the hydraulic conductivity (HC) function. The WRC describes the relationship between the soil’s water content, ϴ [L/L] and matric potential, h [cm]. This curve is modelled using the van Genuchten (1980) equation:

$$\Theta = \frac{\theta - \theta_R}{\theta_S - \theta_R} = \left[\frac{1}{1 + (\alpha h)^N} \right]^M \qquad \text{Eq. [1]}$$

Here S and R indicate saturated and residual values of the soil water content (θ) and the parameters α, N and M (=1-1/N) are fitting parameters that determine the ‘shape’ of the curve. The non-linear routine SOLVER in Microsoft® Excel® was used to determine each of the fitting parameters (Fig. 6).

Soil processes

The decomposition of soil organic matter (biomass) adds to the amount of mineral nitrogen in the soil. This process is known as mineralization. Mineralization is modelled by dividing the soil organic matter into two pools – a fast cycling litter pool (labile C and N) and an almost stable humus pool following Johnsson et al. (1987). This two-pool model then considers the total soil carbon and nitrogen that cycle within soil organic material. The relative amounts of these two components change daily to reflect inputs of new biomass (e.g. from leaf fall and root-turnover) and losses of older biomass as it decomposes. The nitrogen demand for the internal cycling of soil-C and soil-N is regulated by the C/N ratio of the soil biomass, r_O, which is one of the important model inputs, and the other important factor is the fraction of labile C & N. Figure 7 shows modelled mineralization rates compare favourably against laboratories studies from top-soil at Lucaston, Tasmania.

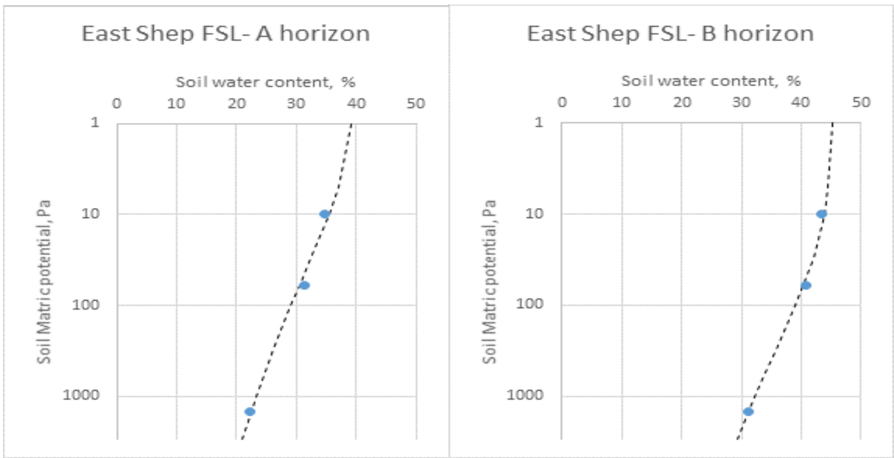


Figure 6. The soil's water retention curve (WRC) for a Lemnos Loam (top panels) and a Shepparton fine sandy loam (bottom panels) from near Shepparton, Victoria. Data (blue markers) were sourced from (Mehta and Wang, 2005). The broken lines are curves fitted for the van Genuchten model (1980) as described by Eq 1. The soil's field capacity (FC) is given by the water content at a potential of -10 kPa. The soil's wilting point (WP) is defined by the water content at a potential of -1500 kPa. The refill point for irrigation (RP) is typically at a potential of about -100 kPa.

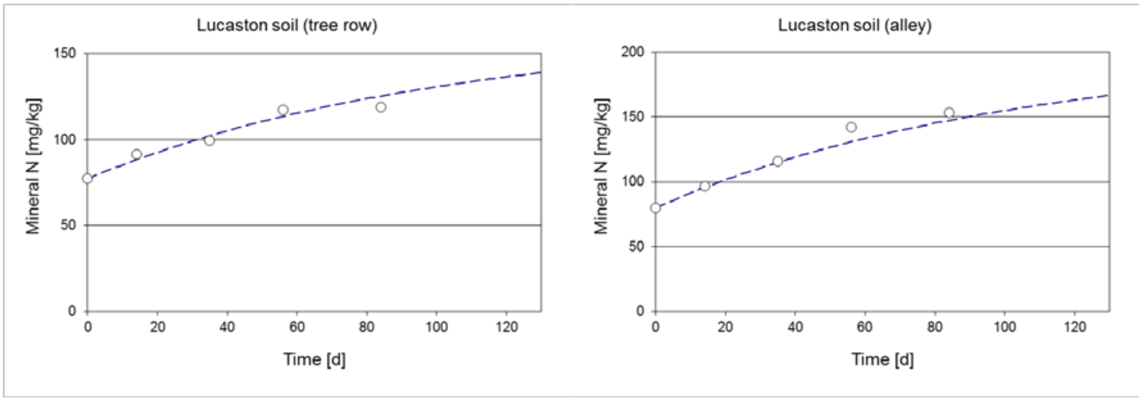
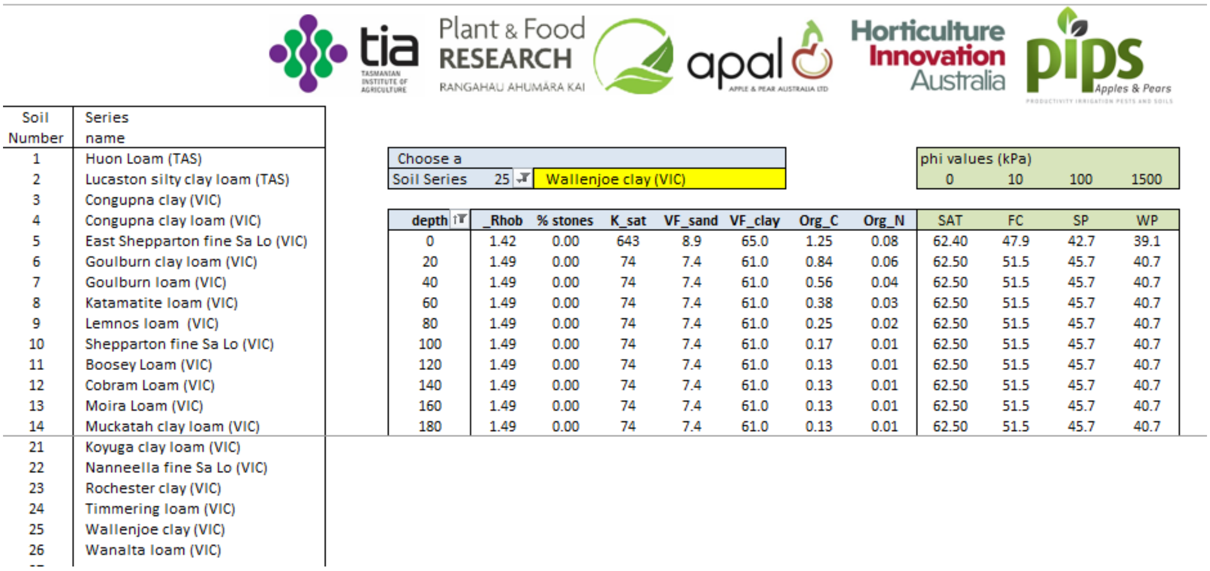


Figure 7. The change in soil mineral nitrogen (marker) observed during laboratory incubations of soils sampled from the Lucastion N-trial site, Tasmania. The broken line is model outputs from the mineralization sub-model of SINATA.

How the soil data is incorporated into SINATA

The soil properties for SINATA are compiled into a 'hidden' database that resides inside the tool. Data for a given soil type are selected using the pull-down menu of Fig. 2. An example of a subset of the soil property data is shown Fig. 8. The hydraulic conductivity and the water holding capacity of the top soil (10 cm) are used to classify the hydrologic status of the soil (e.g. well drained, poorly drained etc). This property modifies the surface runoff component of SINATA which is based on a daily rainfall totals with an adjustment to express the effect of slope and soil water content (Williams 1991).



Soil Number	Series name
1	Huon Loam (TAS)
2	Lucaston silty clay loam (TAS)
3	Congupna clay (VIC)
4	Congupna clay loam (VIC)
5	East Shepparton fine Sa Lo (VIC)
6	Goulburn clay loam (VIC)
7	Goulburn loam (VIC)
8	Katamatite loam (VIC)
9	Lemnos loam (VIC)
10	Shepparton fine Sa Lo (VIC)
11	Boosey Loam (VIC)
12	Cobram Loam (VIC)
13	Moira Loam (VIC)
14	Muckatah clay loam (VIC)
21	Koyuga clay loam (VIC)
22	Nanneella fine Sa Lo (VIC)
23	Rochester clay (VIC)
24	Timmering loam (VIC)
25	Wallenjoe clay (VIC)
26	Wanalta loam (VIC)

Choose a
Soil Series 25 Wallenjoe clay (VIC)

phi values (kPa)
0 10 100 1500

depth	_Rhob	% stones	K_sat	VF_sand	VF_clay	Org_C	Org_N	SAT	FC	SP	WP
0	1.42	0.00	643	8.9	65.0	1.25	0.08	62.40	47.9	42.7	39.1
20	1.49	0.00	74	7.4	61.0	0.84	0.06	62.50	51.5	45.7	40.7
40	1.49	0.00	74	7.4	61.0	0.56	0.04	62.50	51.5	45.7	40.7
60	1.49	0.00	74	7.4	61.0	0.38	0.03	62.50	51.5	45.7	40.7
80	1.49	0.00	74	7.4	61.0	0.25	0.02	62.50	51.5	45.7	40.7
100	1.49	0.00	74	7.4	61.0	0.17	0.01	62.50	51.5	45.7	40.7
120	1.49	0.00	74	7.4	61.0	0.13	0.01	62.50	51.5	45.7	40.7
140	1.49	0.00	74	7.4	61.0	0.13	0.01	62.50	51.5	45.7	40.7
160	1.49	0.00	74	7.4	61.0	0.13	0.01	62.50	51.5	45.7	40.7
180	1.49	0.00	74	7.4	61.0	0.13	0.01	62.50	51.5	45.7	40.7

Figure 8. A screenshot from the SINATA model (Version 2.0) showing the list of available soil series and a subset of parameter values for the hydraulic and physical properties. Data for each soil series can be selected using the filter tab on the "Input Page" worksheet. SINATA has compiled property data for 57 soil profiles from the main apple growing regions of Australia. Values for Western Australia will be added to SINATA once they have been determined.

Plant growth and nutrient uptake

Core components of SINATA's calculations of plant growth and nutrient uptake are derived from a series of model outputs generated by Plant and Food Research's SPASMO model (Soil Plant Atmosphere System Model). SPASMO has previously been parameterized for Australian apple orchards, and verified against field data on tree water use and tree nutrient uptake under the PIPS-1 project (Figs. 9 & 10). Functional relationships in SINATA for plant growth and nitrogen uptake are expressed in a simplified form (Figs 11 & 12). This empirical approach maintains the functionality and integrity of the model outputs.

The empirical curves for crop development are representative of mature trees (i.e. 10 years). The model computes the seasonal development of dry-matter in the various plant components (Fig. 11) and includes temporal adjustments related to key phenological events such as the timing of budburst and harvest (Table 1). This approach accommodates differences in early (e.g. gala) and late (e.g. Pink) apple varieties.

SINATA offers two options to establish nutrient demands of the trees. The first option is a statistical approach, based on yield data provided the by apple-industry, to estimate and expected yield for the four main apple varieties (Gala, Fuji, Pink Lady and Granny Smith). Two yields are suggested: an average orchard with an average yield, or a more productive orchard a higher yield (the upper quartile) as shown in Fig. 13. Some rescaling is applied to the crop-development curves, to account for tree age, and this is done in a non-linear way that mimics the age-related changes in the mid-season crop factor (Fig. 4). The second option to establish the nutrient demands is for tool users to input their anticipated crop yields at harvest time. In this case the crop developmental curves are also re-scaled to match the expected yields.

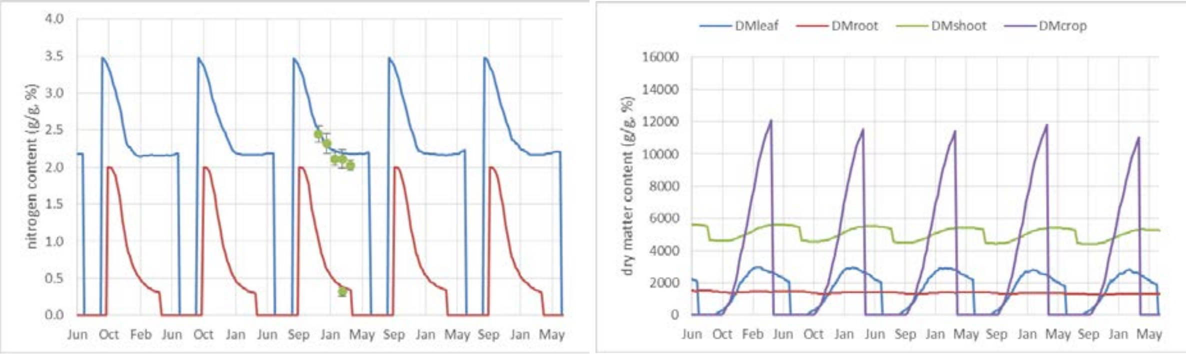


Figure 9. The left panel shows the nitrogen content of leaf (blue lines) and fruit (red lines) material as simulated using Plant and Food Research's SPASMO (**S**oil **P**lant **A**tmosphere **S**ystem **M**odel) model and as measured on Gala trees at Lucaston, Tasmania (green markers). The right panel shows the corresponding dry-matter content of the leaf (blue line), root (red line), shoot (green line) and crop (purple line) material from an orchard of mature (10 years) Gala trees, as simulated using SPASMO.

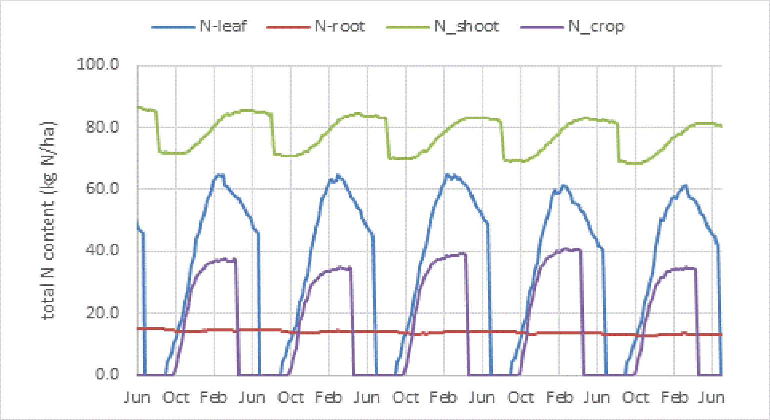


Figure 10. The mass distribution of nitrogen to various components of a model apple orchard, as simulated using Plant and Food Research's SPASMO (**S**oil **P**lant **A**tmosphere **S**ystem **M**odel) model. Trees on the model orchard comprise of leaves (blue line), fine roots (red line), shoots (green line), fruit (purple line) and the woody trunks and structural roots (> 125 kg-N/ha; data not shown).

Fruit are harvested on a set day of year, with all of that nitrogen being removed from the orchard system. Meanwhile a fraction (50%) of the nitrogen in the leaves (at leaf fall) and all of the nitrogen in the pruned shoots (during winter pruning) is returned to the soil surface, as a littler layer, that slowly decomposes releasing organic carbon and nitrogen back to the top soil. The remaining fraction (50%) leaf nitrogen at leaf fall is transferred back to the main structural (woody) components of the tree, to maintain the nitrogen balance. Figure 11 shows functional relationships in SINATA to simulate the temporal development of leaf and fruit dry matter. Figure 12 shows similar functional relationships for the corresponding nitrogen contents. Table 1 lists average dates for key phenological events. The seasonal development of the fruit-N content is adjusted to the length of the fruit-growing season.

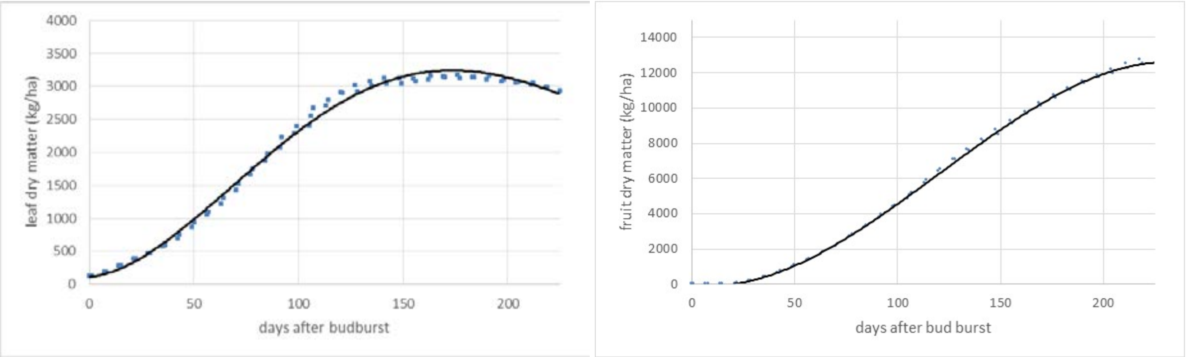


Figure 11. Functional relationships used to describe the temporal development of leaf dry matter (left panel) and fruit dry matter (right panel) of a model orchard of mature Gala apple. The blue markers are average weekly values generated using a range of soils and years. The black lines represent a 4th order polynomial fitted to the model outputs using least-square regression. These functional relations are used in SINATA to calculate dry-matter development and potential nutrient uptake demands. Different developmental curves have been developed the each apple variety, namely (Fuji, Gala, Granny and Pink).

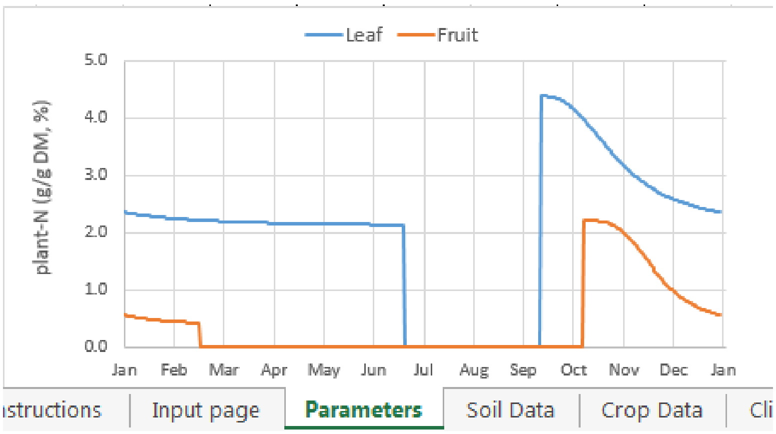


Figure 12. Functional relationships used to describe the temporal development of the nitrogen content of leaf (blue line) and fruit (orange line) material from a model Gala apple tree. SINATA assumes the same N-content range for all apple varieties, and rescales the developmental curves to match the phenology (e.g. Table 1).

Table 1. The average dates for key phenological events occurring on four commercial apple varieties from Australia (Source: adapted from data compiled from the OrchardNet focus orchards (source: HIA database assembled by AgFirst NZ Ltd)

Variety	Budburst	Flowering	Harvest	season (d)
Fuji	18Sep	10Oct	15Mar	178
Gala	13Sep	09Oct	18Feb	157
Granny	10Sep	07Oct	06Apr	208
Pink	09Sep	05Oct	24Apr	227

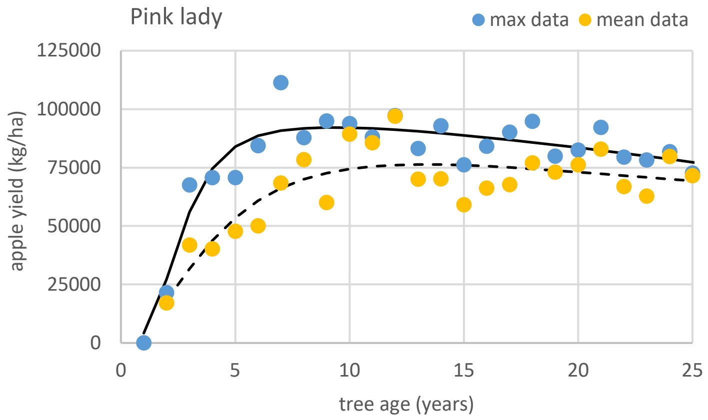
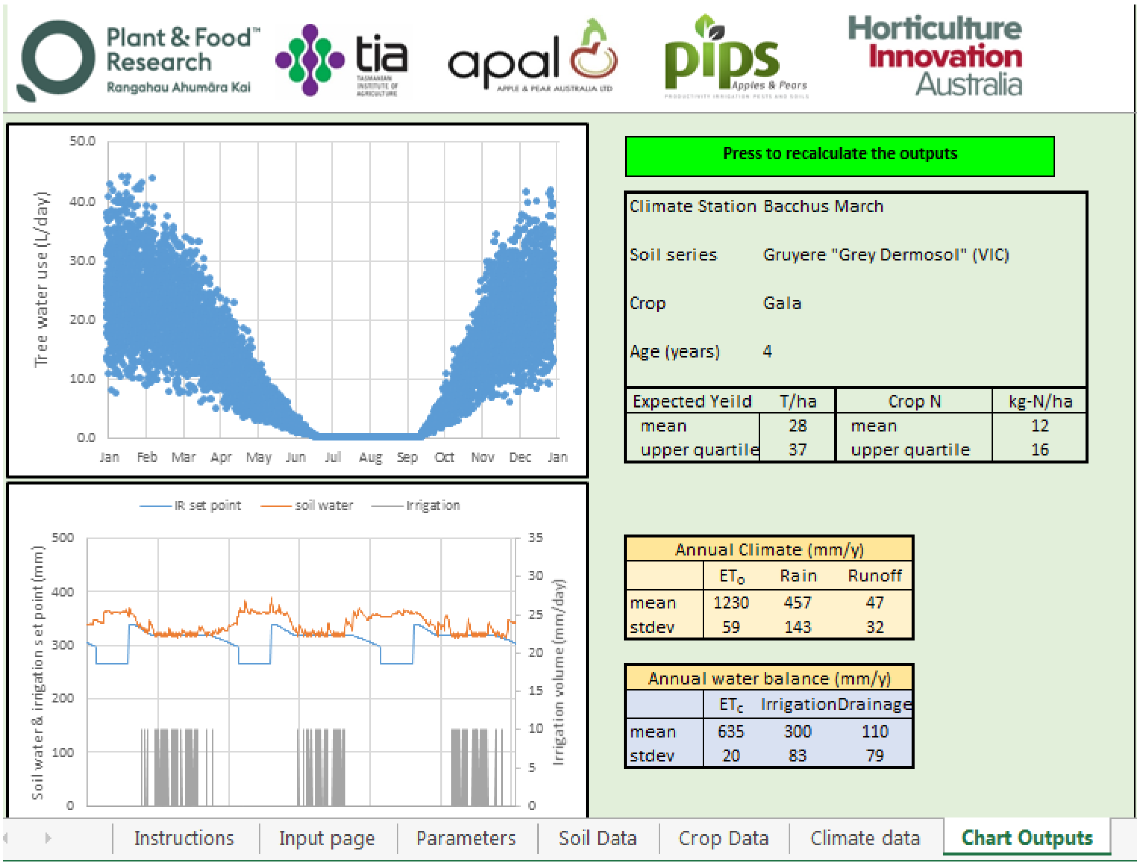


Fig 13. The relationship between harvested fruit yield and tree age for Pink Lady apples grown in Australia (source: HIA database assembled by AgFirst NZ Ltd). Data are regional averages.

Model Outputs

The soil water balance component of the model includes a calculation of the irrigation requirements (Figs 14 & 15). The results are presented on a monthly and an annual basis, using a mean and a standard deviation along with a value for any level of probability e.g. the one in 10 year high.

- Climate data is selected from a pull-down menu on the 'Inputs page' worksheet.
- Users can select one of twenty two climate stations and the press the 'recalculate' button (Fig. 14) to update the model outputs
- All results are summarized on the 'Chart outputs' worksheet
- The tool provides an estimates of the daily tree water use in L per tree. It also shows the water content of the root-zone soil compared against the irrigation strategy. Irrigation volumes are expressed as a depth equivalent (mm) or as a volume ML/ha)
- The tool also displays a monthly summary of the local climate and water balance, reporting values for the long term average (LTA) and the standard deviation of each f the water baace terms (evapotranspiration (ETo), crop water use (ETc), rainfall, irrigation, drainage and runoff components (Fig. 15)



Climate Station Bacchus March

Soil series Gruyere "Grey Dermosol" (VIC)

Crop Gala

Age (years) 4

Expected Yeild	T/ha	Crop N	kg-N/ha
mean	28	mean	12
upper quartile	37	upper quartile	16

Annual Climate (mm/y)			
	ET_o	Rain	Runoff
mean	1230	457	47
stdev	59	143	32

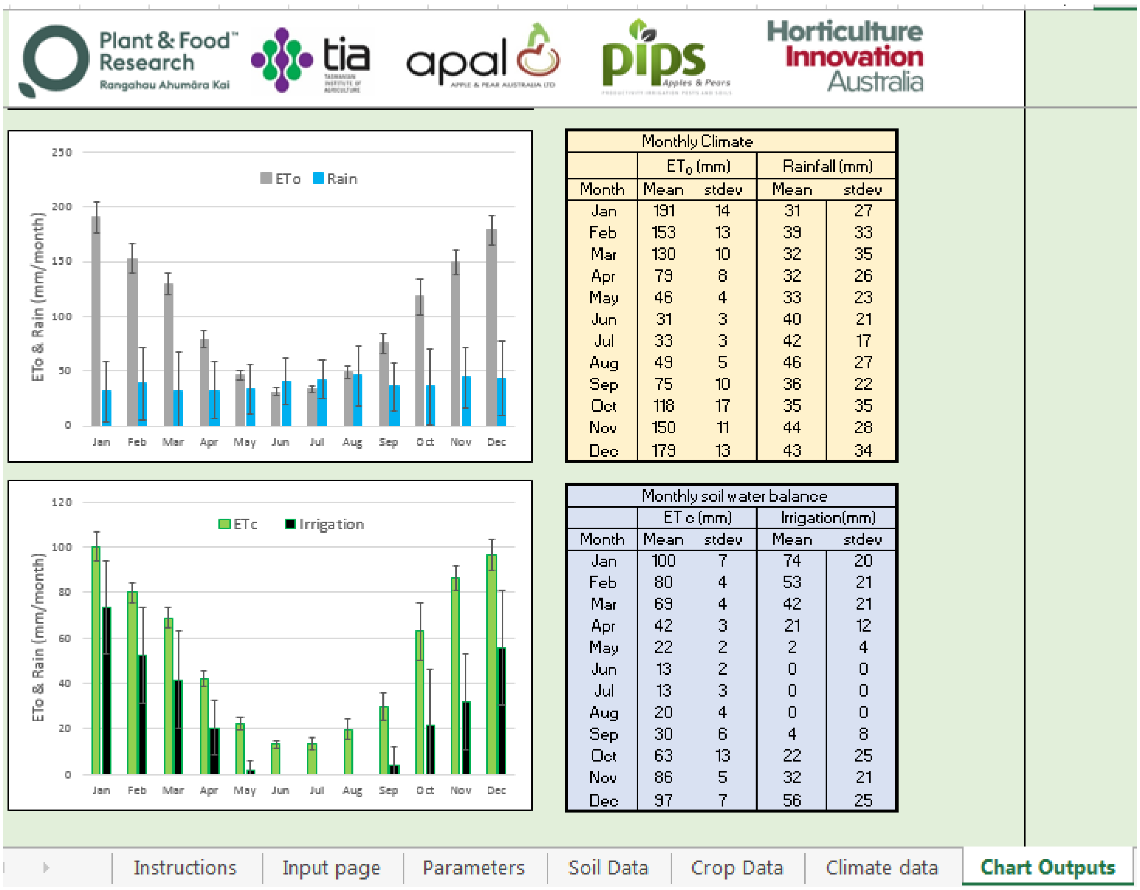
Annual water balance (mm/y)			
	ET_c	Irrigation	Drainage
mean	635	300	110
stdev	20	83	79

Figure 14. A screen image of the 'Chart Outputs' worksheet from the SINATA (**S**trategic **I**rrigation and **N**itrogen **A**ssessment **T**ool for **A**pples) model. The upper right panel records the selected inputs of climate and soil, along with the apple variety (Gala) and the tree age (4 years). Expected values of crop yield and crop nitrogen are derived from the national harvest database (Source: OcrhardNet, AgFirst). The upper left panel shows the daily tree water use computed using 25 years of climate data. The lower left panel shows the water content of the root-zone soil (orange line) compared with irrigation volumes (grey line) required to maintain the set-points for the irrigation strategy (blue line). The lower right panel shows the annual means and standard deviations of the water balance components.

What work remains to be completed?

At the time of writing this report, Plant and Food Research are still finalizing the remaining component of SINATA that deals with nitrogen fate in the soil domain including the potential for N leaching. In most of the apple growing regions of Australia, rainfall is much less that ET_O and so irrigation is essential to maintain production of high quality fruit. SINATA proves guideline values to help with planning for monthly and annual water takes.

Many of the orchard soils in Australia have very poor drainage characteristics, especially in the subsoils. For example, on some of the duplex soils the saturated hydraulic conductivity is reported to be less than 1 mm/day. Drainage is shown to be a relatively small component of the overall water balance. There is a knowledge gap about rooting depth and the impact of soil restrictions such as hard-pan layers or heavy clay subsoils with poor drainage.



Monthly Climate

	ET_0 (mm)		Rainfall (mm)	
Month	Mean	stdev	Mean	stdev
Jan	191	14	31	27
Feb	153	13	39	33
Mar	130	10	32	35
Apr	79	8	32	26
May	46	4	33	23
Jun	31	3	40	21
Jul	33	3	42	17
Aug	49	5	46	27
Sep	75	10	36	22
Oct	118	17	35	35
Nov	150	11	44	28
Dec	179	13	43	34

Monthly soil water balance

	ET c (mm)		Irrigation(mm)	
Month	Mean	stdev	Mean	stdev
Jan	100	7	74	20
Feb	80	4	53	21
Mar	69	4	42	21
Apr	42	3	21	12
May	22	2	2	4
Jun	13	2	0	0
Jul	13	3	0	0
Aug	20	4	0	0
Sep	30	6	4	8
Oct	63	13	22	25
Nov	86	5	32	21
Dec	97	7	56	25

Figure 15. A screen image of the ‘Chart Outputs’ worksheet from the SINATA (**S**trategic **I**rrigation and **N**itrogen **A**ssessment **T**ool for **A**pples) model showing monthly values of the climate, as represented by evapotranspiration (ETo, mm/day) and rainfall (mm/day), the crop water use (ETc, mm/day), and the irrigation demands.

Do these soils factors limit root depth and should such behaviours be included in the SINATA tool? One way to simulate the behaviour of a root restriction would be to ‘set’ the root depth on the ‘Inputs’ worksheet. If the User prescribed root depth then they could do a ‘what-if’ simulation to gauge the outcome e.g how much impact does a restricted rooting depth have on irrigation demand?

It must be remembered that SINATA is primarily a strategic planning tool to enable advisors and growers to estimate the seasonal pattern of irrigation demand for orchards of different ages, climates and soils. A lot of the data needed to populate the model inputs is not yet available so, in some instances, we are still using literature values to fill in some of the knowledge gaps.

In particular there is some uncertainty around the set points for irrigation, and whether they should be derived from a soil matric-potential or from a relative soil water content and where that irrigation trigger-point should be observed (i.e. at what depth in the root zone?)

SINATA will provide outputs for the water and nitrogen balance of an apple orchard. We are yet to gauge the interest in modifying outputs and providing different metrics of production that might include water use efficiency or a cost-benefit analysis of irrigation and fertilizer use. At this stage, SINATA serves as a framework onto which additional features can be added if requested.