SCUM: the Simple Crop Uptake Model

Hamish Brown and Rob Zyskowski, Plant and Food Research, New Zealand

This model has been built using the Plant Modelling Framework (PMF) of (Brown et al., 2014) to simulate a range of different crops in simulations where water and nitrogen balance are of interest but a fully mechanistic plant model is not needed or is not available. It is a daily time step implementation of the crop model that is used on the Overseer nutrient balance model (Cichota et al., 2010). It uses simple sigmoidal functions for estimating daily cover and biomass deltas to give realistic water and nitrogen demands. It does not simulate potential yield, this is specified as an input. Yield will be reduced below the specified potential yield if N or water supplies from the soil are insufficient to meet demand. The model has been paramaterised for simulating water and nitrogen balances of cropping rotations in New Zealand (where over 50 different crop types are grown and it is not feasible to produce full crop models for each of these). Because of this the model is not as generically applicable as full APSIM crop models. It may be adapted for other purposes and other crop types may be added but the user will need to keep in mind that because it is a simple model the the parameters might need changing for crops in different locations or for crops sown at different times of the year. Some sensibility testing or validation is recommended before application in different sutuations.

SCUM has a simple phenology model which divides the crop growth into three main phases; a vegetative phase when the canopy is expanding, a reproductive phase when product is being formed and a senescing phase when the canopy is contracting. SCUM has 4 organ classes to represent different biomass components and the real biomass components that these classes represent changes from crop to crop:
1. A Simple leaf class called Stover which represents the unharvested parts of the plant. Generally, this represents the leaf and stem components of the crop but for crops where stem and leaf are part of the harvested product (e.g forages and leafy vegetables) than stover is the residual fraction of leaf and stem that is not harvested.
2. A Generic organ class called Product which represents the plant parts that are harvested and removed from the field. This could represent grain, fruits, tubers, leaf or stem depending on what sort of crop is being represented.
3. A Root organ which extracts water and nitrogen from the soil for plant growth and returns biomass to the soil on harvest
4. A Nodule organ which is only activated and fixes nitrogen for the legume crops.
An Arbitrator is also included which determines the allocation of drymatter and nitrogen biomass between each of these organs.

Inclusion in APSIM simulations

A scum crop is included in a simulation the same as any other APSIM crop
* The SCUM object needs to be dragged or copied from the Crop folder in the tool box into the field of your simulation.
* It is then planted with a sowing rule

```
SCUM.Sow(cultivar: Wheat_Autumn, population: 1, depth: 10, rowSpacing: 150);
```

- Note that SCUM has no notion of population or rowSpacing but these parameters are required by the Sow method so filler values are provided
- To specify an expected Expected Yield that differs to the defalt value provided, included the following code in a manager script to be executed on the day of sowing.

```
zone.Set("[SCUM].Product.ExpectedYield.Value", ResetValue);
```

- SCUM can be Harvested, Cut, Grazed and Pruned like other crops. Defalt proportions of the biomass in each organ are removed from the sysem and/or added to the fields residue pools. Note that defalt removal fraction for product on harvest is 0 (becaue it is represented with a generic organ) so more appropriate removal fractions should be sepcified in a manager script as follows:

```
[EventSubscribe("Commencing")]
private void OnSimulationCommencing(object sender, EventArgs e)
{
   Remove = new RemovalFractions(SCUM.Organs);
}
[EventSubscribe("DoManagement")]
private void OnDoManagement(object sender, EventArgs e)
{
   if (Clock.Today.Date == HarvestDate2)
   {
     Remove.SetFractionRemoved("Product", 1.0);
     Remove.SetFractionRemoved("Stover", 0.05);
     Remove.SetFractionToResidue("Stover",0.95)
     SCUM.Harvest(Remove);
     SCUM.EndCrop();
   }
}
```

- A Remove class as shown above can be sent with Harvest, Cut, Graze and Prune events to specificy the proportions of removals.
- Once a crop has been ended the field is open to plant another crop using another APSIM crop model or sowing another SCUM crop.

1 Model description

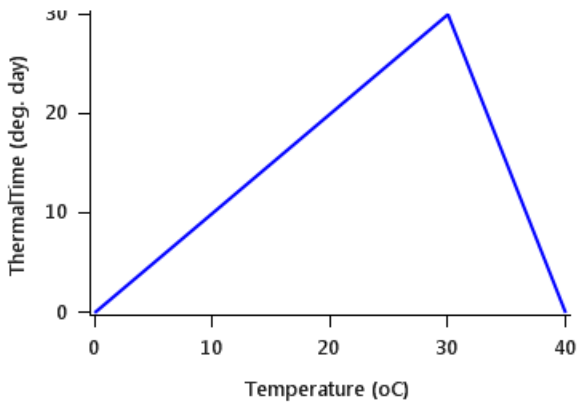
1.1 Phenology

This model simulates the development of the crop through successive developmental *phases*. Each phase is bound by distinct growth *stages*. Phases often require a target to be reached to signal movement to the next phase. Differences between cultivars are specified by changing the values of the default parameters shown below.

1.1.1 ThermalTime

A value is calculated from the mean of 3-hourly estimates of air temperature based on daily max and min temperatures.

Progression through each of the phenological stages is driven by thermal time. As temperature increases from zero to 30 degrees, development acelerates and then slows down again above 30 degress



X	Y
0	0
30	30
40	0

As ThermalTime accumulates the crop progresses through the following phases:

1.1.2 Germinating Phase

This phase goes from Sowing to Germination.

This model assumes that germination will be complete on any day after sowing if the extractable soil water is greater than zero.

1.1.3 Emerging Phase

This phase goes from Germination to Emergence.

This phase simulates time to emergence as a function of sowing depth. The thermal time target from sowing to emergence is given by:
   Target = SowingDepth x ShootRate + ShootLag
Where:
   ShootRate = 0 (deg day/mm),
   ShootLag = 0 (deg day),
and *SowingDepth* (mm) is sent with the sowing event.

Currently the duration of the Emergence phase is set to zero because the period of zero cover and biomass production following sowing is accounted for in the cover and biomass accumulation functions. However this phase is included if parameterisations of other crops in the future wish to give this phase a duration.

Progress toward emergence is driven by Thermal time accumulation where thermal time is calculated as:

ThermalTime = [Phenology].ThermalTime

1.1.4 CanopyExpanding Phase

This phase goes from Emergence to StartReproductive.

During this phase the plant only partitions biomass to Root and Stover (leaf and stem) Organs

This generic phase uses a thermal time target to determine the duration between growth stages. Thermal time is accumulated until the target is met and remaining thermal time is forwarded to the next phase.

Target = 1000 (ºCd).

ThermalTime = [Phenology].ThermalTime

1.1.5 YieldIncreasing Phase

This phase goes from StartReproductive to StartSenescence.

During this phase the plant is partitioning biomass to Root, Stover and Product organs.

This generic phase uses a thermal time target to determine the duration between growth stages. Thermal time is accumulated until the target is met and remaining thermal time is forwarded to the next phase.

Target = 600 (ºCd).

ThermalTime = [Phenology].ThermalTime

1.1.6 Senescing Phase

This phase goes from StartSenescence to EndReproductive.

During this phase the plant is partitioning biomass to Root and Product organs and the canopy cover decreases from its maximum to zero

This generic phase uses a thermal time target to determine the duration between growth stages. Thermal time is accumulated until the target is met and remaining thermal time is forwarded to the next phase.

Target = 600 (ºCd).

ThermalTime = [Phenology].ThermalTime

1.1.7 Mature Phase

This phase goes from EndReproductive to Maturity.

During this phase the plant has completed its growth and is drying ready for harvest.

This generic phase uses a thermal time target to determine the duration between growth stages. Thermal time is accumulated until the target is met and remaining thermal time is forwarded to the next phase.

Target = 600 (ºCd).

ThermalTime = [Phenology].ThermalTime

1.1.8 ReadyForHarvest Phase

This phase goes from Maturity to Unused.

The end phase in phenology

ThermalTime = [Phenology].ThermalTime

1.2 Arbitrator

The Arbitrator class determines the allocation of dry matter (DM) and Nitrogen between each of the organs in the crop model. Eacn organ potentially has three pools of biomass:

- **Structural biomass** which is fixed within an organ once it is partitioned
- **Non-structural biomass** which is available for re-translocation to other organs with high priority demand and is reallocated to other organs when this organ senesces.
- **Metabolic biomass** which is generally fixed in an organ but is able to be reallocated and retranslocated in some cases.

The process followed for biomass arbitration is shown in Figure 1. Arbitration responds to events broadcast daily by the central APSIM infrastructure:

1. **doPotentialPlantGrowth**. When this event is broadcast the attached method executes code to determine the potential growth of each organ, the extent of moisture stress that a crop encounters and the potential biomass supplies and demands of each organ based on these. In addition to demands for structural, non-structural and metabolic biomass (DM and N) each organ may have the following biomass supplies:

- **Fixation supply**. From photosynthesis (DM) or symbiotic fixation (N)
- **Uptake supply**. Typically uptake of N from the soil by the roots but could be uptake by other organs.
- **Retranslocation supply**. Non-structural biomass that may be moved from one organ to meet demands of other organs.
- **Reallocation supply**. Biomass that can be moved from senescing organs to meet the demands of other organs.

2. **doPotentialPlantPartitioning.** On this event the Arbitrator first executes the DoDMSetup() method to establish the DM supplies and demands from each organ. It then executes the DoPotentialDMAllocation() method which works out how much biomass each organ would be allocated assuming N supply is not limiting and sends these allocations to the organs. Each organ then uses their potential DM allocation to determine their N demand (how much N is needed to produce that much DM) and the arbitrator calls DoNSetup() establish N supplies and Demands and begin N arbitration. Firstly DoNReallocation() is called to redistribute N that the plant has available from senescing organs. After this step any unmet N demand is considered the plants demand for N uptake from the soil (N Uptake Demand).
3. **doNutrientArbitration.** When this event is broadcast by the model framework the soil arbitrator gets the N uptake demands from each plant (where multiple plants are growing in competition) and their potential uptake from the soil and determines how nuch of their demand that the soil is able to provide. This value is then passed back to each plant instance as their Nuptake and doNUptakeAllocation() is called to distribute this N between organs.

4. **doActualPlantPartitioning.** On this event the arbitrator call DoNRetranslocation() and DoNFixation() to satisify any unmet N demands from these sources. Finally, DoActualDMAllocation is called where DM allocations to each organ are reduced if the N allocation is insufficient to achieve the organs minimum N conentration and final allocations are sent to organs.

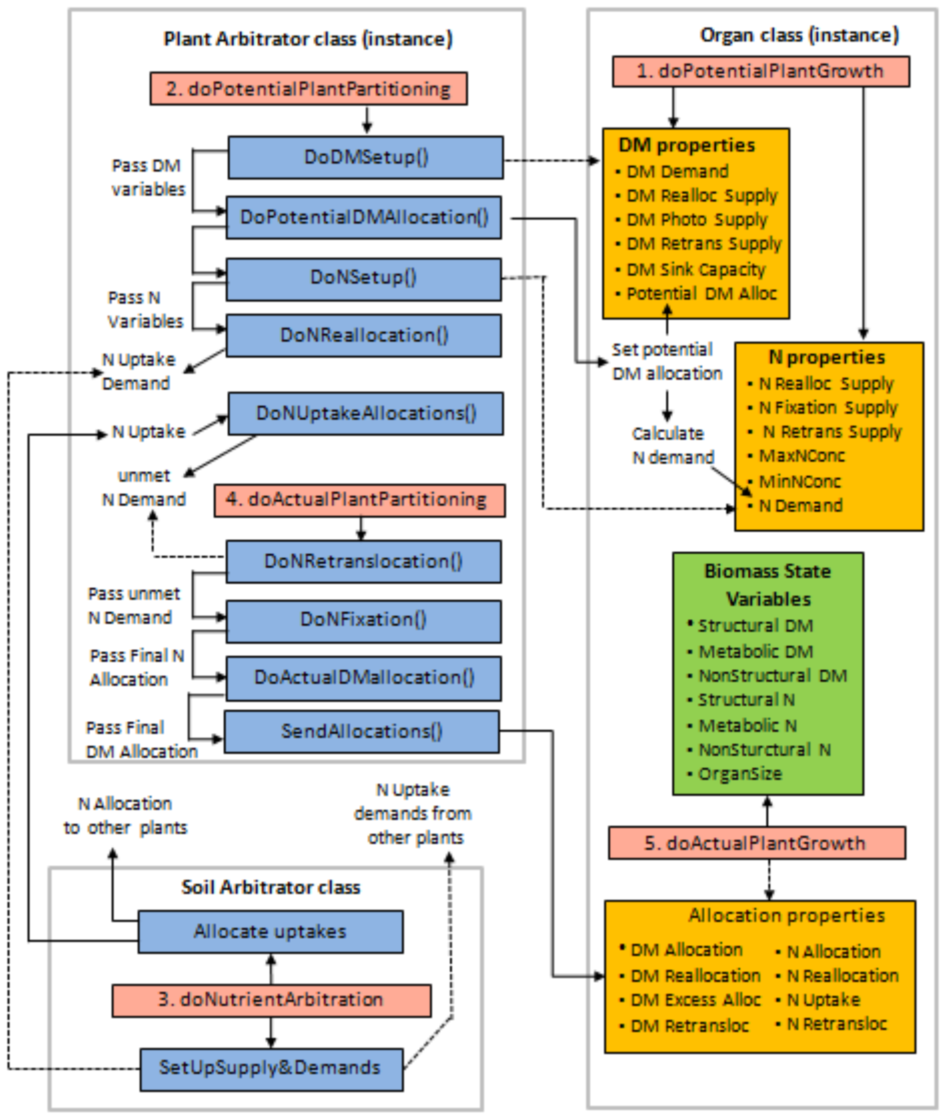


Figure 1. Schematic showing procedure for arbitration of biomass partitioning. Orange boxes contain properties that make up the organ/arbitrator interface. Green boxes are organ specific properties, pink boxes are events that are broadcast each day by the model infrastructure and blue boxes are methods that are triggered by these events.

Arbitration is performed in two passes for each of the biomass supply sources. On the first pass, structural and metabolic biomass is allocated to each organ based on their demand relative to the demand from all organs. On the second pass any remaining biomass is allocated to non-structural demands based on the organ's relative demand.

1.3 Product

Product is parameterised using a generic organ type as follows.

It is the biomass that is removed from the crop at harvest and may include grain, root, leaf, stem, pod or any other organ type depending on the type of crop and how it is harvested.

1.3.1 Dry Matter Demands

100% of the DM demanded from this organ is structural.

The daily DM demand from this organ is calculated using:

> the Partition Fraction Demand Function which returns the product of its PartitionFraction and the total DM supplied to the arbitrator by all organs
>
> The value of PartitionFraction from StartReproductive to StartSenescence is calculated as follows:
>
> > *ProductProportion = 1 - [Root].RootProportion - [Stover].DMDemandFunction.PartitionFraction.YieldIncreasing*
>
> The value of PartitionFraction from StartSenescence to EndReproductive is calculated as follows:
>
> > *StoverFraction = 1 - [Root].RootProportion*

1.3.2 Nitrogen Demands

The daily non-structural N demand from Product is the product of Total DM demand and a Maximum N concentration of 1.2% less the structural N demand.

The daily structural N demand from Product is the product of Total DM demand and a Minimum N concentration of 0.8%

1.3.3 Nitrogen Supplies

N is not reallocated from Product.

Non-structural N in Product is not available for re-translocation to other organs.

1.3.4 Dry Matter Supplies

DM is not retranslocated out of Product.

1.3.5 Biomass Senescece and Detachment

No senescence occurs from Product

No Detachment occurs from Product

1.3.6 Other functionality

In addition to the core processes and parameterisation described above, the Product organ has extra functions which may be referenced by core parameterisation and create additional functionality

1.3.6.1 ExpectedYield

> This is the Product yield (g/m2 fresh weight) that SCUM will predict provided nitrogen and water supply are non-limiting
>
> *ExpectedYield = 800*.

1.3.6.2 DryMatterContent

> This is the dry matter content of the harvested yield and is used to convert fresh yield into *DryYield* which are subsequently used in determining *Ymax* (total biomass production), daily dry matter production, *HarvestIndex* and the *PartitioningFraction* of each organ
>
> *DryMatterContent = 0.87*.

1.3.6.3 DryYield

> This variable is the product yield of the crop in g/m2 dry weight

DryYield = [Product].ExpectedYield x [Product].DryMatterContent

1.3.6.4 WaterContent

This is used to convert the total Dry Matter of this organ back to fresh mass once daily partitining is complete.

WaterContent = 1 - [Product].DryMatterContent

1.3.6.5 HarvestIndex

This is the Product yield (g/m2 fresh weight) that SCUM will predict provided nitrogen and water supply are non-limiting

HarvestIndex = 0.46.

1.4 Stover

Stover is parameterised using a simple leaf organ type which provides the core functions of intercepting radiation, providing a photosynthesis supply and a transpiration demand. It is parameterised as follows.

Stover represents any part of the crop that is not removed at harvest (i.e not part of the product).

1.4.1 Dry Matter Supply

DryMatter Fixation Supply (Photosynthesis) provided to the Organ Arbitrator (for partitioning between organs) is calculated each day as the product of a unstressed potential and a series of stress factors.

Photosynthesis = UnStressedBiomass x WaterStressFactor

Where:

UnStressedBiomass is the daily differential of

a sigmoid function of the form $y = Xmax * 1 / 1 + e^{-(XValue - Xo) / b}$

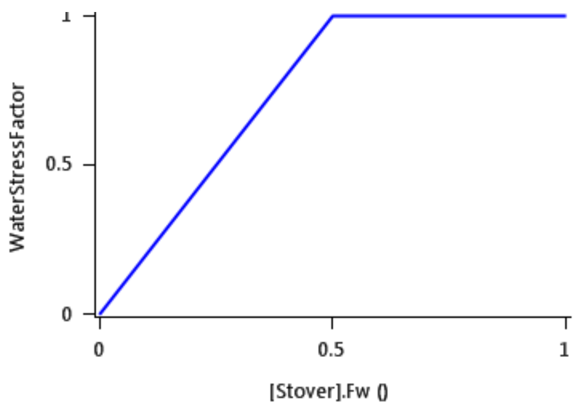
Ymax = [Stover].Ymax

XValue = [Phenology].AccumulatedEmergedTT

Xo = [Stover].XoBiomass

b = [Stover].bBiomass

WaterStressFactor is calculated as a function of *[Stover].Fw*



X	Y
0	0
0	0
0.5	1
1	1

DM is not retranslocated out of Stover

1.4.2 Dry Matter Demands

100% of the DM demanded from this organ is structural

The daily DM demand from this organ is calculated using

the Partition Fraction Demand Function which returns the product of its PartitionFraction and the total DM supplied to the arbitrator by all organs

DM demand is based on a simple partitioning coefficients. At harvest the biomass partitioned to the stover = TotalDM * (1 - RootProportion) * (1 - Harvest index). However the partitioningFraction is more complicated that this as it partitions more biomass to the stover in the CanopyExpanding Phase and less in the Yield increasing phase to give realistic patterns of accumulation of biomass in the Stover and Product over the duration of the crop

The value of PartitionFraction from Emergence to StartReproductive is calculated as follows:

DMPartitionCoefficient = 1 - [Root].RootProportion

The value of PartitionFraction from StartReproductive to StartSenescence is calculated as follows:

DMPartitionCoefficient = StoverBiomass / TotalBiomass

Where:

StoverBiomass = StoverAtMaturity - StoverAtStartReproductive

Where:

StoverAtMaturity = AboveGroundProportion x StoverProportion x [Stover].TotalBiomassAtMaturity

Where:

AboveGroundProportion = 1 - [Root].RootProportion

StoverProportion = 1 - [Product].HarvestIndex

StoverAtStartReproductive = [Stover].TotalBiomassAtStartReproductive x AboveGroundProportion

Where:

AboveGroundProportion = 1 - [Root].RootProportion

TotalBiomass = [Stover].TotalBiomassAtStartSenescence - [Stover].TotalBiomassAtStartReproductive

1.4.3 Nitrogen Demands

The daily structural N demand from Stover is the product of Total DM demand and a Nitrogen concentration of 0.8%

The Nitrogen demand swith is a multiplier applied to nitrogen demand so it can be turned off at certain phases. For the Stover Organ it is set as:

0 between Emergence and StartSenescence and a value of zero outside of this period

1.4.4 Nitrogen Supplies

N is not reallocated from Stover

Non-structural N in Stover is not available for re-translocation to other organs

1.4.5 Biomass Senescece and Detachment

No senescence occurs from Stover

No Detachment occurs from Stover

1.4.6 Canopy

The Green cover (proportion of ground cover comprising green leaf) and Leaf area index (LAI, the area of leaf per unit area of ground) estimations are calculated using a CoverFunction as folows

The value of CoverFunction from Emergence to StartSenescence is calculated as follows:

a sigmoid function of the form $y = Xmax * 1 / 1 + e^{-(XValue - Xo) / b}$

Ymax = 0.97.

XValue = [Phenology].AccumulatedEmergedTT

Xo = 540.

b = 120.

The value of CoverFunction from StartSenescence to Maturity is calculated as follows:

DecreasingCover = MaxCover x ProportionLost

Where:

MaxCover is the same as ValueToHold.Value until it raches StartSenescence stage when it fixes its value

ValueToHold = [Stover].CoverGreen

ProportionLost = 1 - ProportionRemaining

Where:

ProportionRemaining = TTSenesce / [Phenology].Senescing.Target

Where:

TTSenesce = [Phenology].AccumulatedEmergedTT - ThermalTimeAtStartSenescence

Where:

ThermalTimeAtStartSenescence = [Phenology].CanopyExpanding.Target + [Phenology].YieldIncreasing.Target

Then LAI is calculated using an inverted Beer Lamberts equation with the estimated Cover value:

LAI = Log(1 - Cover) / (ExtinctionCoefficient * -1));

Where ExtinctionCoefficient has a value of 0.5

The canopies values of Cover and LAI are passed to the MicroClimate module which uses the Penman Monteith equation to calculate potential evapotranspiration for each canopy and passes the value back to the crop

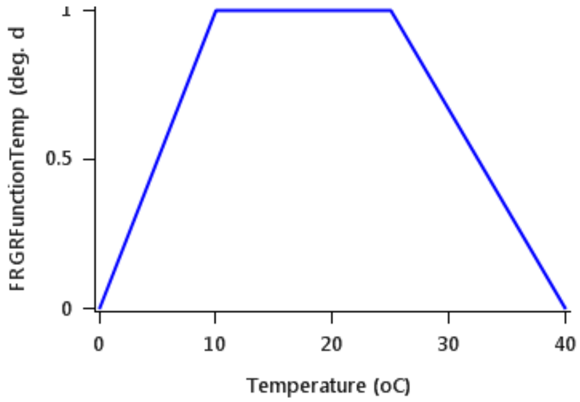
The effect of growth rate on transpiration is captured using the Fractional Growth Rate (FRGR) function which is parameterised as a function of temperature for the simple leaf

1.4.7 FRGRFunction

FRGRFunction = minimum (FRGRFunctionTemp)

Where:

A value is calculated from the mean of 3-hourly estimates of air temperature based on daily max and min temperatures.



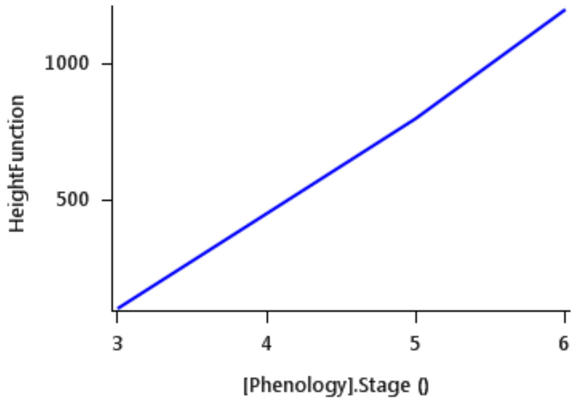
X	Y
0	0
10	1
25	1
40	0

1.4.8 Other functionality

In addition to the core functionality and parameterisation described above, the Stover organ has additional functions used to provide paramters for core functions and create additional functionality

1.4.8.1 HeightFunction

HeightFunction is calculated as a function of *[Phenology].Stage*



X	Y
3	100
5	800
6	1200

1.4.8.2 XoBiomass

Is a coefficient for the potential biomass accumulation function

XoBiomass = 800.

1.4.8.3 bBiomass

Is another coefficient for the potential biomass accumulation function

bBiomass = 800.

1.4.8.4 Ymax

This variable is the total biomass (g/m2dry weight) that the crop will produce at maturity in the absence of stress

Ymax = [Product].DryYield / AboveGroundDMProportion / [Product].HarvestIndex

Where:

AboveGroundDMProportion = 1 - [Root].RootProportion

1.4.8.5 TotalBiomassAtStartReproductive

a sigmoid function of the form y = Xmax * 1 / 1 + $e^{-(XValue - Xo) / b}$

XValue = [Phenology].CanopyExpanding.Target

Ymax = [Stover].Ymax

Xo = [Stover].XoBiomass

b = [Stover].bBiomass

1.4.8.6 TotalBiomassAtStartSenescence

a sigmoid function of the form y = Xmax * 1 / 1 + $e^{-(XValue - Xo) / b}$

XValue = [Phenology].CanopyExpanding.Target + [Phenology].YieldIncreasing.Target

Ymax = [Stover].Ymax

Xo = [Stover].XoBiomass

b = [Stover].bBiomass

1.4.8.7 TotalBiomassAtMaturity

a sigmoid function of the form y = Xmax * 1 / 1 + $e^{-(XValue - Xo) / b}$

XValue = [Phenology].CanopyExpanding.Target + [Phenology].YieldIncreasing.Target + [Phenology].Senescing.Target

Ymax = [Stover].Ymax

Xo = [Stover].XoBiomass

b = [Stover].bBiomass

1.5 Root

Root is parameterised using the PMF Root class which provides the core functions of taking up water and nutrients from the soil. It is parameterised as follows.

The root organ demands and is partitioned N and DM and its depth increases through time to provide a water uptake supply

1.5.1 Root Growth

Roots grow downward through the soil profile and rate is determined by:

RootFrontVelocity = RootFrontVelocity x [Phenology].ThermalTime

Where:

FIXME: This can be generalised to a IF function

TestVariable = [Phenology].AccumulatedEmergedTT

GrowthDuration = [Phenology].CanopyExpanding.Target + [Phenology].YieldIncreasing.Target

IfTrue = [Root].MaximumRootDepth / [Root].RootFrontVelocity.RootFrontVelocity.GrowthDuration

IfFalse = 0.

The RootFrontVelocity is also influenced by the extension resistance posed by the soil, paramterised using the soil XF value

1.5.2 Drymatter Demands

100% of the DM demanded from the root is structural

The daily DM demand from root is calculated as a proportion of total DM supply using:

0 between Emergence and EndReproductive and a value of zero outside of this period

1.5.3 Nitrogen Demands

The daily structural N demand from Root is the product of Total DM demand and a Nitrogen concentration of 0.9%

The Nitrogen demand swith is a multiplier applied to nitrogen demand so it can be turned off at certain phases. For the Root Organ it is set as:

Returns a value of 1 if phenology is between start and end phases and otherwise a value of 0.

1.5.4 Nitrogen Uptake

potential N uptake by the root system is calculated for each soil layer that the roots have extended into.

In each layer potential uptake is calculated as the product of the mineral nitrogen in the layer, a factor controllint the rate of extraction (kNO_3 and kNH_4), the concentration of of N (ppm) and a soil moisture factor which decreases as the soil dries.

The KNO_3 and kNH_4 are calculated in relation to root length density in each layer as :

Need to produce a table of k fractors

Nitrogen uptake demand is limited to the maximum of potential uptake and the plants N demand. Uptake N demand is then passed to the soil arbitrator which determines how much of their Nitrogen uptake demand each plant instance will be allowed to take up:

1.5.5 Water Uptake

Potential water uptake by the root system is calculated for each soil layer that the roots have extended into.

In each layer potential uptake is calculated as the product of the available Water in the layer, and a factor controllint the rate of extraction (kl)

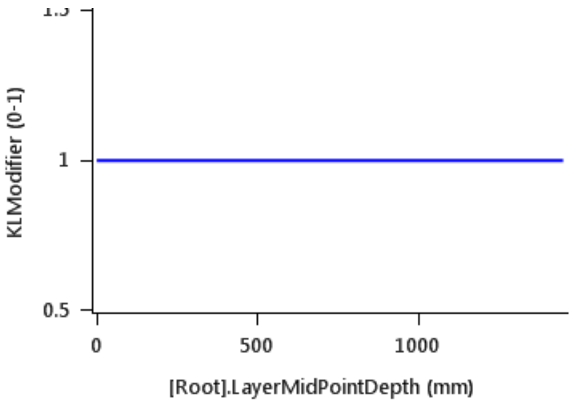
The kl values are set in the soil and may be further modified by the crop. are calculated in relation to root length density in each layer as :

This is important in SCUM as it is set for each species to represent their differences in rooting patterns between crop species. The values for each crop type are calculated externally from APSIM using the root depth of the crop and an exponential of the form:

```
for (int layer = 0; layer lessthan Soil.Thickness.Length; layer++)
{
if (layer.depth lessthan 305)
  layer.KLModifier = 1;
else if (layer.depth lessthan Crop.RootDepth)
  layer.KLModifier = 1*exp(-.002*(1500/(Crop.RootDepth-300)*(layer.depth-300)));
else:
  layer.KLModifier = 0;
}
```

This gives KLModifiers that decline exponentially from 1 in the top 300mm of soil to 0 at the crops maximum rooting depth.

> It is important to note that these modifiers are applied to the kl value specified in the SCUMSoil node under the soil in your field so the values on the soil node should be set to 0.1 throughout the depth of the profile to produce sensible kl values.
>
> *KLModifier* is calculated as a function of *[Root].LayerMidPointDepth*



X	Y
0	1
50	1
100	1
150	1
200	1
250	1
300	1
350	1
400	1
450	1
500	1
550	1
600	1
650	1
700	1
750	1
800	1
850	1
900	1
950	1
1000	1
1050	1
1100	1
1150	1
1200	1
1250	1
1300	1
1350	1
1400	1
1450	1

1.5.6 Other functionality

In addition to the core functionality and parameterisation described above, the Root organ has additional functions used to provide paramters for core functions and create additional functionality

Nodule is a simple parameterisation which provides all the N the crop demands with not DM cost if NFixationOption for the cultivar is set to Majic and fixies no nitrogen of NFixationOption is set to None

1.6 Total

A composite biomass i.e. a biomass made up of 1 or more biomass objects.

1.7 AboveGround

A composite biomass i.e. a biomass made up of 1 or more biomass objects.

The AboveGround composite biomass object includes Stover and Product organs.

1.8 Cultivars

The section below lists each of the cultivars currently included in the model and each of the parameters that they differ from the base model

1.8.1 Barley_Spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 848.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 652.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.46

[Product].MaximumNConc.Value = 0.012

[Product].MinimumNConc.Value = 0.0084

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.2 Barley_SpringForage

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 326.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1174.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 2000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.3 Beets

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 874.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 1076.0

[Product].DryMatterContent.Value = 0.14

[Product].ExpectedYield.Value = 5500

[Product].HarvestIndex.Value = 0.815

[Product].MaximumNConc.Value = 0.015

[Product].MinimumNConc.Value = 0.0105

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.95

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.4 Brassica

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = nan

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = nan

[Product].DryMatterContent.Value = 1.0

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.0

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.021

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.5 Broccoli_summer

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1664.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 436.0

[Product].DryMatterContent.Value = 0.11

[Product].ExpectedYield.Value = 1200

[Product].HarvestIndex.Value = 0.2

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 450

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.038

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.6 Broccoli_winter_spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1739.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 361.0

[Product].DryMatterContent.Value = 0.11

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.13

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 450

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.038

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.7 BrusselSprouts

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1470.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 630.0

[Product].DryMatterContent.Value = 0.2

[Product].ExpectedYield.Value = 1500

[Product].HarvestIndex.Value = 0.4

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 450

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.038

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.8 Cabbage_summer

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1080.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 1020.0

[Product].DryMatterContent.Value = 0.08

[Product].ExpectedYield.Value = 7000

[Product].HarvestIndex.Value = 0.75

[Product].MaximumNConc.Value = 0.026

[Product].MinimumNConc.Value = 0.0182

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 360

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.9 Cabbage_winter_spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1269.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 831.0

[Product].DryMatterContent.Value = 0.12

[Product].ExpectedYield.Value = 5000

[Product].HarvestIndex.Value = 0.6

[Product].MaximumNConc.Value = 0.026

[Product].MinimumNConc.Value = 0.0182

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 360

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.10 Carrots

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 955.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 2045.0

[Product].DryMatterContent.Value = 0.12

[Product].ExpectedYield.Value = 7000

[Product].HarvestIndex.Value = 0.9

[Product].MaximumNConc.Value = 0.01

[Product].MinimumNConc.Value = 0.007

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.9

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1875.0

[Stover].bBiomass.Value = 375.0

1.8.11 Cauliflower_summer

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1422.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 678.0

[Product].DryMatterContent.Value = 0.09

[Product].ExpectedYield.Value = 5000

[Product].HarvestIndex.Value = 0.45

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 450

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.038

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.12 Cauliflower_winter_spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1566.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 534.0

[Product].DryMatterContent.Value = 0.1

[Product].ExpectedYield.Value = 3000

[Product].HarvestIndex.Value = 0.3

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 450

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.038

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.13 Clover_1styear

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 2141.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1159.0

[Product].DryMatterContent.Value = 0.85

[Product].ExpectedYield.Value = 60

[Product].HarvestIndex.Value = 0.09

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 900

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 750

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.04

[Stover].XoBiomass.Value = 1800.0

[Stover].bBiomass.Value = 360.0

1.8.14 Clover_2ndyear

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 1249.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 551.0

[Product].DryMatterContent.Value = 0.85

[Product].ExpectedYield.Value = 60

[Product].HarvestIndex.Value = 0.09

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 900

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 300

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.04

[Stover].XoBiomass.Value = 1050.0

[Stover].bBiomass.Value = 210.0

1.8.15 Dried_Beans

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 755.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 595.0

[Product].DryMatterContent.Value = 0.86

[Product].ExpectedYield.Value = 350

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.16 Dried_Peas

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 755.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 595.0

[Product].DryMatterContent.Value = 0.86

[Product].ExpectedYield.Value = 350

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 1200

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.17 Green_Beans

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 782.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 568.0

[Product].DryMatterContent.Value = 0.21

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.45

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.18 Green_Peas

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 782.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 568.0

[Product].DryMatterContent.Value = 0.21

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.45

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 1200

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.19 Kale

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1150.0

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = 1850.0

[Product].DryMatterContent.Value = 0.16

[Product].ExpectedYield.Value = 7500

[Product].HarvestIndex.Value = 0.7

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.02

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0

[Root].MaximumNConc.Value = 0.008

[Root].MaximumRootDepth.Value = 3000

[Root].MinimumNConc.Value = 0.008

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 867

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 141

[Stover].NConc.Value = 0.01

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.20 Kumara

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 716.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 1234.0

[Product].DryMatterContent.Value = 0.23

[Product].ExpectedYield.Value = 5000

[Product].HarvestIndex.Value = 0.89

[Product].MaximumNConc.Value = 0.018

[Product].MinimumNConc.Value = 0.0126

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.21 Lentils

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 755.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 595.0

[Product].DryMatterContent.Value = 0.86

[Product].ExpectedYield.Value = 350

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.035

[Product].MinimumNConc.Value = 0.0245

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.22 Lettuce

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1299.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 2001.0

[Product].DryMatterContent.Value = 0.05

[Product].ExpectedYield.Value = 5000

[Product].HarvestIndex.Value = 0.8

[Product].MaximumNConc.Value = 0.026

[Product].MinimumNConc.Value = 0.0182

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 360

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 1950.0

[Stover].bBiomass.Value = 390.0

1.8.23 Lupins

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = nan

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = nan

[Product].DryMatterContent.Value = 1.0

[Product].ExpectedYield.Value = 1200

[Product].HarvestIndex.Value = 0.0

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.021

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.015

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.015

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.24 Maize_Long

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1923.0

[Phenology].Senescing.Target.Value = 1800

[Phenology].YieldIncreasing.Target.Value = 477.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 1350

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.007

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.007

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 1050

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.92

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 180

[Stover].NConc.Value = 0.007

[Stover].XoBiomass.Value = 2100.0

[Stover].bBiomass.Value = 420.0

1.8.25 Maize_Med

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1785.0

[Phenology].Senescing.Target.Value = 1650

[Phenology].YieldIncreasing.Target.Value = 465.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 1330

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.007

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.007

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 960

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.85

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 180

[Stover].NConc.Value = 0.007

[Stover].XoBiomass.Value = 1950.0

[Stover].bBiomass.Value = 390.0

1.8.26 Maize_Short

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1648.0

[Phenology].Senescing.Target.Value = 1500

[Phenology].YieldIncreasing.Target.Value = 452.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 1220

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.007

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.007

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 900

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.75

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 180

[Stover].NConc.Value = 0.007

[Stover].XoBiomass.Value = 1800.0

[Stover].bBiomass.Value = 360.0

1.8.27 Maizesilage

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 652.0

[Phenology].Senescing.Target.Value = 1350

[Phenology].YieldIncreasing.Target.Value = 1598.0

[Product].DryMatterContent.Value = 0.35

[Product].ExpectedYield.Value = 5000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.007

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.007

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 960

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.85

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 180

[Stover].NConc.Value = 0.007

[Stover].XoBiomass.Value = 1800.0

[Stover].bBiomass.Value = 360.0

1.8.28 Mustard

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = nan

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = nan

[Product].DryMatterContent.Value = 1.0

[Product].ExpectedYield.Value = 700

[Product].HarvestIndex.Value = 0.0

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.021

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.29 Oats&Rye

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = nan

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = nan

[Product].DryMatterContent.Value = 1.0

[Product].ExpectedYield.Value = 1000

[Product].HarvestIndex.Value = 0.0

[Product].MaximumNConc.Value = 0.012

[Product].MinimumNConc.Value = 0.0084

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.30 Oats_Autumn

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1546.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 854.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.32

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.31 Oats_AutumnForage

[Nodule].NFixationOption = Majic

[Phenology].CanopyExpanding.Target.Value = 543.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1857.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 3000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.32 Oats_Spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 939.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 561.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 400

[Product].HarvestIndex.Value = 0.3

[Product].MaximumNConc.Value = 0.012

[Product].MinimumNConc.Value = 0.0084

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.33 Oats_SpringForage

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 326.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1174.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 2000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.34 Onions

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 899.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 1051.0

[Product].DryMatterContent.Value = 0.11

[Product].ExpectedYield.Value = 7000

[Product].HarvestIndex.Value = 0.8

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y = 1,1,1,1,1,1,1,0.223,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 400

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 780

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.35 Parsnips

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 489.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 1461.0

[Product].DryMatterContent.Value = 0.17

[Product].ExpectedYield.Value = 4400

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.95

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.36 Phacelia

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = nan

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = nan

[Product].DryMatterContent.Value = 1.0

[Product].ExpectedYield.Value = 500

[Product].HarvestIndex.Value = 0.0

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.021

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.03

[Stover].XoBiomass.Value = 825.0

[Stover].bBiomass.Value = 165.0

1.8.37 Potatoes_Long

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 690.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1560.0

[Product].DryMatterContent.Value = 0.22

[Product].ExpectedYield.Value = 7100

[Product].HarvestIndex.Value = 0.911

[Product].MaximumNConc.Value = 0.018

[Product].MinimumNConc.Value = 0.0126

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1425.0

[Stover].bBiomass.Value = 285.0

1.8.38 Potatoes_Medium

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 638.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1312.0

[Product].DryMatterContent.Value = 0.22

[Product].ExpectedYield.Value = 6400

[Product].HarvestIndex.Value = 0.904

[Product].MaximumNConc.Value = 0.018

[Product].MinimumNConc.Value = 0.0126

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1275.0

[Stover].bBiomass.Value = 255.0

1.8.39 Potatoes_Short

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 590.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1060.0

[Product].DryMatterContent.Value = 0.23

[Product].ExpectedYield.Value = 5300

[Product].HarvestIndex.Value = 0.893

[Product].MaximumNConc.Value = 0.018

[Product].MinimumNConc.Value = 0.0126

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 60

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1125.0

[Stover].bBiomass.Value = 225.0

1.8.40 Rape

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 999.0

[Phenology].Senescing.Target.Value = 0

[Phenology].YieldIncreasing.Target.Value = 2001.0

[Product].DryMatterContent.Value = 0.13

[Product].ExpectedYield.Value = 4615

[Product].HarvestIndex.Value = 0.8

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.02

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0

[Root].MaximumNConc.Value = 0.008

[Root].MaximumRootDepth.Value = 2400

[Root].MinimumNConc.Value = 0.008

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 770

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 57

[Stover].NConc.Value = 0.01

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.41 RyeCorn_Autumn

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 543.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1857.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 3000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.42 RyeCorn_Spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 326.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1174.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 2000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.43 Ryegrass_1styear

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1590.0

[Phenology].Senescing.Target.Value = 450

[Phenology].YieldIncreasing.Target.Value = 660.0

[Product].DryMatterContent.Value = 0.85

[Product].ExpectedYield.Value = 150

[Product].HarvestIndex.Value = 0.105

[Product].MaximumNConc.Value = 0.015

[Product].MinimumNConc.Value = 0.0105

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.015

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.44 Ryegrass_2ndyear

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1237.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 563.0

[Product].DryMatterContent.Value = 0.85

[Product].ExpectedYield.Value = 150

[Product].HarvestIndex.Value = 0.105

[Product].MaximumNConc.Value = 0.015

[Product].MinimumNConc.Value = 0.0105

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.741,0.549,0.407,0.301,0.223,0.165,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 700

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 300

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.015

[Stover].XoBiomass.Value = 1050.0

[Stover].bBiomass.Value = 210.0

1.8.45 Spinach

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1150.0

[Phenology].Senescing.Target.Value = 900

[Phenology].YieldIncreasing.Target.Value = 950.0

[Product].DryMatterContent.Value = 0.05

[Product].ExpectedYield.Value = 2200

[Product].HarvestIndex.Value = 0.7

[Product].MaximumNConc.Value = 0.03

[Product].MinimumNConc.Value = 0.021

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 360

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.8

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.015

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.46 Squash

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 899.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1501.0

[Product].DryMatterContent.Value = 0.2

[Product].ExpectedYield.Value = 2500

[Product].HarvestIndex.Value = 0.8

[Product].MaximumNConc.Value = 0.02

[Product].MinimumNConc.Value = 0.014

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 600

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.94

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 90

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.47 Sweetcorn

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 794.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 706.0

[Product].DryMatterContent.Value = 0.5

[Product].ExpectedYield.Value = 2500

[Product].HarvestIndex.Value = 0.55

[Product].MaximumNConc.Value = 0.014

[Product].MinimumNConc.Value = 0.0098

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.007

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.007

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.75

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.009

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.48 Tomato

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1236.0

[Phenology].Senescing.Target.Value = 750

[Phenology].YieldIncreasing.Target.Value = 714.0

[Product].DryMatterContent.Value = 0.05

[Product].ExpectedYield.Value = 10000

[Product].HarvestIndex.Value = 0.5

[Product].MaximumNConc.Value = 0.02

[Product].MinimumNConc.Value = 0.014

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.497,0.247,0.122,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.01

[Root].MaximumRootDepth.Value = 500

[Root].MinimumNConc.Value = 0.01

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 690

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.02

[Stover].XoBiomass.Value = 1350.0

[Stover].bBiomass.Value = 270.0

1.8.49 Triticalie_Autumn

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 543.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 1857.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 3000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.50 Triticalie_Spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 326.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 1174.0

[Product].DryMatterContent.Value = 0.4

[Product].ExpectedYield.Value = 2000

[Product].HarvestIndex.Value = 0.95

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

[Stover].bBiomass.Value = 180.0

1.8.51 Wheat_Autumn

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 1461.0

[Phenology].Senescing.Target.Value = 600

[Phenology].YieldIncreasing.Target.Value = 939.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 1100

[Product].HarvestIndex.Value = 0.41

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.905,0.819,0.741,0.67,0.607,0.549,0.497,0.449,0.407,0.368,0.333,0.301,0.273,0.247,0.223,0.202,

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1500

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 1500.0

[Stover].bBiomass.Value = 300.0

1.8.52 Wheat_Spring

[Nodule].NFixationOption = None

[Phenology].CanopyExpanding.Target.Value = 848.0

[Phenology].Senescing.Target.Value = 300

[Phenology].YieldIncreasing.Target.Value = 652.0

[Product].DryMatterContent.Value = 0.87

[Product].ExpectedYield.Value = 800

[Product].HarvestIndex.Value = 0.46

[Product].MaximumNConc.Value = 0.013

[Product].MinimumNConc.Value = 0.0091

[Root].KLModifier.XYPairs.Y =
1,1,1,1,1,1,1,0.819,0.67,0.549,0.449,0.368,0.301,0.247,0.202,0.165,0.135,0.111,0.091,0.074,0,0,0,0,0,0,0,0,0,0

[Root].MaximumNConc.Value = 0.009

[Root].MaximumRootDepth.Value = 1000

[Root].MinimumNConc.Value = 0.009

[Root].RootProportion.Value = 0.1

[Stover].CoverFunction.Expanding.SigCoverFunction.Xo.Value = 540

[Stover].CoverFunction.Expanding.SigCoverFunction.Ymax.Value = 0.96

[Stover].CoverFunction.Expanding.SigCoverFunction.b.Value = 120

[Stover].NConc.Value = 0.005

[Stover].XoBiomass.Value = 900.0

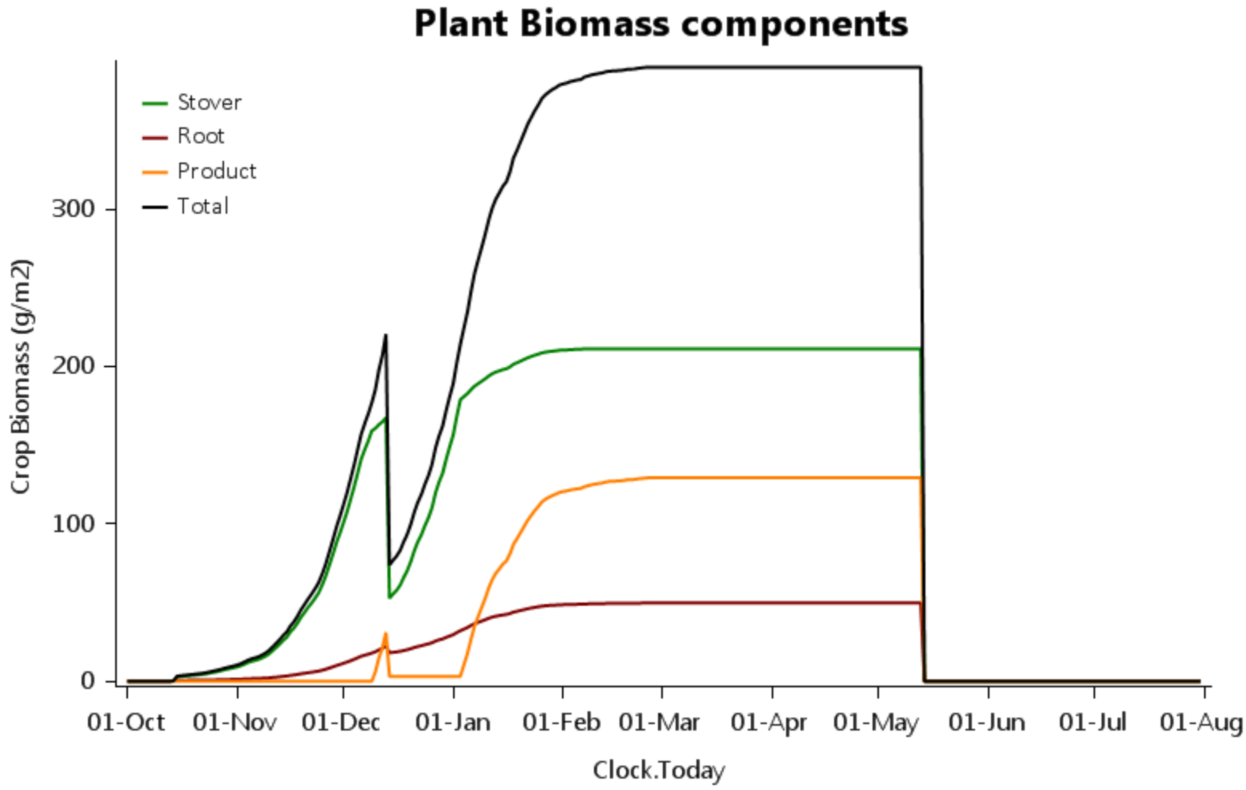
[Stover].bBiomass.Value = 180.0

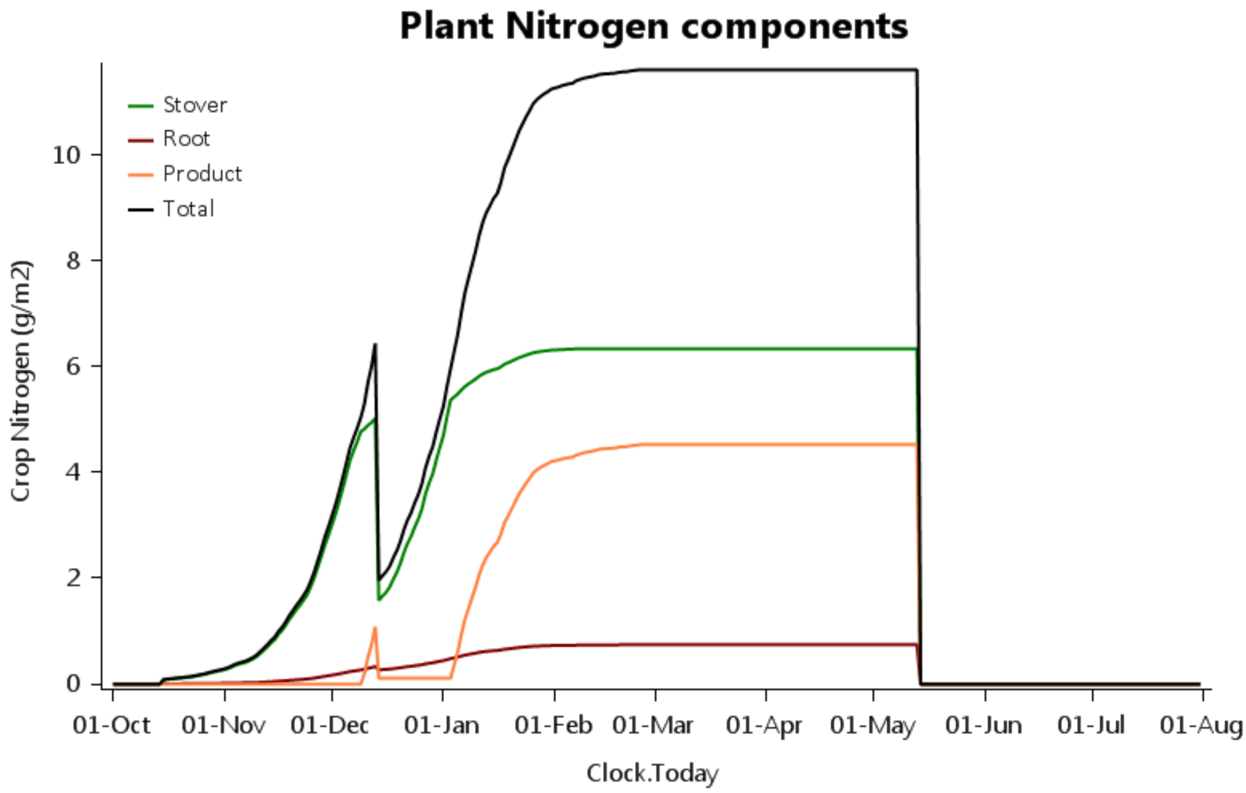
2 Validation

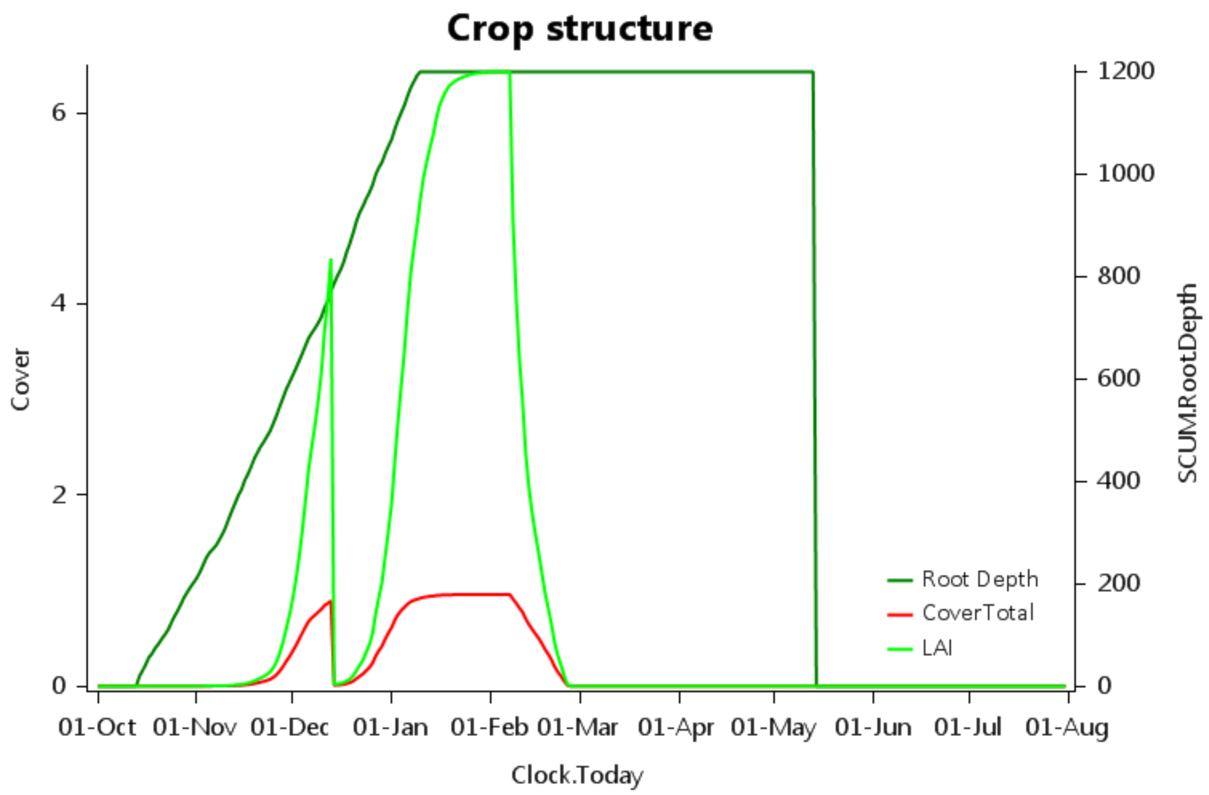
2.1 Simple test with Biomass Cut

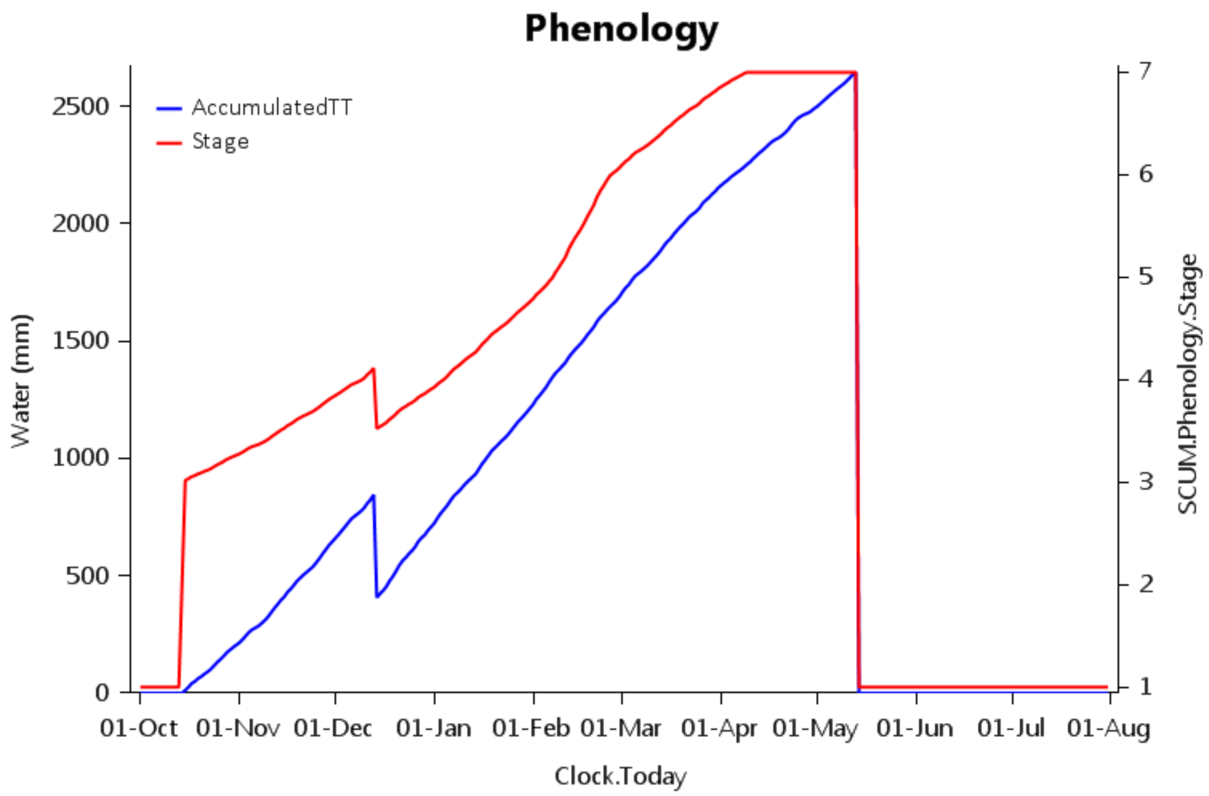
In this test an Autumn wheat crop is planted, and defoliated part way through its growth. The series of graphs show how SCUM accumulates biomass and nitrogen and what happens when a biomass removal event is invoked.

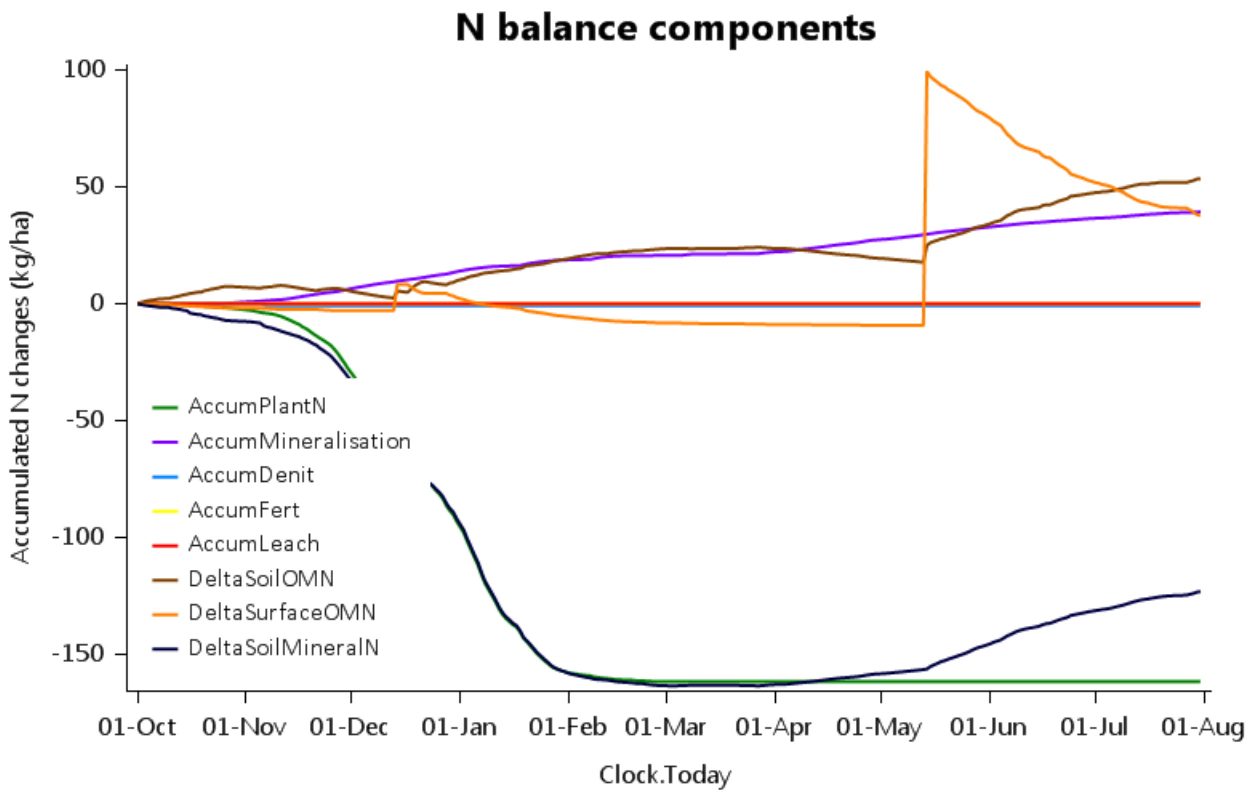
The also demonstrate that componenst of the Nitrogen and water balances are behaving sensibly with the inclusion of SCUM in a simulation.

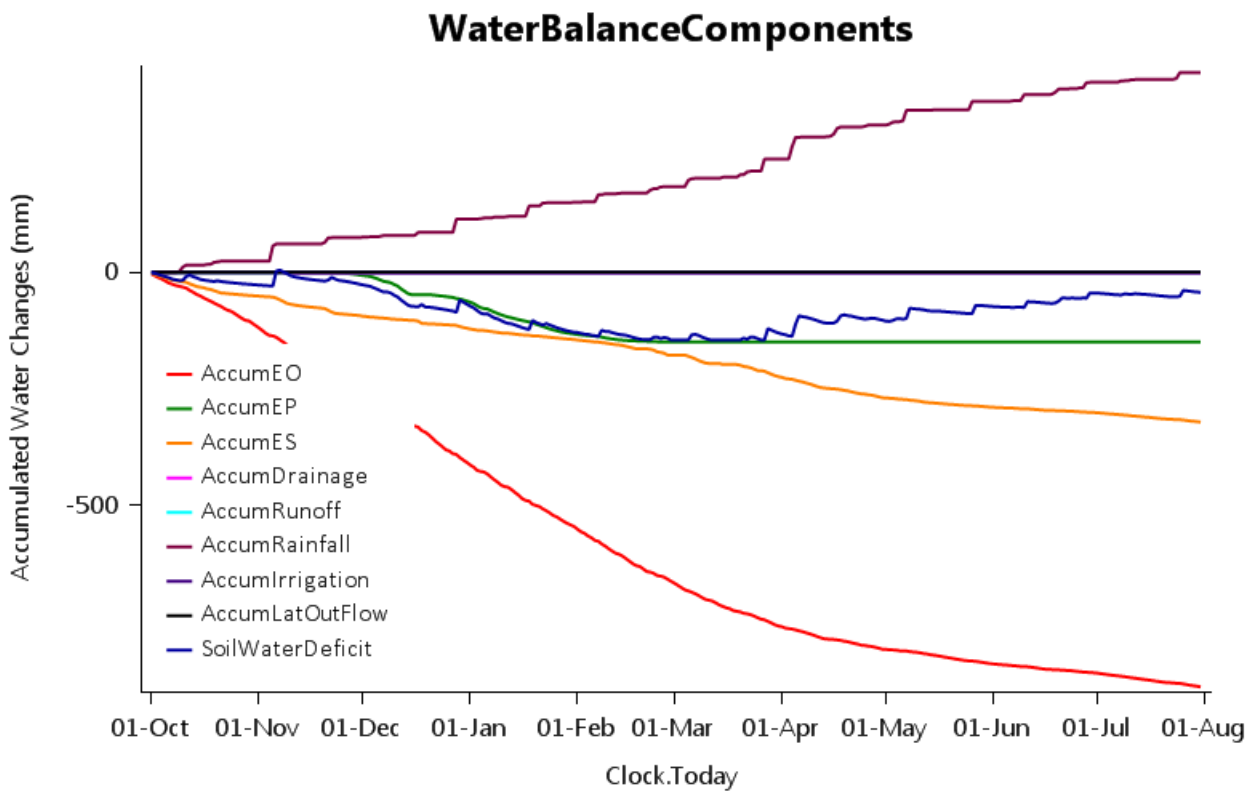





Crop structure
Cover
SCUM.RootDepth
Root Depth
CoverTotal
LAI
Clock.Today
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
0
2
4
6
0
200
400
600
800
1000
1200

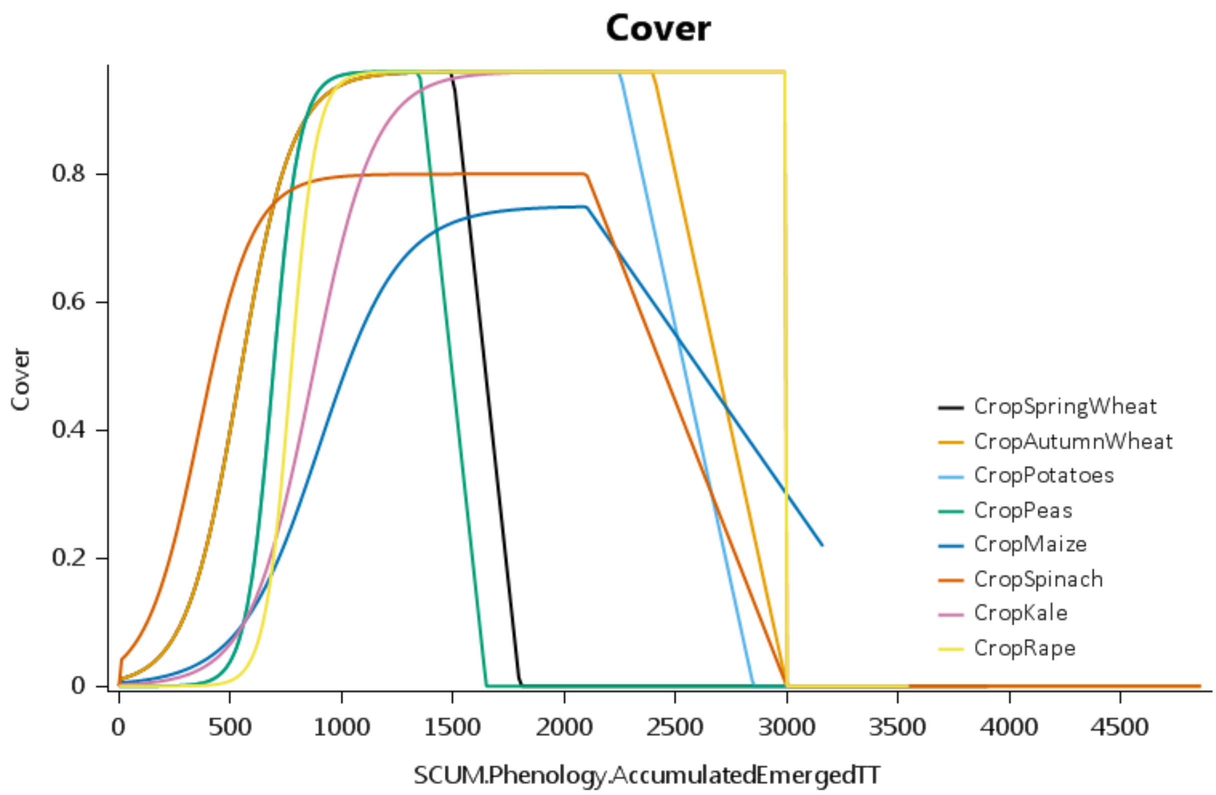

Phenology
Water (mm)
SCUM.Phenology.Stage
AccumulatedTT
Stage
Clock.Today
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
0
500
1000
1500
2000
2500
1
2
3
4
5
6
7



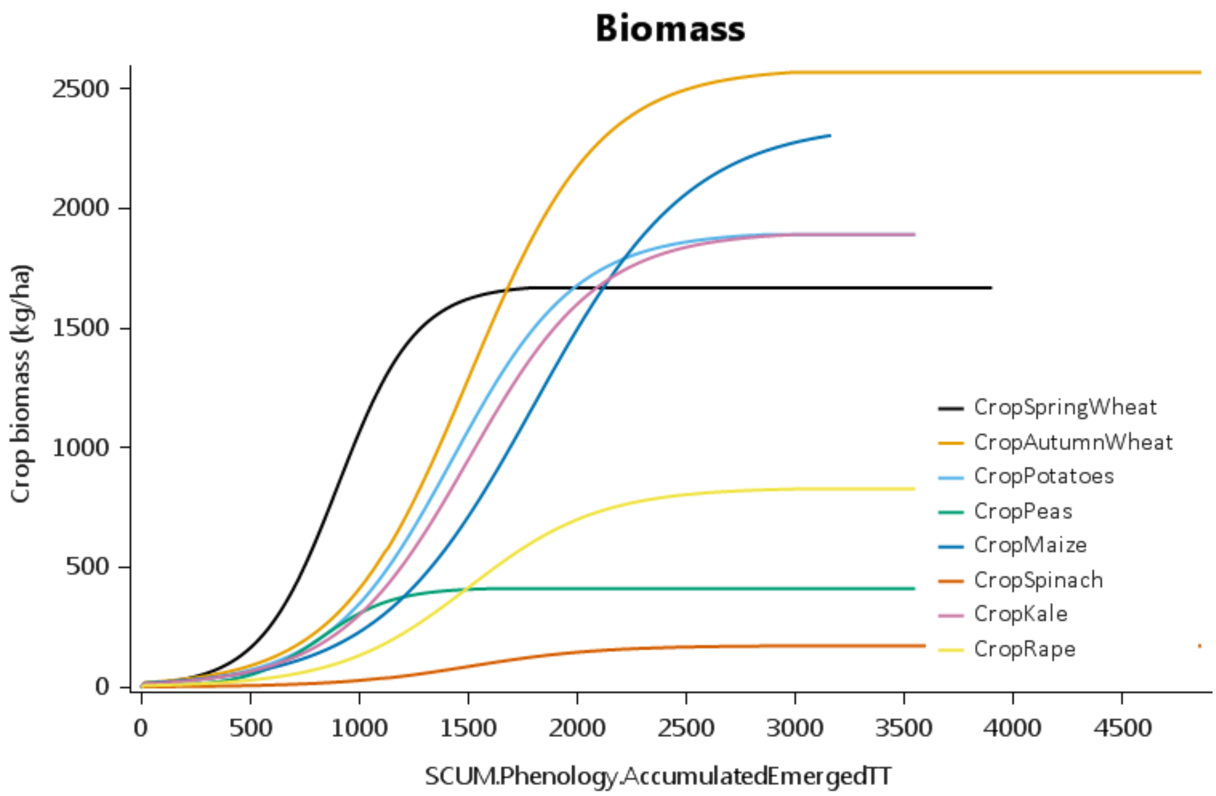


2.2 Crop Comparisions

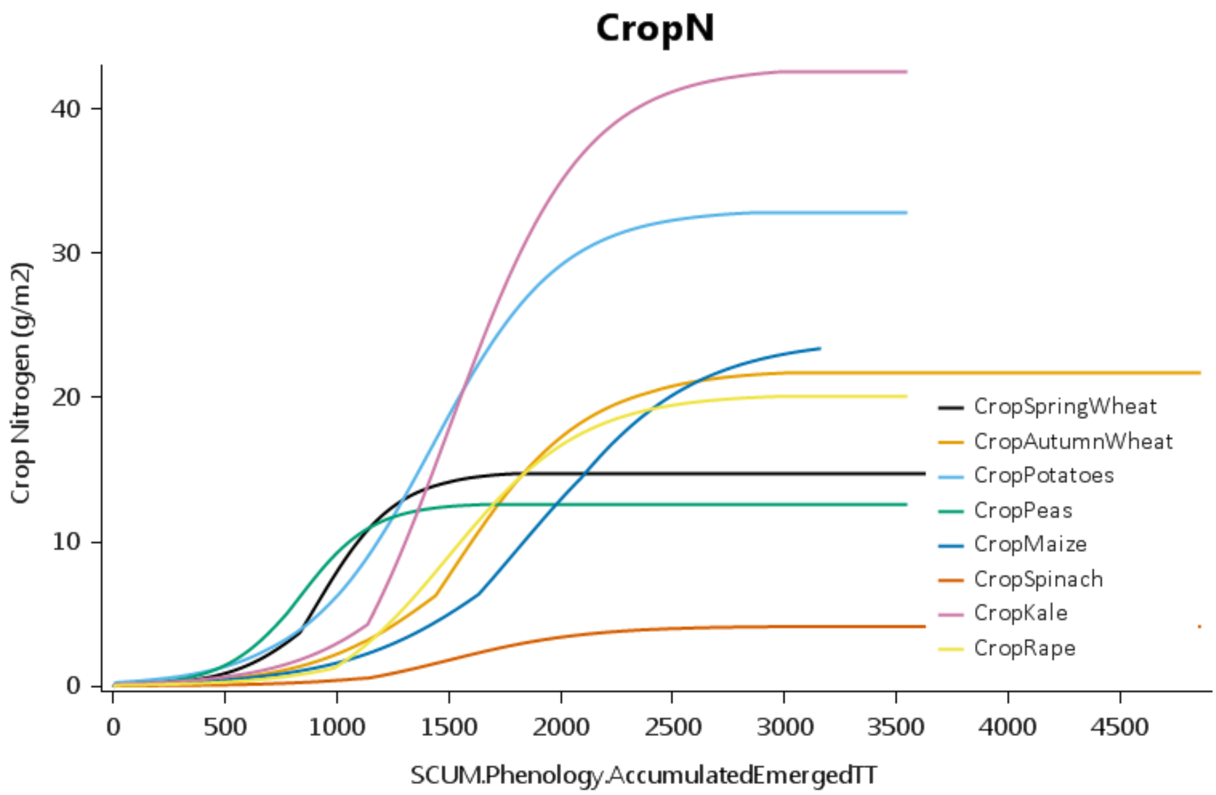
This test simply simulates a range of different SCUM crop types to show how they differ in their canopy and biomass accumulation patterns. The 5 graphs demonstrate the differences in:
- The speed at which cover is attained
- The maximum cover that is achieved
- The speed and which cover is senesced again - The speed and extent of biomass and N accumulation - The timing and extent of dry and fresh yield productinThese graphs are intended to demonstrate how SCUM represents approximate differences in differnt crops types with simple yet realistic temporal patterns

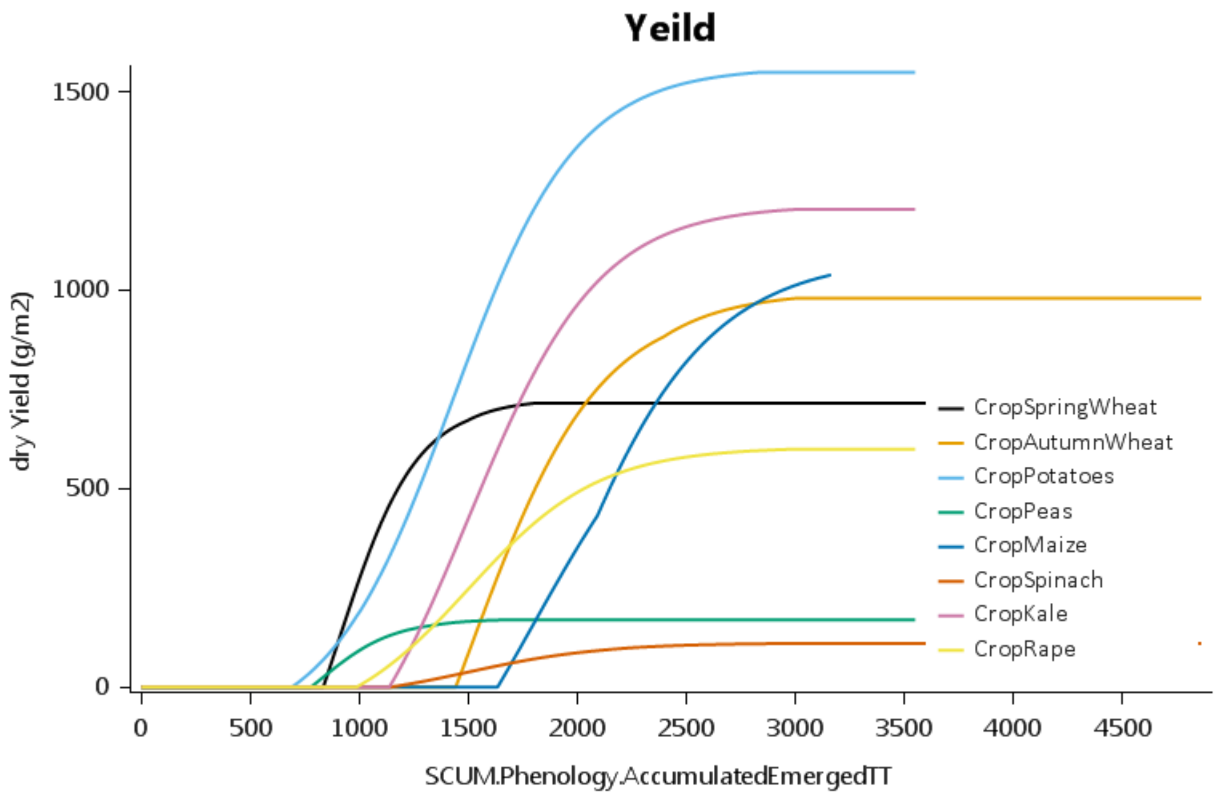


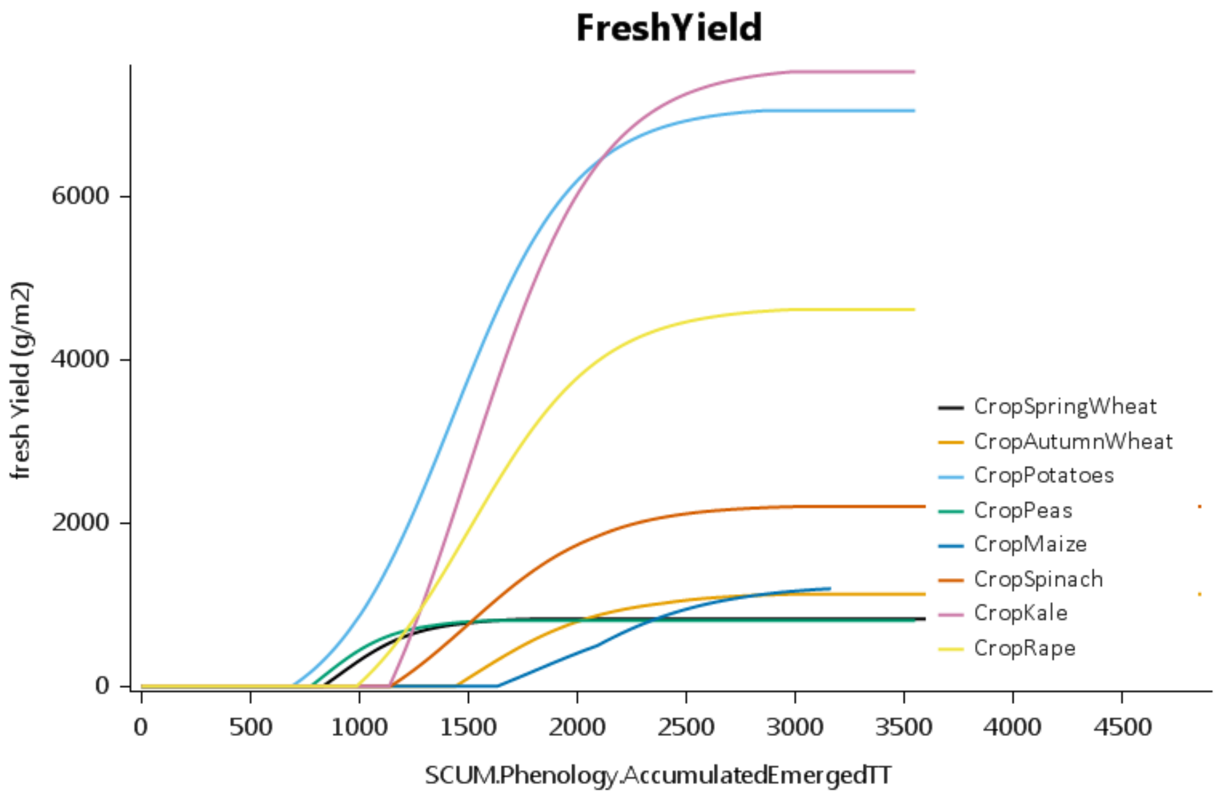
Cover
Cover
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
SCUM.Phenology.AccumulatedEmergedTT
CropSpringWheat
CropAutumnWheat
CropPotatoes
CropPeas
CropMaize
CropSpinach
CropKale
CropRape



Biomass
Crop biomass (kg/ha)
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
SCUM.Phenology.AccumulatedEmergedTT
CropSpringWheat
CropAutumnWheat
CropPotatoes
CropPeas
CropMaize
CropSpinach
CropKale
CropRape


CropN
Crop Nitrogen (g/m2)
0
10
20
30
40
0
500
1000
1500
2000
2500
3000
3500
4000
4500
SCUM.Phenology.AccumulatedEmergedTT
CropSpringWheat
CropAutumnWheat
CropPotatoes
CropPeas
CropMaize
CropSpinach
CropKale
CropRape


Yeild
dry Yield (g/m2)
0
500
1000
1500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
SCUM.Phenology.AccumulatedEmergedTT
CropSpringWheat
CropAutumnWheat
CropPotatoes
CropPeas
CropMaize
CropSpinach
CropKale
CropRape



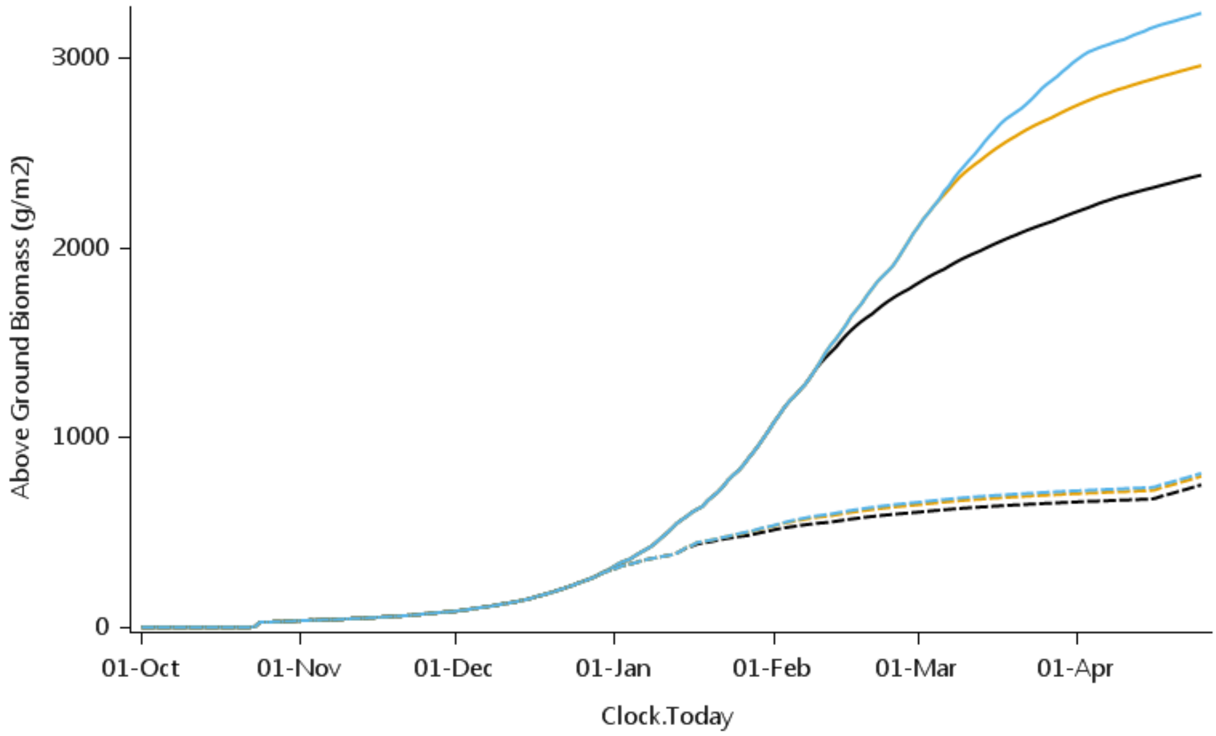
2.3 Lincoln2012

Lincoln2012 (Rain-Shelter Trail)

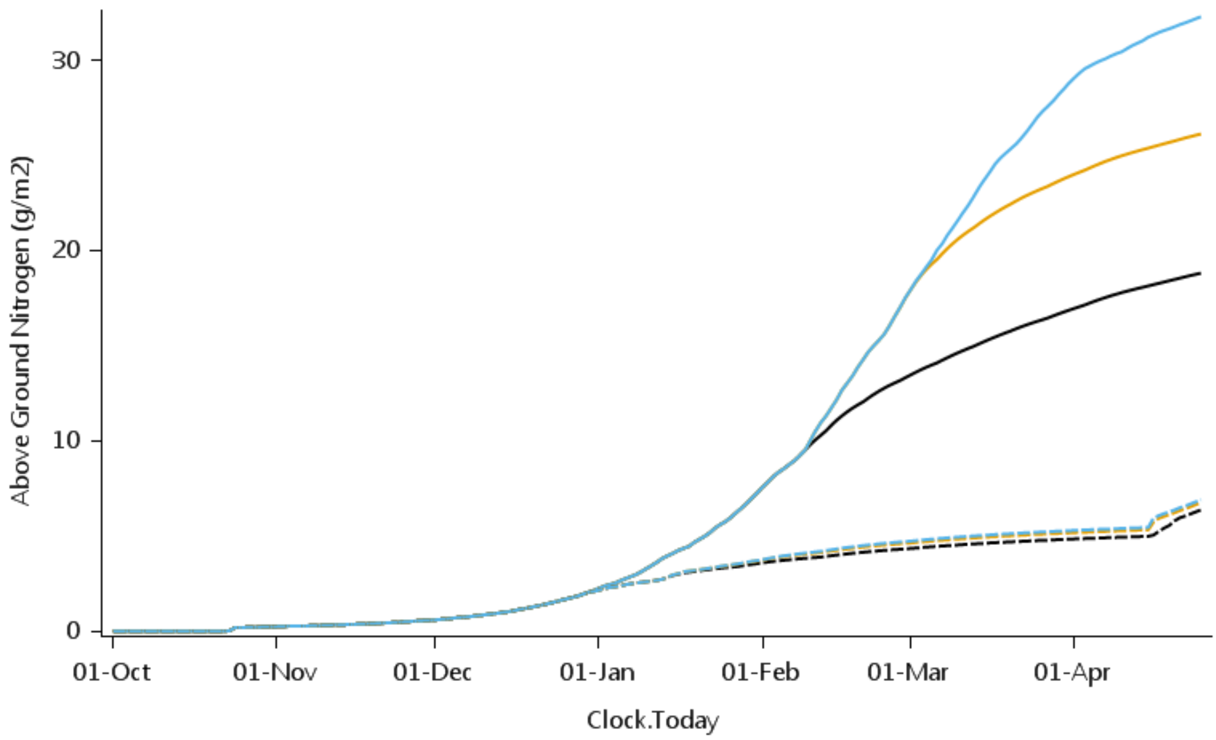
Testing of SCUM under New Zealand conditions was undertaken using the data Maize data of Teixeira et al (2014). This dataset includes the impact of three N (0 to 250 kg/ha N) and two water regimes (dryland and fully irrigated) using a rain-shelter structure. Observations include biomass and nitrogen accumulation, soil water contents. Total biomass ranged from 8000 kg/ha for dryland nil N crops to up to 28000kg/ha for fully irrigated and N fertilised crops. Dryland crops recovered 25 percent less N from applied fertilizer than irrigated crops. The expected yields were set to 18 t/ha (the yield achieved in the fully irrigation Med N plots) for all treatments and the simple N and water responses of SCUM were allowed to predict treatment effects. The three graphs below show that SCUM gave adequate estimations of biomass and N accumulations in respone to irrigation and fertiliser treatments and adequate estimations of soil water content. This suggests Scum is suitable for its intended purpose of providing realistic N and water uptake patterns for N and water balance studies.

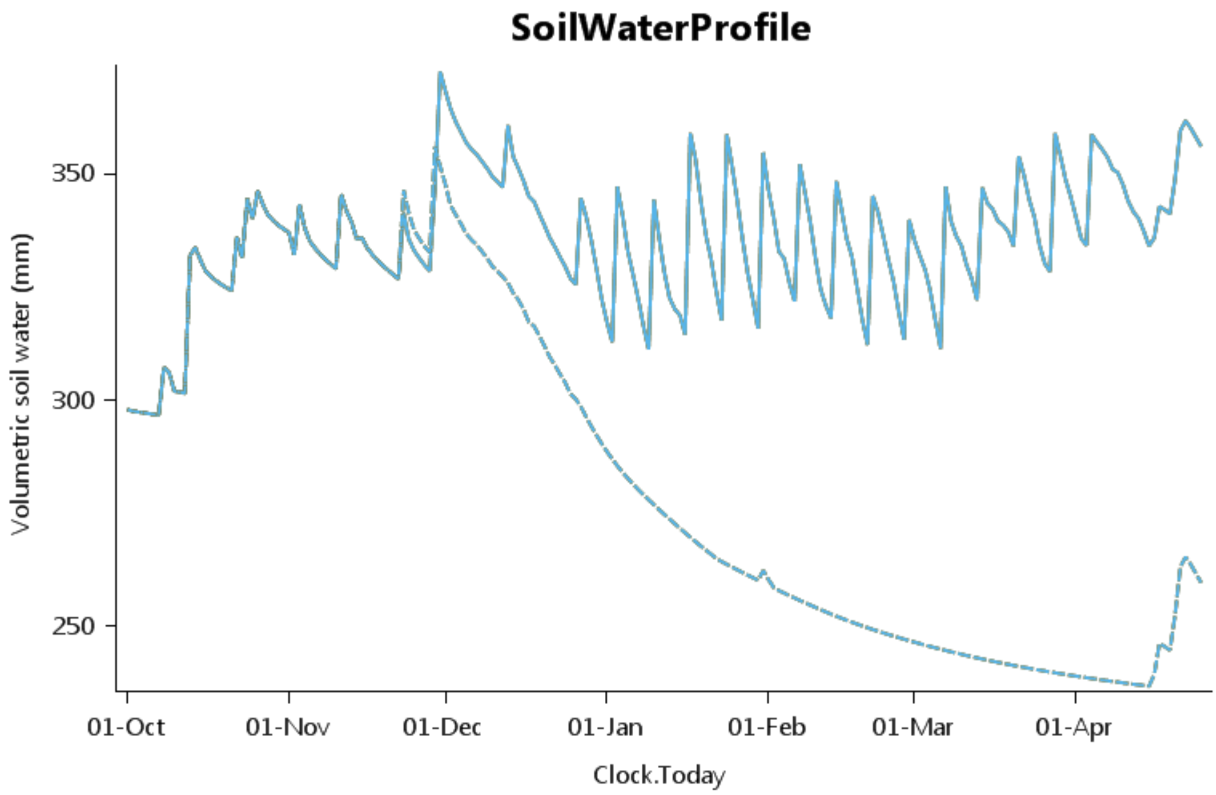
2.3.1 Graphs

AboveGroundWt



AboveGroundN

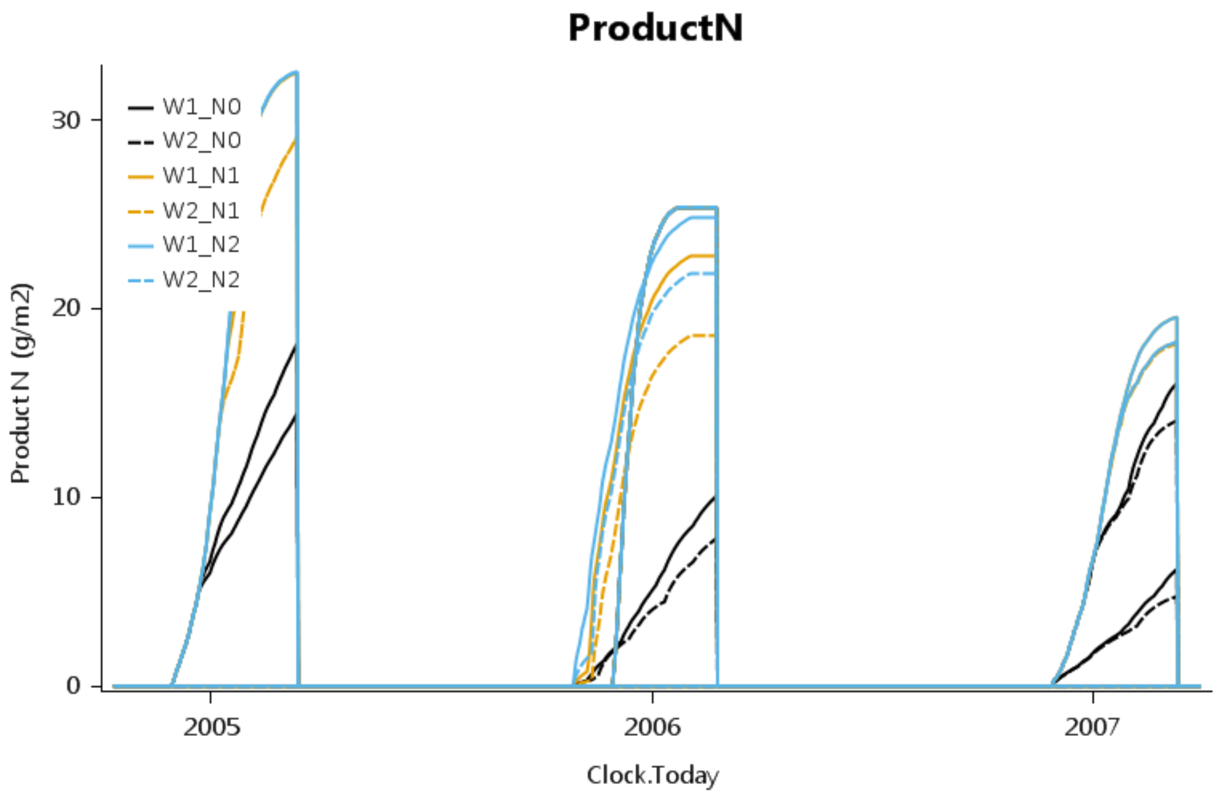




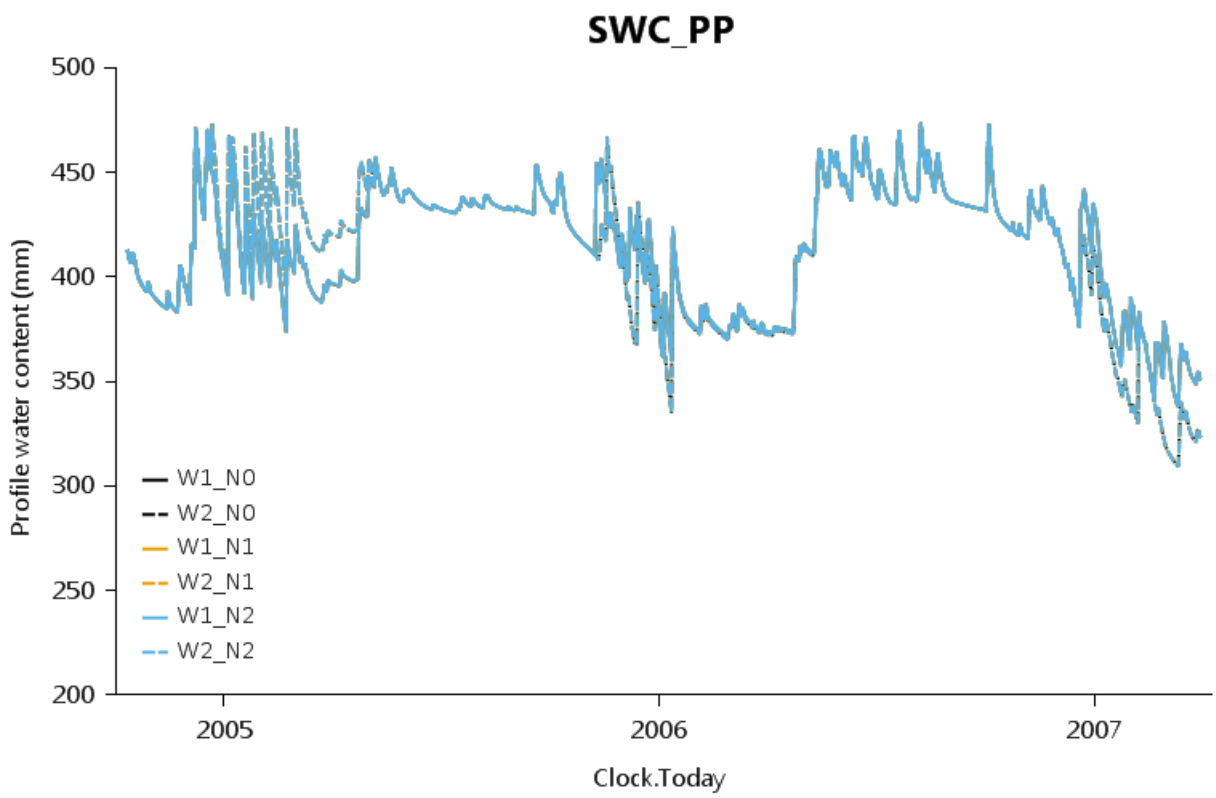
2.4 ABlock

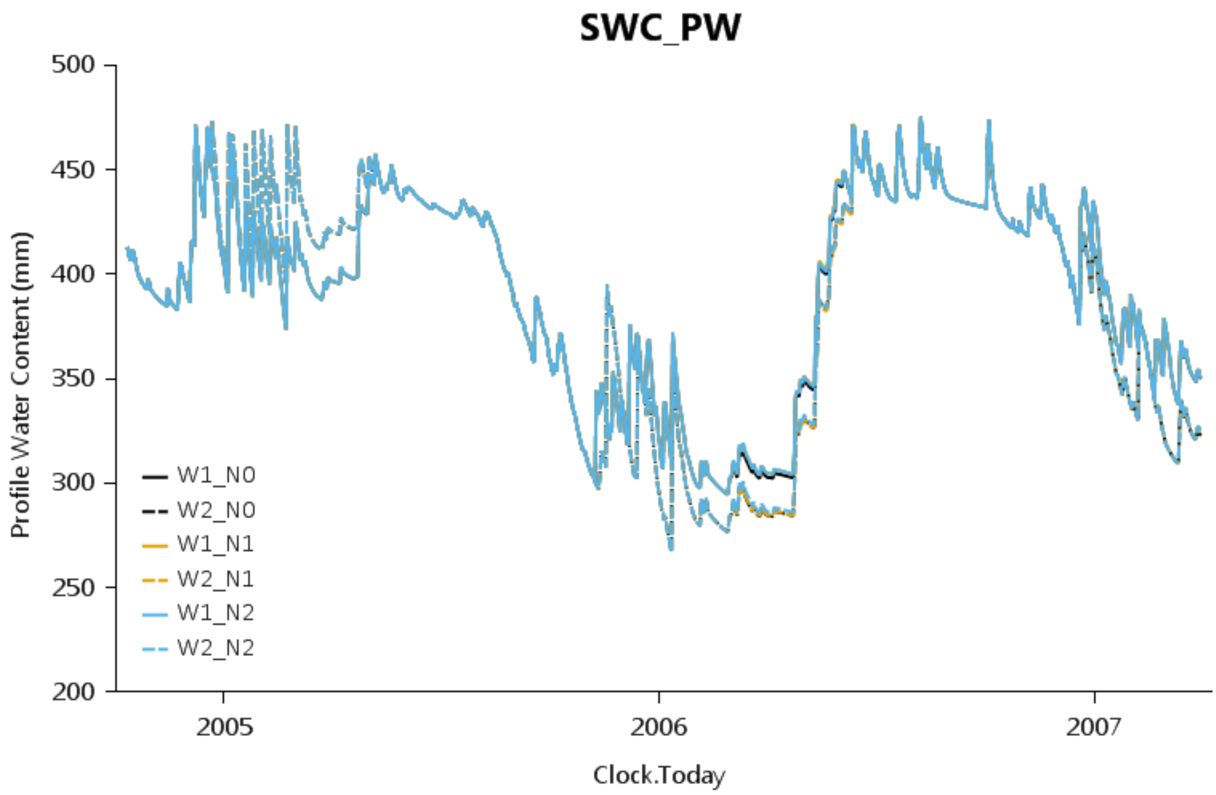
In this test we use SCUM to represent differnt crops in two different rotation treatments (Potatoes -> Wheat -> Potatoes and Potatoes -> Peas -> Potatoes) with two irrigation (W1 and W2) and three N fertiliser treatments (N0, N1 and N2). These rotations ran over three years and were conducted to provide data for testing N leaching predictions of different models. SCUM yields were set to the High N full irrigation treatment values for each crop and SCUMs N and water responses were allowed to predict any differences in crop N uptake. It is importnat to note that the soilN organic matter degridation coefficients were set to custom (non-release) values as this has been necessary to predict accurate N mineralisation values in new zealand arable soils.

SCUM gave reasionable predictions of Product N removals, soil water contents and accumulated leaching from each crop treatment. This provides further support that SCUM is adequate for the task of providing realistic N and Water uptakes for the purpose of N and water balance studies.

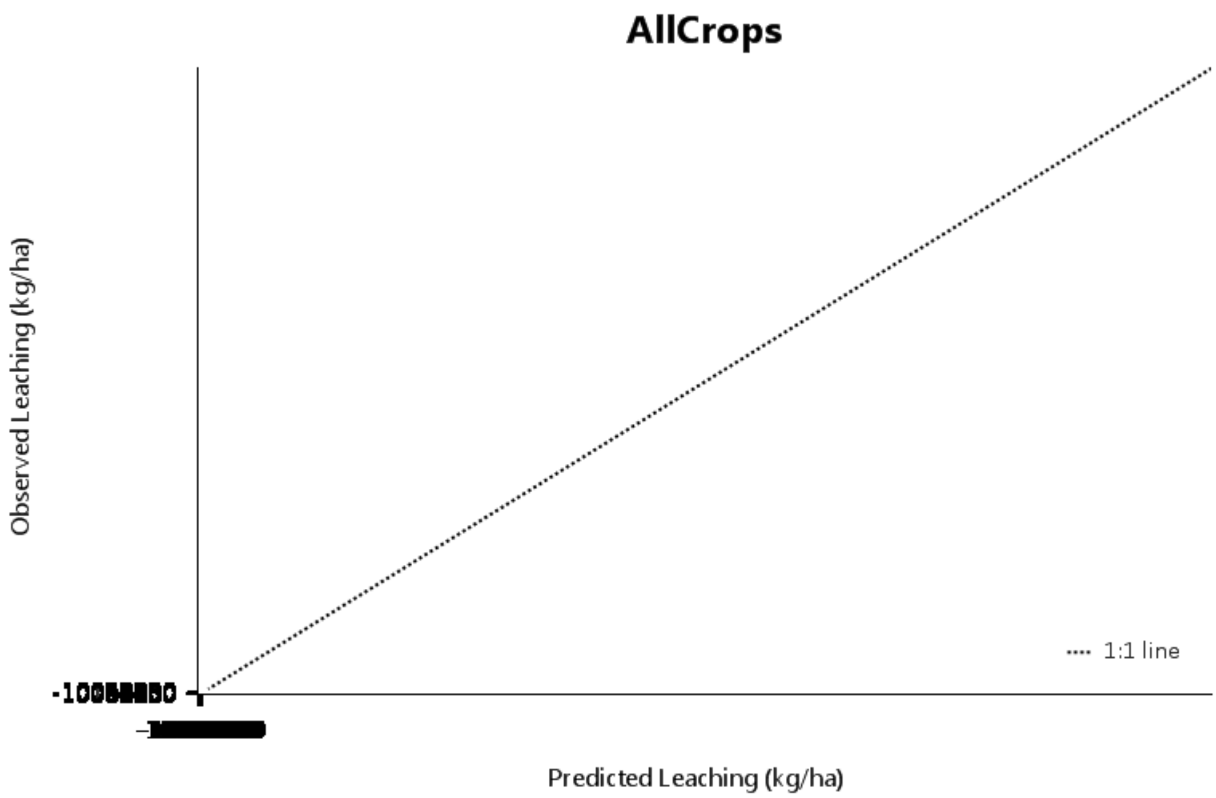

ProductN
W1_N0
W2_N0
W1_N1
W2_N1
W1_N2
W2_N2
Product N (g/m2)
0
10
20
30
2005
2006
2007
Clock.Today

2.4.1 SWC

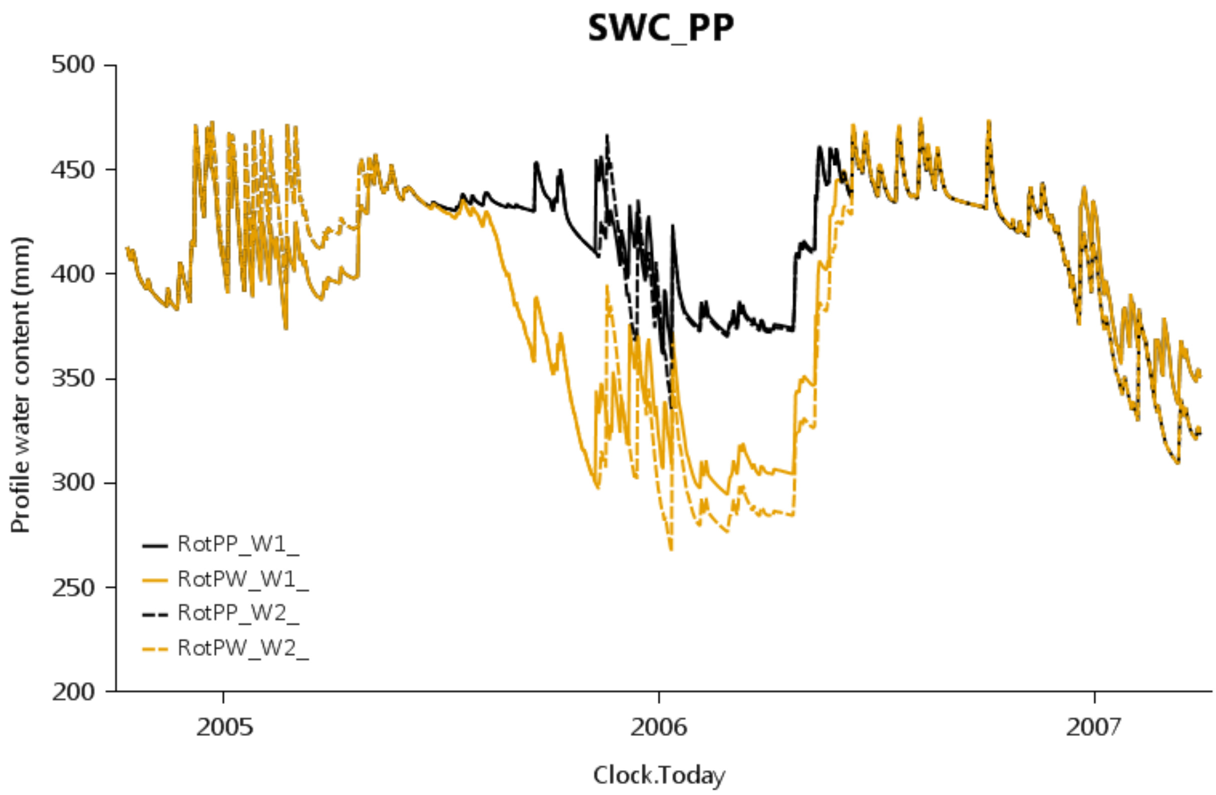

SWC_PP
Profile water content (mm)
200
250
300
350
400
450
500
W1_N0
W2_N0
W1_N1
W2_N1
W1_N2
W2_N2
2005
2006
2007
Clock.Today



2.4.2 LeachingObsPre



Predictions working well for all but the high N treatment in the final wheat crop following the potato crop. I suspect the model is under predicting Denitrification here



3 References

Brown, Hamish E., Huth, Neil I., Holzworth, Dean P., Teixeira, Edmar I., Zyskowski, Rob F., Hargreaves, John N. G., Moot, Derrick J., 2014. Plant Modelling Framework: Software for building and running crop models on the APSIM platform. Environmental Modelling and Software 62, 385-398.

Cichota, R., Brown, H., Snow, V. O., Wheeler, D. M., Hedderley, D., Zyskowski, R., Thomas, S., 2010. A nitrogen balance model for environmental accountability in cropping systems. New Zealand Journal of Crop and Horticultural Science 38 (3), 189-207.