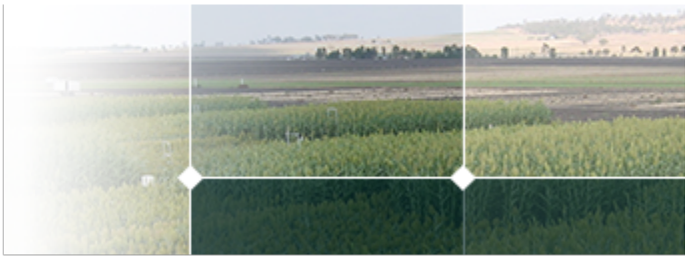


1 The APSIM Wheat Model

Brown, H.E., Huth, N.I. and Holzworth, D.P.

The APSIM wheat model has been developed using the Plant Modelling Framework (PMF) of Brown et al., 2014. This new framework provides a library of plant organ and process submodels that can be coupled, at runtime, to construct a model in much the same way that models can be coupled to construct a simulation. This means that dynamic composition of lower level process and organ classes (e.g. photosynthesis, leaf) into larger constructions (e.g. maize, wheat, sorghum) can be achieved by the model developer without additional coding.

The wheat model consists of:

* a phenology model to simulate development through sequential developmental phases
* a structure model to simulate plant morphology
* a collection of organs to simulate the various plant parts
* an arbitrator to allocate resources (N, biomass) to the various plant organs

This work builds upon earlier APSIM Wheat models such as NWheat (S Asseng et al., 2002, BA Keating, 2001), NWheatS (S Asseng et al., 1998), Cropmod-Wheat (Wang et al., 2002), and the earlier versions developed in Plant (APSIM Wheat 7.5") and then within the Plant Modelling Framework (Brown et al., 2014).

The model has been developed using the Plant Modelling Framework (PMF) of Brown et al., 2014. This new framework provides a library of plant organ and process submodels that can be coupled, at runtime, to construct a model in much the same way that models can be coupled to construct a simulation.This means that dynamic composition of lower level process and organ classes(e.g.photosynthesis, leaf) into larger constructions(e.g.maize, wheat, sorghum) can be achieved by the model developer without additional coding.

The model is constructed from the following list of software components. Details of the implementation and model parameterisation are provided in the following sections.

List of Plant Model Components.

Component Name	Component Type
Arbitrator	Models.PMF.OrganArbitrator
Phenology	Models.PMF.Phen.Phenology
Structure	Models.PMF.Struct.Structure
Grain	Models.PMF.Organs.ReproductiveOrgan
Root	Models.PMF.Organs.Root
Leaf	Models.PMF.Organs.Leaf
Spike	Models.PMF.Organs.GenericOrgan
Stem	Models.PMF.Organs.GenericOrgan
MortalityRate	Models.Functions.Constant

1.1 Arbitrator

1.1.1 Arbitrator

The Arbitrator class determines the allocation of dry matter (DM) and Nitrogen between each of the organs in the crop model. Each organ can have up to three different pools of biomass:

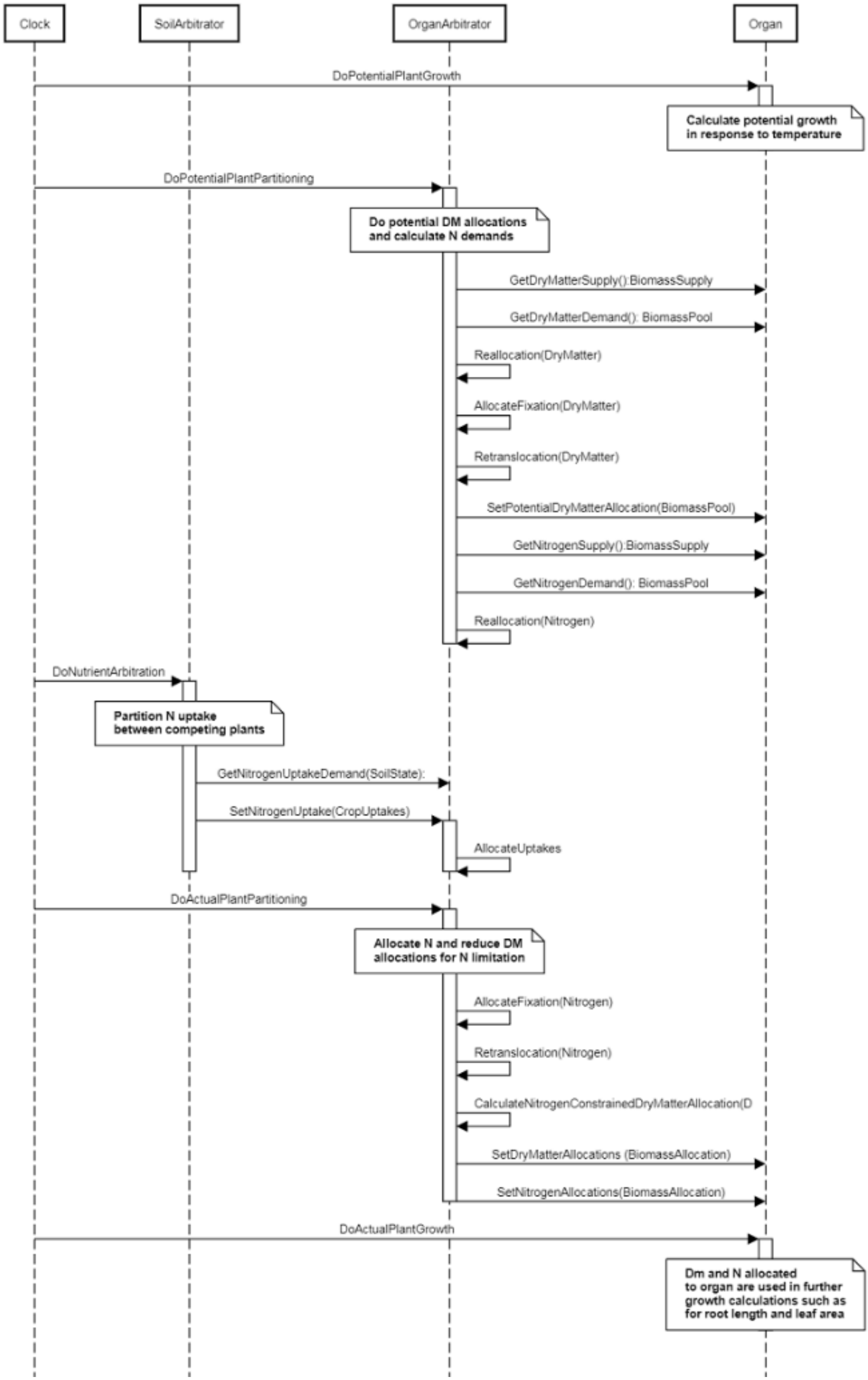
* **Structural biomass** which is essential for growth and remains within the organ once it is allocated there.
* **Metabolic biomass** which generally remains within an organ but is able to be re-allocated when the organ senesces and may be retranslocated when demand is high relative to supply.
* **Storage biomass** which is partitioned to organs when supply is high relative to demand and is available for retranslocation to other organs whenever supply from uptake, fixation, or re-allocation is lower than demand.

The process followed for biomass arbitration is shown in the figure below. Arbitration calculations are triggered by a series of events (shown below) that are raised every day. For these calculations, at each step the Arbitrator exchange information with each organ, so the basic computations of demand and supply are done at the organ level, using their specific parameters.

1. **doPotentialPlantGrowth**. When this event occurs, each organ class executes code to determine their potential growth, biomass supplies and demands. 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 also be uptake by other organs (eg foliage application of N).
* **Retranslocation supply**. Storage biomass that may be moved from organs to meet demands of other organs.
* **Reallocation supply**. Biomass that can be moved from senescing organs to meet the demands of other organs.

1. **doPotentialPlantPartitioning.** On this event the Arbitrator first executes the DoDMSetup() method to gather the DM supplies and demands from each organ, these values are computed at the organ level. 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() to gather the N supplies and demands from each organ 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 as plant demand for N uptake from the soil (N Uptake Demand).
2. **doNutrientArbitration.** When this event occurs, 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 much 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.
3. **doActualPlantPartitioning.** On this event the arbitrator call DoNRetranslocation() and DoNFixation() to satisfy 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 concentration and final allocations are sent to organs.



Clock
SoilArbitrator
OrganArbitrator
Organ
DoPotentialPlantGrowth
Calculate potential growth in response to temperature
DoPotentialPlantPartitioning
Do potential DM allocations and calculate N demands
GetDryMatterSupply():BiomassSupply
GetDryMatterDemand(): BiomassPool
Reallocation(DryMatter)
AllocateFixation(DryMatter)
Retranslocation(DryMatter)
SetPotentialDryMatterAllocation(BiomassPool)
GetNitrogenSupply():BiomassSupply
GetNitrogenDemand(): BiomassPool
Reallocation(Nitrogen)
DoNutrientArbitration
Partition N uptake between competing plants
GetNitrogenUptakeDemand(SoilState):
SetNitrogenUptake(CropUptakes)
AllocateUptakes
DoActualPlantPartitioning
Allocate N and reduce DM allocations for N limitation
AllocateFixation(Nitrogen)
Retranslocation(Nitrogen)
CalculateNitrogenConstrainedDryMatterAllocation(D
SetDryMatterAllocations (BiomassAllocation)
SetNitrogenAllocations(BiomassAllocation)
DoActualPlantGrowth
Dm and N allocated to organ are used in further growth calculations such as for root length and leaf area

Figure 1: Schematic showing the procedure for arbitration of biomass partitioning. Pink boxes represent events that occur every day and their numbering shows the order of calculations. Blue boxes represent the methods that are called when these events occur. Orange boxes contain properties that make up the organ/arbitrator interface. Green boxes are organ specific properties.

1.2 Phenology

The phenological development is simulated as the progression through a series of developmental phases, each bound by distinct growth stage.

Wheat exhibits a range of developmental responses to environment and these are strongly influences by genotype characteristics. Temperature effects development increasing development rates and decreasing phase durations as temperatures increase. Theset affects are captured by thermal time, . However, wheat also exhibits vernalisation and photoperiod sensitivities in its Vegetative phase and further photoperiod sensitivity in the EarlyReproducivePhase. Photoperiod responses are seen as a reduction in the length of a phase for a photoperiod sensitive genotype in response to a longer photoperiod. Vernalisation responses are more complicated as they are driven by temperature but interact with photoperiod. For vernalisation sensitive varieties (Winter types) exposure to cool temperatures or short photoperiods during the Vegetative phase will reduce the thermal time duration of the vegetative phase.

We draw on the Kirby Framework to capture these vernalisation and photoperiod responses. This framework assumes that the timing of anthesis is a result of the timing of flag leaf and an additional thermal time passage from there to anthesis. It also assumes the timing of flag leaf is a result of the Final Leaf Number which sets a target, and leaf appearance rate, which sets the rate of progress toward this target. Leaf appearance rate is a function of Thermal time and a genotype specific Phyllochron which changes with Haun stage as described by Jamieson et al., 1995.

Final Leaf Number (FLN) is modeled as the sum of three numbers:

FLN = MinLeafNumber + VernalLeaves + PhotoLeaves

Where MinLeafNumber is the number of leaves that a wheat crop will produce when vernalisation is satisified early in the crops duration (before 2nd true leaf) and it is grown in a long photoperiod.. VernalLeaves are the number of leaves that are added due to vernalisation effects. For insensitive varieties this will always be zero but this is potentially a larger number for sensitivie varieties and the number progresively decreases as the crop encounters more vernalisation. PhotoLeaves are the number of leaves that are added to the minimum leaf number as a result of short day exposure. For insensitive varieties this will be zero but is potential larger for more sensitivie varieties and decreases as day length increases. More detailed explinations of the components of phenology are provided below.

1.2.1 ThermalTime

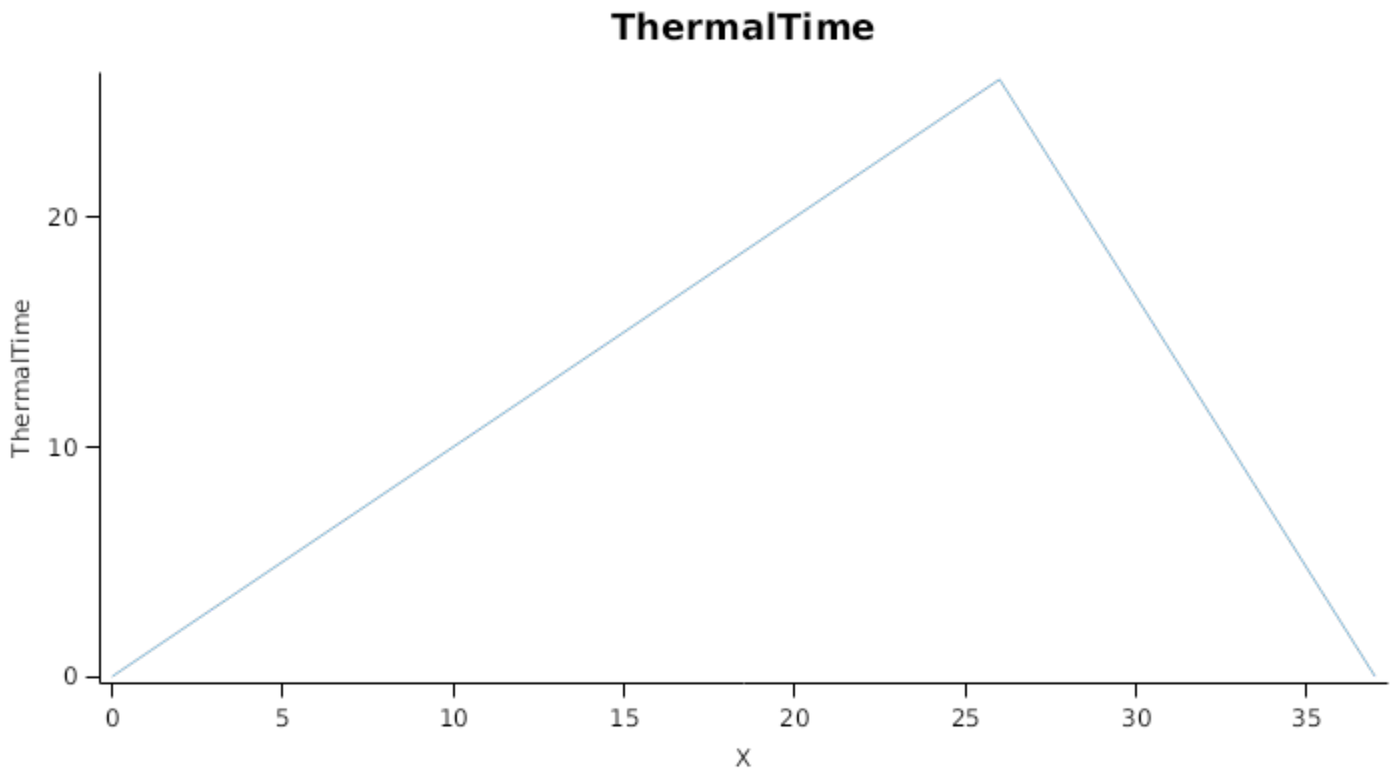
ThermalTime is the average of sub-daily values from a XYPairs.

Thermal time determines the rate of developmental progress through many of the crops phases and is used by organs to determing potential growth rates.

Firstly 3-hourly estimates of air temperature (Ta) are interpolated using the method of Jones et al., 1986 which assumes a sinusoidal temperature. pattern between Tmax and Tmin.

Each of the interpolated air temperatures are then passed into the following Response and the Average taken to give daily ThermalTime

X	ThermalTime
0.0	0.0
26.0	26.0
37.0	0.0



List of stages and phases used in the simulation of crop phenological development

Phase Number	Phase Name	Initial Stage	Final Stage
1	Germinating	Sowing	Germination
2	Emerging	Germination	Emergence
3	Vernalising	Emergence	VernalSaturation
4	SpikeletDifferentiation	VernalSaturation	TerminalSpikelet
5	StemElongation	TerminalSpikelet	FlagLeaf
6	HeadEmergence	FlagLeaf	Heading
7	EarlyFlowering	Heading	Flowering
8	GrainDevelopment	Flowering	StartGrainFill
9	GrainFilling	StartGrainFill	EndGrainFill
10	Maturing	EndGrainFill	Maturity
11	Ripening	Maturity	HarvestRipe
12	ReadyForHarvesting	HarvestRipe	Unused

1.2.2 Germinating

The phase goes from sowing to germination and assumes germination will be reached on the day after sowing or the first day thereafter when the extractable soil water at sowing depth is greater than zero.

1.2.3 Emerging

This phase goes from germination to emergence and simulates time to emergence as a function of sowing depth. The *ThermalTime Target* for ending this phase is given by:

Target = *SowingDepth* x *ShootRate* + *ShootLag*

Where:

ShootRate = 1.5 (deg day/mm),

ShootLag = 40 (deg day),

SowingDepth (mm) is sent from the manager with the sowing event.

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

ThermalTime = [Phenology].ThermalTime

1.2.4 Vernalising

This phase goes from emergence to vernalsaturation and extends from the end of the previous phase until the *CompletionNodeNumber* is achieved. The duration of this phase is determined by leaf appearance rate and the *CompletionNodeNumber* target

ThermalTime = [Phenology].ThermalTime

CompletionNodeNumber = [Phenology].HaunStageTerminalSpikelet

LeafTipNumber = [Structure].LeafTipsAppeared

1.2.5 SpikeletDifferentiation

This phase goes from vernalsaturation to terminalspikelet.

The *Target* for completion is calculated as:

Target = 0 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.6 StemElongation

This phase goes from terminalspikelet to flagleaf and it continues until the final main-stem leaf has finished expansion. The duration of this phase is determined by leaf appearance rate (Structure.Phyllochron) and the number of leaves produced on the mainstem (Structure.FinalLeafNumber)

The Final leaf number is fixed at Terminal Spikelet and leaves contune to appear at a rate set by thermal time and phyllochron until flag leaf liguale appears and this phase is completed.

ThermalTime = [Phenology].ThermalTime

FinalLeafNumber = [Structure].FinalLeafNumber

LeafNumber = [Leaf].ExpandedCohortNo + [Leaf].NextExpandingLeafProportion

FullyExpandedLeafNo = [Leaf].ExpandedCohortNo

InitialisedLeafNumber = [Leaf].InitialisedCohortNo

1.2.7 HeadEmergence

This phase goes from flagleaf to heading.

The *Target* for completion is calculated as:

Target = [Phenology].Phyllochron.BasePhyllochron x *Phyllochrons*

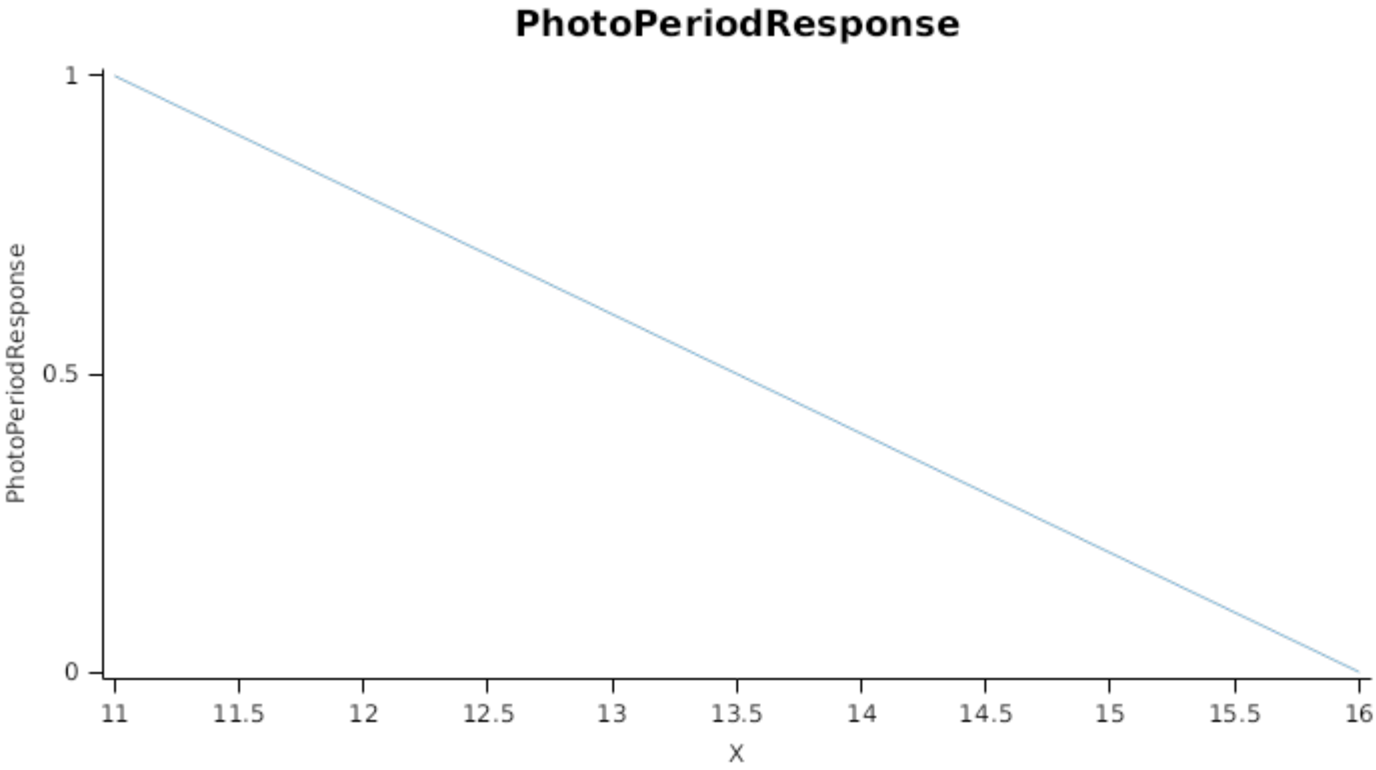
Phyllochrons = [Phenology].HeadEmergenceLongDayBase + *IncreaseDueToShortPhotoPeriod*

IncreaseDueToShortPhotoPeriod = PhotoPeriodResponse x [Phenology].HeadEmergencePpSensitivity

PhotoPeriodResponse is calculated using linear interpolation

X	PhotoPeriodResponse
11.0	1.0

X	PhotoPeriodResponse
16.0	0.0



Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.8 EarlyFlowering

This phase goes from heading to flowering.

The *Target* for completion is calculated as:

Target = 0 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.9 GrainDevelopment

This phase goes from flowering to startgrainfill.

The *Target* for completion is calculated as:

Target = 120 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.10 GrainFilling

This phase goes from startgrainfill to endgrainfill.

The *Target* for completion is calculated as:

Target = 545 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.11 Maturing

This phase goes from endgrainfill to maturity.

The *Target* for completion is calculated as:

Target = 35 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.12 Ripening

This phase goes from maturity to harvestripe.

The *Target* for completion is calculated as:

Target = 300 (oD)

Progression through phase is calculated daily and accumulated until the *Target* is reached.

Progression = [Phenology].ThermalTime

1.2.13 ReadyForHarvesting

It is the end phase in phenology and the crop will sit, unchanging, in this phase until it is harvested or removed by other method

1.2.14 Constants

Number of leaves the plant will produce when fully vernalised early and grown in long photoperiod

MinimumLeafNumber = 7 (Leaves)

The difference between Inherent earlyness leaf number and the number of leaves produced when the plant is unvernalised and grown in long photoperiod

VrnSensitivity = 0 (Leaves)

The amount of vernalising temperature required before vernalisation response will be evident. Value of relative to the amount offl vernalisation temperature required from the end of the lag until vernalisation saturation. A value of 0 means there is no lag, a value of 1 means the lag is the same (in vernal time) as the vernalisation requirement and a value of 2 means the lag is twice as long as the vernalisation response phase

VernLag = 1 (Unitless)

The reduction in leaf number going from 8 to 16 h Pp

PpSensitivity = 3 (Leaves)

The phyllochrons duration for the plant to go from flag leaf ligual appearance at 16 h Pp compared to the phyllochron duration for the same phase at 8 h Pp.

HeadEmergencePpSensitivity = 0

The phyllochrons duration for the plant to go from flag leaf ligual appearance at 16 h Pp.

HeadEmergenceLongDayBase = 2.5

1.2.15 DailyVernalisation

Vernalisation responses are based on those described by Brown et al., 2013. Vernalisation is assumed to be related to the expression of the Vrn1 Gene. Its experssion is accumulated daily and daily upregulation as a function of development (DeltaHaunStage) and a TempResponseProfile that declines exponentially from a maximum at 1^{o}C to zero at 0^{o}C and at 18^{o}C.

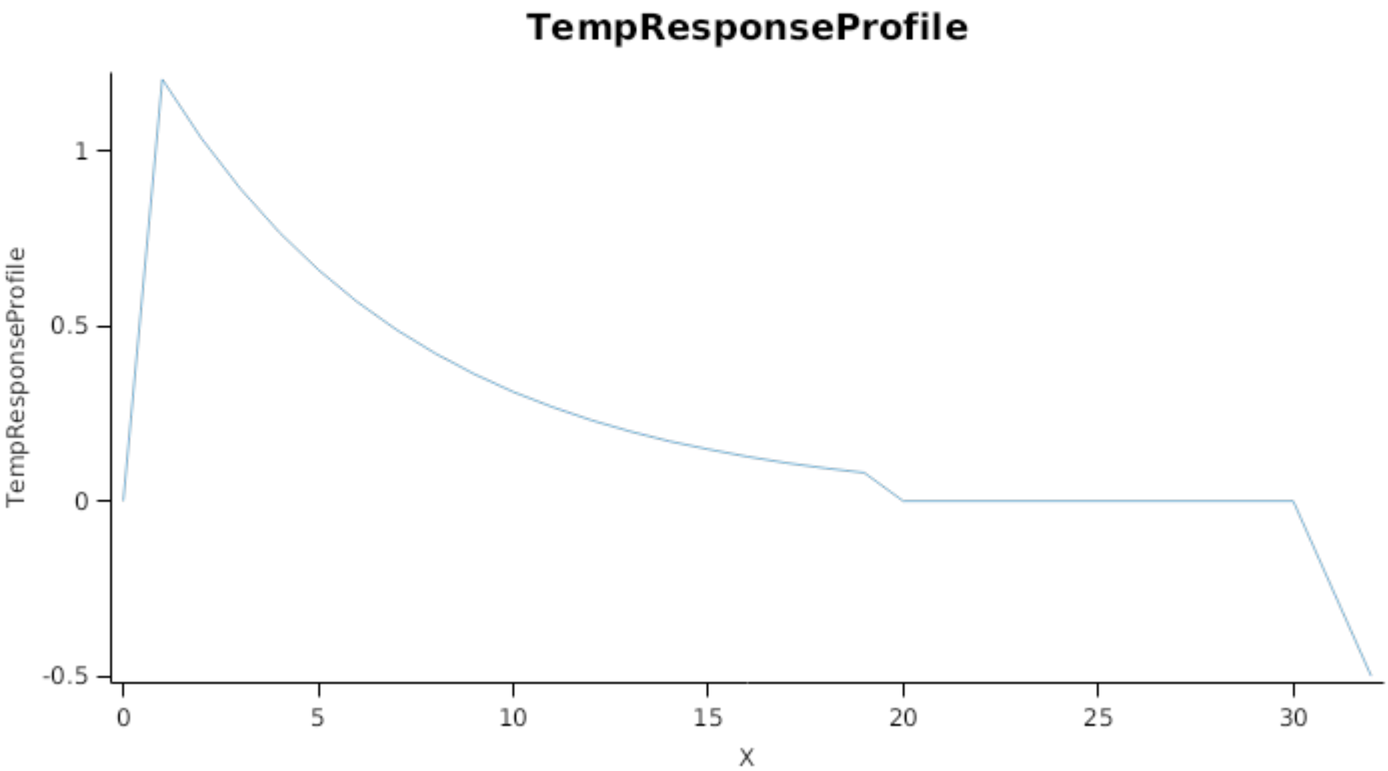
DailyVernalisation = [Phenology].HaunStage.Delta x *TempResponseProfile*

TempResponseProfile is the average of sub-daily values from a XYPairs.

Firstly 3-hourly estimates of air temperature (Ta) are interpolated using the method of Jones et al., 1986 which assumes a sinusoidal temperature. pattern between Tmax and Tmin.

Each of the interpolated air temperatures are then passed into the following Response and the Average taken to give daily TempResponseProfile

X	TempResponseProfile
0.0	0.0
1.0	1.2
2.0	1.0
3.0	0.9
4.0	0.8
5.0	0.7
6.0	0.6
7.0	0.5
8.0	0.4
9.0	0.4
10.0	0.3
11.0	0.3
12.0	0.2
13.0	0.2
14.0	0.2
15.0	0.1
16.0	0.1
17.0	0.1
18.0	0.1
19.0	0.1
20.0	0.0
30.0	0.0
32.0	-0.5



1.2.16 Photoperiod

Returns the duration of the day, or photoperiod, in hours. This is calculated using the specified latitude (given in the weather file) and twilight sun angle threshold. If a variable called ClimateControl.PhotoPeriod is found in the simulation, it will be used instead.

The day length is calculated with \ref MathUtilities.DayLength.

Twilight = -6 (degrees)

1.2.17 PerceivedPhotoPeriod

PerceivedPhotoPeriod is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

ApexBelowGround has a value between Germination and Emergence calculated as:

Photoperiod = 0 (h)

ApexAboveGround has a value between Emergence and HarvestRipe calculated as:

Photoperiod = [Phenology].Photoperiod

1.2.18 Vrn1

Vrn1 accumulation begins when Vrn4 experssion is down regulated to zero and stops, assuming vernalisation saturation, at a value of 1

Vrn1 = Min(*Saturation*, *CurrentExpression*)

Where:

Saturation = 1 (Relative Experssion)

CurrentExpression = Accumulated *Vernalisation* between germination and terminalspikelet

IF [Phenology].Vrn4 < [Phenology].VernLag THEN

Return_Zero = 0

ELSE

elseReturn_Vernalisation = [Phenology].DailyVernalisation

1.2.19 Vrn4

Vrn4 = Min(*MaxExpression*, *CurrentExpression*)

Where:

MaxExpression = [Phenology].VernLag

CurrentExpression = Accumulated *VernalisationConditioning* between germination and terminalspikelet

VernalisationConditioning = [Phenology].DailyVernalisation

1.2.20 HaunStage

HaunStage = Accumulated *Delta* between emergence and flagleaf

Delta is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

Growing has a value between Germination and HarvestRipe calculated as:

Value = [Phenology].ThermalTime / [Phenology].Phyllochron

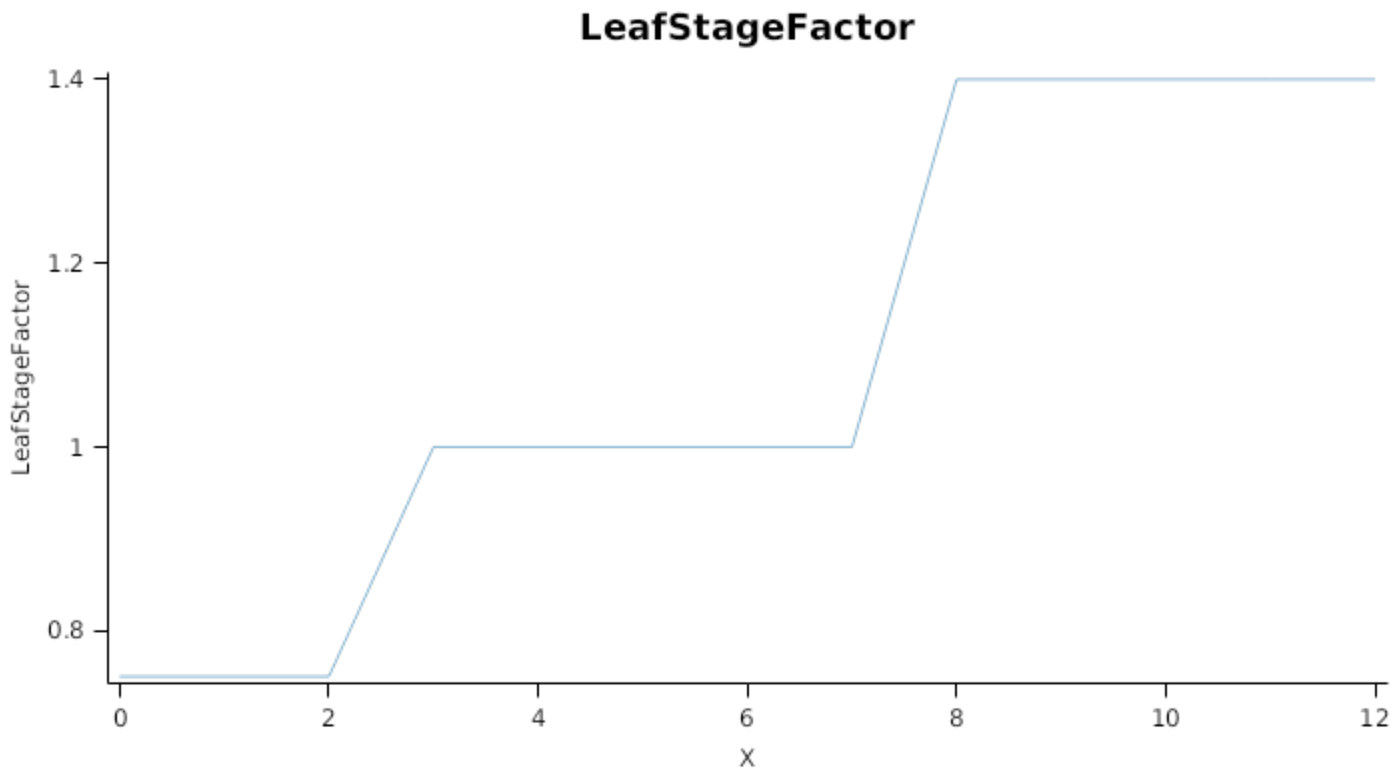
1.2.21 Phyllochron

This is the thermal time between the emergence of leaf tips. The model used here is based on Jamieson et al., 1998 where leaf appearace could be described by a base phyllochron determined between leaves 2 and 7 and a phyllochron that was 70% of base phyllochron for leaves < 2 and 130% of base phyllochron for leaves > 7

Phyllochron = *LeafStageFactor* x *BasePhyllochron* x *PhotoPeriodEffect*

LeafStageFactor is calculated using linear interpolation

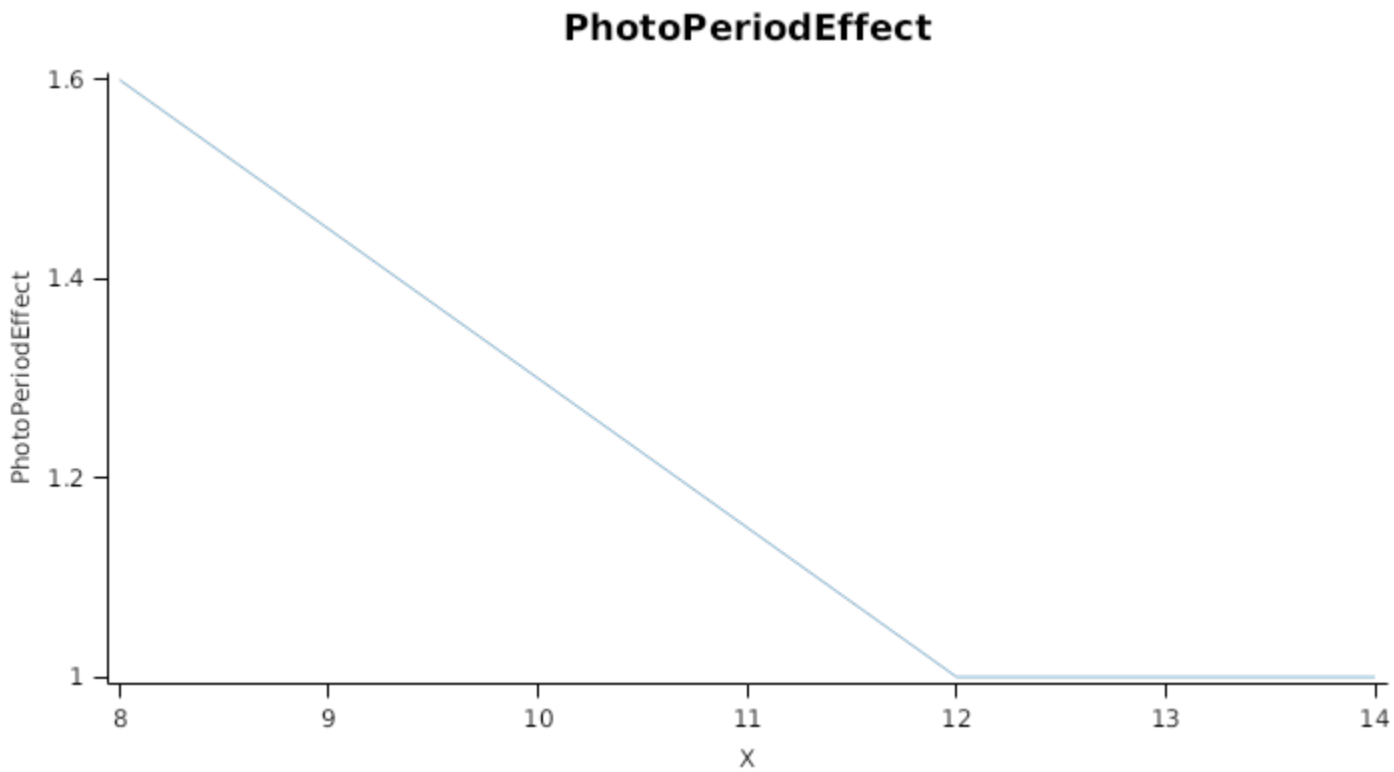
X	LeafStageFactor
0.0	0.8
2.0	0.8
3.0	1.0
7.0	1.0
8.0	1.4
11.0	1.4
12.0	1.4



BasePhyllochron = 120 (oC.d)

PhotoPeriodEffect is calculated using linear interpolation

X	PhotoPeriodEffect
8.0	1.6
12.0	1.0
14.0	1.0



1.2.22 HaunStageTerminalSpikelet

HaunStageTerminalSpikelet = ([Structure].FinalLeafNumber - 2.85)/1.1

1.2.23 FinalLeafNumber

FinalLeafNumber = *FinalNodeNumber* until TerminalSpikelet after which the value is fixed.

FinalNodeNumber = [Phenology].MinimumLeafNumber + *VernalLeaves* + *PhotoPLeaves*

VernalLeaves = [Phenology].VrnSensitivity x *VernalisationReductionFactor*

VernalisationReductionFactor = 1 - [Phenology].Vrn1

PhotoPLeaves = [Phenology].PpSensitivity x *PhotoPeriodReductionFactor*

PhotoPeriodReductionFactor is calculated using linear interpolation

X	PhotoPeriodReductionFactor
10.0	1.0
16.0	0.0

1.2.24 Zadok

This model calculates a Zadok growth stage value based upon the current phenological growth stage within the model. The model uses information regarding germination, emergence, leaf appearance and tiller appearance for early growth stages (Zadok stages 0 to 30). The model then uses simulated phenological growth stages for Zadok stages 30 to 100.

List of growth phases

Growth Phase	Descriptipon
Germinating	ZadokStage = 5 x FractionThroughPhase
Emerging	ZadokStage = 5 + 5 x FractionThroughPhase
Vegetative	ZadokStage = 10 + Structure.LeafTipsAppeared
Reproductive	ZadokStage is interpolated from values of stage number using the following table

List of growth stages

Growth Stage	ZadokStage
4.3	30
4.9	33
5	39
6	55
7	65
8	71
9	87
10	90

1.2.25 TerminalSpikeletDAS

Before TerminalSpikelet

PreEventValue = 0

On TerminalSpikelet the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.26 FlagLeafDAS

Before FlagLeaf

PreEventValue = 0

On FlagLeaf the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.27 HeadingDAS

Before Heading

PreEventValue = 0

On Heading the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.28 FloweringDAS

Before Flowering

PreEventValue = 0

On Flowering the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.29 MaturityDAS

Before Maturity

PreEventValue = 0

On Maturity the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.30 EmergenceDAS

Before Emergence

PreEventValue = 0

On Emergence the value is set to:

PostEventValue = [Plant].DaysAfterSowing

1.2.31 PTQ

PTQ = Radn_mol_per_m2 / [Phenology].ThermalTime

Multiply Radn (MJ/m2/d) by 4.57 to convert to mol/m2/day and divide by 2 to convert to mol PAR/m2/d

Radn_mol_per_m2 = [IWeather].Radn x 2.285 x [Leaf].Photosynthesis.FT

1.3 Structure

The structure model simulates morphological development of the plant to inform the Leaf class when and how many leaves and branches appear and provides an estimate of height.

1.3.1 Plant and Main-Stem Population

The *Plant.Population* is set at sowing with information sent from a manager script in the Sow method. The *PrimaryBudNumber* is also sent with the Sow method. The main-stem population (*MainStemPopn*) for Wheat is calculated as:

MainStemPopn = Plant.Population x *PrimaryBudNumber*

Primary bud number is > 1 for crops like potato and grape vine where there are more than one main-stem per plant

1.3.2 Main-Stem leaf appearance

Each day the number of main-stem leaf tips appeared (*LeafTipsAppeared*) is calculated as:

LeafTipsAppeared += DeltaTips

Where *DeltaTips* is calculated as:

DeltaTips = ThermalTime / *Phyllochron*

Where *Phyllochron* is the thermal time duration between the appearance of leaf tips given by:

Phyllochron = [Phenology].Phyllochron

ThermalTime is given by

ThermalTime = [Phenology].ThermalTime

LeafTipsAppeared continues to increase until *FinalLeafNumber* is reached where *FinalLeafNumber* is calculated as:

FinalLeafNumber = [Phenology].FinalLeafNumber

1.3.3 Branching and Branch Mortality

The total population of stems (*TotalStemPopn*) is calculated as:

TotalStemPopn = MainStemPopn + *NewBranches* - *NewlyDeadBranches*

Where:

NewBranches = MainStemPopn x *BranchingRate*

BranchingRate is given by:

Potential branching rate is determined by the commonly observed pattern of tillering in wheat, in which each tiller emerges with the third leaf on its parent axis (e.g. first tiller emerges at the same time as the third leaf on the main stem, the first secondary tiller appears with the third leaf on tiller 1). This is described as a simple function of main stem leaf number.

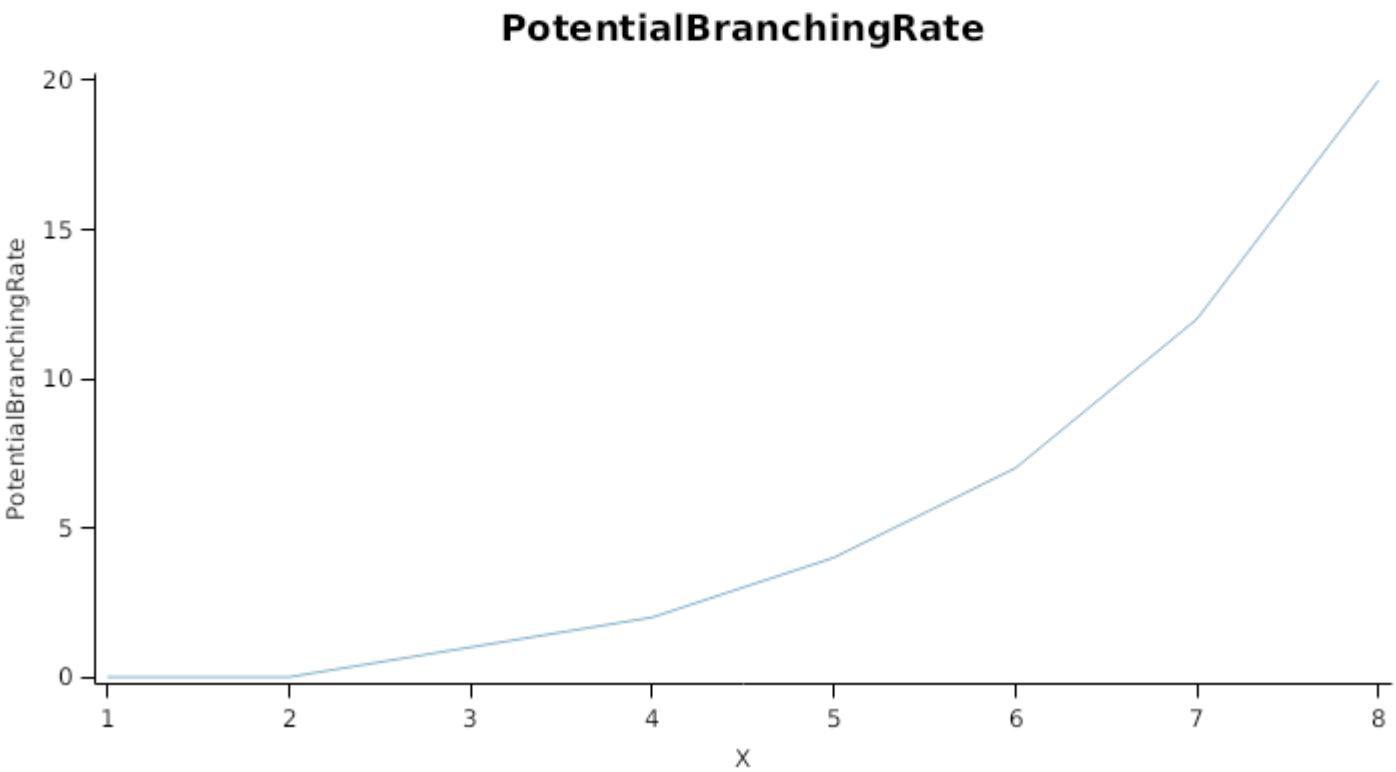
BranchingRate = PotentialBranchingRate x *StressFactors*

PotentialBranchingRate is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

Vegetative has a value between Emergence and TerminalSpikelet calculated as:

PotentialBranchingRate is calculated using linear interpolation

X	PotentialBranchingRate
1.0	0.0
2.0	0.0
3.0	1.0
4.0	2.0
5.0	4.0
6.0	7.0
7.0	12.0
8.0	20.0



Reproductive has a value between TerminalSpikelet and HarvestRipe calculated as:

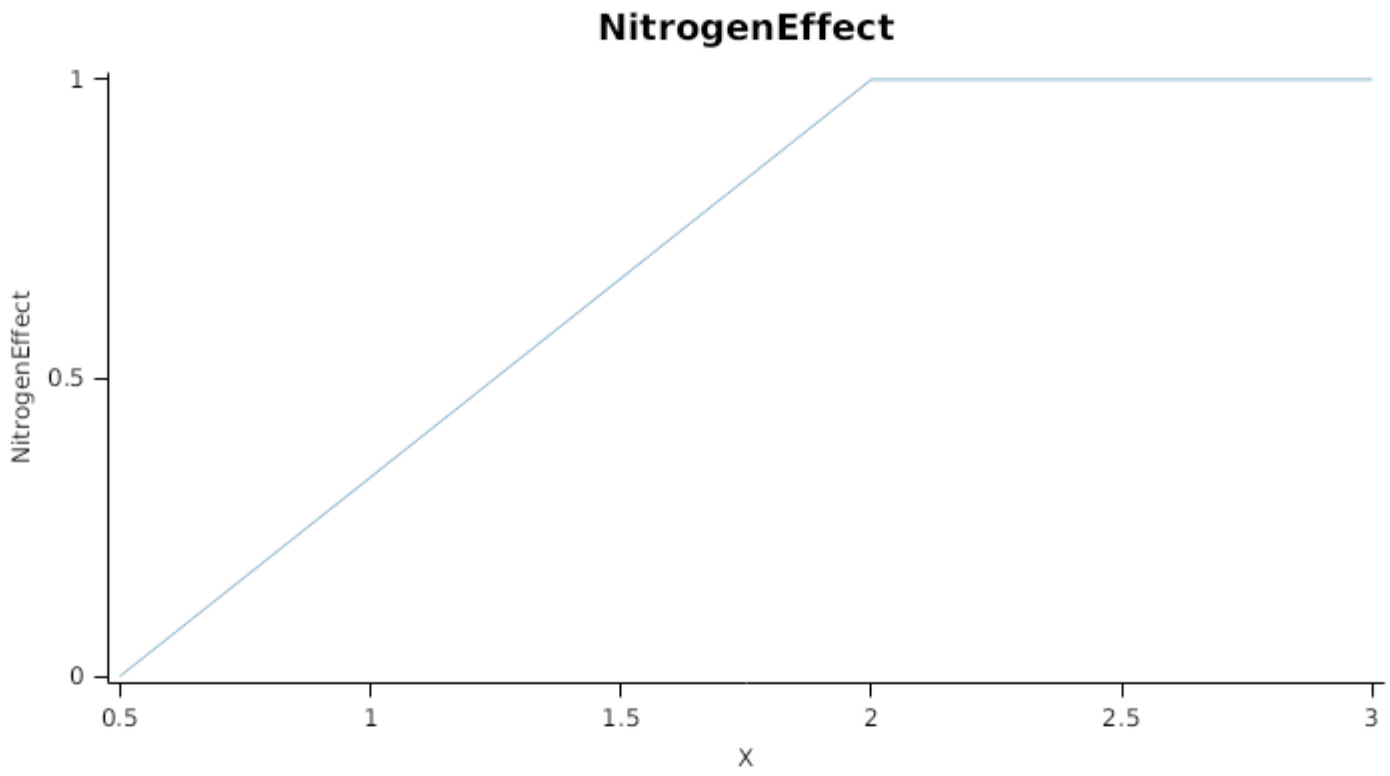
Zero = 0

StressFactors = Min(*NitrogenEffect*, *CoverEffect*, *WaterStressEffect*)

Where:

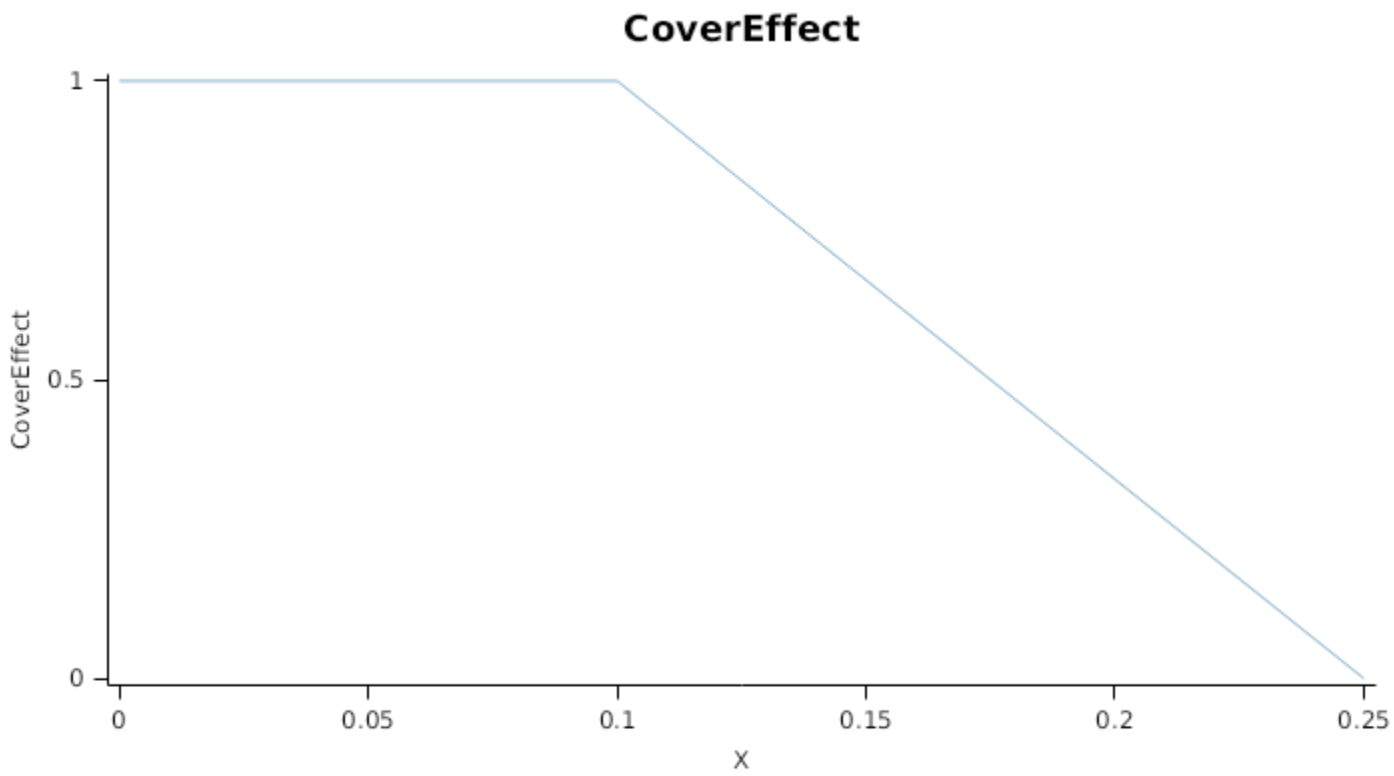
NitrogenEffect is calculated using linear interpolation

X	NitrogenEffect
0.5	0.0
2.0	1.0
3.0	1.0



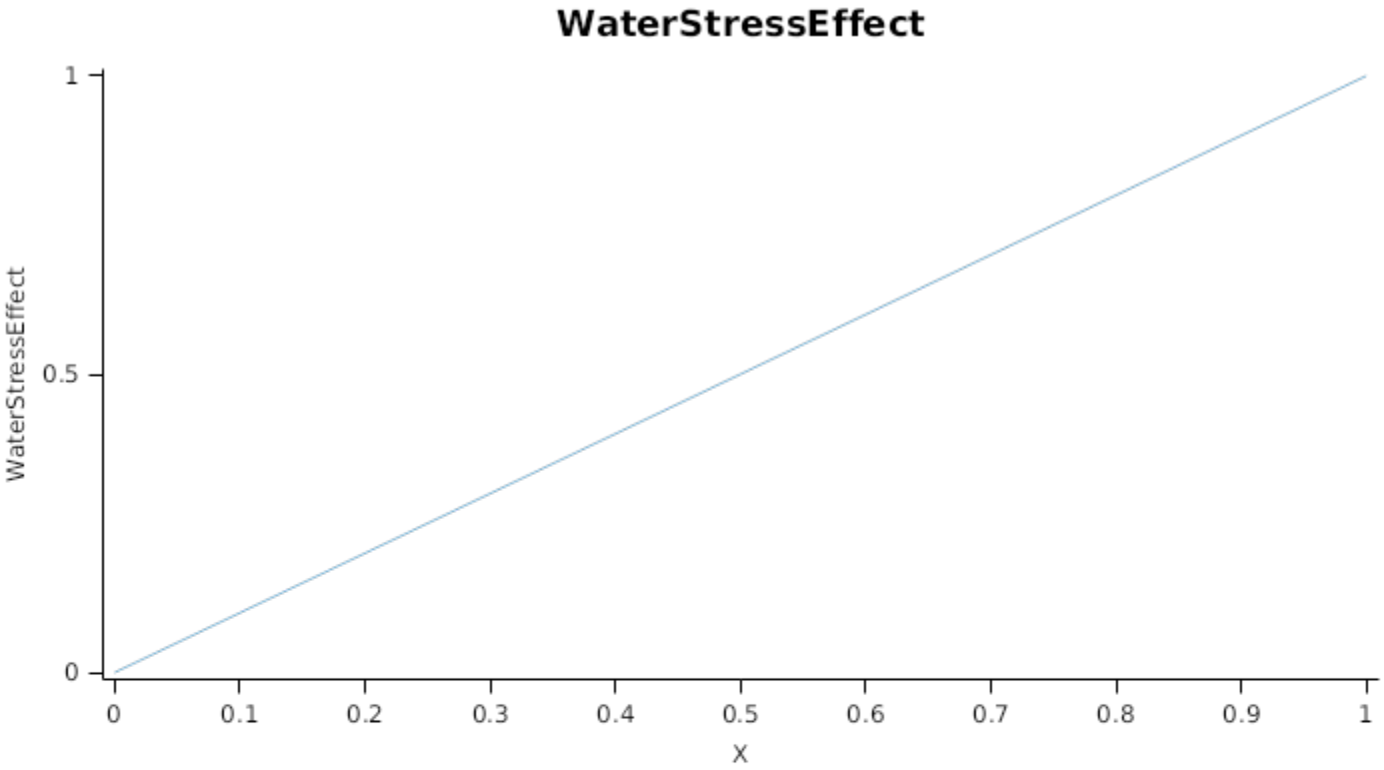
CoverEffect is calculated using linear interpolation

X	CoverEffect
0.0	1.0
0.1	1.0
0.2	0.0



WaterStressEffect is calculated using linear interpolation

X	WaterStressEffect
0.0	0.0
1.0	1.0



NewlyDeadBranches is calcualted as:

NewlyDeadBranches = (*TotalStemPopn* - *MainStemPopn*) x *BranchMortality*

where *BranchMortality* is given by:

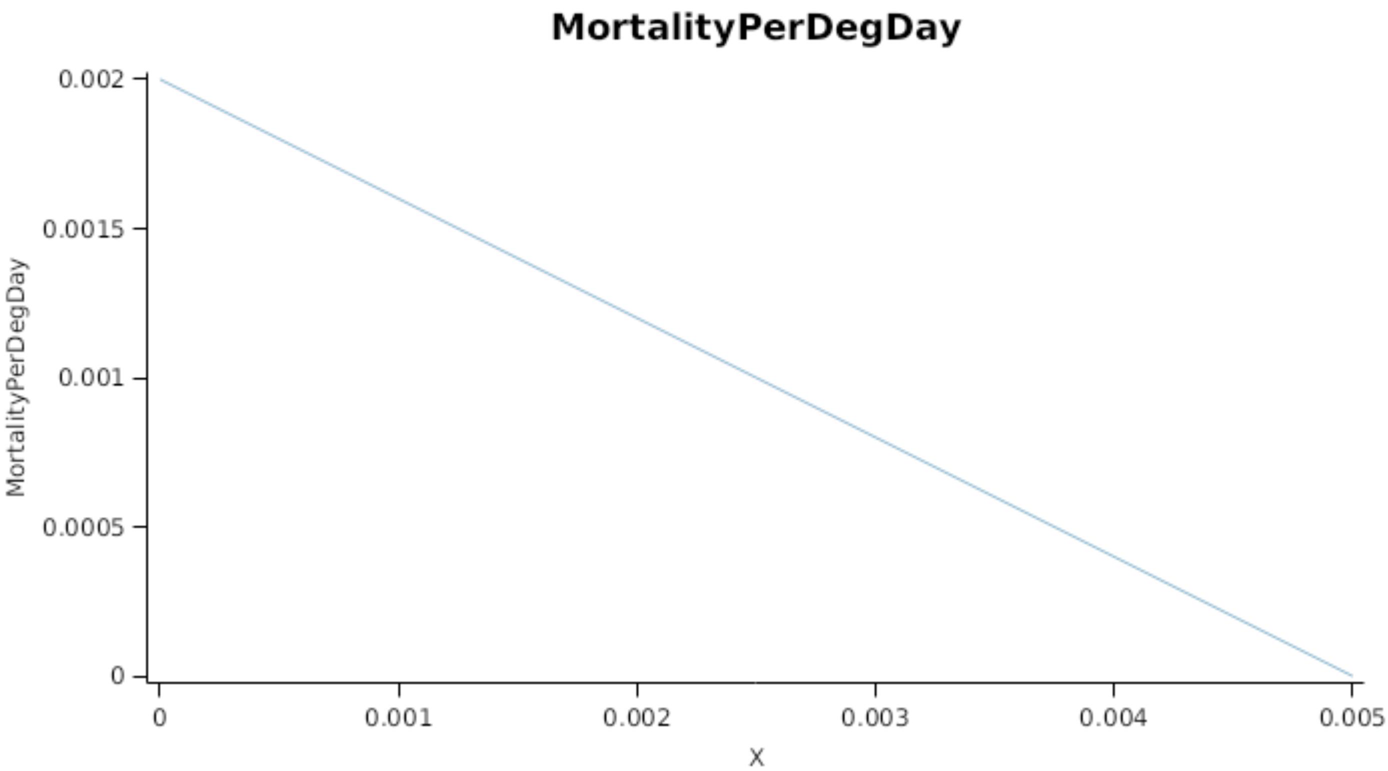
BranchMortality is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

MortalityPhase has a value between FlagLeaf and Flowering calculated as:

Mortality = *MortalityPerDegDay* x [Phenology].ThermalTime

MortalityPerDegDay is calculated using linear interpolation

X	MortalityPerDegDay
0.0	0.0
0.0	0.0



1.3.4 Height

The height of the crop is calculated by the *HeightModel*

Height is used by the MicroClimate model to calculate the aerodynamic resistance used for calculation of potential transpiration. Calculates the potential height increment and then multiplies it by the smallest of any childern functions (Child functions represent stress).

1.4 Grain

This organ uses a generic model for plant reproductive components. Yield is calculated from its components in terms of organ number and size (for example, grain number and grain size).

1.4.1 Constants

DMConversionEfficiency = 1

RemobilisationCost = 0

InitialGrainProportion = 0.05

MaximumPotentialGrainSize = 0.05 (g)

MinimumNConc = 0.0123

MaxNConcDailyGrowth = 0.03

MaximumNConc = 0.03

WaterContent = 0.12

CarbonConcentration = 0.4

1.4.2 NumberFunction

NumberFunction = *GrainNumber* until Flowering after which the value is fixed.

GrainNumber = *GrainsPerGramOfStem* x [StemPlusSpike].Wt

GrainsPerGramOfStem = 26 (grains)

1.4.3 DMDemandFunction

DMDemandFunction is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

InitialPhase has a value between Flowering and StartGrainFill calculated as:

Filling rate is calculated from grain number, a maximum mass to be filled and the duration of the filling process.

NumberFunction = [Grain].NumberFunction

FillingDuration = [Phenology].GrainDevelopment.Target

ThermalTime = [Phenology].ThermalTime

PotentialSizeIncrement = [Grain].InitialGrainProportion x [Grain].MaximumPotentialGrainSize

LinearPhase has a value between StartGrainFill and EndGrainFill calculated as:

Filling rate is calculated from grain number, a maximum mass to be filled and the duration of the filling process.

NumberFunction = [Grain].NumberFunction

FillingDuration = [Phenology].GrainFilling.Target

ThermalTime = [Phenology].ThermalTime

PotentialSizeIncrement = *ProportionLinearPhase* x [Grain].MaximumPotentialGrainSize

ProportionLinearPhase = 1 - [Grain].InitialGrainProportion

1.4.4 NFillingRate

NFillingRate is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

GrainFilling has a value between Flowering and EndGrainFill calculated as:

Filling rate is calculated from grain number, a maximum mass to be filled and the duration of the filling process.

NumberFunction = [Grain].NumberFunction

FillingDuration = [Phenology].GrainDevelopment.Target + [Phenology].GrainFilling.Target

ThermalTime = [Phenology].ThermalTime

PotentialSizeIncrement = [Grain].MaximumPotentialGrainSize x [Grain].MaximumNConc

1.4.5 AccumThermalTime

AccumThermalTime = Accumulated *DailyThermalTimeValue* between flowering and maturity

DailyThermalTimeValue = [Phenology].ThermalTime

1.4.6 Protein

Protein = ([Grain].Live.N + [Grain].Dead.N)/([Grain].Live.Wt + [Grain].Dead.Wt) x 100 x 5.71

1.4.7 BiomassRemovalDefaults

This organ will respond to certain management actions by either removing some of its biomass from the system or transferring some of its biomass to the soil surface residues. The following table describes the default proportions of live and dead biomass that are transferred out of the simulation using "Removed" or to soil surface residue using "To Residue" for a range of management actions. The total percentage removed for live or dead must not exceed 100%. The difference between the total and 100% gives the biomass remaining on the plant. These can be changed during a simulation using a manager script.

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Harvest	100	0	0	0
Cut	100	0	0	0

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Prune	0	0	80	0
Graze	60	0	20	0
Thin	0	0	5	0

1.4.8 DMDemandPriorityFactors

This class holds the functions for calculating the absolute demands for each biomass fraction.

Structural = 1

Metabolic = 1

Storage = 1

1.4.9 NDemandPriorityFactors

This class holds the functions for calculating the absolute demands for each biomass fraction.

Structural = 1

Metabolic = 1

Storage = 1

1.5 Root

The root model calculates root growth in terms of rooting depth, biomass accumulation and subsequent root length density in each soil layer.

1.5.1 Growth

Roots grow downwards through the soil profile, with initial depth determined by sowing depth and the growth rate determined by RootFrontVelocity. The RootFrontVelocity is modified by multiplying it by the soil's XF value, which represents any resistance posed by the soil to root extension.

$Root\ Depth\ Increase = RootFrontVelocity \times XF_i \times RootDepthStressFactor$

where i is the index of the soil layer at the rooting front.

Root depth is also constrained by a maximum root depth.

Root length growth is calculated using the daily DM partitioned to roots and a specific root length. Root proliferation in layers is calculated using an approach similar to the generalised equimarginal criterion used in economics. The uptake of water and N per unit root length is used to partition new root material into layers of higher 'return on investment'. For example, the Root Activity for water is calculated as

$RAw_i = -WaterUptake_i / LiveRootWt_i \times LayerThickness_i \times ProportionThroughLayer$

The amount of root mass partitioned to a layer is then proportional to root activity

$DMAllocated_i = TotalDMAllocated \times RAw_i / TotalRAw$

1.5.2 Dry Matter Demands

A daily DM demand is provided to the organ arbitrator and a DM supply returned. By default, 100% of the dry matter (DM) demanded from the root is structural. The daily loss of roots is calculated using a SenescenceRate function. All senesced material is automatically detached and added to the soil FOM.

1.5.3 Nitrogen Demands

The daily structural N demand from root is the product of total DM demand and the minimum N concentration. Any N above this is considered Storage and can be used for retranslocation and/or reallocation as the respective factors are set to values other then zero.

1.5.4 Nitrogen Uptake

Potential N uptake by the root system is calculated for each soil layer (i) 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 controlling the rate of extraction (kNO3 or kNH4), the concentration of N form (ppm), and a soil moisture factor (NUptakeSWFactor) which typically decreases as the soil dries. *NO3 uptake* = $NO3_i$ *x kNO3 x* $NO3_{ppm, i}$ *x NUptakeSWFactor* _NH4 uptake = $NH4_i$ x kNH4 x $NH4_{ppm, i}$ x NUptakeSWFactor_As can be seen from the above equations, the values of kNO3 and kNH4 equate to the potential fraction of each mineral N pool which can be taken up per day for wet soil when that pool has a concentration of 1 ppm.Nitrogen uptake demand is limited to the maximum daily potential uptake (MaxDailyNUptake) and the plant's N demand. The former provides a means to constrain N uptake to a maximum value observed in the field for the crop as a whole.The demand for soil N is then passed to the soil arbitrator which determines how much of the N uptake demandeach 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 (water above LL limit) and a factor controlling the rate of extraction (KL). The values of both LL and KL are set in the soil interface and KL may be further modified by the crop via the KLModifier function. *SW uptake* = $(SW_i - LL_i) \times KL_i \times KLModifier$

1.5.6 Constants

DMConversionEfficiency = 1

RemobilisationCost = 0

KLModifier = 1

SoilWaterEffect = 1

MaxDailyNUptake = 20

SenescenceRate = 0.005

MaximumRootDepth = 1000000

MaximumNConc = 0.01

MinimumNConc = 0.01

KNO3 = 0.02

KNH4 = 0.01

SpecificRootLength = 105 (m/g)

CarbonConcentration = 0.4

MaintenanceRespirationFunction = 0

RootDepthStressFactor = 1

1.5.7 RootShape

This model calculates the proportion of each soil layer occupided by roots.

1.5.8 NitrogenDemandSwitch

NitrogenDemandSwitch has a value between Germination and Maturity calculated as:

Constant = 1

1.5.9 BiomassRemovalDefaults

This organ will respond to certain management actions by either removing some of its biomass from the system or transferring some of its biomass to the soil surface residues. The following table describes the default proportions of live and dead biomass that are transferred out of the simulation using "Removed" or to soil surface residue using "To Residue" for a range of management actions. The total percentage removed for live or dead must not exceed 100%. The difference between the total and 100% gives the biomass remaining on the plant. These can be changed during a simulation using a manager script.

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Harvest	0	0	20	0
Cut	0	0	30	0
Prune	0	0	10	0
Graze	0	0	15	0
Thin	0	0	5	0

1.5.10 RootFrontVelocity

RootFrontVelocity = *PotentialRootFrontVelocity* x *TemperatureFactor* x *WaterFactor*

PotentialRootFrontVelocity is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

PreEmergence has a value between Germination and Emergence calculated as:

Value = 5 (mm/d)

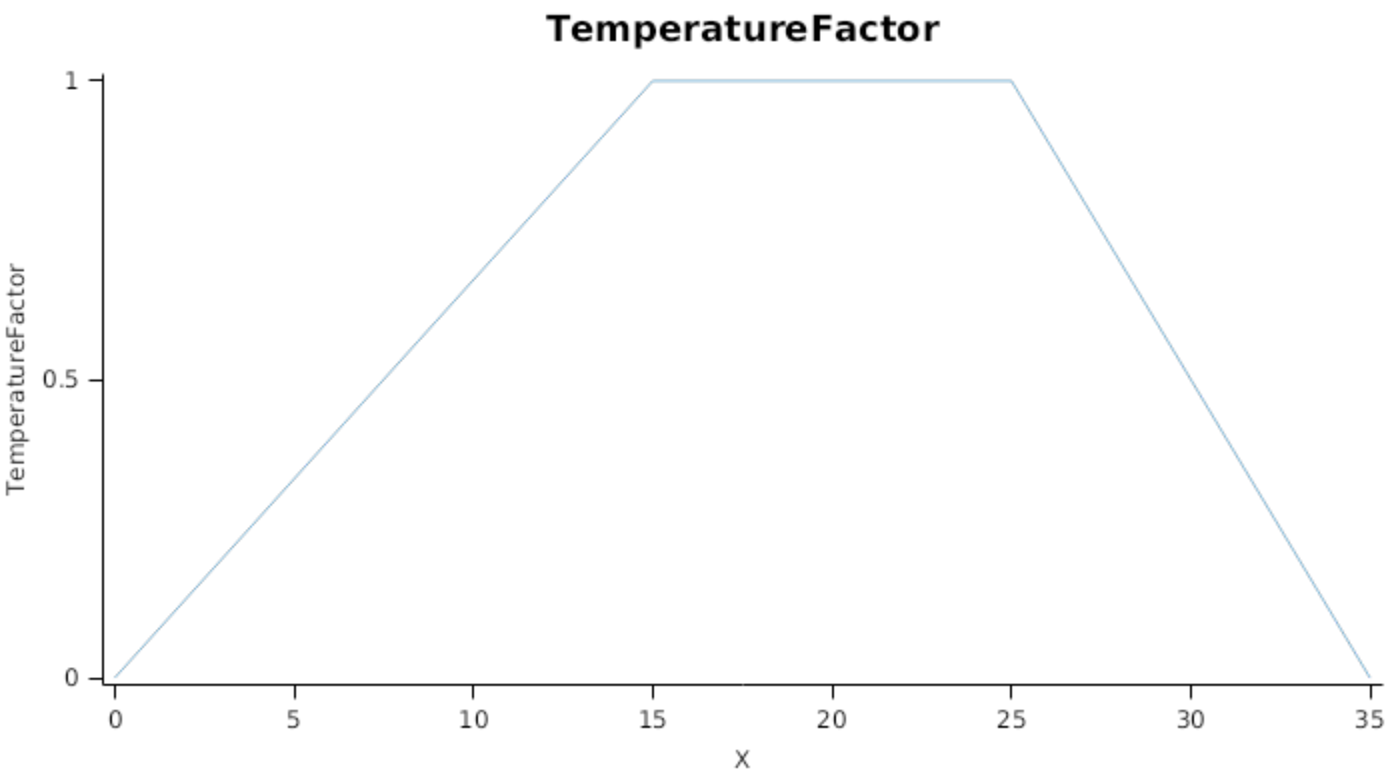
PostEmergence has a value between Emergence and Maturity calculated as:

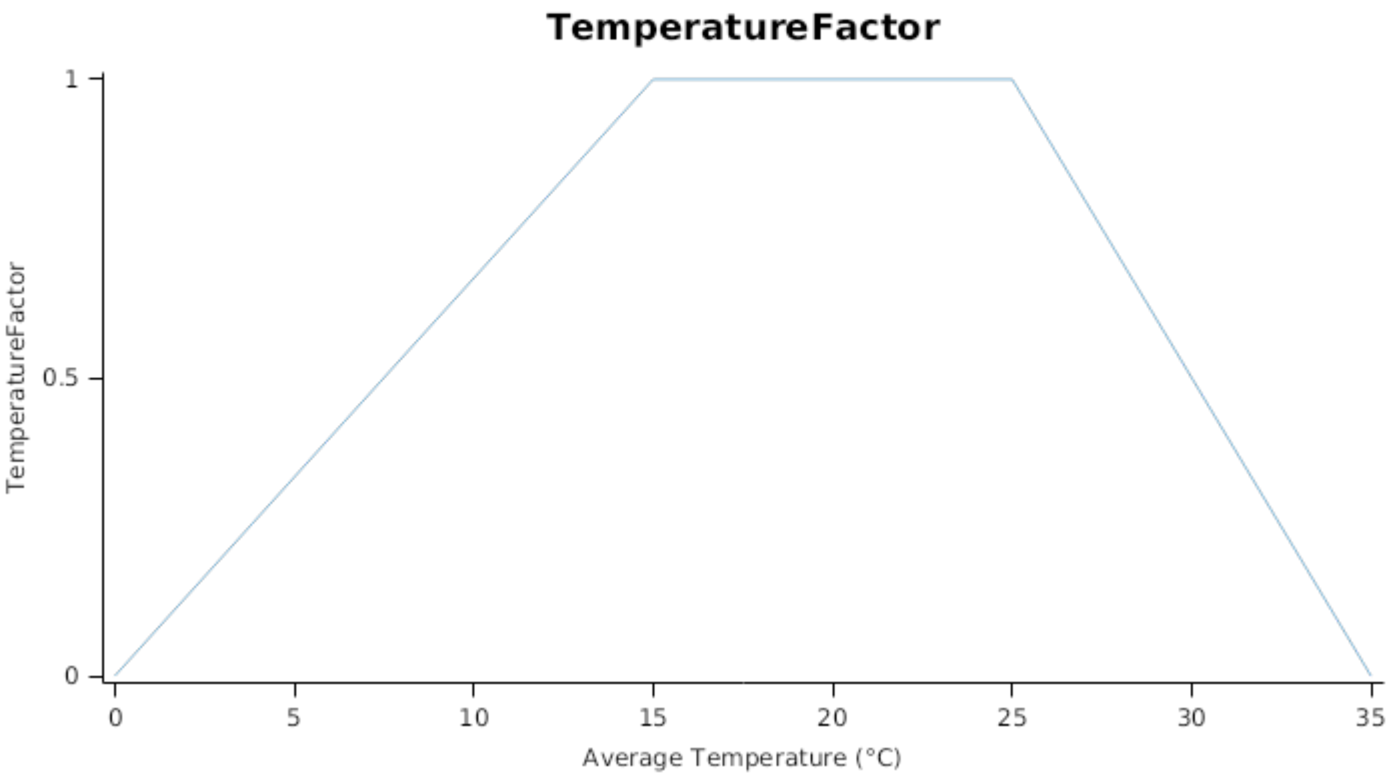
Value = 20 (mm/d)

TemperatureFactor is calculated as a function of daily min and max temperatures, these are weighted toward max temperature according to the specified MaximumTemperatureWeighting factor. A value equal to 1.0 means it will use max temperature, a value of 0.5 means average temperature.

MaximumTemperatureWeighting = 0.5

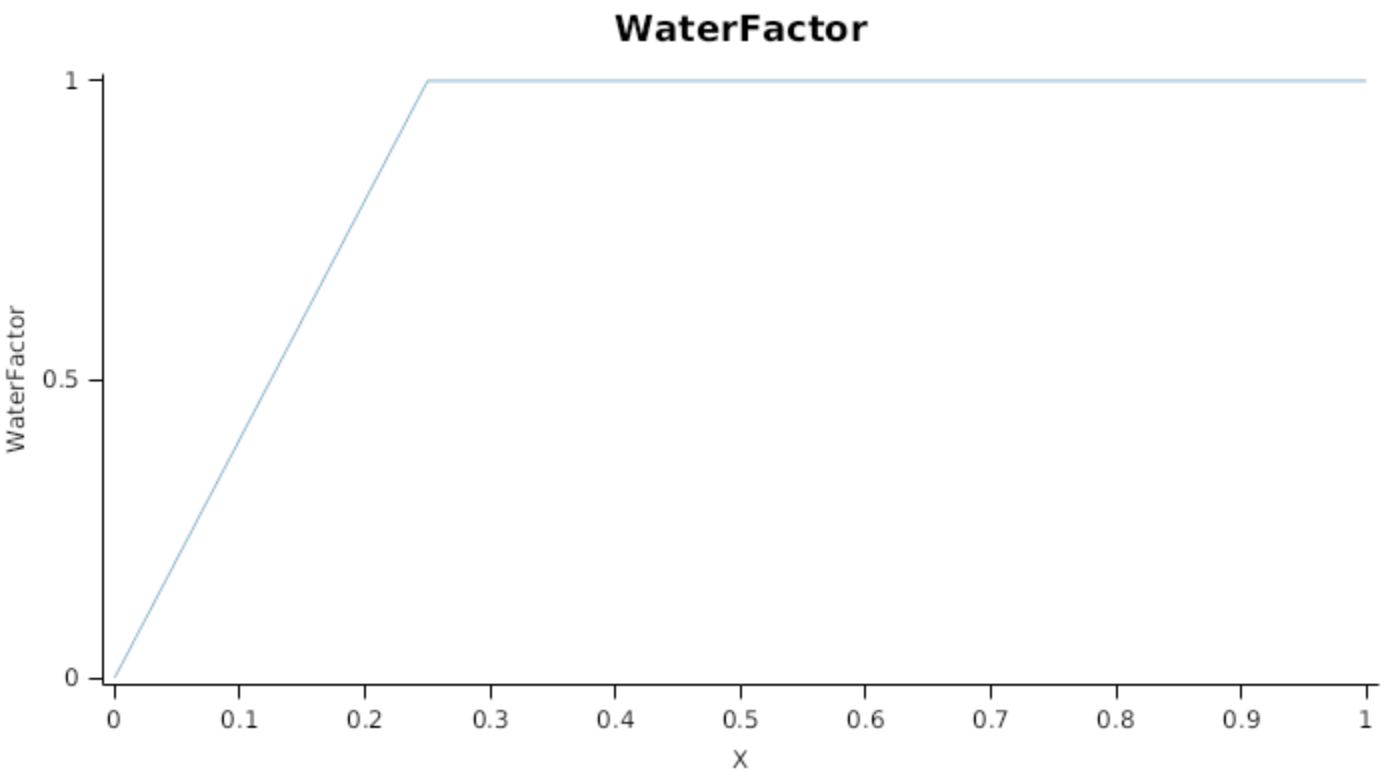
X	TemperatureFactor
0.0	0.0
15.0	1.0
25.0	1.0
35.0	0.0





WaterFactor is calculated using linear interpolation

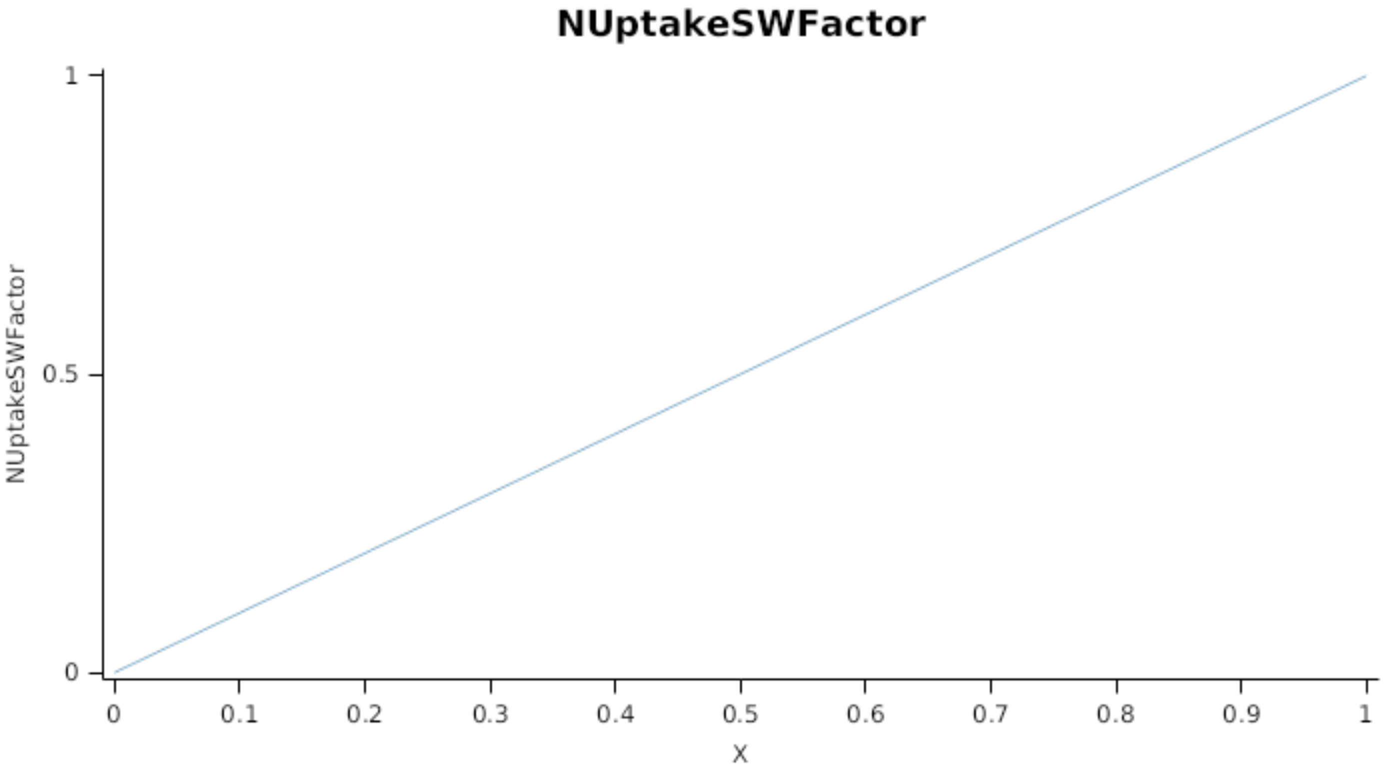
X	WaterFactor
0.0	0.0
0.2	1.0
1.0	1.0



1.5.11 NUptakeSWFactor

NUptakeSWFactor is calculated using linear interpolation

X	NUptakeSWFactor
0.0	0.0
1.0	1.0



1.5.12 DMDemands

1.5.12.1 DMDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = *DMDemandFunction* x *StructuralFraction*

Returns the product of its PartitionFraction and the total DM supplied to the arbitrator by all organs.

DMDemandFunction = PartitionFraction x [Arbitrator].DM.TotalFixationSupply

PartitionFraction is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

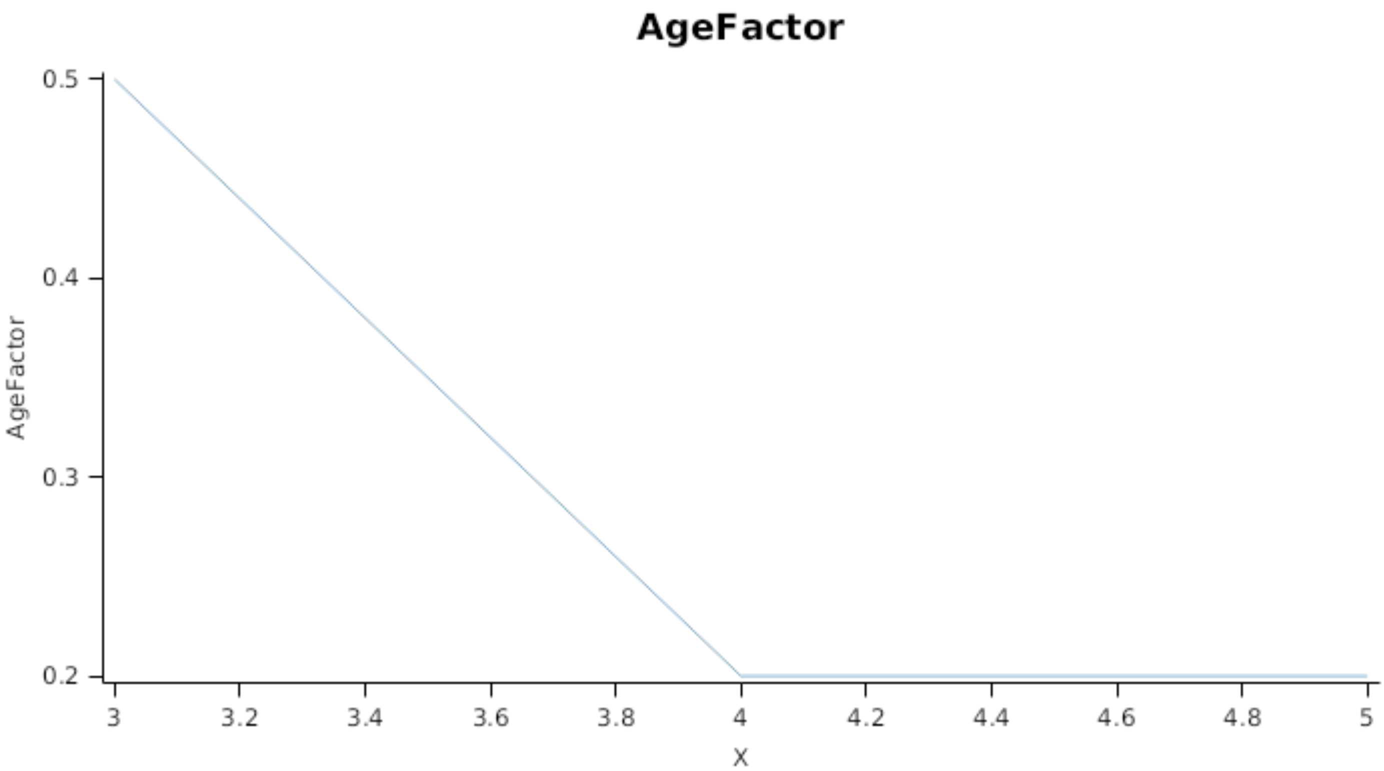
PreEmergence has a value between Germination and Emergence calculated as:

Value = 0

PreFlowering has a value between Emergence and Flowering calculated as:

AgeFactor is calculated using linear interpolation

X	AgeFactor
3.0	0.5
4.0	0.2
5.0	0.2



PostFlowering has a value between Flowering and EndGrainFill calculated as:

Value = 0.2

StructuralFraction = 1

Metabolic = 0

The partitioning of daily growth to storage biomass is based on a storage fraction.

StorageFraction = 1 - [Root].DMDemands.Structural.StructuralFraction

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.5.13 NDemands

1.5.13.1 NDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = [Root].minimumNconc x [Root].potentialDMAllocation.Structural

Metabolic = *MetabolicNconc* x [Root].potentialDMAllocation.Structural

MetabolicNconc = [Root].criticalNConc - [Root].minimumNconc

The partitioning of daily N supply to storage N attempts to bring the organ's N content to the maximum concentration.

Storage = [Root].maximumNconc × ([Root].Live.Wt + potentialAllocationWt) - [Root].Live.N

The demand for storage N is further reduced by a factor specified by the [Root].NitrogenDemandSwitch.

NitrogenDemandSwitch = [Root].nitrogenDemandSwitch

MaxNconc = [Root].maximumNconc

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.5.14 CriticalNConc

CriticalNConc = [Root].MinimumNConc

1.5.15 InitialWt

This class holds the functions for calculating the absolute demands for each biomass fraction.

Structural = 0.005 (g/plant)

Metabolic = 0

Storage = 0

1.6 Leaf

The leaves are modelled as a set of leaf cohorts and the properties of each of these cohorts are summed to give overall values for the leaf organ.
A cohort represents all the leaves of a given main- stem node position including all of the branch leaves appearing at the same time as the given main-stem leaf (Lawless et al., 2005).
The number of leaves in each cohort is the product of the number of plants per m^2 and the number of branches per plant.
The *Structure* class models the appearance of main-stem leaves and branches. Once cohorts are initiated the *Leaf* class models the area and biomass dynamics of each.
It is assumed all the leaves in each cohort have the same size and biomass properties. The modelling of the status and function of individual cohorts is delegated to *LeafCohort* classes.

1.6.1 Dry Matter Fixation

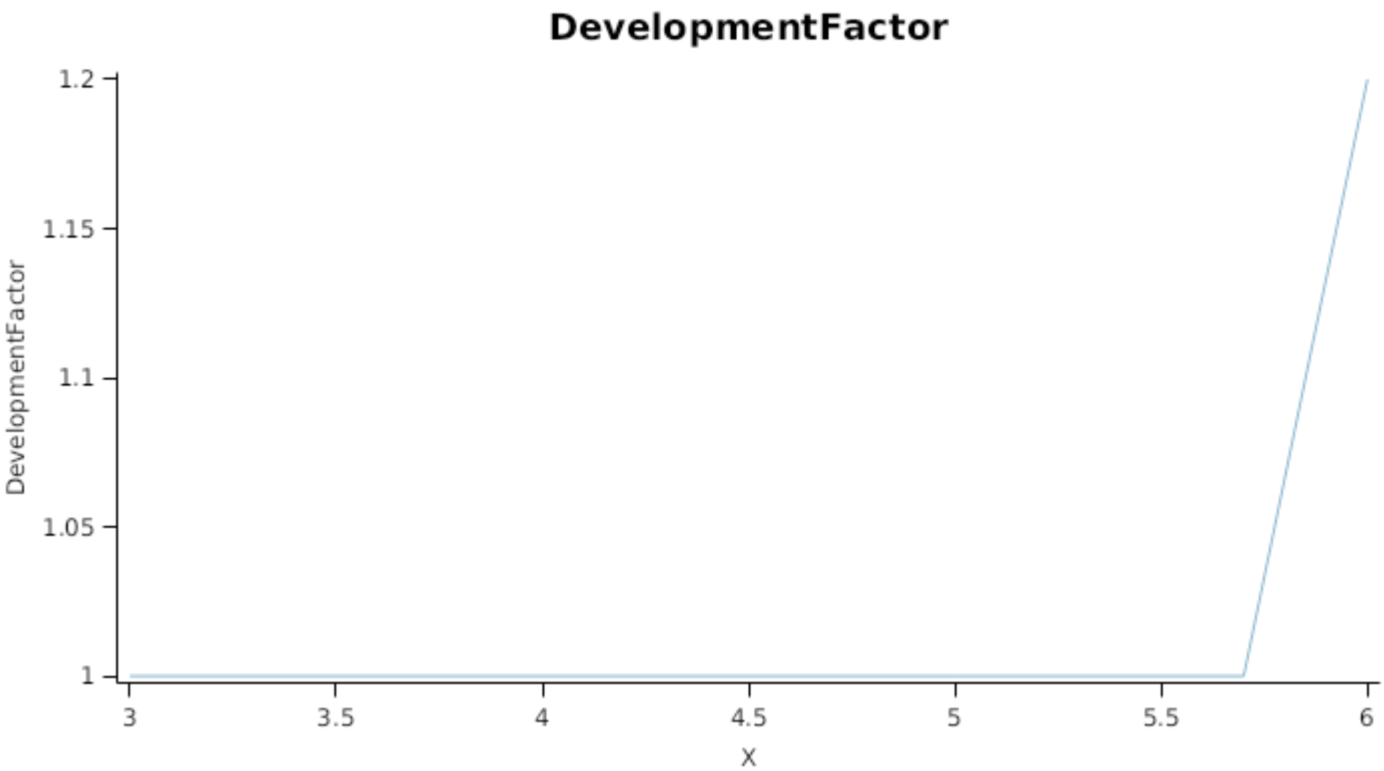
The most important DM supply from leaf is the photosynthetic fixation supply. Radiation interception is calculated from LAI using an extinction coefficient of:

ExtinctionCoeff = *VegetativePhase* x *DevelopmentFactor*

VegetativePhase = 0.5

DevelopmentFactor is calculated using linear interpolation

X	DevelopmentFactor
3.0	1.0
4.0	1.0
5.0	1.0
5.7	1.0
6.0	1.2



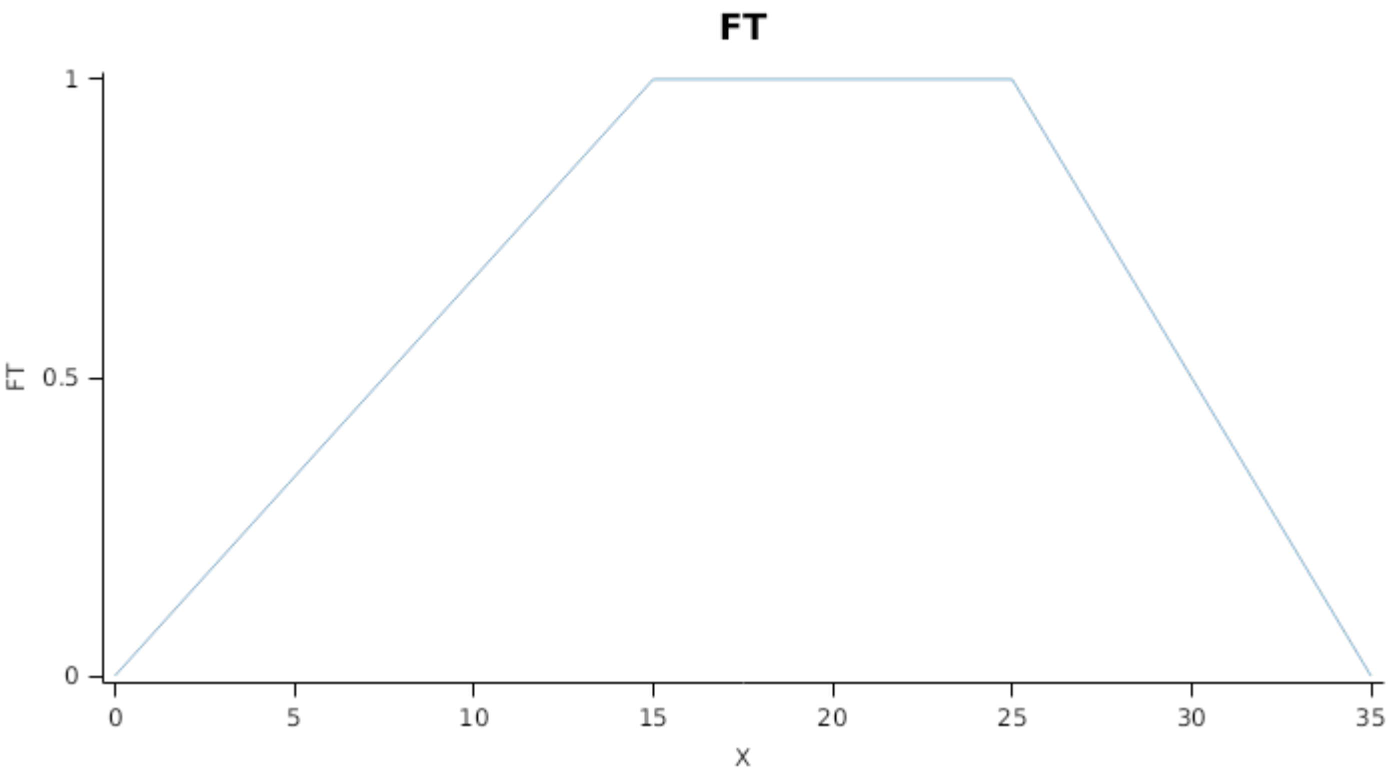
Biomass fixation is modelled as the product of intercepted radiation and its conversion efficiency, the radiation use efficiency (RUE) (Monteith et al., 1977).
This approach simulates net photosynthesis rather than providing separate estimates of growth and respiration.
The potential photosynthesis calculated using RUE is then adjusted according to stress factors, these account for plant nutrition (FN), air temperature (FT), vapour pressure deficit (FVPD), water supply (FW) and atmospheric CO_2 concentration (FCO2).
NOTE: RUE in this model is expressed as g/MJ for a whole plant basis, including both above and below ground growth.

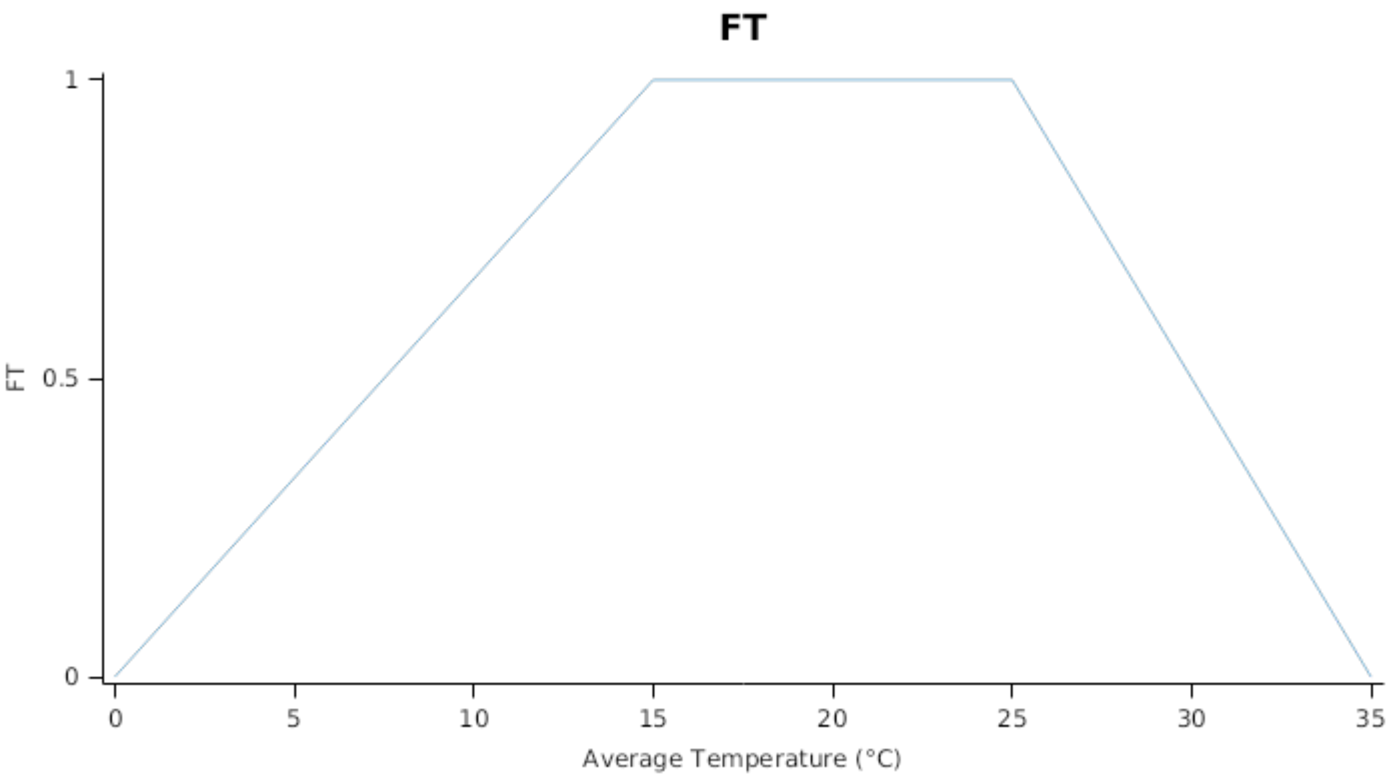
RUE = 1.5

FT is calculated as a function of daily min and max temperatures, these are weighted toward max temperature according to the specified MaximumTemperatureWeighting factor. A value equal to 1.0 means it will use max temperature, a value of 0.5 means average temperature.

MaximumTemperatureWeighting = 0.75

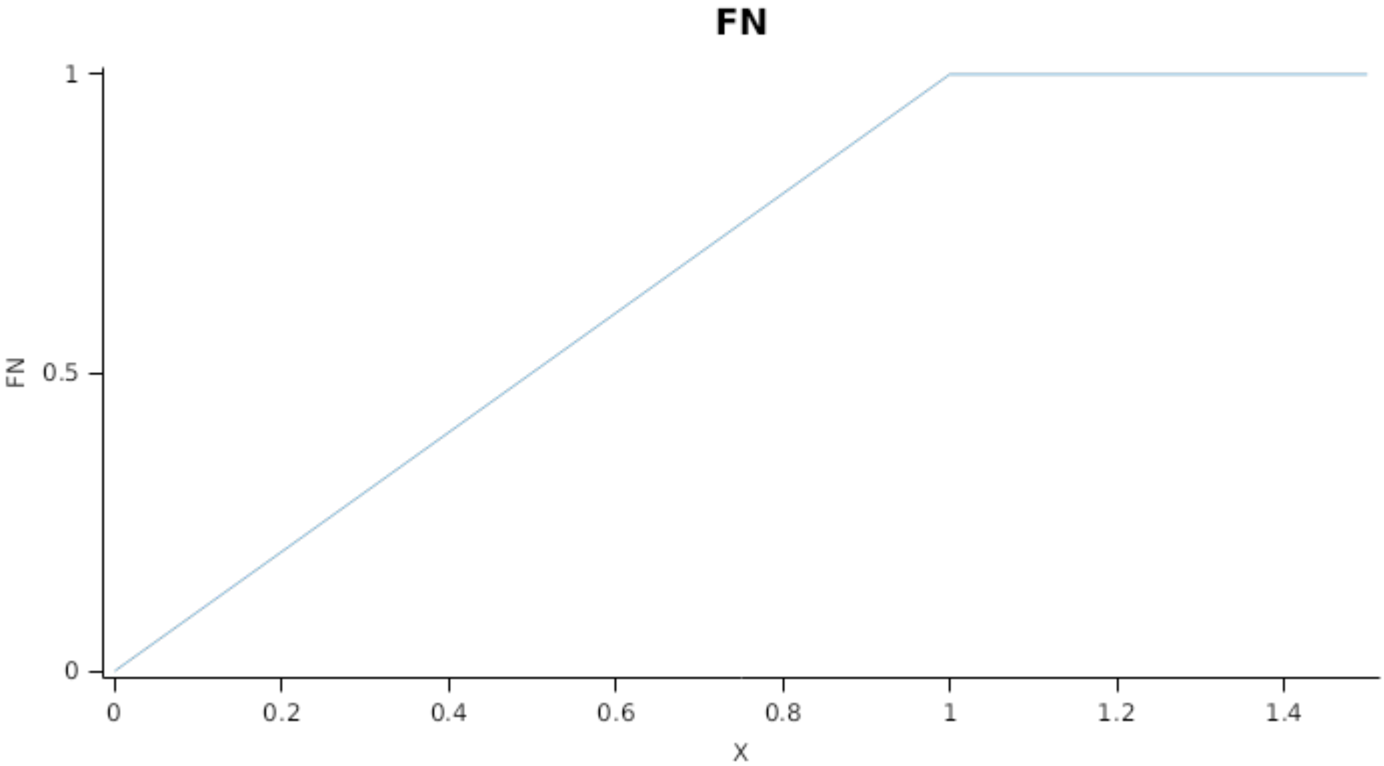
X	FT
0.0	0.0
15.0	1.0
25.0	1.0
35.0	0.0





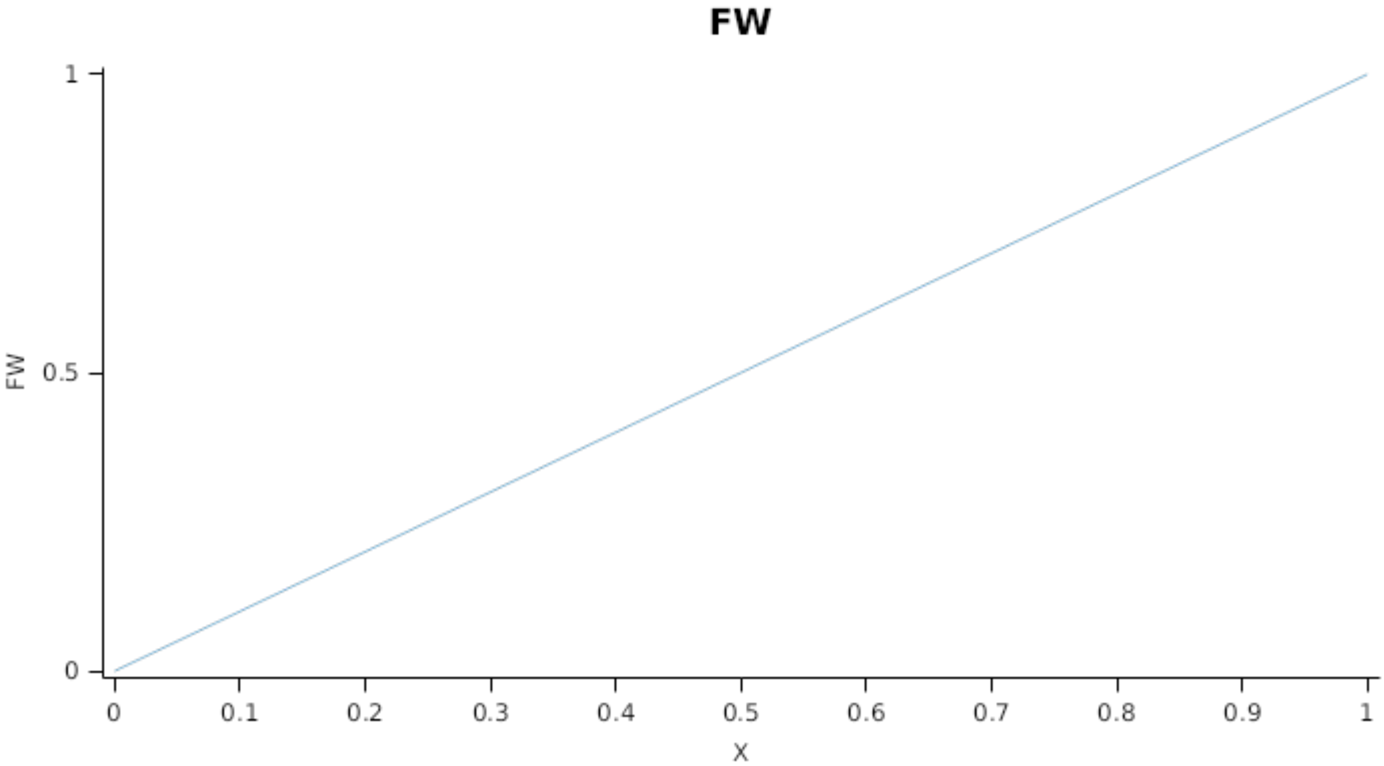
FN is calculated using linear interpolation

X	FN
0.0	0.0
1.0	1.0
1.5	1.0



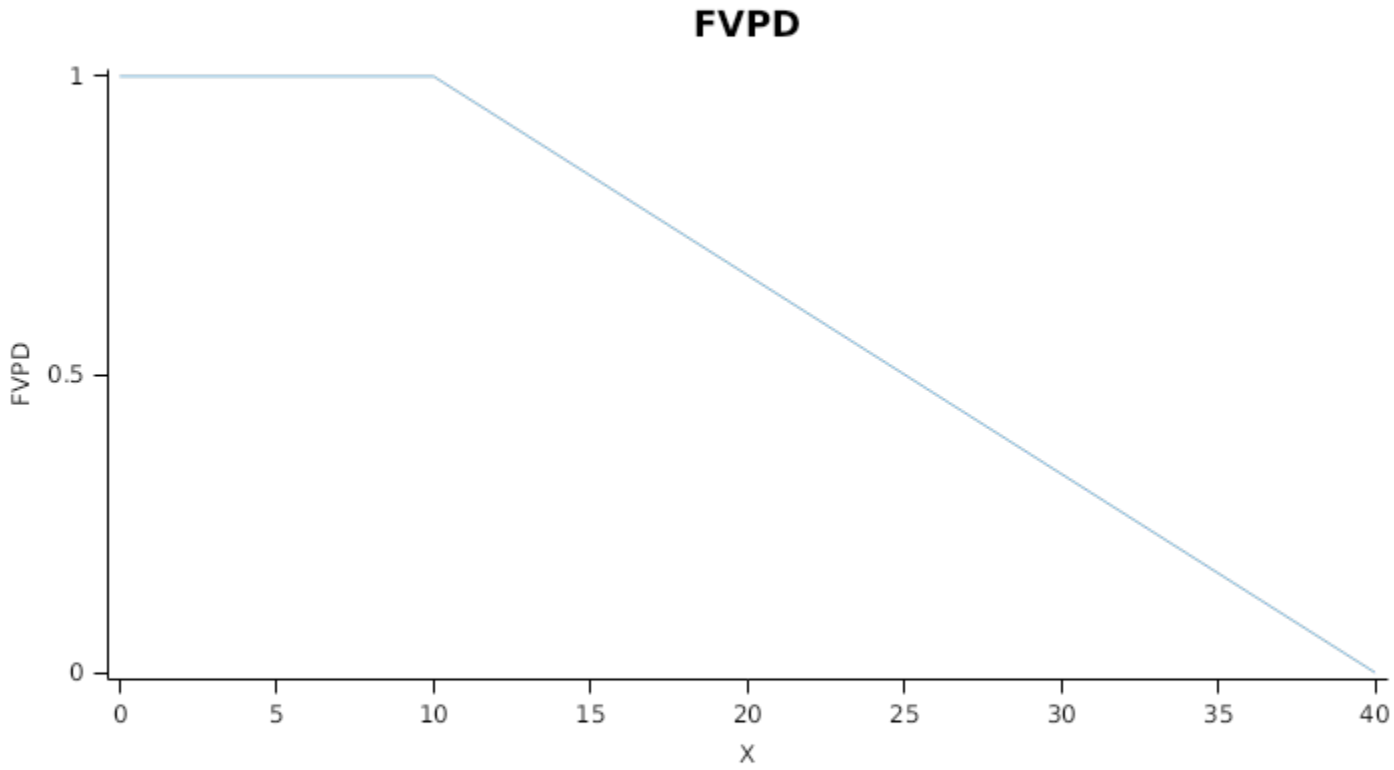
FW is calculated using linear interpolation

X	FW
0.0	0.0
1.0	1.0
1.0	1.0



FVPD is calculated using linear interpolation

X	FVPD
0.0	1.0
10.0	1.0
40.0	0.0



This model calculates the CO_2 impact on RUE using the approach of Reyenga et al., 1999.

For C3 plants,

$F_{CO2} = (CO_2 - CP) \times (350 + 2 \times CP)/(CO_2 + 2 \times CP) \times (350 - CP)$

where CP, is the compensation point calculated from daily average temperature (T) as

$CP = (163.0 - T) / (5.0 - 0.1 * T)$

For C4 plants,

$F_{CO2} = 0.000143 * CO_2 + 0.95$

RadnInt = [Leaf].RadiationIntercepted

1.6.2 Constants

FrostFraction = 0

RemobilisationCost = 0

StructuralFraction = 0.5

DMConversionEfficiency = 1

CarbonConcentration = 0.4

WidthFunction = 0

1.6.3 StomatalConductanceCO2Modifier

This model calculates the CO_2 impact on stomatal conductance using the approach of Elli et al., 2020.

$StomatalConductanceCO2Modifier = PhotosynthesisCO2Modifier \times (350 - CP)/(CO_2 - CP)$

where CP, is the compensation point calculated from daily average temperature (T) as

*CP = (163.0 - T) / (5.0 - 0.1 * T)*

PhotosynthesisCO2Modifier = [Leaf].Photosynthesis.FCO2

1.6.4 InitialLeaves[1]

Area = 200

1.6.5 InitialLeaves[2]

Area = 0

1.6.6 CohortParameters

1.6.6.1 Potential Leaf Area index

Leaf area index is calculated as the sum of the area of each cohort of leaves. The appearance of a new cohort of leaves occurs each time Structure.LeafTipsAppeared increases by one. From tip appearance the area of each cohort will increase for a certian number of degree days defined by the *GrowthDuration*

GrowthDuration = 1.3 x [Phenology].Phyllochron

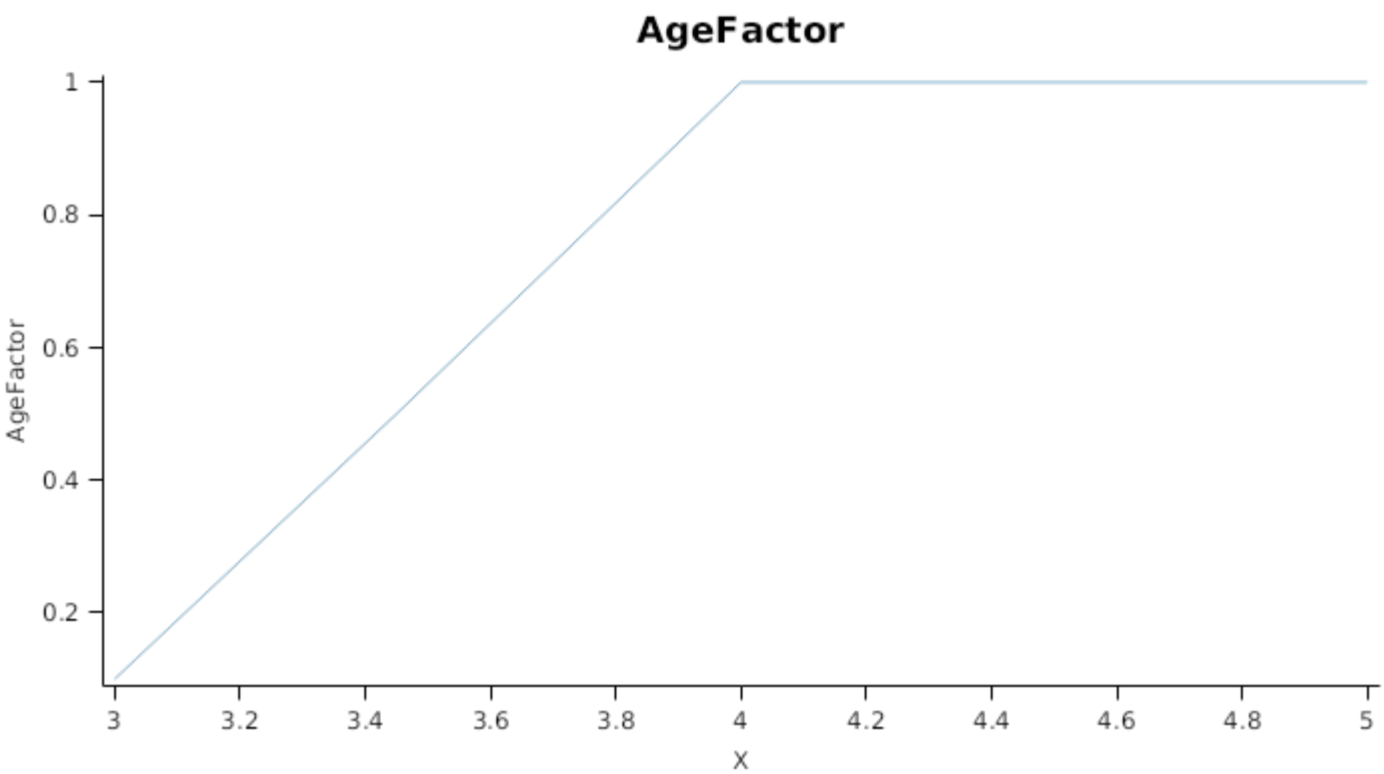
If no stress occurs the leaves will reach a Maximum area (*MaxArea*) at the end of the *GrowthDuration*. The *MaxArea* is defined by:

MaxArea = *AreaLargestLeaves* x *AgeFactor*

AreaLargestLeaves = 2600 (mm^2)

AgeFactor is calculated using linear interpolation

X	AgeFactor
3.0	0.1
3.5	0.5
4.0	1.0
5.0	1.0

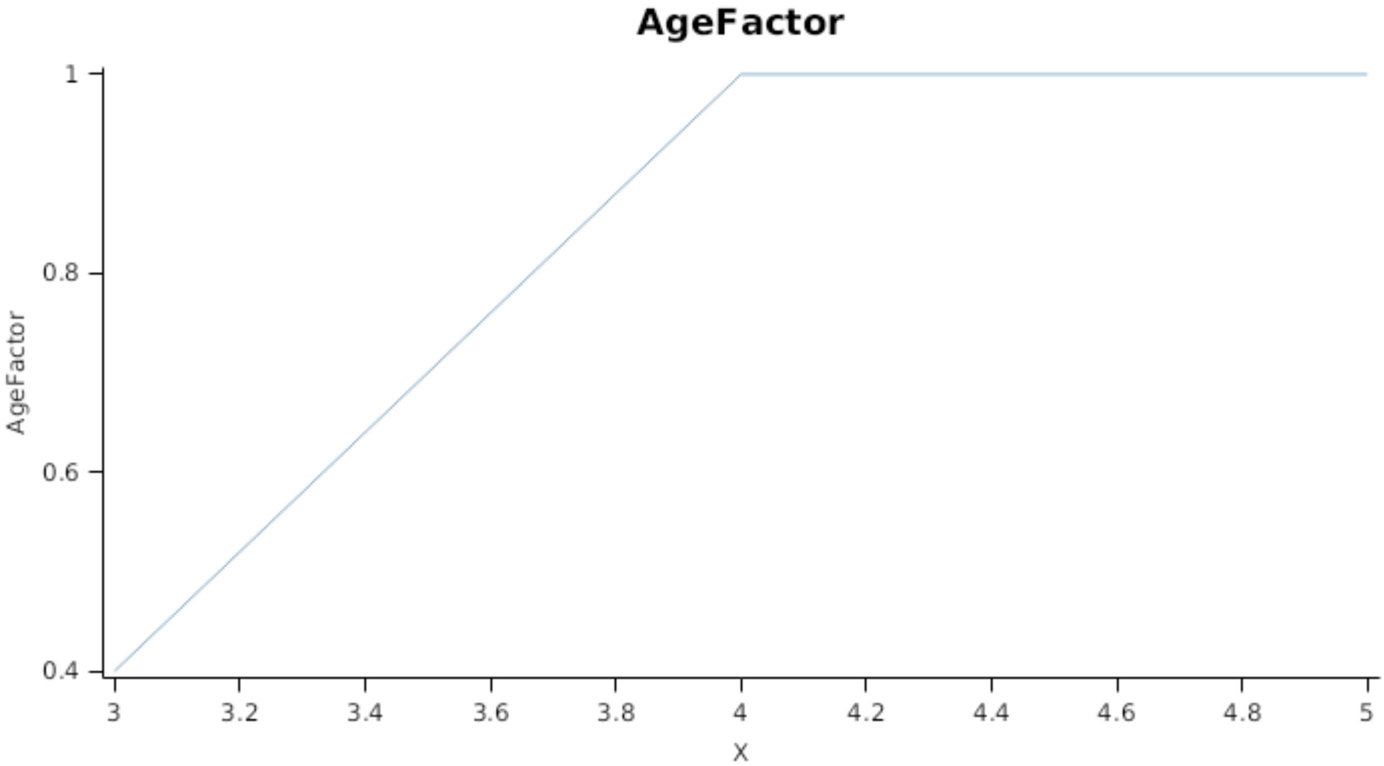


In the absence of stress the leaf will remain at *MaxArea* for a number of degree days set by the *LagDuration* and then area will senesce to zero at the end of the *SenescenceDuration*

LagDuration = *AgeFactor* x *LastLeafDuration*

AgeFactor is calculated using linear interpolation

X	AgeFactor
3.0	0.4
4.0	1.0
5.0	1.0



LastLeafDuration = *ThermalTimeToRipe* - [Leaf].CohortParameters.SenescenceDuration

ThermalTimeToRipe = [Phenology].HeadEmergence.Target + [Phenology].EarlyFlowering.Target + [Phenology].GrainDevelopment.Target + [Phenology].GrainFilling.Target + [Phenology].Maturing.Target + [Phenology].Ripening.Target

SenescenceDuration = 3 x [Phenology].Phyllochron

Mutual shading can cause premature senescence of cohorts if the leaf area above them becomes too great. Each cohort models the proportion of its area that is lost to shade induced senescence each day as:

ShadeInducedSenescenceRate = 0

1.6.6.2 Stress effects on Leaf Area Index

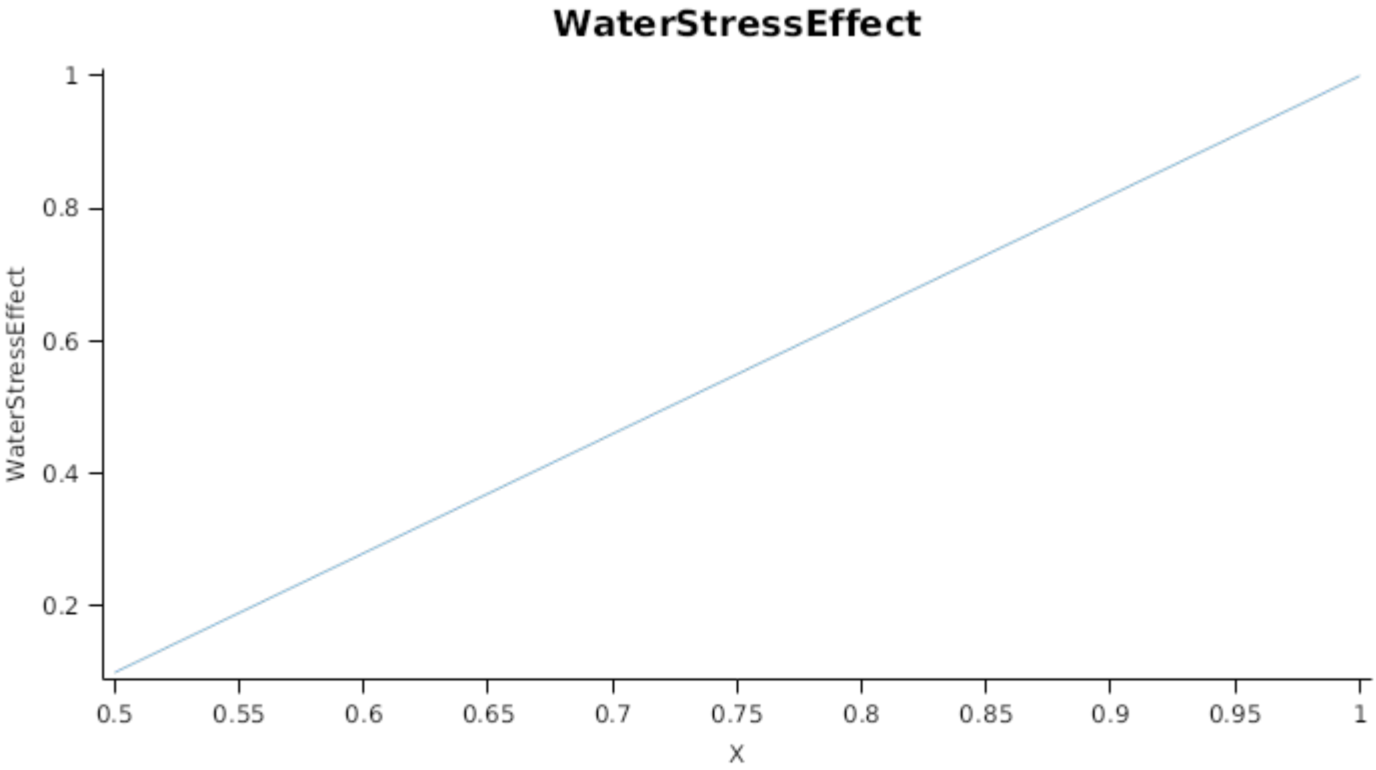
Stress reduces leaf area in a number of ways. Firstly, stress occuring prior to the appearance of the cohort can reduce cell division, so reducing the maximum leaf size. Leaf captures this by multiplying the *MaxSize* of each cohort by a *CellDivisionStress* factor which is calculated as:

CellDivisionStress = Min(*WaterStressEffect*, *NitrogenStressEffect*)

Where:

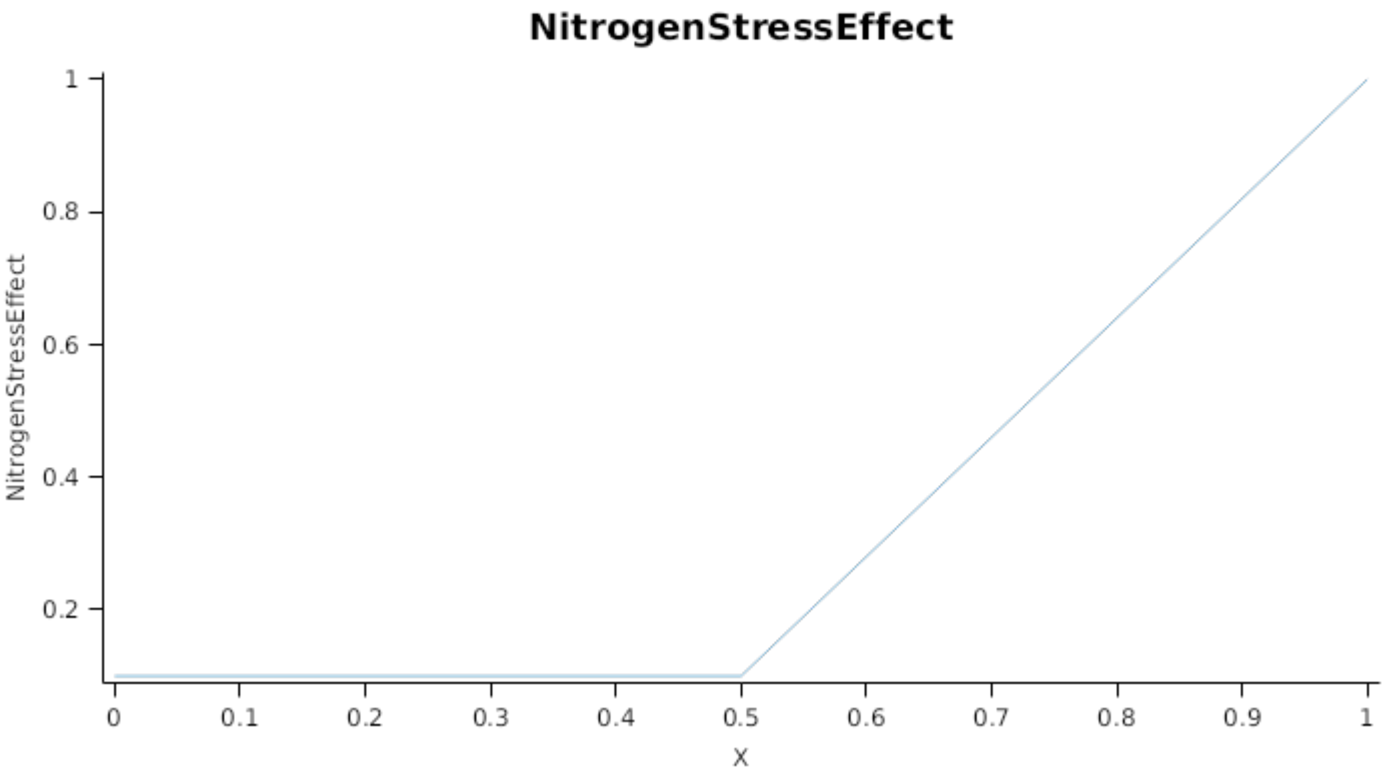
WaterStressEffect is calculated using linear interpolation

X	WaterStressEffect
0.5	0.1
1.0	1.0



NitrogenStressEffect is calculated using linear interpolation

X	NitrogenStressEffect
0.0	0.1
0.5	0.1
1.0	1.0



Leaf.FN quantifys the N stress status of the plant and represents the concentration of metabolic N relative the maximum potentil metabolic N content of the leaf calculated as (*Leaf.NConc* - *MinimumNConc*)/(*CriticalNConc* - *MinimumNConc*).

Leaf.FW quantifies water stress and is calculated as *Leaf.Transpiration*/*Leaf.WaterDemand*, where *Leaf.Transpiration* is the minimum of *Leaf.WaterDemand* and *Root.WaterUptake*

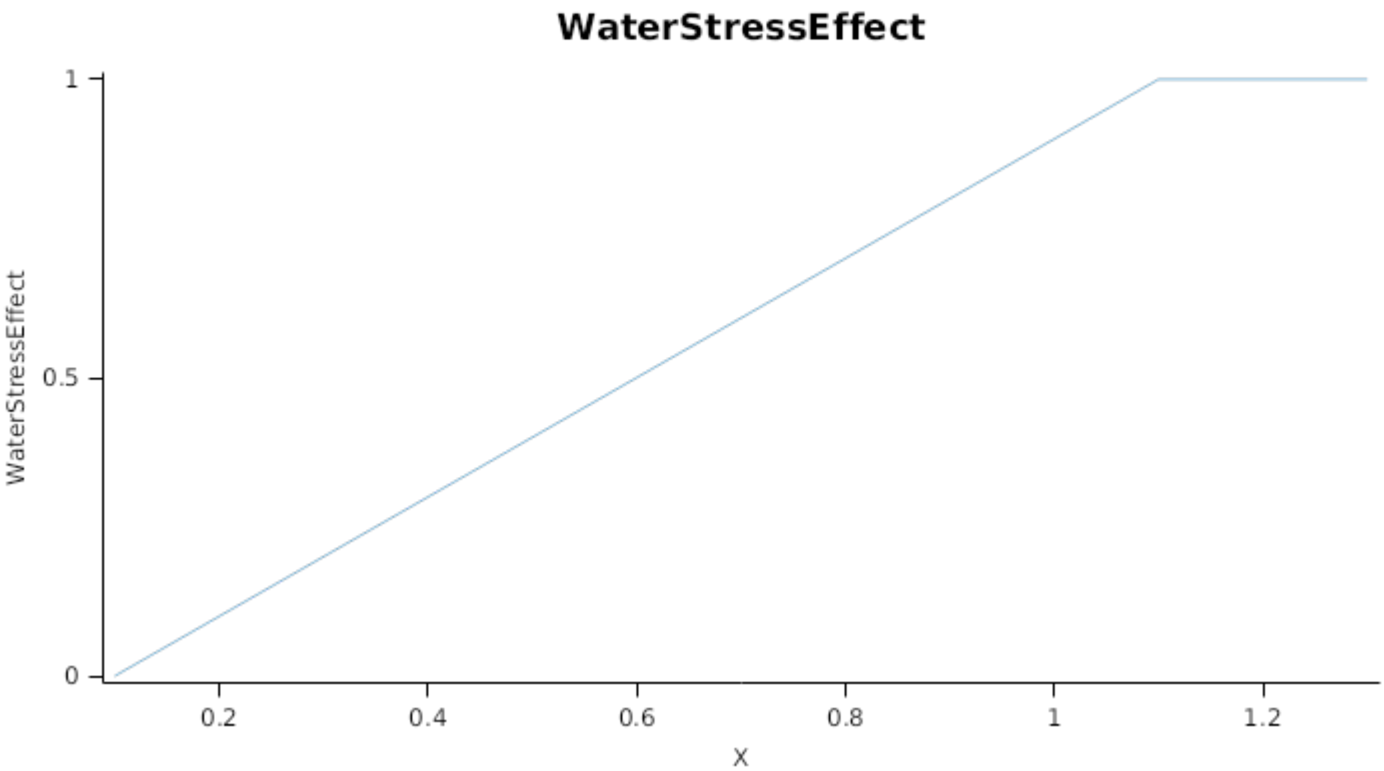
Stress during the <i>GrowthDuration* of the cohort reduces the size increase of the cohort by multiplying the potential increase by a *ExpansionStress* factor:

ExpansionStress = Min(*WaterStressEffect*, *TemperatureEffect*, *NitrogenStressEffect*)

Where:

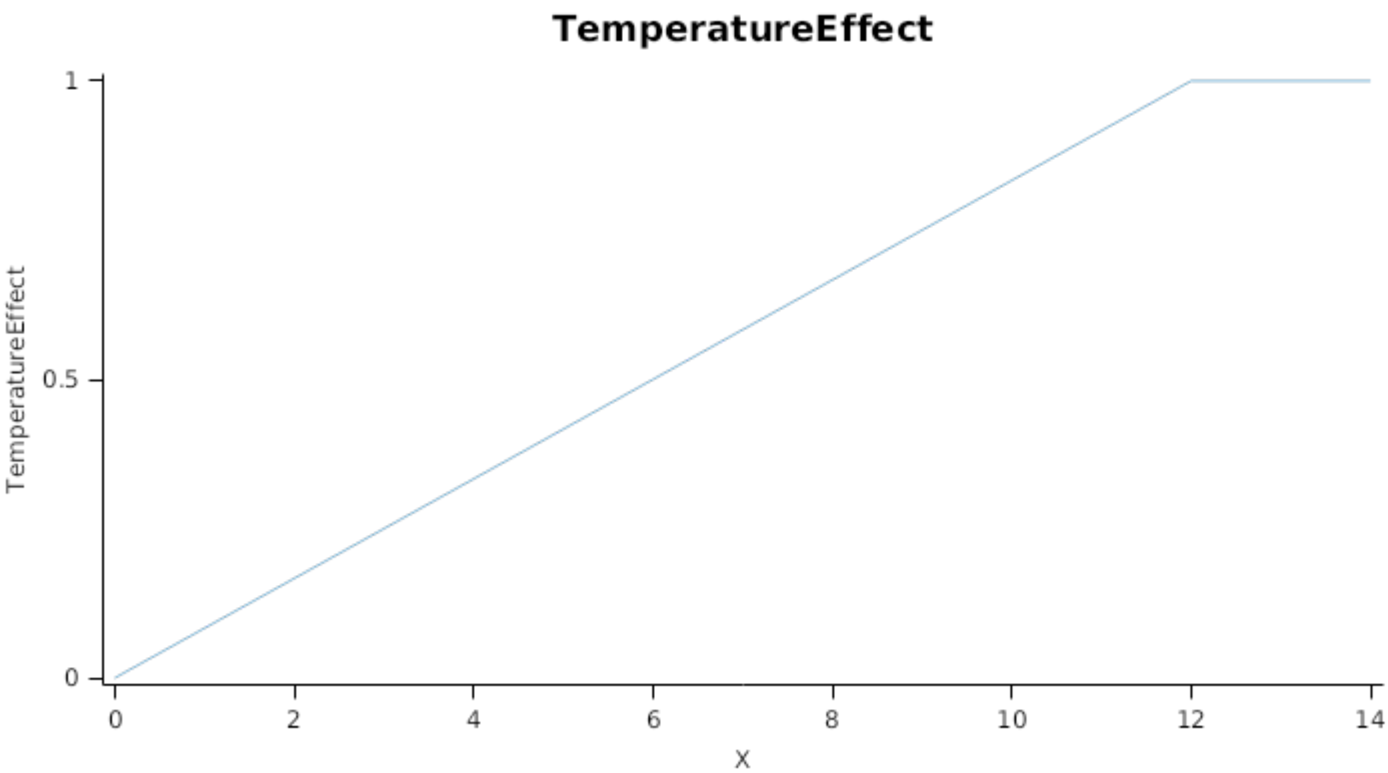
WaterStressEffect is calculated using linear interpolation

X	WaterStressEffect
0.1	0.0
1.1	1.0
1.3	1.0



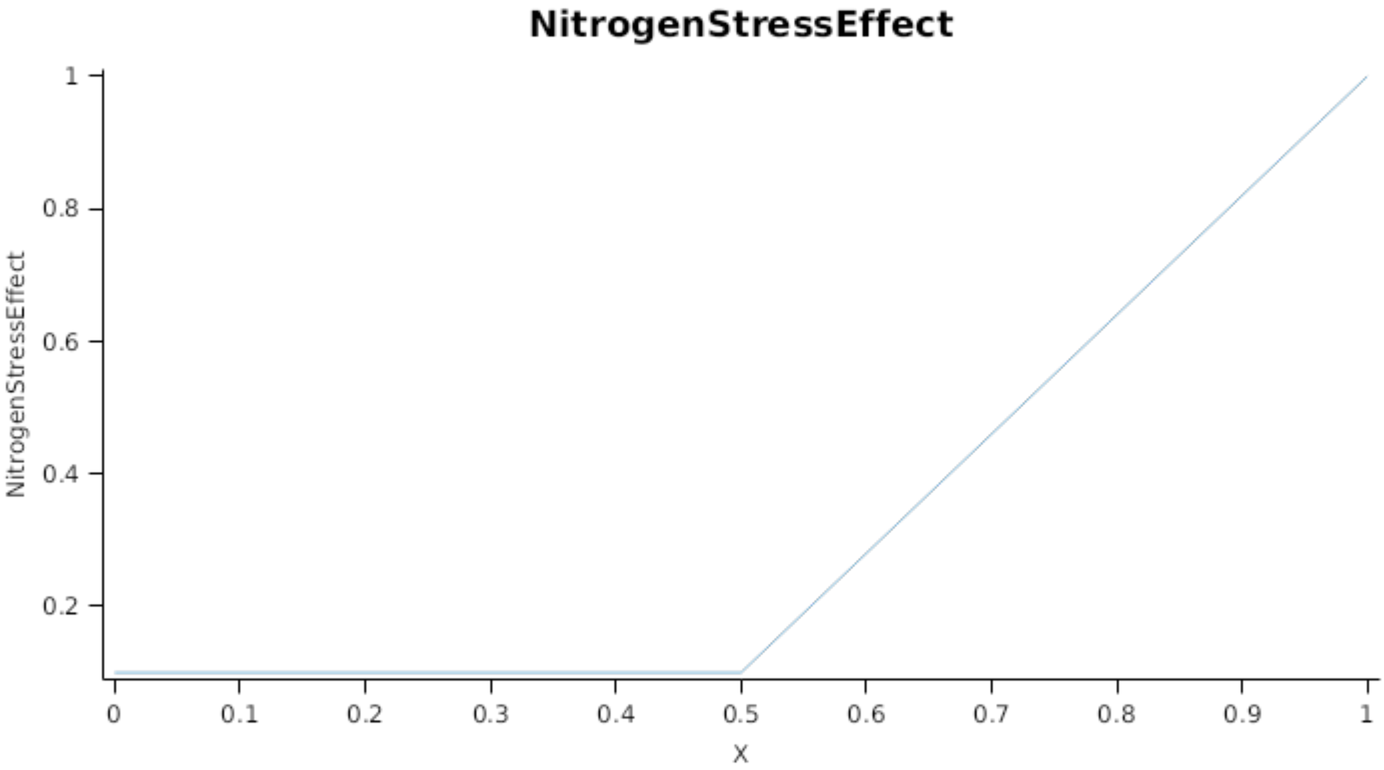
TemperatureEffect is calculated using linear interpolation

X	TemperatureEffect
0.0	0.0
12.0	1.0
14.0	1.0



NitrogenStressEffect is calculated using linear interpolation

X	NitrogenStressEffect
0.0	0.1
0.5	0.1
1.0	1.0



Stresses can also acellerate the onset and rate of senescence in a number of ways. Nitrogen shortage will cause N to be retranslocated out of lower order leaves to support the expansion of higher order leaves and other organs When this happens the lower order cohorts will have their area reduced in proportion to the amount of N that is remobilised out of them.

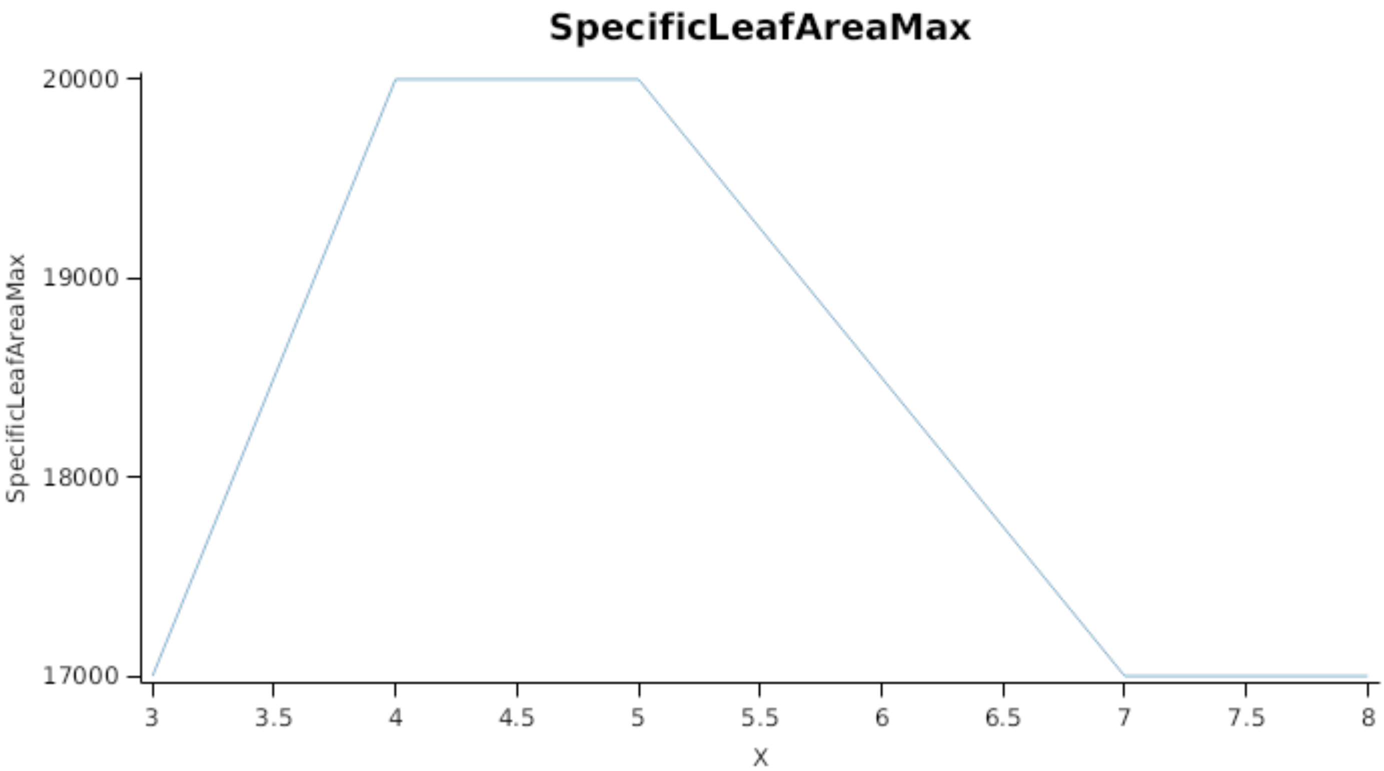
Water stress hastens senescence by increasing the rate of thermal time accumulation in the lag and senescence phases. This is done by multiplying thermal time accumulation by *DroughtInducedLagAcceleration* and *DroughtInducedSenescenceAcceleration* factors, respectively

1.6.6.3 Dry matter Demand

Leaf calculates the DM demand from each cohort as a function of the potential size increment (DeltaPotentialArea) an specific leaf area bounds. Under non stressed conditions the demand for non-storage DM is calculated as *DeltaPotentialArea* divided by the mean of *SpecificLeafAreaMax* and *SpecificLeafAreaMin*. Under stressed conditions it is calculated as *DeltaWaterConstrainedArea* divided by *SpecificLeafAreaMin*.

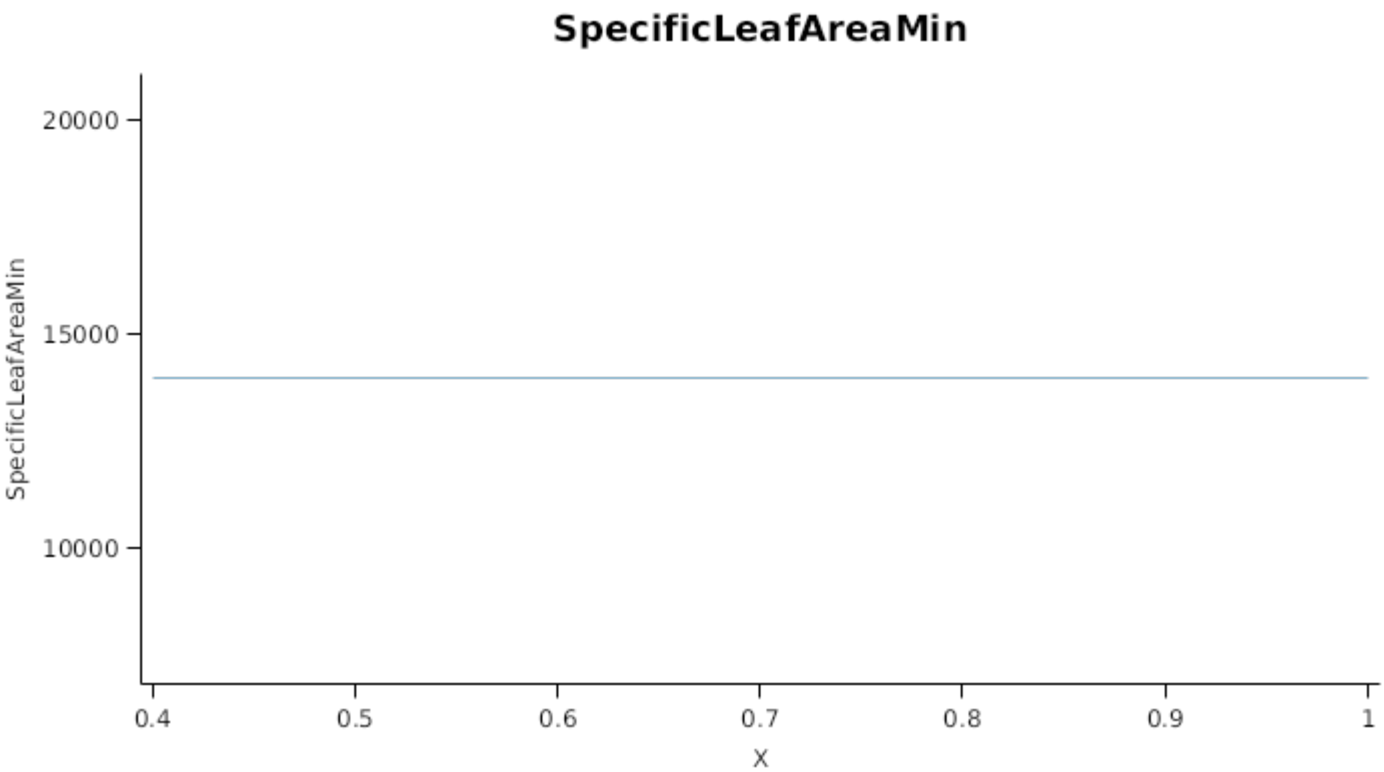
SpecificLeafAreaMax is calculated using linear interpolation

X	SpecificLeafAreaMax
3.0	17000.0
4.0	20000.0
5.0	20000.0
6.0	18500.0
7.0	17000.0
8.0	17000.0



SpecificLeafAreaMin is calculated using linear interpolation

X	SpecificLeafAreaMin
0.4	14000.0
1.0	14000.0



Non-storage DM Demand is then seperated into structural and metabolic DM demands using the *StructuralFraction*:

StructuralFraction = 0.5

The storage DM demand is calculated from the sum of metabolic and structural DM (including todays demands) multiplied by a *NonStructuralFraction*

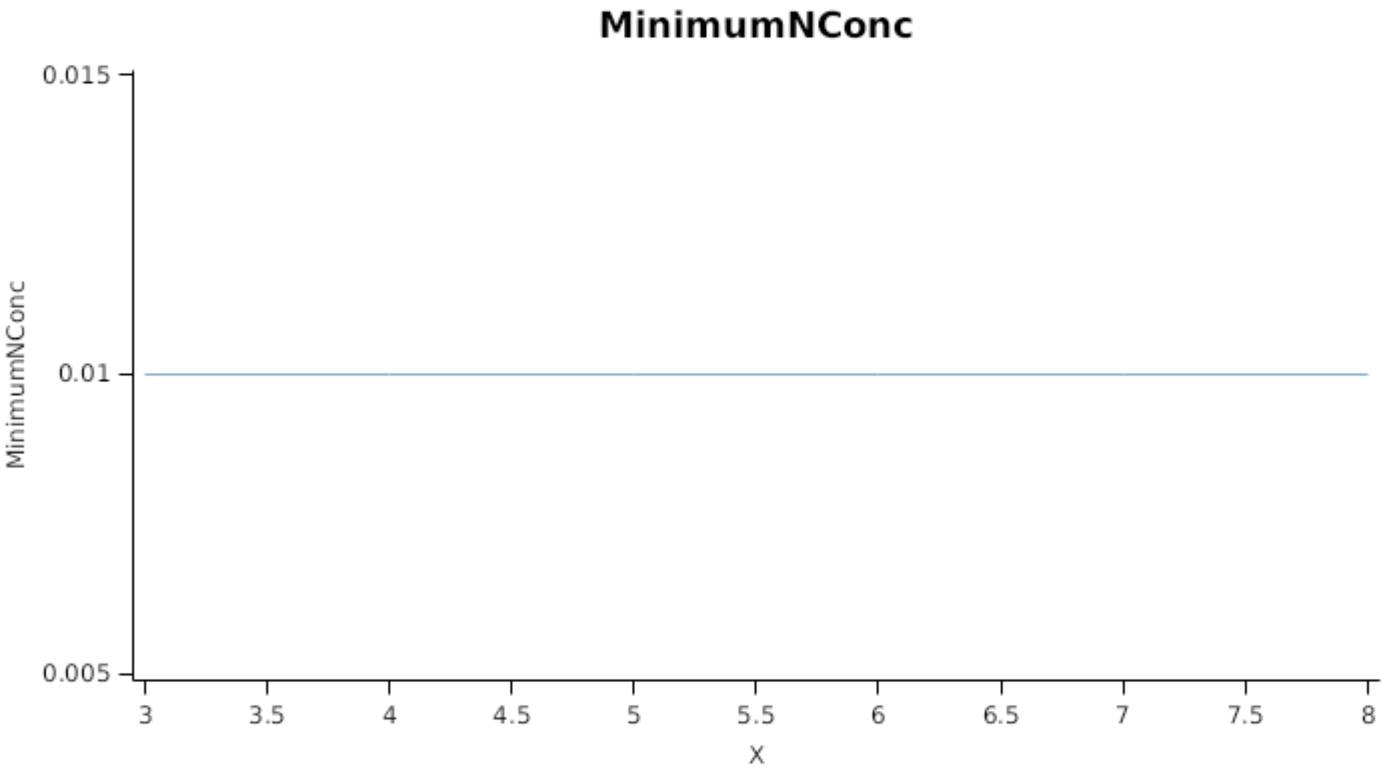
1.6.6.4 Nitrogen Demand

Leaf calculates the N demand from each cohort as a function of the potential DM increment and N concentration bounds.

Structural N demand = *PotentialStructuralDMAllocation* * *MinimumNConc* where:

MinimumNConc is calculated using linear interpolation

X	MinimumNConc
3.0	0.0
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.0
8.0	0.0

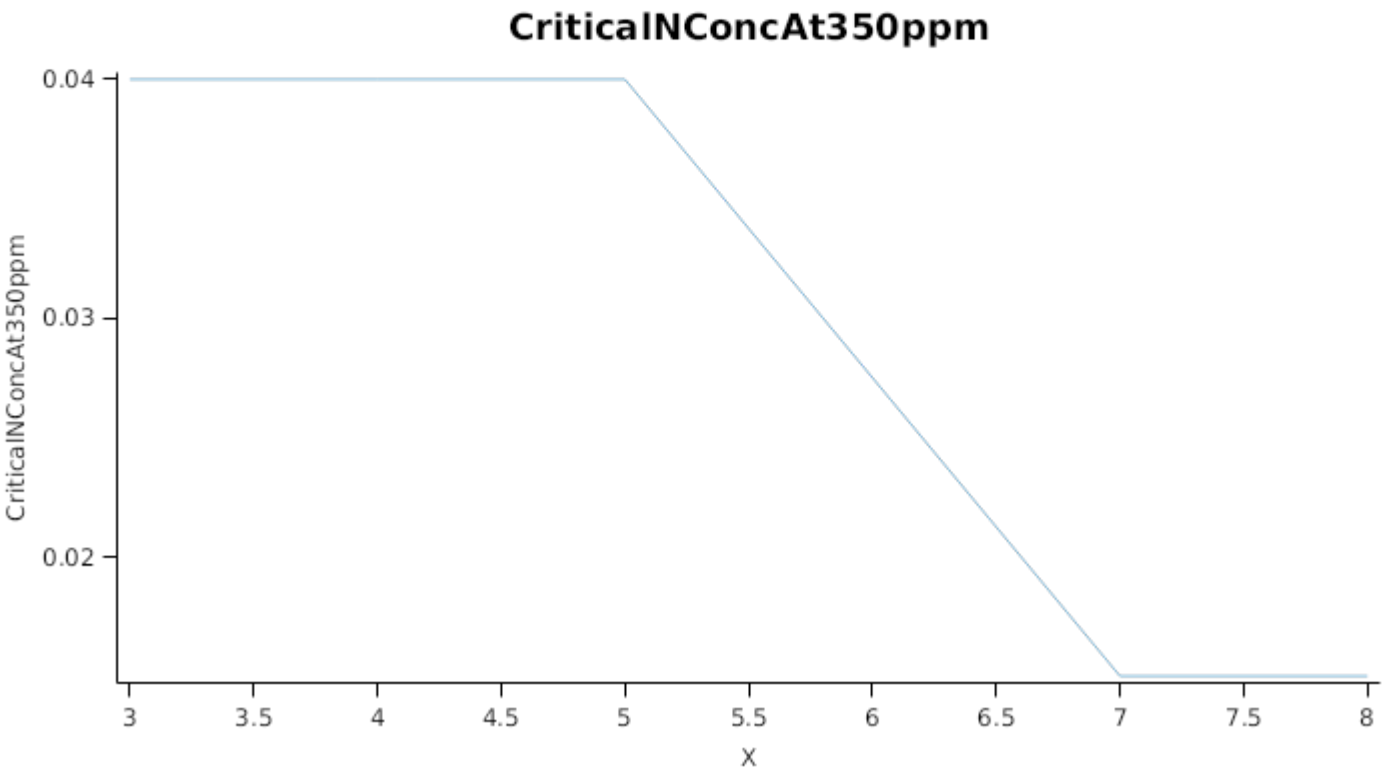


Metabolic N demand is calculated as *PotentialMetabolicDMAllocation* * (*CriticalNConc* - *MinimumNConc*) where:

CriticalNConc = *CriticalNConcAt350ppm* x *CO2Factor*

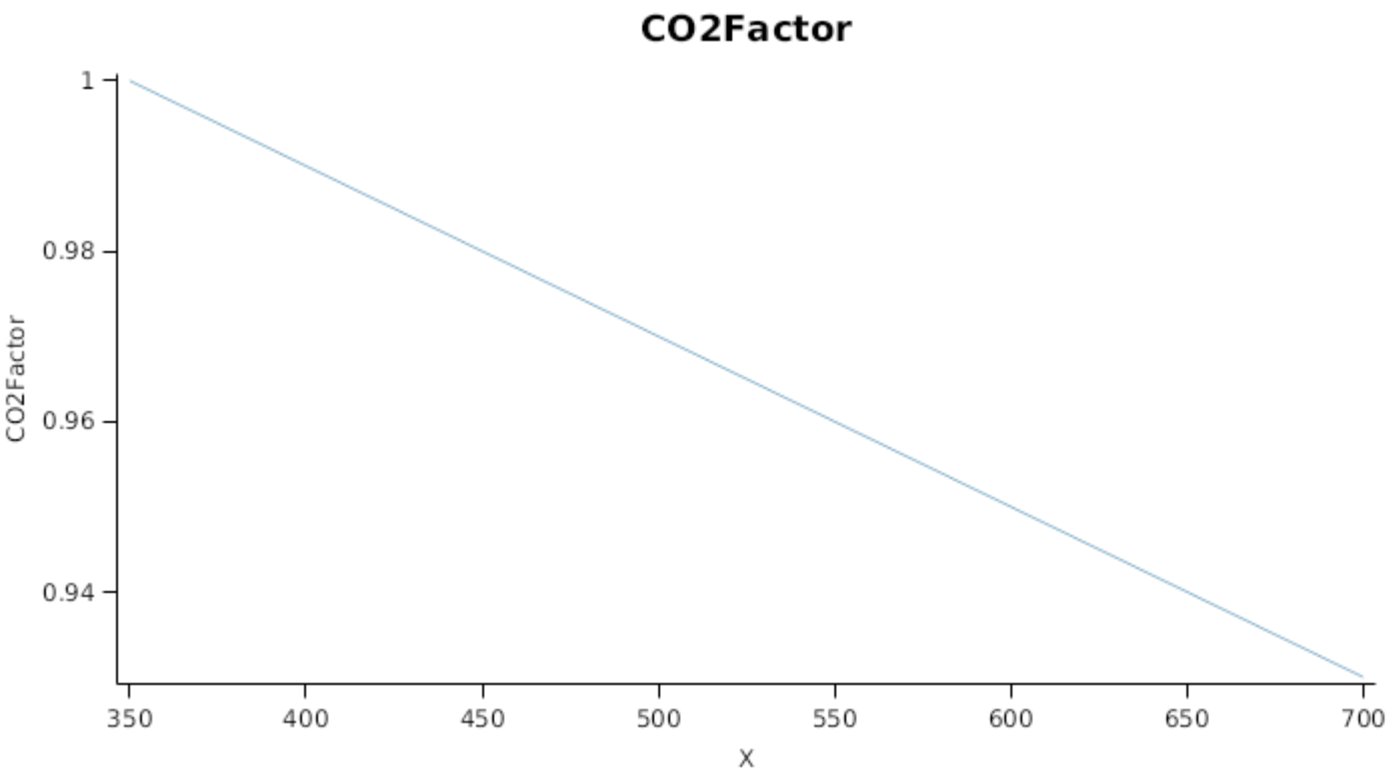
CriticalNConcAt350ppm is calculated using linear interpolation

X	CriticalNConcAt350ppm
3.0	0.0
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.0
8.0	0.0



CO2Factor is calculated using linear interpolation

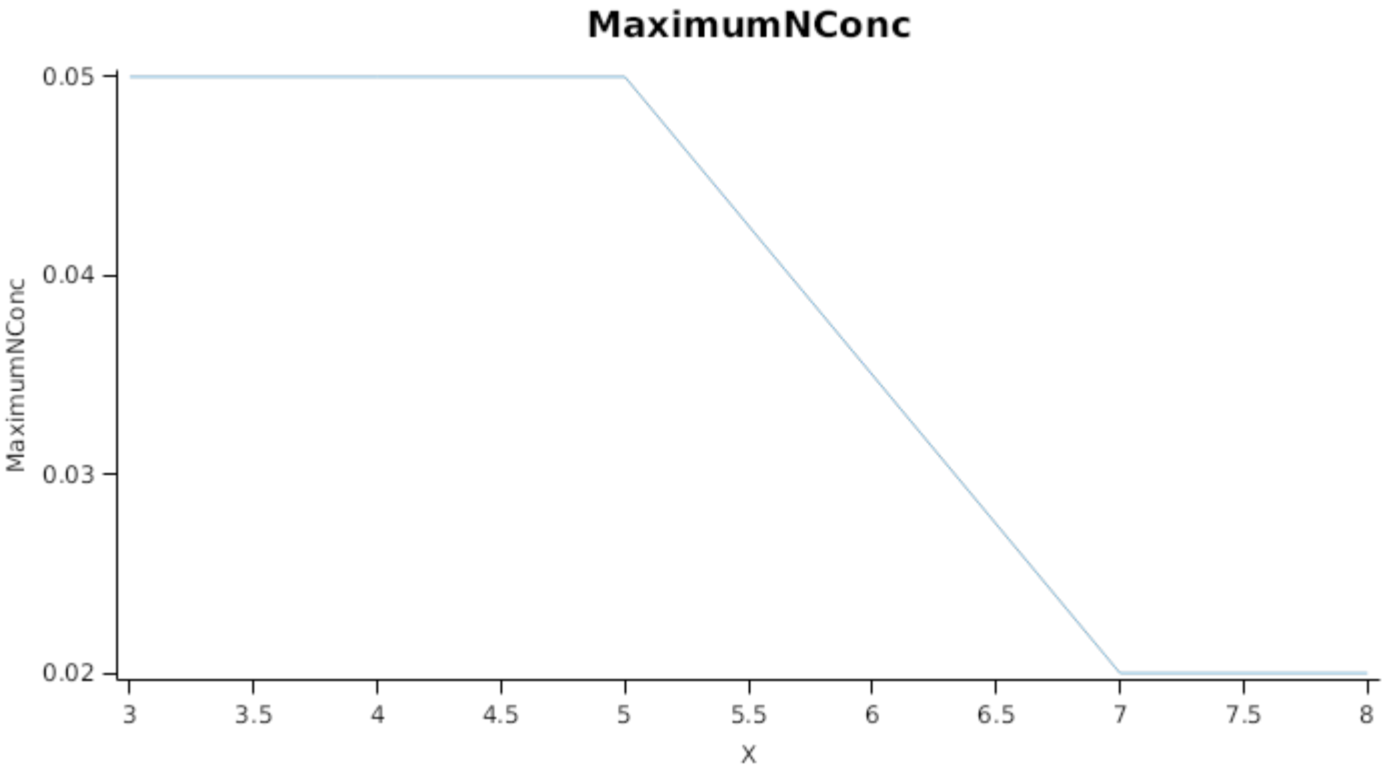
X	CO2Factor
350.0	1.0
700.0	0.9



Storage N demand is calculated as the sum of metabolic and structural wt (including todays demands) multiplied by *LuxaryNconc* (*MaximumNConc* - *CriticalNConc*) less the amount of storage N already present. *MaximumNConc* is given by:

MaximumNConc is calculated using linear interpolation

X	MaximumNConc
3.0	0.1
4.0	0.1
5.0	0.1
6.0	0.0
7.0	0.0
8.0	0.0



1.6.6.5 Drymatter supply

In additon to photosynthesis, the leaf can also supply DM by reallocation of senescing DM and retranslocation of storgage DM:Reallocation supply is a proportion of the metabolic and non-structural DM that would be senesced each day where the proportion is set by:

DMReallocationFactor = 1

Retranslocation supply is calculated as a proportion of the amount of storage DM in each cohort where the proportion is set by :

DMRetranslocationFactor = 1

1.6.6.6 Nitrogen supply

Nitrogen supply from the leaf comes from the reallocation of metabolic and storage N in senescing material and the retranslocation of metabolic and storage N. Reallocation supply is a proportion of the Metabolic and Storage DM that would be senesced each day where the proportion is set by:

NReallocationFactor = 1

Retranslocation supply is calculated as a proportion of the amount of storage and metabolic N in each cohort where the proportion is set by :

NRetranslocationFactor = 0.03

1.6.6.7 Constants

NReallocationFactor = 1

RemobilisationCost = 0

MaintenanceRespirationFunction = 0

NRetranslocationFactor = 0.03

DMReallocationFactor = 1

DMRetranslocationFactor = 1

DetachmentLagDuration = 1000000

DetachmentDuration = 1000000

RelativeBranchLeafSize = 1

InitialNConc = 0

StructuralFraction = 0.5

StorageFraction = 0.3

LeafSizeShapeParameter = 0.3

SenessingLeafRelativeSize = 1 (0-1)

ShadeInducedSenescenceRate = 0

1.6.7 ThermalTime

ThermalTime = [Phenology].ThermalTime

1.6.8 FRGRFunction

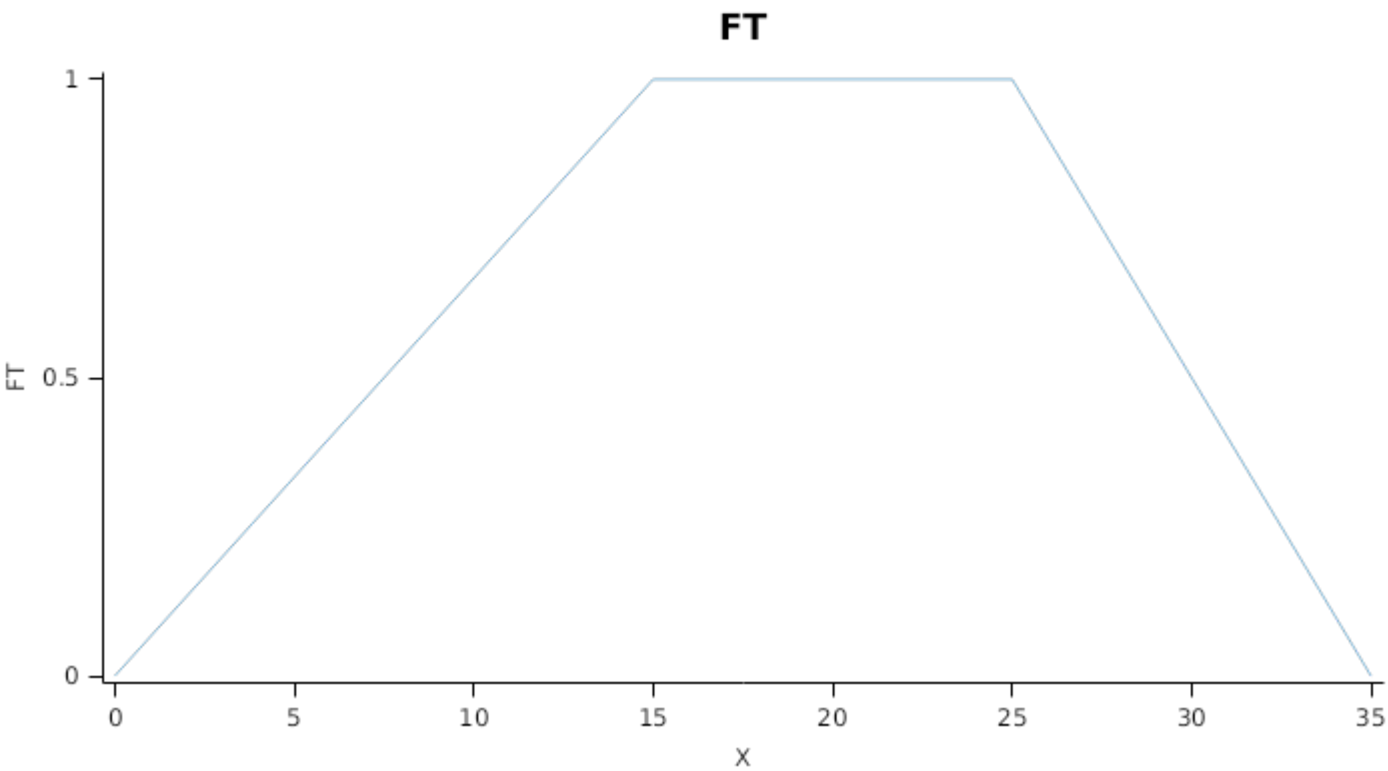
FRGRFunction = Min(*FT*, *FN*, *FVPD*)

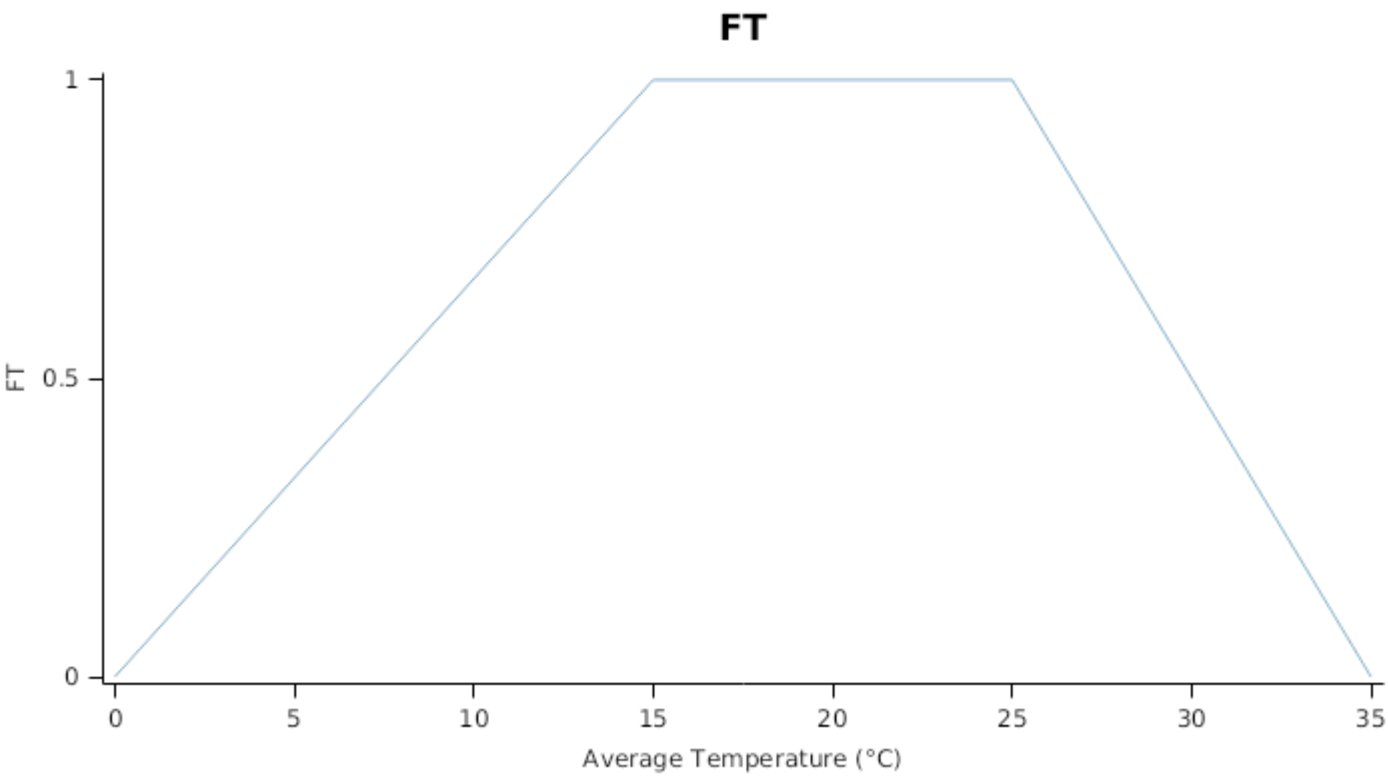
Where:

FT is calculated as a function of daily min and max temperatures, these are weighted toward max temperature according to the specified MaximumTemperatureWeighting factor. A value equal to 1.0 means it will use max temperature, a value of 0.5 means average temperature.

MaximumTemperatureWeighting = 0.75

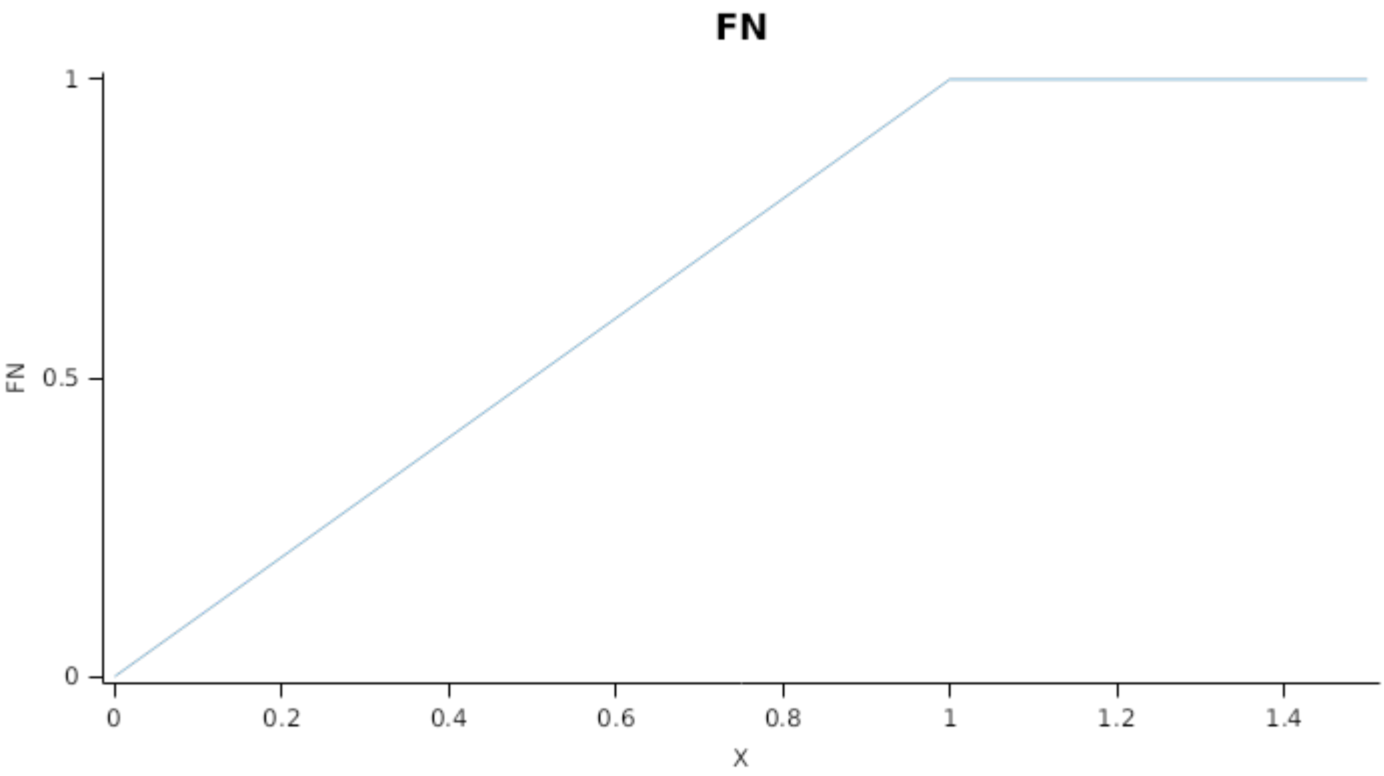
X	FT
0.0	0.0
15.0	1.0
25.0	1.0
35.0	0.0





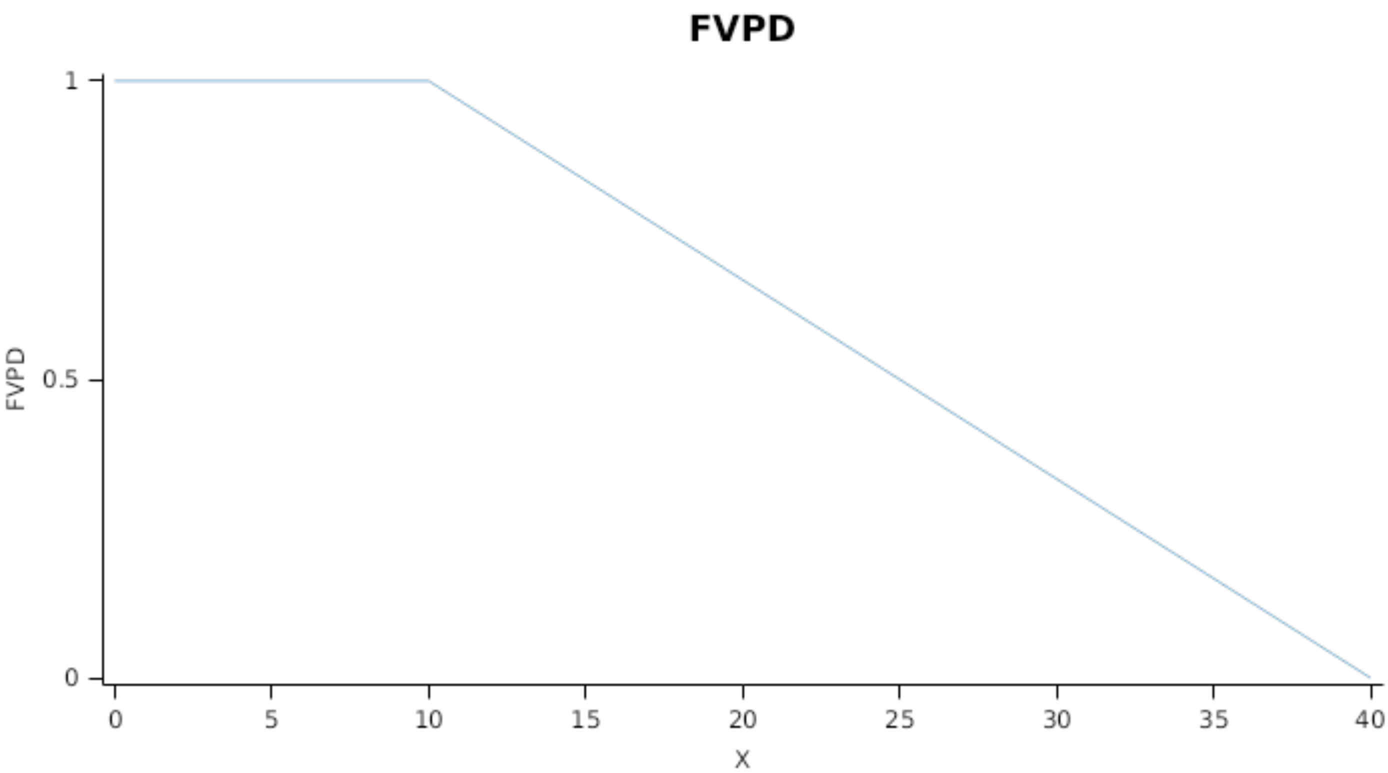
FN is calculated using linear interpolation

X	FN
0.0	0.0
1.0	1.0
1.5	1.0



FVPD is calculated using linear interpolation

X	FVPD
0.0	1.0
10.0	1.0
40.0	0.0



1.6.9 BiomassRemovalDefaults

This organ will respond to certain management actions by either removing some of its biomass from the system or transferring some of its biomass to the soil surface residues. The following table describes the default proportions of live and dead biomass that are transferred out of the simulation using "Removed" or to soil surface residue using "To Residue" for a range of management actions. The total percentage removed for live or dead must not exceed 100%. The difference between the total and 100% gives the biomass remaining on the plant. These can be changed during a simulation using a manager script.

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Harvest	0	0	30	30
Cut	80	80	0	0
Prune	0	0	60	60
Graze	60	60	10	10
Thin	0	0	5	5

1.6.10 DepthFunction

DepthFunction = [Leaf].Height

1.6.11 DMDemandPriorityFactors

This class holds the functions for calculating the absolute demands for each biomass fraction.

Structural = 1

Metabolic = 1

Storage = 1

1.6.12 NDemandPriorityFactors

This class holds the functions for calculating the absolute demands for each biomass fraction.

Structural = 1

Metabolic = 1

Storage = 1

1.7 Spike

1.7.1 Spike

This organ is simulated using a GenericOrgan type. It is parameterised to calculate the growth, senescence, and detachment of any organ that does not have specific functions.

1.7.2 Dry Matter Demand

The dry matter demand for the organ is calculated as defined in DMDemands, based on the DMDemandFunction and partition fractions for each biomass pool.

1.7.2.1 DMDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = DMDemandFunction x *StructuralFraction*

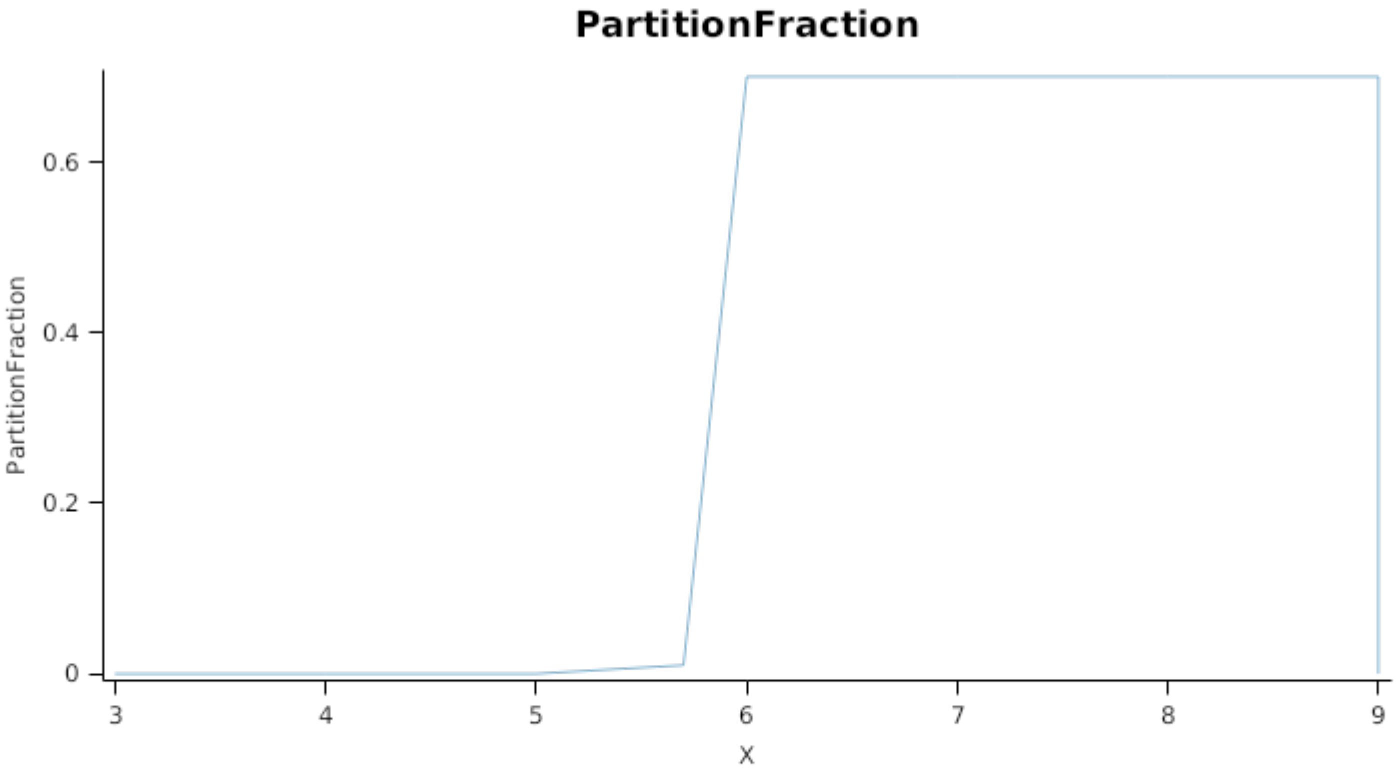
Returns the product of its PartitionFraction and the total DM supplied to the arbitrator by all organs.

DMDemandFunction = PartitionFraction x [Arbitrator].DM.TotalFixationSupply

PartitionFraction is calculated using linear interpolation

X	PartitionFraction
3.0	0.0
4.0	0.0

X	PartitionFraction
5.0	0.0
5.7	0.0
6.0	0.7
7.0	0.7
8.0	0.7
9.0	0.7
9.0	0.0



StructuralFraction is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

VegetativeGrowth has a value between Emergence and StartGrainFill calculated as:

StructuralFractionEG = 0.3

ReproductiveGrowth has a value between StartGrainFill and EndGrainFill calculated as:

StructuralFractionGF = 0

Metabolic = 0

The partitioning of daily growth to storage biomass is based on a storage fraction.

StorageFraction = 1 - [Spike].DMDemands.Structural.StructuralFraction

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.7.3 Nitrogen Demand

The N demand is calculated as defined in NDemands, based on DM demand the N concentration of each biomass pool.

1.7.3.1 NDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = [Spike].minimumNconc x [Spike].potentialDMAllocation.Structural

Metabolic = *MetabolicNconc* x [Spike].potentialDMAllocation.Structural

MetabolicNconc = [Spike].criticalNConc - [Spike].minimumNconc

The partitioning of daily N supply to storage N attempts to bring the organ's N content to the maximum concentration.

Storage = [Spike].maximumNconc × ([Spike].Live.Wt + potentialAllocationWt) - [Spike].Live.N

The demand for storage N is further reduced by a factor specified by the [Spike].NitrogenDemandSwitch.

NitrogenDemandSwitch = [Spike].nitrogenDemandSwitch

MaxNconc = [Spike].maximumNconc

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.7.4 N Concentration Thresholds

MinimumNConc = 0.004

CriticalNConc = [Spike].MinimumNConc + *MetabolicNconc*

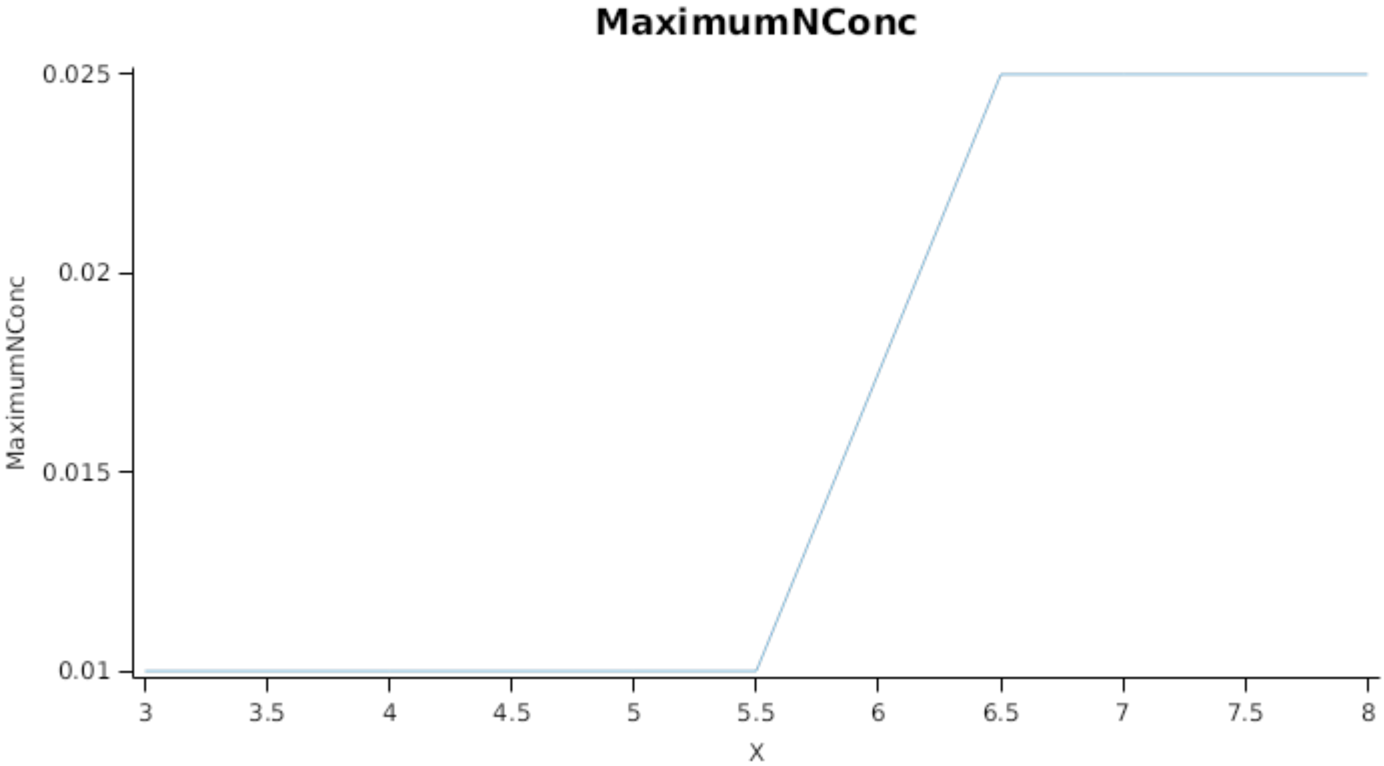
MetabolicNconc = *NonStructuralN* x *Proportion*

NonStructuralN = [Spike].MaximumNConc - [Spike].MinimumNConc

Proportion = 0.8

MaximumNConc is calculated using linear interpolation

X	MaximumNConc
3.0	0.0
4.0	0.0
5.0	0.0
5.5	0.0
6.5	0.0
7.0	0.0
8.0	0.0



The demand for N is reduced by a factor specified by the NitrogenDemandSwitch.

NitrogenDemandSwitch has a value between Emergence and StartGrainFill calculated as:

Constant = 1

1.7.5 Dry Matter Supply

Spike does not reallocate DM when senescence of the organ occurs.

The proportion of non-structural DM that is allocated each day is quantified by the DMReallocationFactor.

DMRetranslocationFactor is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

VegetativeGrowth has a value between Emergence and StartGrainFill calculated as:

DMRetranslocationFactor = 0

ReproductiveGrowth has a value between StartGrainFill and EndGrainFill calculated as:

DMRetranslocationFactor = 0.5

1.7.6 Nitrogen Supply

Spike does not reallocate N when senescence of the organ occurs.

The proportion of non-structural N that is allocated each day is quantified by the NReallocationFactor.

NRetranslocationFactor is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

EarlyGrowth has a value between Emergence and StartGrainFill calculated as:

ValueDuringEarlyGrowth = 0

ReproductiveGrowth has a value between StartGrainFill and EndGrainFill calculated as:

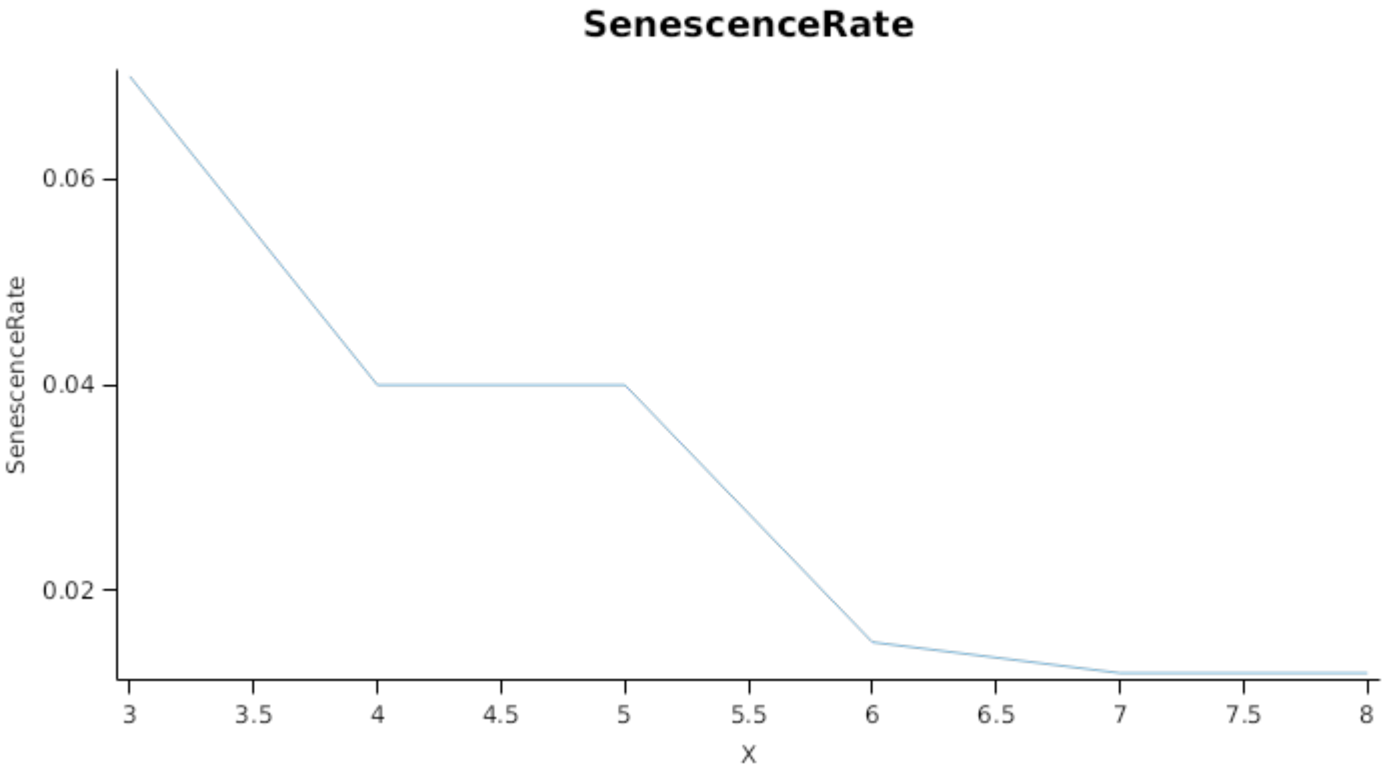
ValueDuringGrainFill = 0.5

1.7.7 Senescence and Detachment

The proportion of live biomass that senesces and moves into the dead pool each day is quantified by the SenescenceRate.

SenescenceRate is calculated using linear interpolation

X	SenescenceRate
3.0	0.1
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.0
8.0	0.0



Spike has detachment parameterised to zero so all biomass in this organ will remain with the plant until a defoliation or harvest event occurs.

This organ will respond to certain management actions by either removing some of its biomass from the system or transferring some of its biomass to the soil surface residues. The following table describes the default proportions of live and dead biomass that are transferred out of the simulation using "Removed" or to soil surface residue using "To Residue" for a range of management actions. The total percentage removed for live or dead must not exceed 100%. The difference between the total and 100% gives the biomass remaining on the plant. These can be changed during a simulation using a manager script.

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Harvest	50	0	10	0
Cut	80	0	0	0
Prune	0	0	60	0
Graze	60	0	20	0
Thin	0	0	5	0

1.8 Stem

1.8.1 Stem

This organ is simulated using a GenericOrgan type. It is parameterised to calculate the growth, senescence, and detachment of any organ that does not have specific functions.

1.8.2 Dry Matter Demand

The dry matter demand for the organ is calculated as defined in DMDemands, based on the DMDemandFunction and partition fractions for each biomass pool.

1.8.2.1 DMDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = *DMDemandFunction* x *StructuralFraction*

Returns the product of its PartitionFraction and the total DM supplied to the arbitrator by all organs.

DMDemandFunction = PartitionFraction x [Arbitrator].DM.TotalFixationSupply

PartitionFraction is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

PreStemElongation has a value between Emergence and TerminalSpikelet calculated as:

StemFraction = 0.2

StemElongation has a value between TerminalSpikelet and StartGrainFill calculated as:

StemFraction = 0.7 (0)

EarEmergence has a value between StartGrainFill and HarvestRipe calculated as:

StemFraction = 0

StructuralFraction is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

VegetativeGrowth has a value between Sowing and StartGrainFill calculated as:

Fraction = 0.3

ReproductiveGrowth has a value between StartGrainFill and HarvestRipe calculated as:

Fraction = 0.01

Metabolic = 0

The partitioning of daily growth to storage biomass is based on a storage fraction.

StorageFraction = 1 - [Stem].DMDemands.Structural.StructuralFraction

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.8.3 Nitrogen Demand

The N demand is calculated as defined in NDemands, based on DM demand the N concentration of each biomass pool.

1.8.3.1 NDemands

This class holds the functions for calculating the absolute demands and priorities for each biomass fraction.

Structural = [Stem].minimumNconc x [Stem].potentialDMAllocation.Structural

Metabolic = *MetabolicNconc* x [Stem].potentialDMAllocation.Structural

MetabolicNconc = [Stem].criticalNConc - [Stem].minimumNconc

The partitioning of daily N supply to storage N attempts to bring the organ's N content to the maximum concentration.

Storage = [Stem].maximumNconc × ([Stem].Live.Wt + potentialAllocationWt) - [Stem].Live.N

The demand for storage N is further reduced by a factor specified by the [Stem].NitrogenDemandSwitch.

NitrogenDemandSwitch = [Stem].nitrogenDemandSwitch

MaxNconc = [Stem].maximumNconc

QStructuralPriority = 1

QMetabolicPriority = 1

QStoragePriority = 1

1.8.4 N Concentration Thresholds

MinimumNConc = 0.0025

CriticalNConc = [Stem].MinimumNConc + *MetabolicNconc*

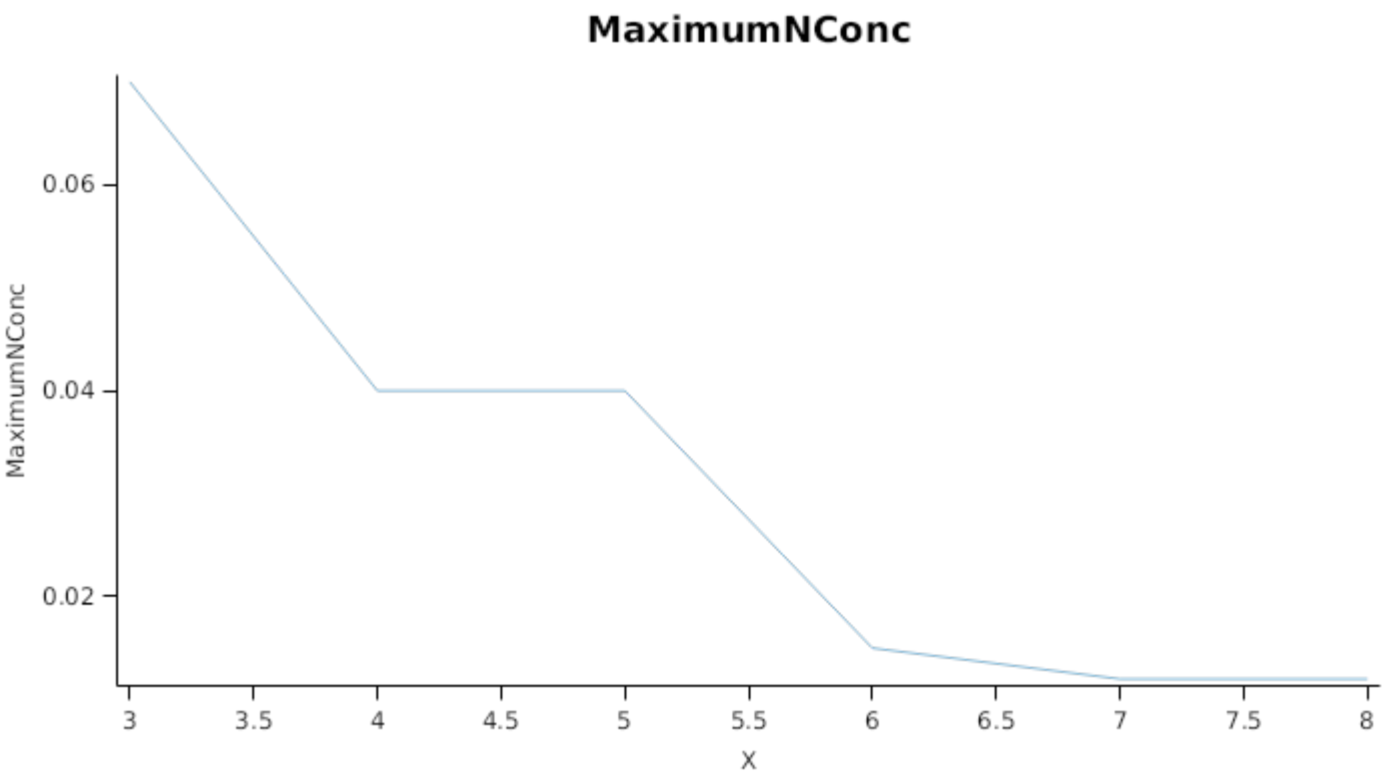
MetabolicNconc = *NonStructuralN* x *Proportion*

NonStructuralN = [Stem].MaximumNConc - [Stem].MinimumNConc

Proportion = 0.5

MaximumNConc is calculated using linear interpolation

X	MaximumNConc
3.0	0.1
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.0
8.0	0.0



The demand for N is reduced by a factor specified by the NitrogenDemandSwitch.

NitrogenDemandSwitch has a value between Emergence and StartGrainFill calculated as:

Constant = 1

1.8.5 Dry Matter Supply

Stem does not reallocate DM when senescence of the organ occurs.

The proportion of non-structural DM that is allocated each day is quantified by the DMReallocationFactor.

DMRetranslocationFactor is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

VegetativeGrowth has a value between Emergence and StartGrainFill calculated as:

DMRetranslocationFactor = 0

ReproductiveGrowth has a value between StartGrainFill and EndGrainFill calculated as:

DMRetranslocationFactor = 0.5

1.8.6 Nitrogen Supply

Stem does not reallocate N when senescence of the organ occurs.

The proportion of non-structural N that is allocated each day is quantified by the NReallocationFactor.

NRetranslocationFactor is calculated using specific values or functions for various growth phases. The function will use a value of zero for phases not specified below.

VegetativeGrowth has a value between Sowing and Flowering calculated as:

Fraction = 0

ReproductiveGrowth has a value between Flowering and HarvestRipe calculated as:

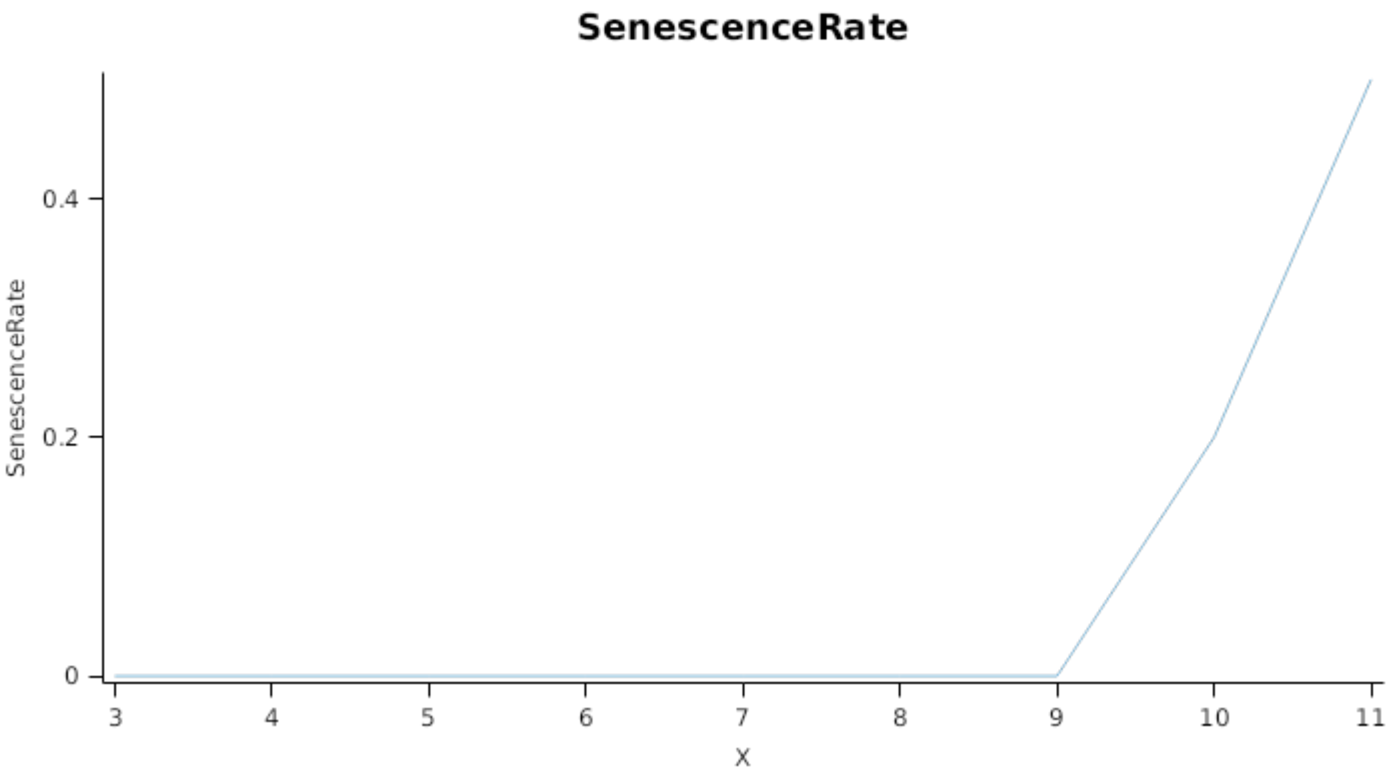
Fraction = 0.5

1.8.7 Senescence and Detachment

The proportion of live biomass that senesces and moves into the dead pool each day is quantified by the SenescenceRate.

SenescenceRate is calculated using linear interpolation

X	SenescenceRate
3.0	0.0
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.0
8.0	0.0
9.0	0.0
10.0	0.2
11.0	0.5



Stem has detachment parameterised to zero so all biomass in this organ will remain with the plant until a defoliation or harvest event occurs.

This organ will respond to certain management actions by either removing some of its biomass from the system or transferring some of its biomass to the soil surface residues. The following table describes the default proportions of live and dead biomass that are transferred out of the simulation using "Removed" or to soil surface residue using "To Residue" for a range of management actions. The total percentage removed for live or dead must not exceed 100%. The difference between the total and 100% gives the biomass remaining on the plant. These can be changed during a simulation using a manager script.

Method	% Live Removed	% Dead Removed	% Live To Residue	% Dead To Residue
Harvest	50	0	10	0
Cut	80	0	0	0
Prune	0	0	60	0
Graze	60	0	20	0
Thin	0	0	5	0

1.9 AboveGround

1.9.1 AboveGround

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

AboveGround summarises the following biomass objects:

* Leaf
* Stem
* Spike
* Grain

1.10 AboveGroundLive

1.10.1 AboveGroundLive

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

AboveGroundLive summarises the following biomass objects:

* Leaf
* Stem
* Spike
* Grain

1.11 AboveGroundDead

1.11.1 AboveGroundDead

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

AboveGroundDead summarises the following biomass objects:

* Leaf
* Stem
* Spike
* Grain

1.12 BelowGround

1.12.1 BelowGround

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

BelowGround summarises the following biomass objects:

* Root

1.13 Total

1.13.1 Total

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

Total summarises the following biomass objects:

* Leaf
* Stem
* Root
* Spike
* Grain

1.14 TotalLive

1.14.1 TotalLive

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

TotalLive summarises the following biomass objects:

* Leaf
* Stem
* Root
* Spike
* Grain

1.15 TotalDead

1.15.1 TotalDead

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

TotalDead summarises the following biomass objects:

* Leaf
* Stem
* Root
* Spike
* Grain

1.16 Ear

1.16.1 Ear

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

Ear summarises the following biomass objects:

* Spike
* Grain

1.17 StemPlusSpike

1.17.1 StemPlusSpike

This is a composite biomass class, representing the sum of 1 or more biomass objects from one or more organs.

StemPlusSpike summarises the following biomass objects:

* Stem
* Spike

1.18 Cultivars

1.18.1 New Zealand

1.18.1.1 Alberic

Alberic overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.2 Amarok

Amarok overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 10

[Phenology].PpSensitivity.FixedValue = 6

[Phenology].HeadEmergencePpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 80

1.18.1.3 Aspiring

Aspiring overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.4 BattenWinter

BattenWinter overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 8

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.7

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 22

1.18.1.5 BattenSpring

BattenSpring overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.7

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 22

1.18.1.6 Centaur

Centaur overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.7 Claire

Claire overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 8

[Phenology].PpSensitivity.FixedValue = 8

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.1.8 Conquest

Conquest overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.1.9 CRWT153

CRWT153 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 14

[Phenology].VrnSensitivity.FixedValue = 1

[Phenology].PpSensitivity.FixedValue = 2

1.18.1.10 Discovery

Discovery overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8.5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 0

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 80

[Leaf].CohortParameters.MaxArea.AreaLargestLeaves.FixedValue = 1600

[Grain].MaximumPotentialGrainSize.FixedValue = 0.051

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 35

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.5

[Structure].BranchingRate.PotentialBranchingRate.Vegetative.PotentialBranchingRate.XYPairs.Y = 0,0,0,0,4,7,12,20

[Grain].MaximumNConc.FixedValue = 0.025

[Grain].MaxNConcDailyGrowth.FixedValue = 0.025

[Leaf].ExtinctionCoeff.DevelopmentFactor.XYPairs.Y = 1,1,1,1,1.4

[Leaf].CohortParameters.MinimumNConc.XYPairs.Y = 0.01,0.008, 0.008,0.008, 0.008, 0.008

[Stem].MinimumNConc.FixedValue = 0.006

[Spike].DMRetranslocationFactor.ReproductiveGrowth.DMRetranslocationFactor.FixedValue = 0.05

1.18.1.11 Einstein

Einstein overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.12 Exceed

Exceed overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.13 Majestic

Majestic overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.14 Option

Option overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.15 Otane

Otane overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].HeadEmergencePpSensitivity.FixedValue = 2

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.1.16 Pennant

Pennant overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.17 Regency

Regency overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.18 Richmond

Richmond overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.19 Robigus

Robigus overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.20 Rongotea

Rongotea overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 2

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.1.21 Rubric

Rubric overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.22 Sage

Sage overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.23 Saracen

Saracen overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.24 Savannah

Savannah overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.25 Solstice

Solstice overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.26 Tanker

Tanker overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.27 Tribute

Tribute overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.1.28 Wakanui

Wakanui overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 10

[Phenology].PpSensitivity.FixedValue = 0

[Phenology].HeadEmergenceLongDayBase.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Phenology].DailyVernalisation.TempResponseProfile.Response.X = 0,1,8

[Phenology].DailyVernalisation.TempResponseProfile.Response.Y = 0,1.204,0

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.7

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 22

[Grain].MaximumPotentialGrainSize.FixedValue = 0.045

[Leaf].CohortParameters.MaxArea.AreaLargestLeaves.FixedValue = 3000

1.18.1.29 Weston

Weston overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

1.18.2 Australia

1.18.2.1 Axe

Axe overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].HeadEmergencePpSensitivity.FixedValue = 0

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.2 Bolac

Bolac overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.3 Cunningham

Cunningham overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.4 Derrimut

Derrimut overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.5 Gregory

Gregory overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 1

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 85

1.18.2.6 Gamenya

Gamenya overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 3.5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Phenology].HeadEmergencePpSensitivity.FixedValue = 0

1.18.2.7 Gauntlet

Gauntlet overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.8 Gladius

Gladius overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.9 Gutha

Gutha overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].MaximumPotentialGrainSize.FixedValue = 0.041

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 17

1.18.2.10 H45

H45 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 20

1.18.2.11 H46

H46 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.12 Hartog

Hartog overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].MaximumPotentialGrainSize.FixedValue = 0.041

1.18.2.13 Wills

Wills overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].HeadEmergenceLongDayBase.FixedValue = 3.5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 70

1.18.2.14 Mercury

Mercury overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].HeadEmergenceLongDayBase.FixedValue = 3.5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 80

1.18.2.15 Batavia

Batavia overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.16 Egret

Egret overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue =80

1.18.2.17 Janz

Janz overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 1

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.18 Kellalac

Kellalac overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.19 Kennedy

Kennedy overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.20 Lang

Lang overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.21 Livingston

Livingston overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.22 Lincoln

Lincoln overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.23 Mace

Mace overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.24 MacKellar

MacKellar overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 5

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].HeadEmergenceLongDayBase.FixedValue = 3.5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.25 Matong

Matong overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 1

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 22

1.18.2.26 McCubbin

McCubbin overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 90

1.18.2.27 Ruby

Ruby overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.28 Spear

Spear overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].MaximumPotentialGrainSize.FixedValue = 0.045

1.18.2.29 Sunbri

Sunbri overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.30 Sunco

Sunco overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6.5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 3.5

[Phenology].HeadEmergencePpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.31 Ventura

Ventura overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.32 Eaglehawk

Eaglehawk overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 90

1.18.2.33 Wedgetail

Wedgetail overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.34 Westonia

Westonia overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.35 Wilgoyne

Wilgoyne overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 20

[Grain].MaximumPotentialGrainSize.FixedValue = 0.045

1.18.2.36 Wyalkatchem

Wyalkatchem overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.37 Yitpi

Yitpi overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 5

[Phenology].HeadEmergenceLongDayBase.FixedValue = 2.5

[Phenology].HeadEmergencePpSensitivity.FixedValue = 5

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 80

1.18.2.38 Young

Young overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.2.39 Scepter

Scepter overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6.3

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 5.0

1.18.2.40 Cutlass

Cutlass overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 5.7

[Phenology].PpSensitivity.FixedValue = 5.3

[Phenology].VrnSensitivity.FixedValue = 2.3

1.18.2.41 Longsword

Longsword overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 8.0

1.18.2.42 CSIROW007

CSIROW007 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7.3

[Phenology].PpSensitivity.FixedValue = 0.0

[Phenology].VrnSensitivity.FixedValue = 6.3

1.18.2.43 CSIROW023

CSIROW023 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 5.3

1.18.2.44 CSIROW073

CSIROW073 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7.7

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 6.3

1.18.3 Turkey

1.18.3.1 Konya

Konya overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 4

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 16

[Grain].MaximumPotentialGrainSize.FixedValue = 0.050

[Grain].MaximumNConc.FixedValue = 0.026

[Phenology].GrainFilling.Target.FixedValue = 450

[Stem].DMRetranslocationFactor.ReproductiveGrowth.DMRetranslocationFactor.FixedValue = 0.2

[Stem].DMDemands.Structural.StructuralFraction.VegetativeGrowth.Fraction.FixedValue = 0.6

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.8

1.18.4 China

1.18.4.1 Keyu13

Keyu13 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 5

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.5 USA

1.18.5.1 Yecora

Yecora overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 6

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 90

[Leaf].CohortParameters.MaxArea.AreaLargestLeaves.FixedValue = 4000

1.18.5.2 Rex

Rex overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 6

[Phenology].PpSensitivity.FixedValue = 4

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 18

[Grain].MaximumNConc.FixedValue = 0.02

1.18.5.3 Nugaines

Nugaines overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 6

[Phenology].PpSensitivity.FixedValue = 4

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 20

[Grain].MaximumNConc.FixedValue = 0.02

1.18.5.4 Hyslop

Hyslop overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 6

[Phenology].PpSensitivity.FixedValue = 4

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 22

[Grain].MaximumNConc.FixedValue = 0.02

1.18.5.5 Stephens

Stephens overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 6

[Phenology].PpSensitivity.FixedValue = 4

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 25

[Grain].MaximumNConc.FixedValue = 0.02

1.18.6 Europe

1.18.6.1 Dekan

Dekan overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.8

1.18.6.2 Rosario

Rosario overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.8

1.18.6.3 Ararat

Ararat overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 7

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].HeadEmergencePpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Leaf].ExtinctionCoeff.VegetativePhase.FixedValue = 0.8

1.18.6.4 Tybalt

Tybalt overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 9

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 0

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 90

1.18.7 Africa

1.18.7.1 HAR1685

HAR1685 overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 3

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

[Grain].NumberFunction.GrainNumber.GrainsPerGramOfStem.FixedValue = 17

[Phenology].GrainFilling.Target.FixedValue = 350

1.18.8 Iran

1.18.8.1 Gorgan

Gorgan overrides the following properties:

[Phenology].MinimumLeafNumber.FixedValue = 7

[Phenology].VrnSensitivity.FixedValue = 0

[Phenology].PpSensitivity.FixedValue = 4

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100

1.18.9 Just Added

1.18.9.1 Adv08_0008

Adv08_0008 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100.4

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 5.0

1.18.9.2 Bennett

Bennett overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 95.1

[Phenology].MinimumLeafNumber.FixedValue = 8.3

[Phenology].PpSensitivity.FixedValue = 0.7

[Phenology].VrnSensitivity.FixedValue = 5.7

1.18.9.3 Scythe

Scythe overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 84.4

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 2.0

[Phenology].VrnSensitivity.FixedValue = 5.7

1.18.9.4 Beaufort

Beaufort overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 100.0

[Phenology].MinimumLeafNumber.FixedValue = 9.0

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 6.3

1.18.9.5 Braewood

Braewood overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.5

[Phenology].MinimumLeafNumber.FixedValue = 7.3

[Phenology].PpSensitivity.FixedValue = 3.7

[Phenology].VrnSensitivity.FixedValue = 1.3

1.18.9.6 Calingiri

Calingiri overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 80.8

[Phenology].MinimumLeafNumber.FixedValue = 7.7

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 3.7

1.18.9.7 Catalina

Catalina overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.8

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 2.3

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.8 Condo

Condo overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 73.6

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.9 Crusader

Crusader overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 76.0

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 2.0

[Phenology].VrnSensitivity.FixedValue = 6.7

1.18.9.10 CSIROW002

CSIROW002 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 88.9

[Phenology].MinimumLeafNumber.FixedValue = 6.3

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 3.7

1.18.9.11 CSIROW003

CSIROW003 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 90.1

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 0.7

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.12 CSIROW005

CSIROW005 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 81.3

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 0.7

[Phenology].VrnSensitivity.FixedValue = 5.0

1.18.9.13 CSIROW011

CSIROW011 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 93.0

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 0.0

1.18.9.14 CSIROW018

CSIROW018 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 89.2

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 3.7

1.18.9.15 CSIROW021

CSIROW021 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 85.1

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 5.3

1.18.9.16 CSIROW027

CSIROW027 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 89.2

[Phenology].MinimumLeafNumber.FixedValue = 5.7

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 0.3

1.18.9.17 CSIROW029

CSIROW029 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 96.6

[Phenology].MinimumLeafNumber.FixedValue = 5.7

[Phenology].PpSensitivity.FixedValue = 0.3

[Phenology].VrnSensitivity.FixedValue = 0.3

1.18.9.18 CSIROW077

CSIROW077 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 93.7

[Phenology].MinimumLeafNumber.FixedValue = 5.3

[Phenology].PpSensitivity.FixedValue = 0.7

[Phenology].VrnSensitivity.FixedValue = 0.7

1.18.9.19 CSIROW087

CSIROW087 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.5

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 0.0

1.18.9.20 CSIROW102

CSIROW102 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 92.9

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 2.0

1.18.9.21 CSIROW105

CSIROW105 overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 94.0

[Phenology].MinimumLeafNumber.FixedValue = 5.0

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.22 Hume

Hume overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 97.0

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 2.7

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.23 Ellison

Ellison overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 103.7

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 4.0

[Phenology].VrnSensitivity.FixedValue = 4.7

1.18.9.24 Emu_Rock

Emu_Rock overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 95.7

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 0.0

1.18.9.25 Forrest

Forrest overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 88.0

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 5.0

[Phenology].VrnSensitivity.FixedValue = 1.3

1.18.9.26 Grenade

Grenade overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 97.5

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 2.7

[Phenology].VrnSensitivity.FixedValue = 1.3

1.18.9.27 Kittyhawk

Kittyhawk overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 82.8

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 3.0

[Phenology].VrnSensitivity.FixedValue = 9.0

1.18.9.28 Lancer

Lancer overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 92.3

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 3.7

[Phenology].VrnSensitivity.FixedValue = 0.7

1.18.9.29 Nighthawk

Nighthawk overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.7

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.30 Magenta

Magenta overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 99.4

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 5.7

1.18.9.31 Manning

Manning overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 109.8

[Phenology].MinimumLeafNumber.FixedValue = 9.0

[Phenology].PpSensitivity.FixedValue = 2.3

[Phenology].VrnSensitivity.FixedValue = 5.0

1.18.9.32 Merinda

Merinda overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 94.9

[Phenology].MinimumLeafNumber.FixedValue = 7.3

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 0.0

1.18.9.33 Mitch

Mitch overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 76.6

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 2.0

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.34 Ouyen

Ouyen overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 81.7

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 3.3

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.35 Peake

Peake overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 79.3

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 2.3

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.36 Revenue

Revenue overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 109.7

[Phenology].MinimumLeafNumber.FixedValue = 9.0

[Phenology].PpSensitivity.FixedValue = 1.5

[Phenology].VrnSensitivity.FixedValue = 7.5

1.18.9.37 Rosella

Rosella overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 85.4

[Phenology].MinimumLeafNumber.FixedValue = 8.7

[Phenology].PpSensitivity.FixedValue = 2.7

[Phenology].VrnSensitivity.FixedValue = 8.8

1.18.9.38 Scout

Scout overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 75.8

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 5.3

1.18.9.39 Spitfire

Spitfire overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 84.4

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.40 Strzelecki

Strzelecki overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 82.7

[Phenology].MinimumLeafNumber.FixedValue = 7.3

[Phenology].PpSensitivity.FixedValue = 1.7

[Phenology].VrnSensitivity.FixedValue = 5.3

1.18.9.41 Sunbee

Sunbee overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.3

[Phenology].MinimumLeafNumber.FixedValue = 6.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.42 Sunlamb

Sunlamb overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 93.8

[Phenology].MinimumLeafNumber.FixedValue = 7.3

[Phenology].PpSensitivity.FixedValue = 3.7

[Phenology].VrnSensitivity.FixedValue = 6.7

1.18.9.43 Sunstate

Sunstate overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 84.1

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 3.3

1.18.9.44 Suntop

Suntop overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 92.2

[Phenology].MinimumLeafNumber.FixedValue = 7.0

[Phenology].PpSensitivity.FixedValue = 1.3

[Phenology].VrnSensitivity.FixedValue = 1.0

1.18.9.45 Trojan

Trojan overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 85.8

[Phenology].MinimumLeafNumber.FixedValue = 6.7

[Phenology].PpSensitivity.FixedValue = 3.3

[Phenology].VrnSensitivity.FixedValue = 4.0

1.18.9.46 Illabo

Illabo overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 92.0

[Phenology].MinimumLeafNumber.FixedValue = 8.0

[Phenology].PpSensitivity.FixedValue = 1.0

[Phenology].VrnSensitivity.FixedValue = 6.7

1.18.9.47 Whistler

Whistler overrides the following properties:

[Phenology].Phyllochron.BasePhyllochron.FixedValue = 91.5

[Phenology].MinimumLeafNumber.FixedValue = 8.3

[Phenology].PpSensitivity.FixedValue = 2.0

[Phenology].VrnSensitivity.FixedValue = 6.2

1.19 MortalityRate

MortalityRate = 0

2 The APSIM Wheat Model

Brown, H.E., Huth, N.I. and Holzworth, D.P.

The APSIM wheat model has been developed using the Plant Modelling Framework (PMF) of Brown et al., 2014. This new framework provides a library of plant organ and process submodels that can be coupled, at runtime, to construct a model in much the same way that models can be coupled to construct a simulation. This means that dynamic composition of lower level process and organ classes (e.g. photosynthesis, leaf) into larger constructions (e.g. maize, wheat, sorghum) can be achieved by the model developer without additional coding.

The wheat model consists of:

* a phenology model to simulate development through sequential developmental phases
* a structure model to simulate plant morphology
* a collection of organs to simulate the various plant parts
* an arbitrator to allocate resources (N, biomass) to the various plant organs

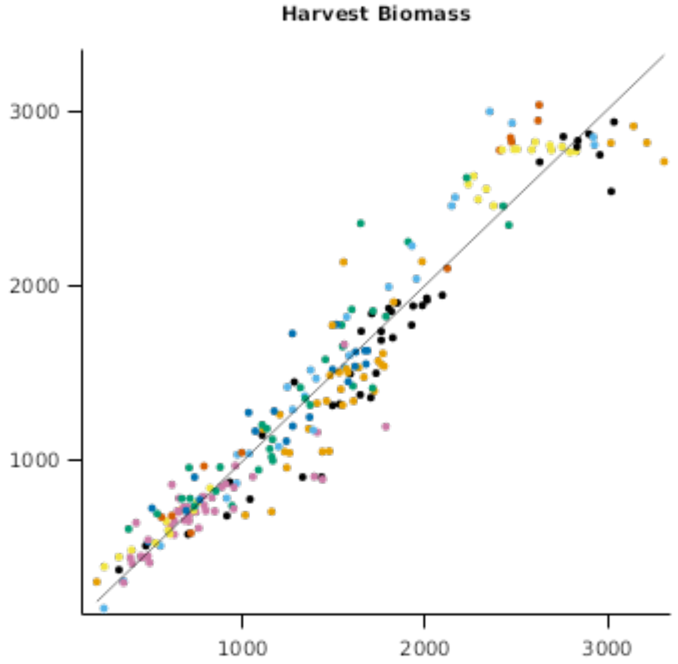
This work builds upon earlier APSIM Wheat models such as NWheat (S Asseng et al., 2002, BA Keating, 2001), NWheatS (S Asseng et al., 1998), Cropmod-Wheat (Wang et al., 2002), and the earlier versions developed in Plant (APSIM Wheat 7.5") and then within the Plant Modelling Framework (Brown et al., 2014).

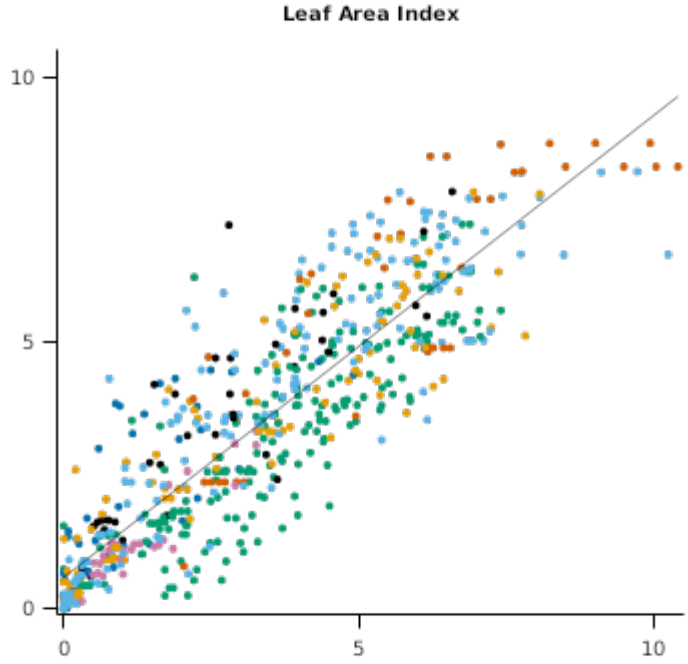
3 Validation

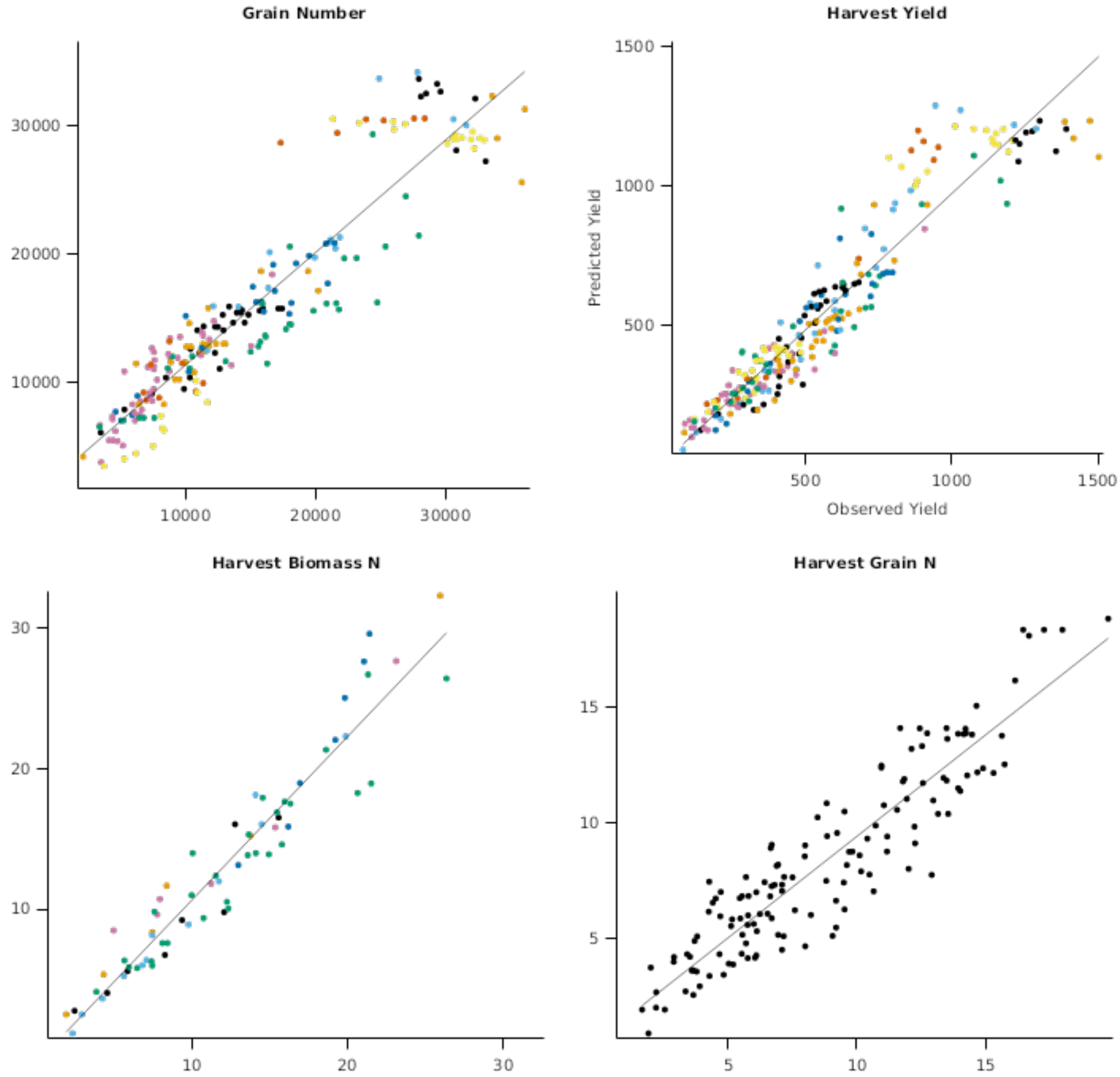
A test dataset has been developed to test the APSIM Wheat model for a range of environmental (soil and climate) conditions, management options (sowing dates, populations, nitrogen rates, row spacing, irrigation), genetic backgrounds (different regions, cultivar types) and for special considerations such as crop damage. These tests have been grouped into various geographical regions to allow the user to evaluate the suitability of the model for their particular region of interest. Graphs of model performance are provided for yield, biomass production, canopy development, phenological development, water and nitrogen uptake, and grain yield components.

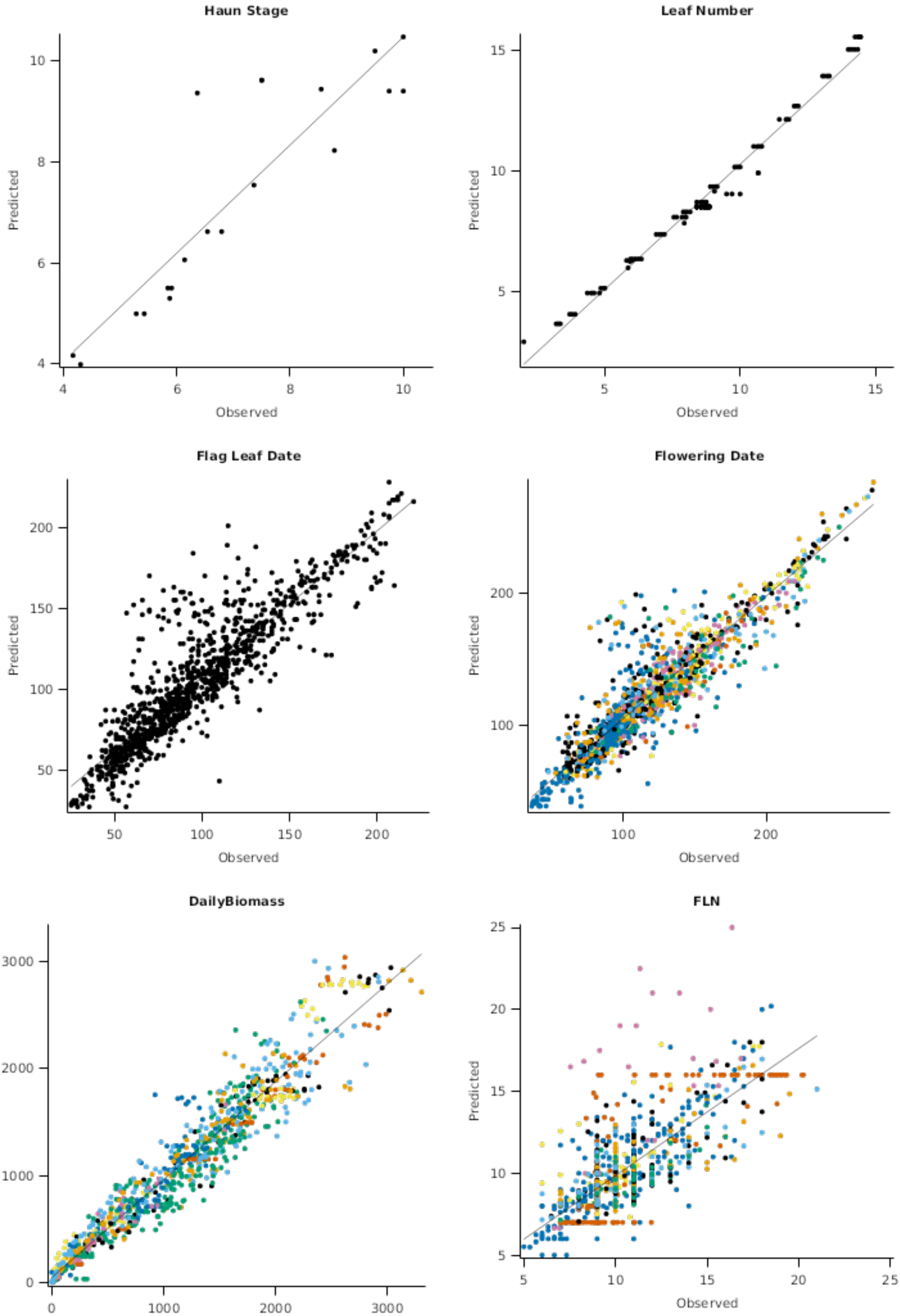
3.1 Combined Results

Simulation results for the combined datasets from the various countries are shown in the following graphs. The model is able to adequately capture the influence of growing conditions (soil, climate) and management (population, Nitrogen, irrigation, sowing date).






Grain Number
30000
20000
10000
10000
20000
30000
Harvest Yield
1500
1000
500
Predicted Yield
500
1000
1500
Observed Yield
Harvest Biomass N
30
20
10
10
20
30
Harvest Grain N
15
10
5
5
10
15

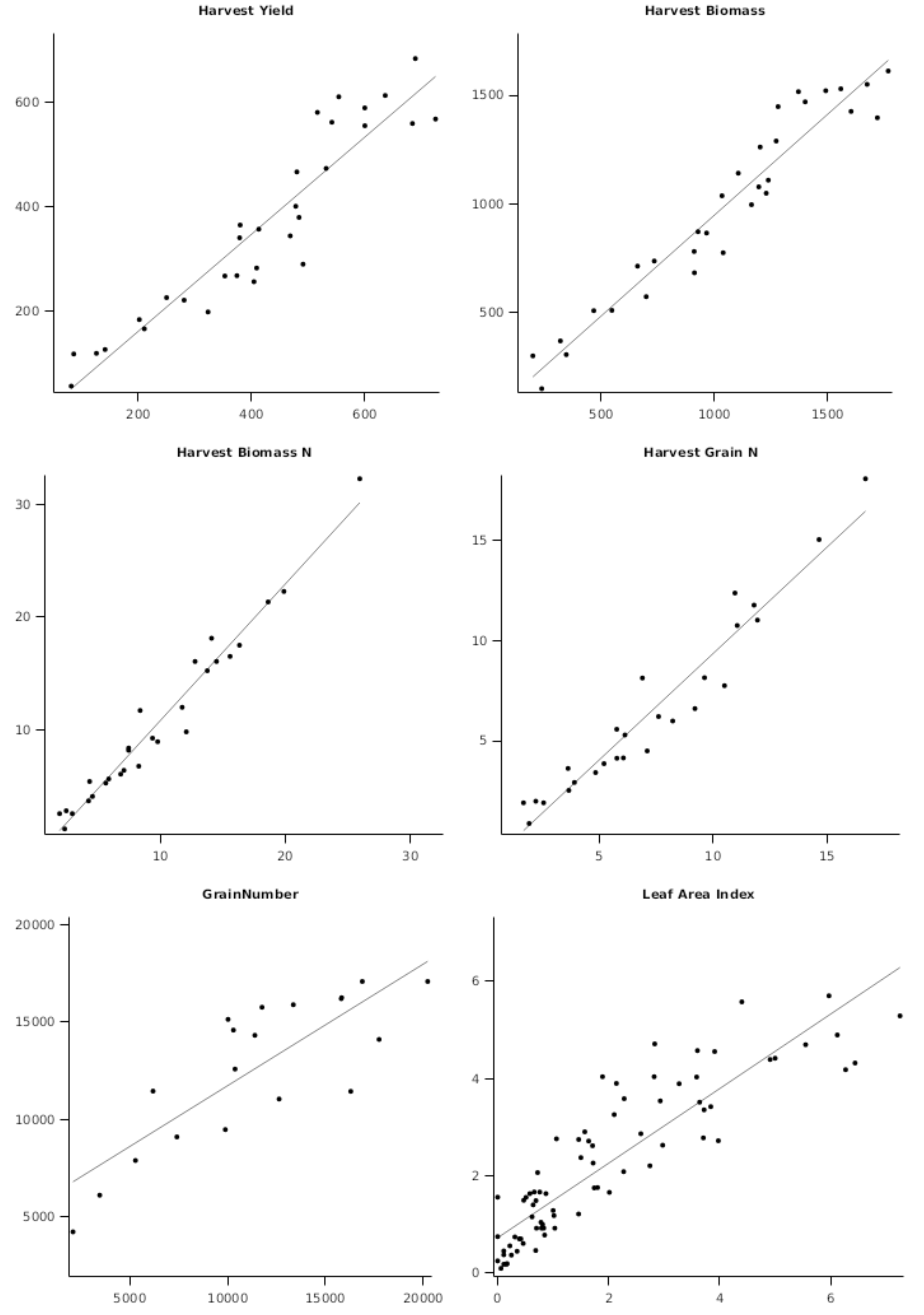

Haun Stage
Predicted
Observed
4
6
8
10
Leaf Number
Predicted
Observed
5
10
15
Flag Leaf Date
Predicted
Observed
50
100
150
200
Flowering Date
Predicted
Observed
100
200
DailyBiomass
0
1000
2000
3000
FLN
Predicted
Observed
5
10
15
20
25

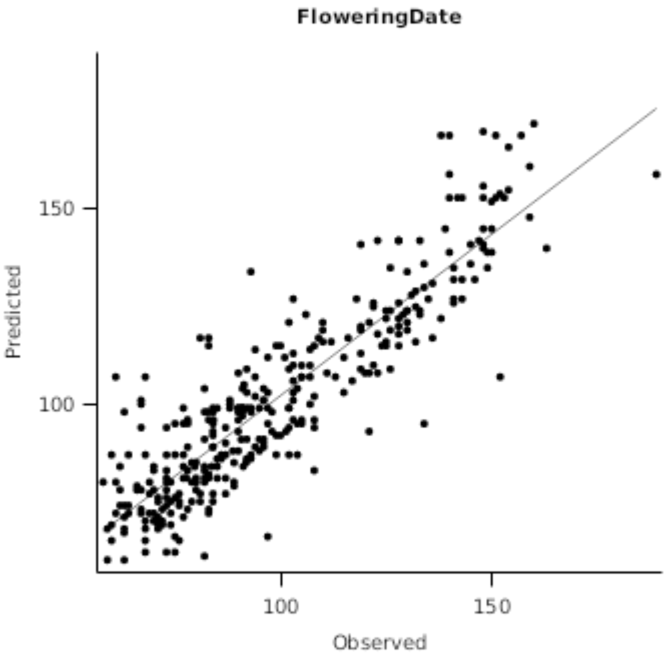
3.2 SE Queensland

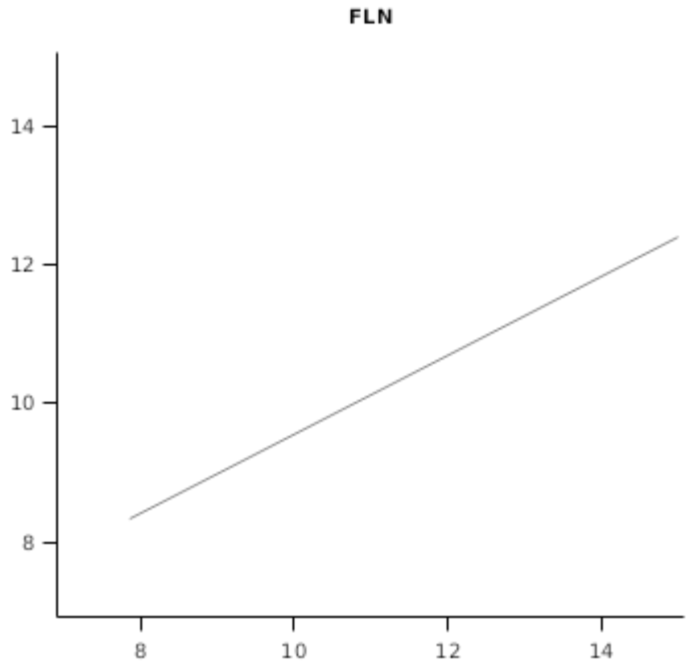
South-eastern Queensland has a warm subtropical environment. Daytime temperatures are moderate due to the relatively low latitudes for wheat growing in Australia, but inland continental conditions can provide cool nights with occaisional frosts. Many of the datasets used here have been published as part of previous APSIM Wheat model tests. Further datasets have been added to provide information on phenological development of modern cultivars.

List of experiments.

Experiment Name	Design (Number of Treatments)
APS26	NRate x Water (8)
APS6	NRate (6)
APS14	Stubble x NRate (12)
APS2	TOS (2)
GattonRowSpacing	RowSpace (3)
Gatton94	Cv x TOS (12)
Gatton2009	TOS x Cv (48)
Gatton2011	TOS x Cv (15)
Gatton2014	TOS x Cv (148)
Gatton2014AE	V x P x Cv (148)
TraitMod2015	TOS x Cv (10)
TraitMod2016	TOS x Cv (5)


Harvest Yield
200
400
600
Harvest Biomass
500
1000
1500
Harvest Biomass N
10
20
30
Harvest Grain N
5
10
15
GrainNumber
5000
10000
15000
20000
Leaf Area Index
0
2
4
6

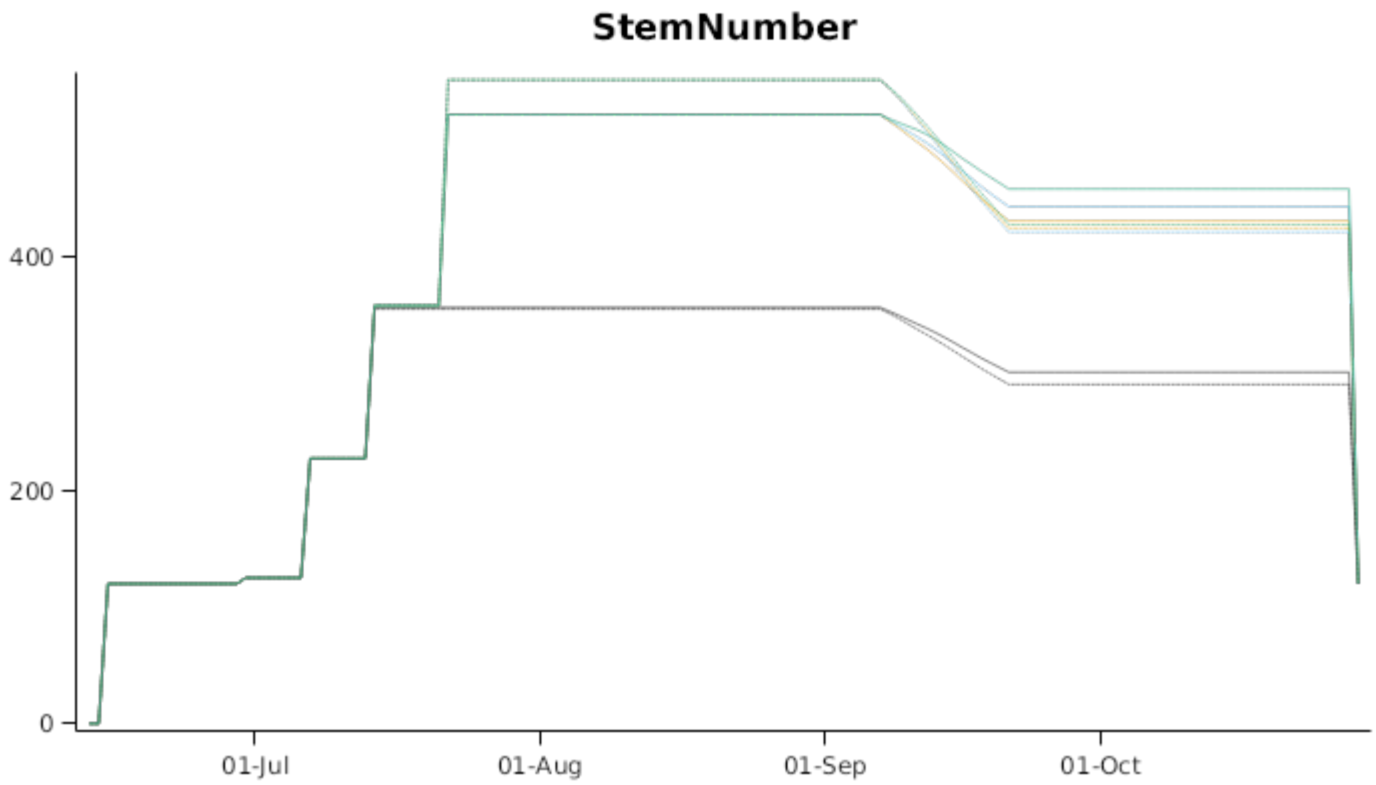


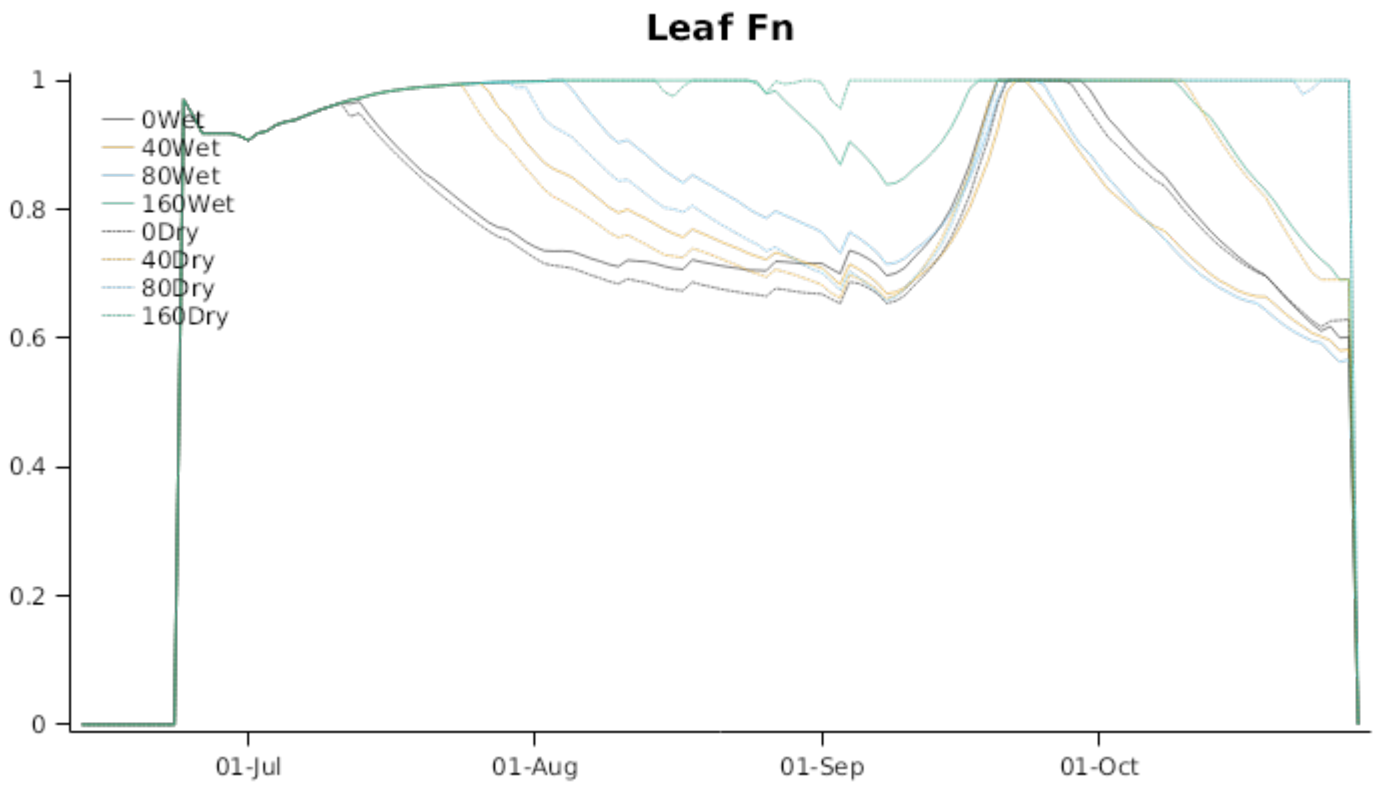


3.2.1 APS26

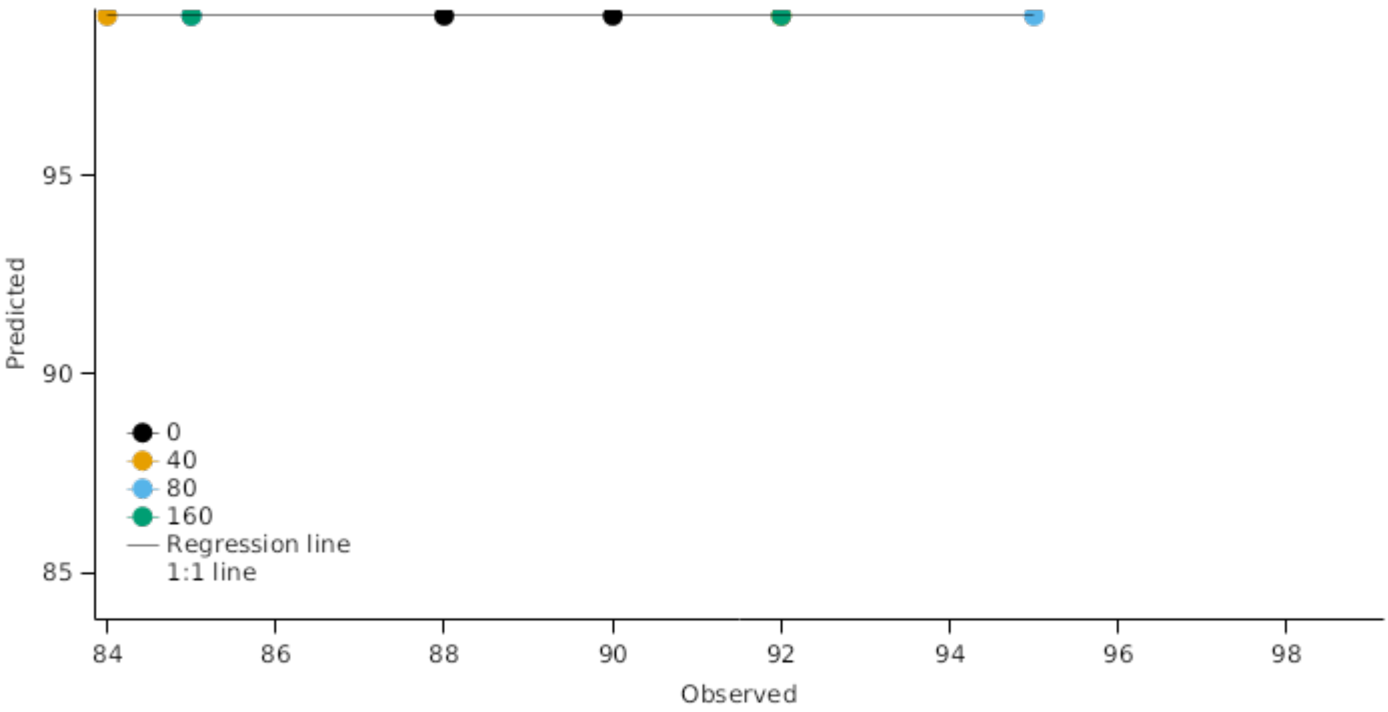
This trial was conducted at Gatton in 1995 using the local variety, Hartog. It consisted of 4 Nitrogen rates (0,40,80,160) with two irrigation rates (minimal amount for establishment, fully irrigated). Yields ranged from 1.4 t/ha to 5.4 t/ha.

FW photo


StemNumber
0
200
400
01-Jul
01-Aug
01-Sep
01-Oct


Leaf Fn
0
0.2
0.4
0.6
0.8
1
01-Jul
01-Aug
01-Sep
01-Oct
0Wet
40Wet
80Wet
160Wet
0Dry
40Dry
80Dry
160Dry

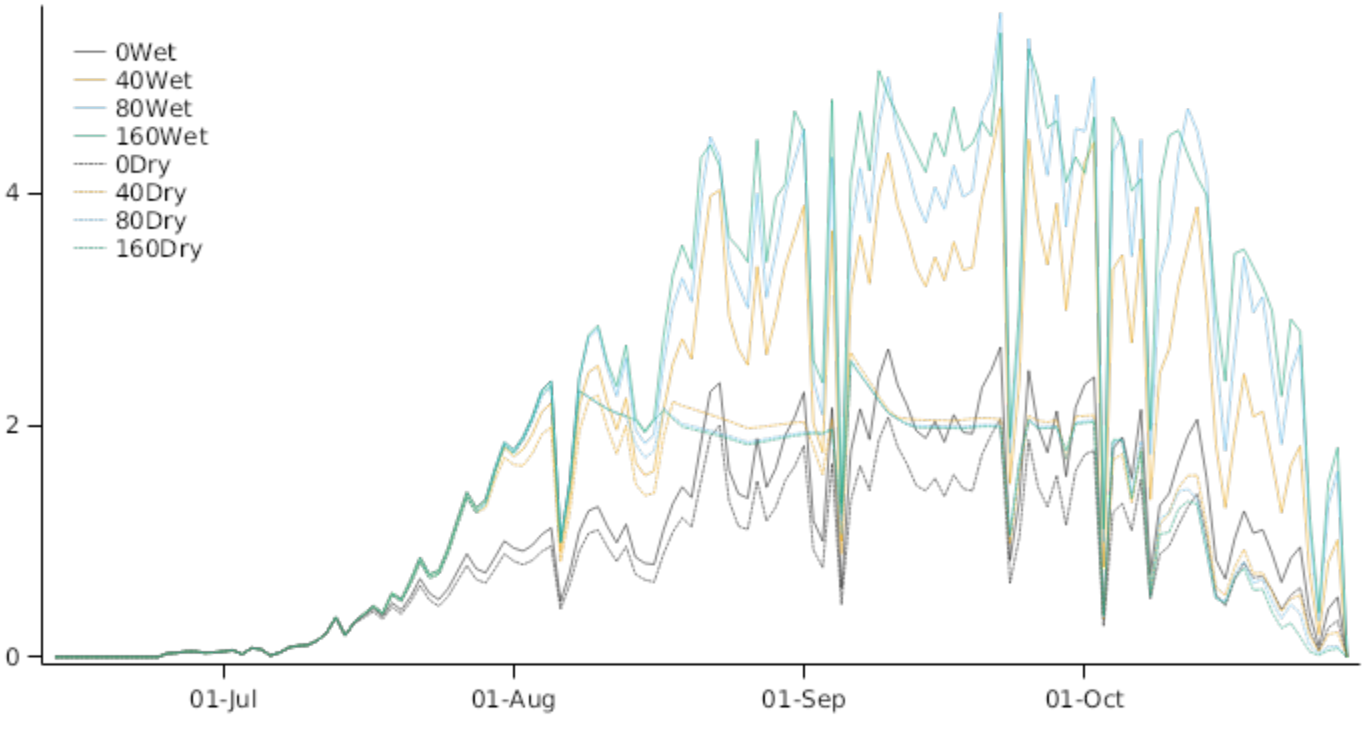
FloweringDate

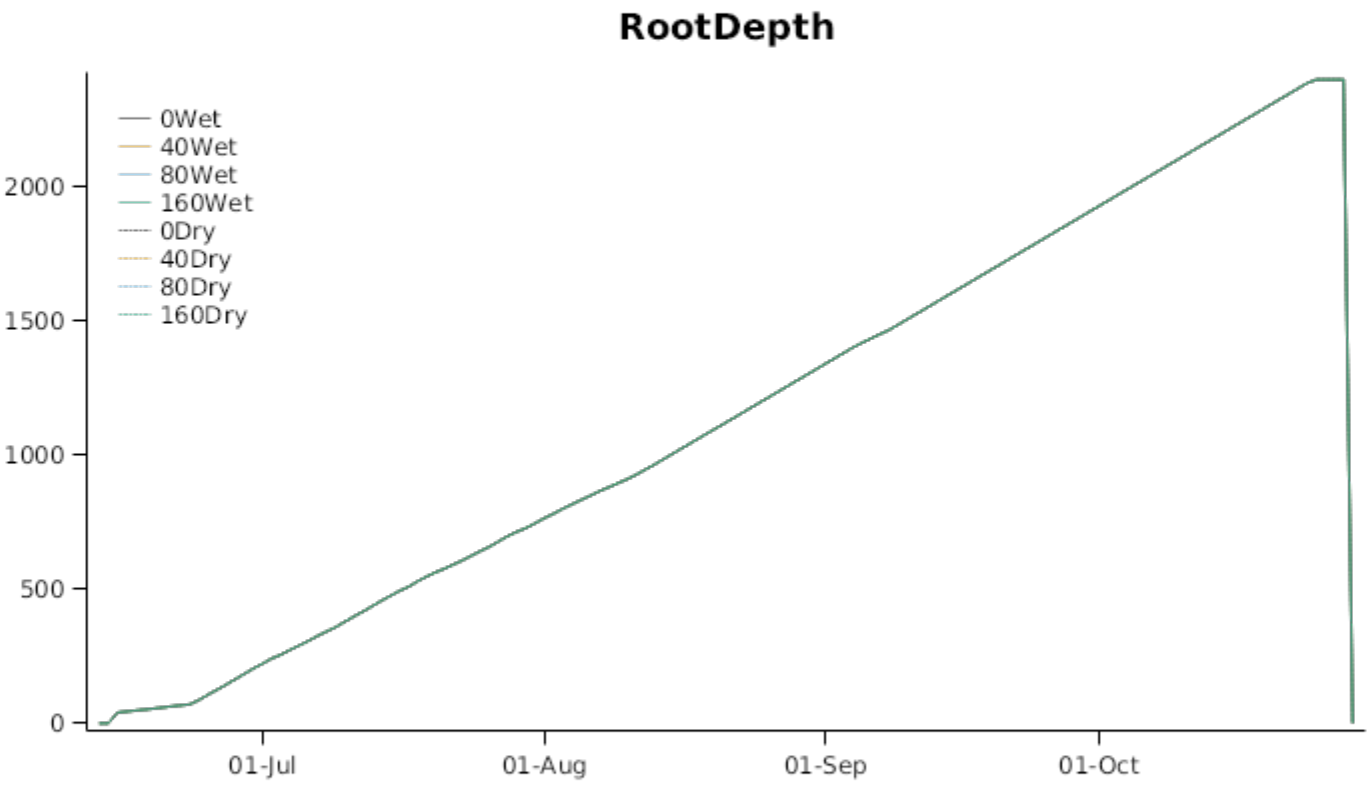


WaterPotential

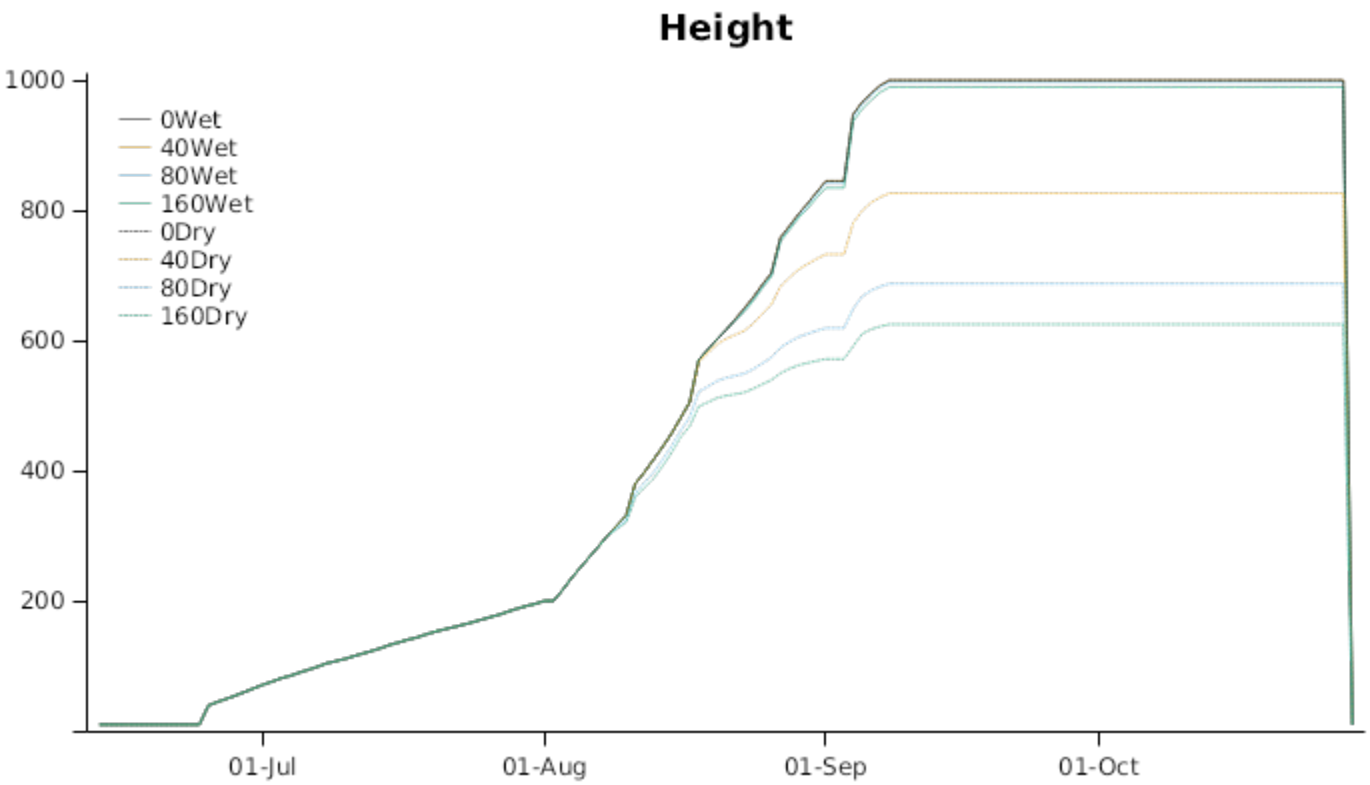
C Supply and Demand

ET





RootDepth
0Wet
40Wet
80Wet
160Wet
0Dry
40Dry
80Dry
160Dry
2000
1500
1000
500
0
01-Jul
01-Aug
01-Sep
01-Oct



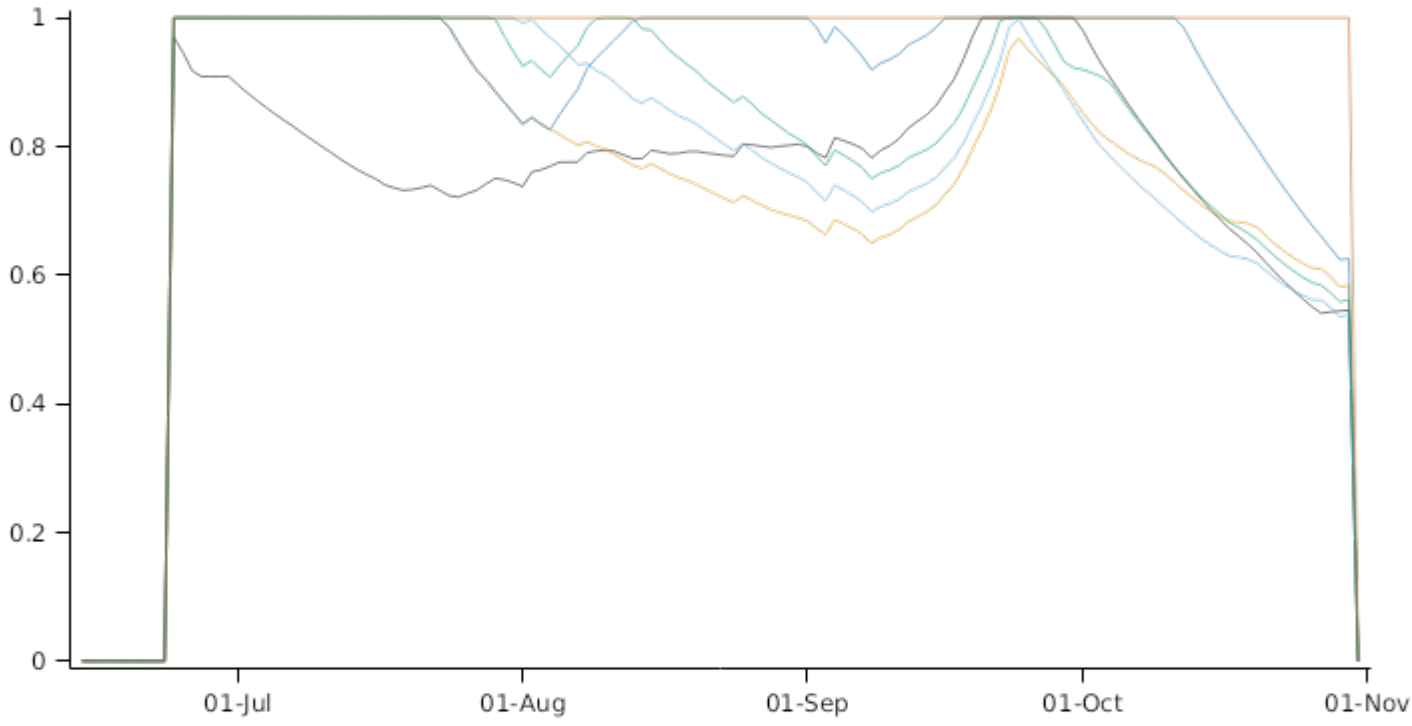
Height
0Wet
40Wet
80Wet
160Wet
0Dry
40Dry
80Dry
160Dry
1000
800
600
400
200
01-Jul
01-Aug
01-Sep
01-Oct

RootLengthDensity

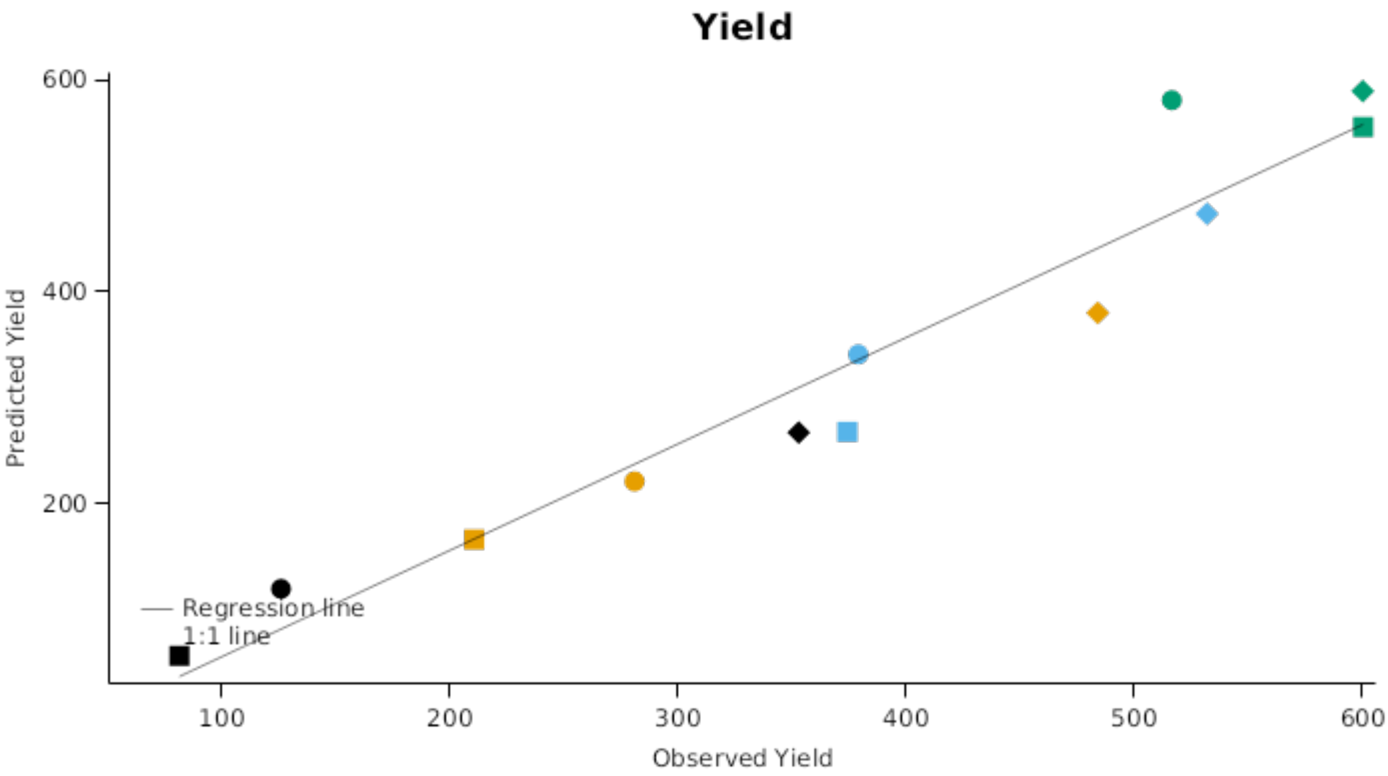
3.2.2 APS6

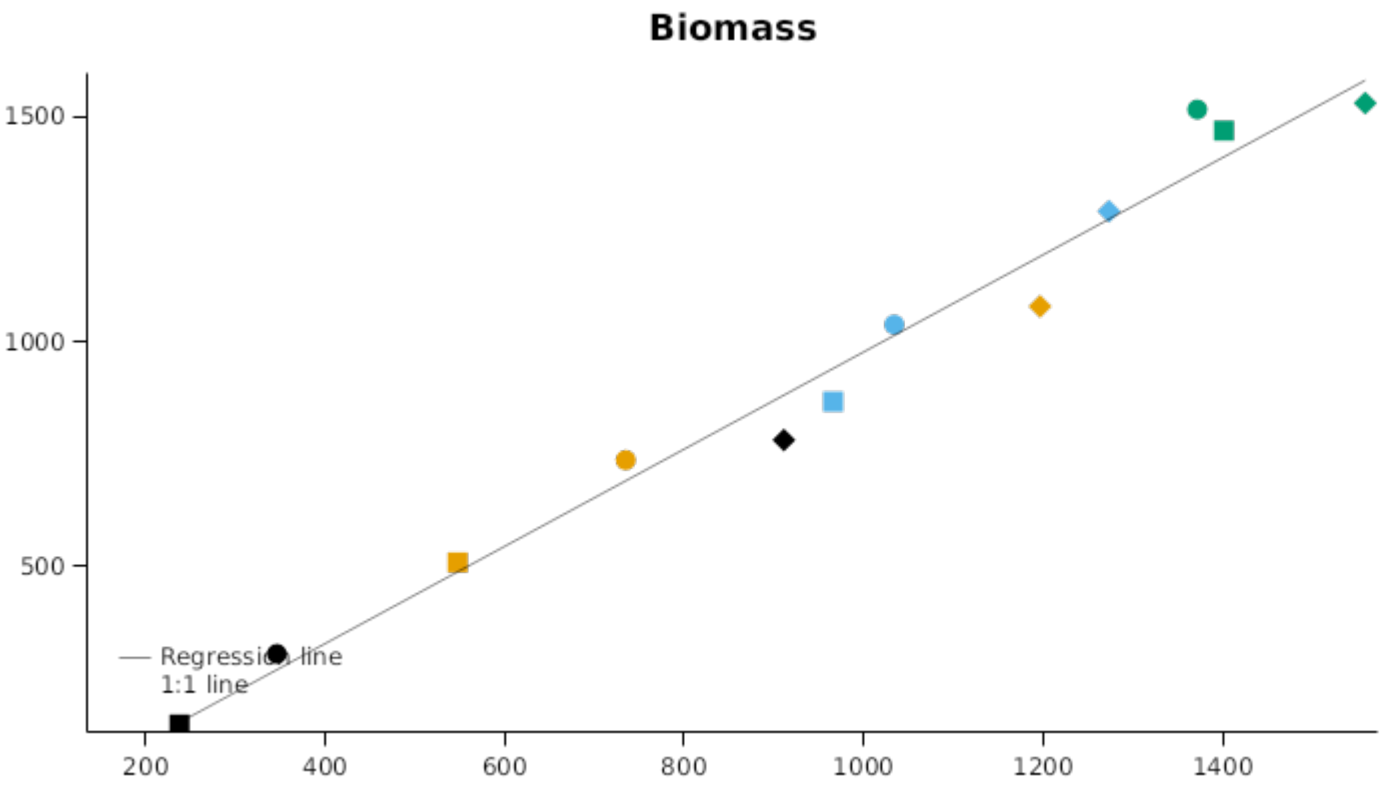
NOTE: High N treatment logdged. Final grain sizes were less than expected.

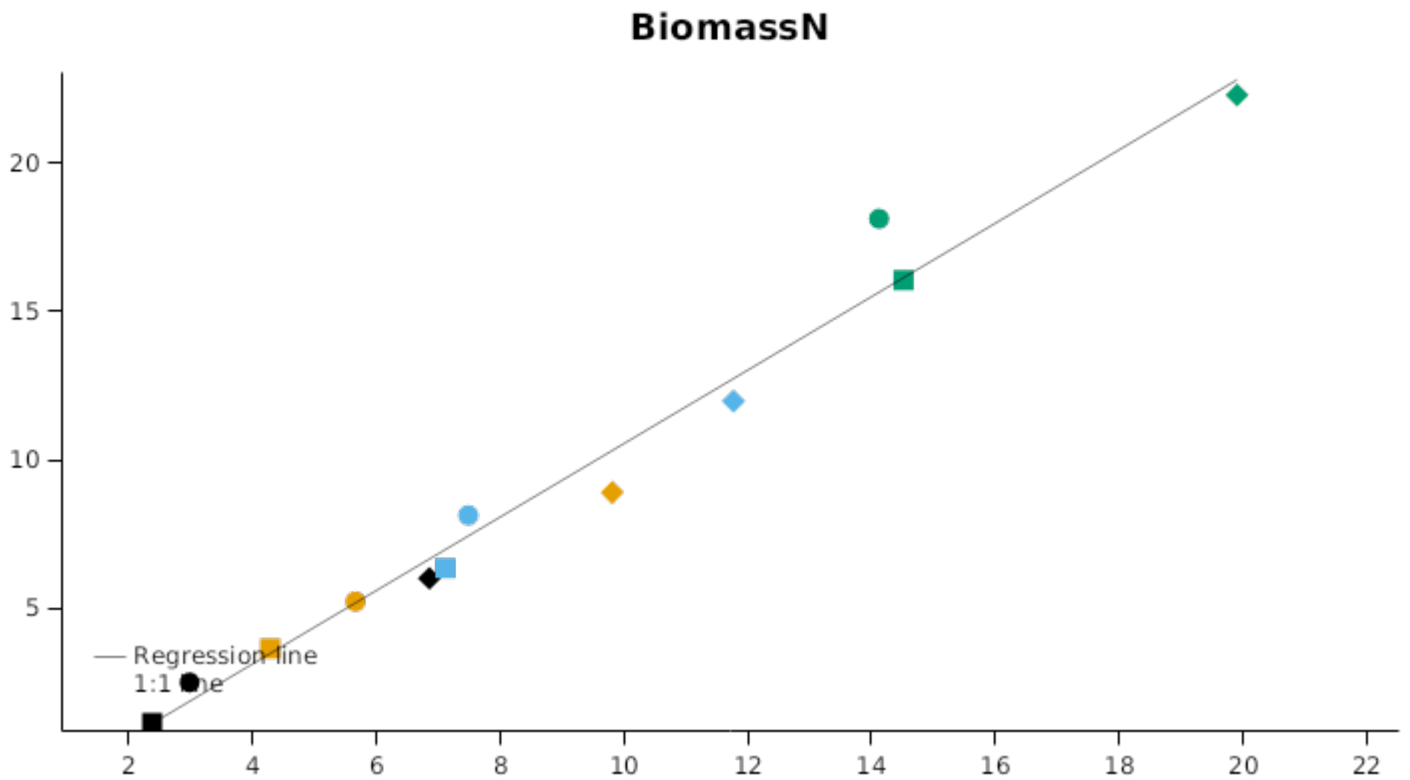
NStress



3.2.3 APS14

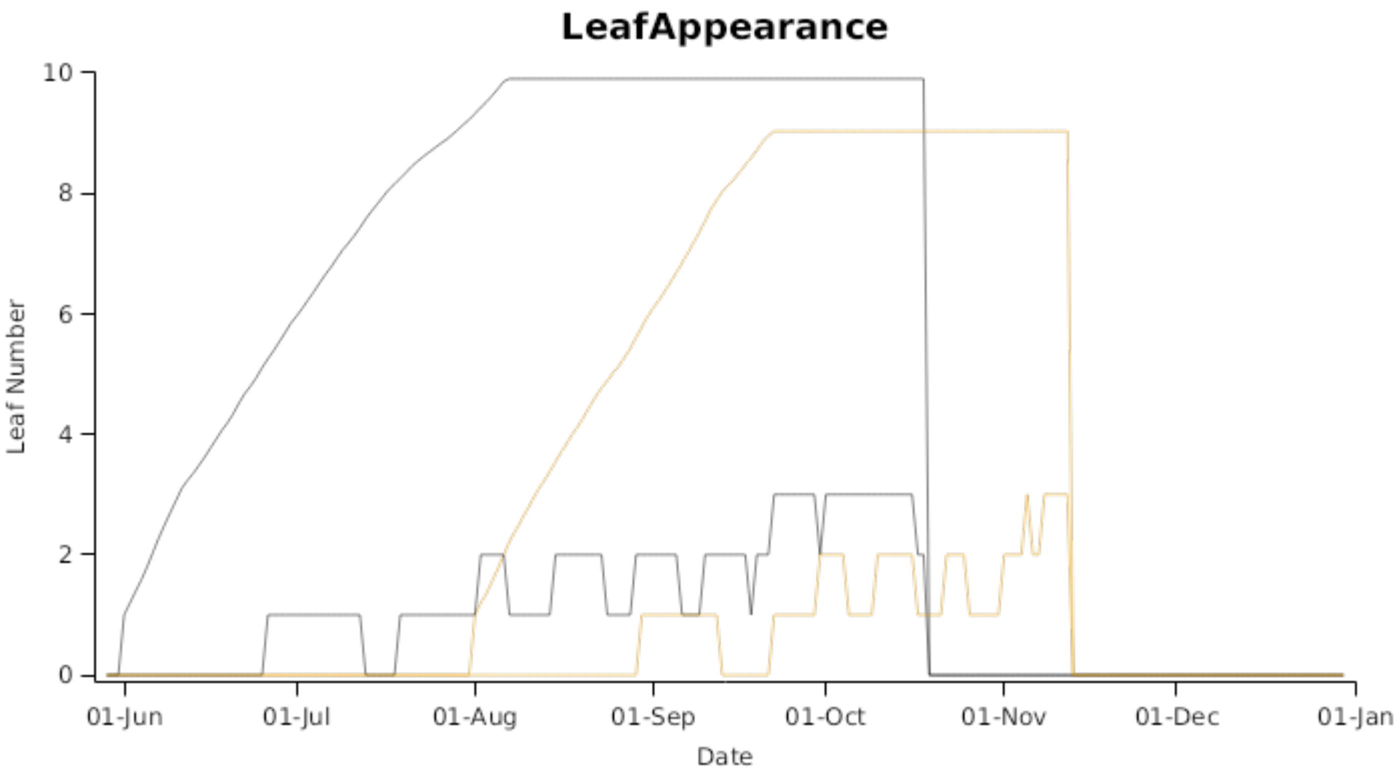

Yield
600
400
200
Predicted Yield
Regression line
1:1 line
100
200
300
400
500
600
Observed Yield

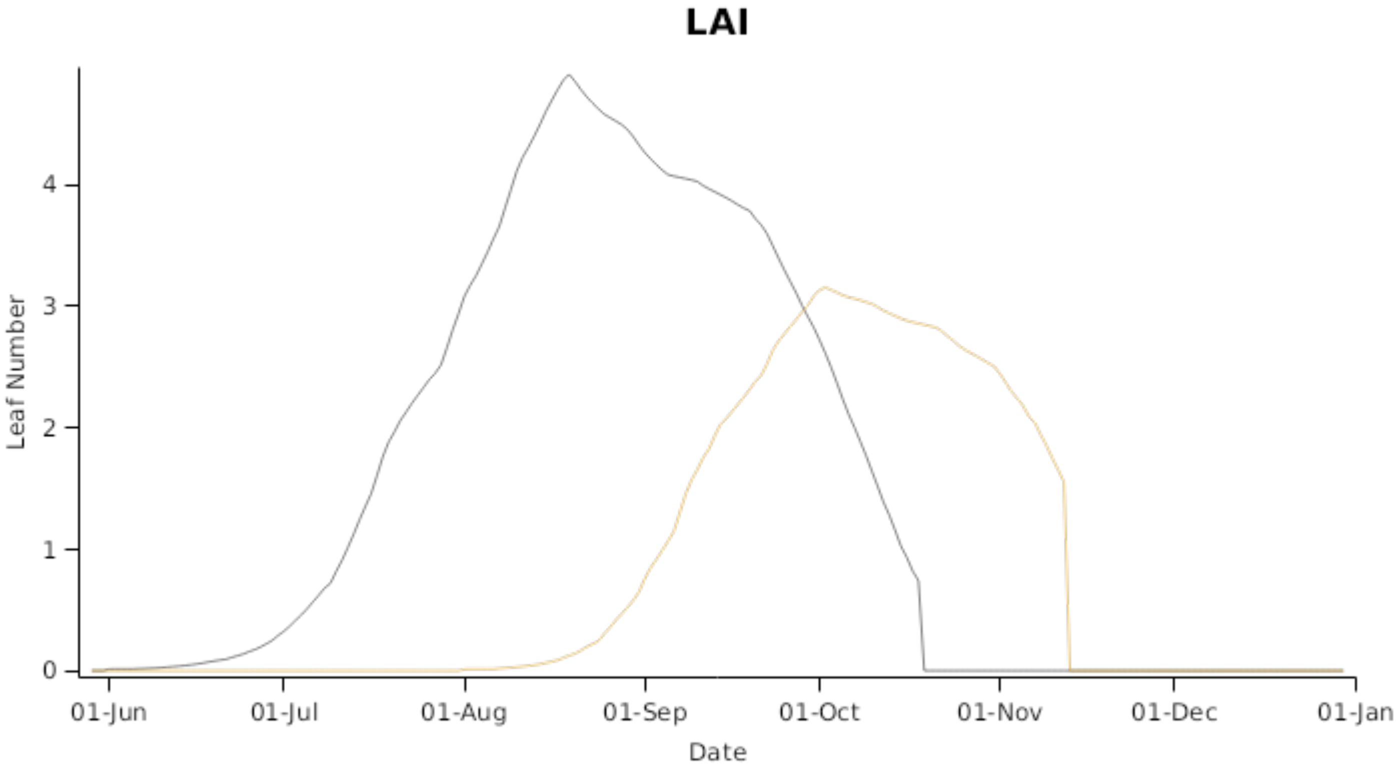

Biomass
1500
1000
500
Regression line
1:1 line
200
400
600
800
1000
1200
1400

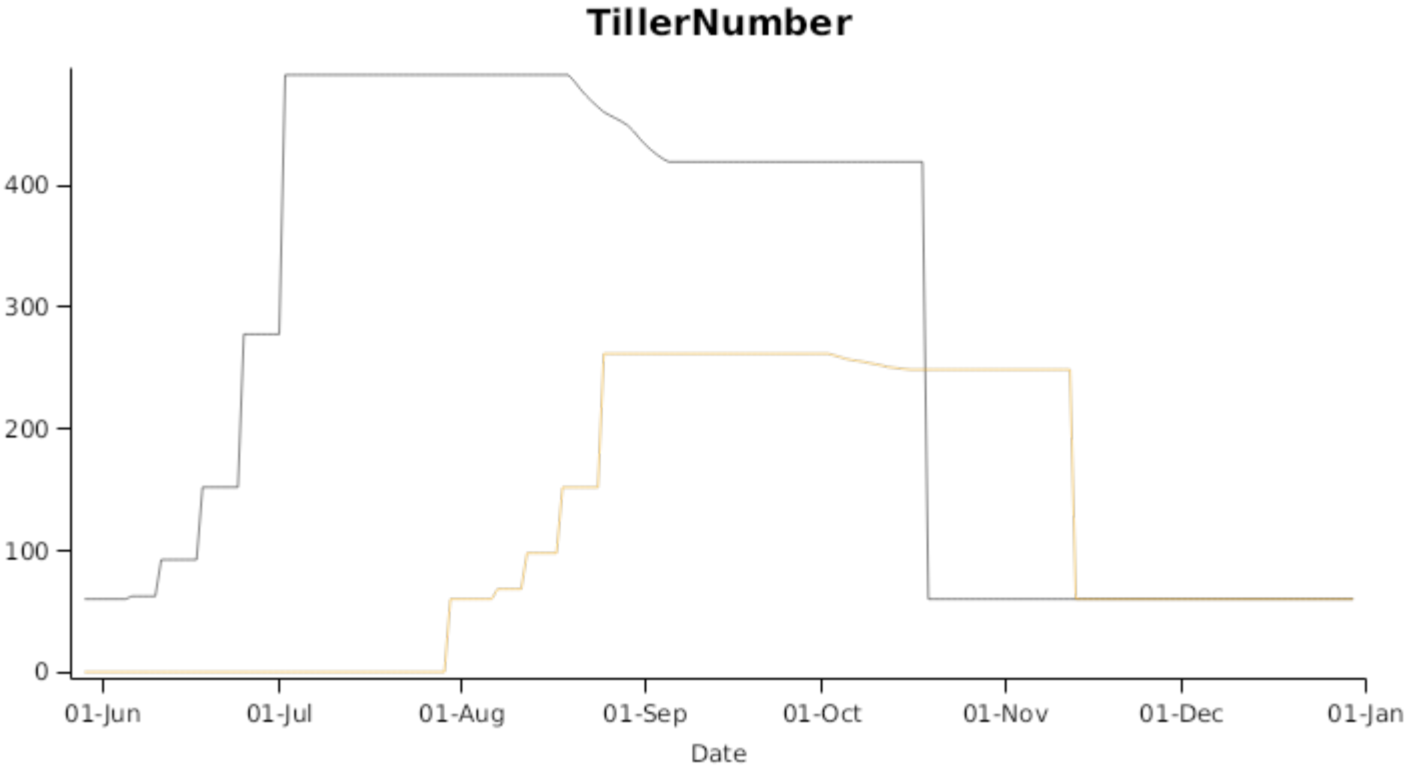


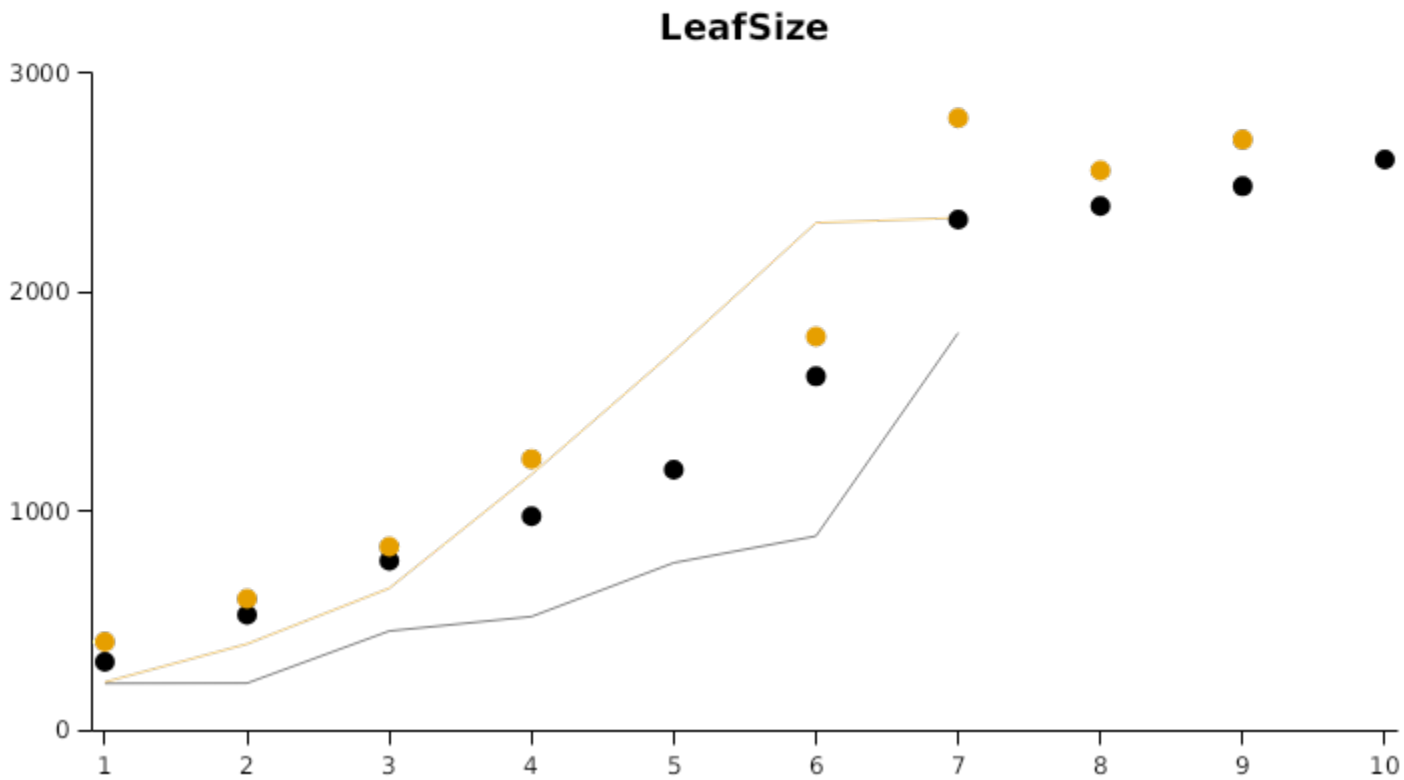
3.2.4 APS2

This simple experiment was conducted to investigate the impact of time of sowing on canopy development and growth of wheat. Wheat (cv. Hartog) was sown at Gatton on 30th of May and 30th of July in 1991. Data were collected on canopy development, biomass accumulation and yield.



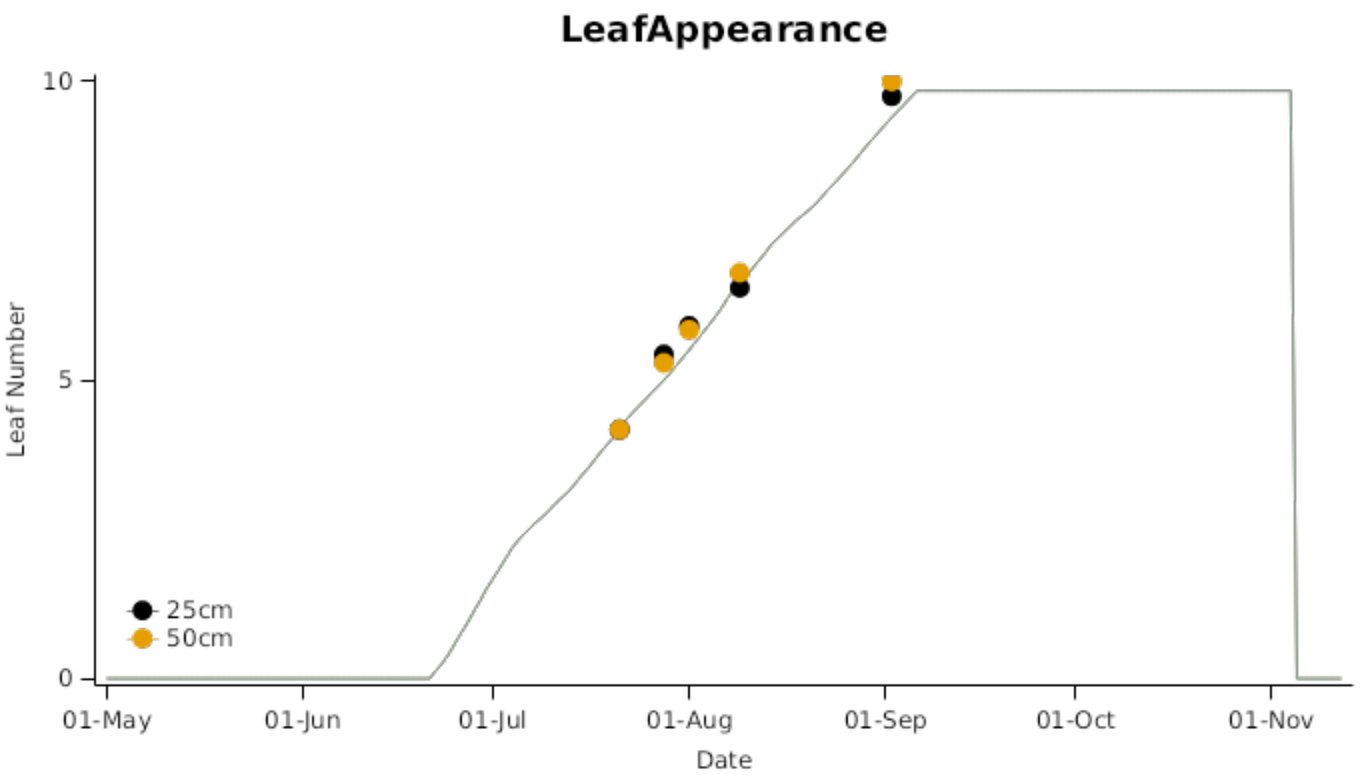

LAI
Leaf Number
0
1
2
3
4
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
Date

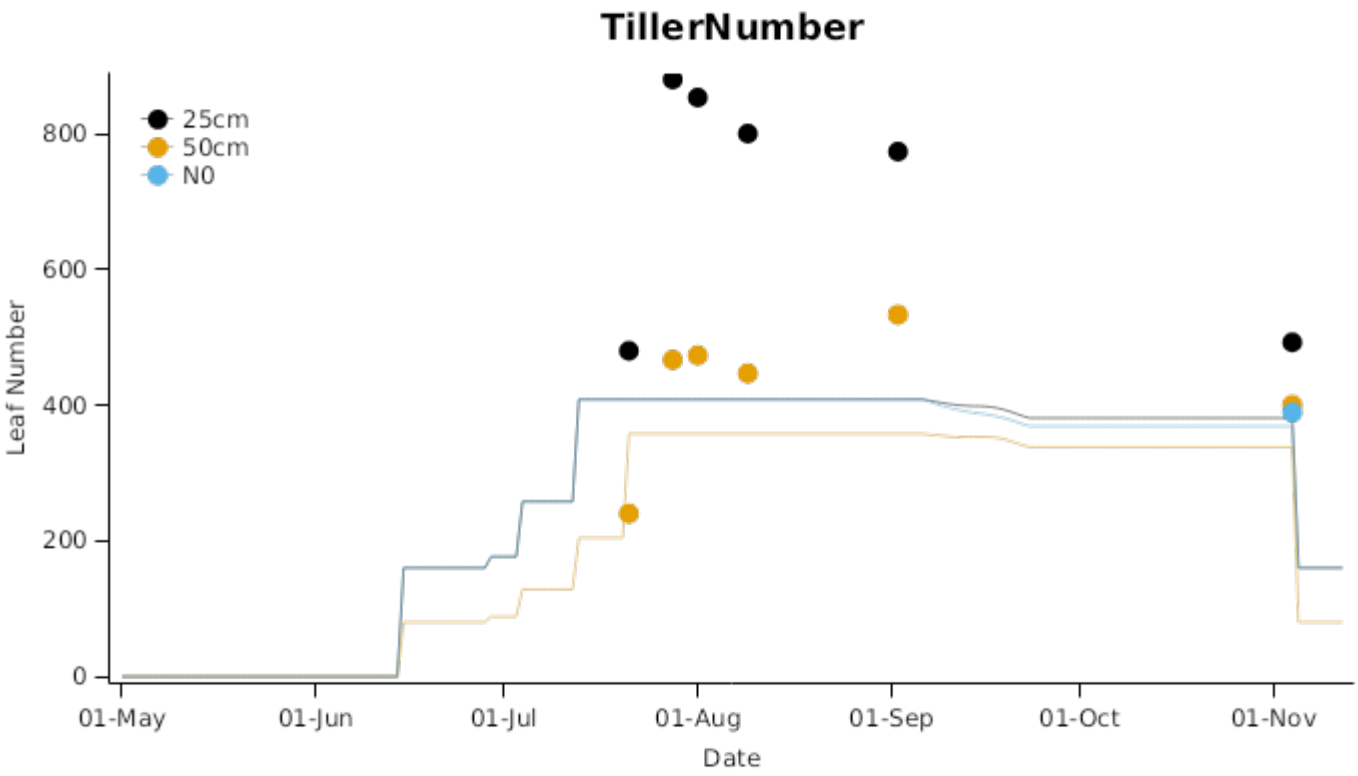

TillerNumber
0
100
200
300
400
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
Date

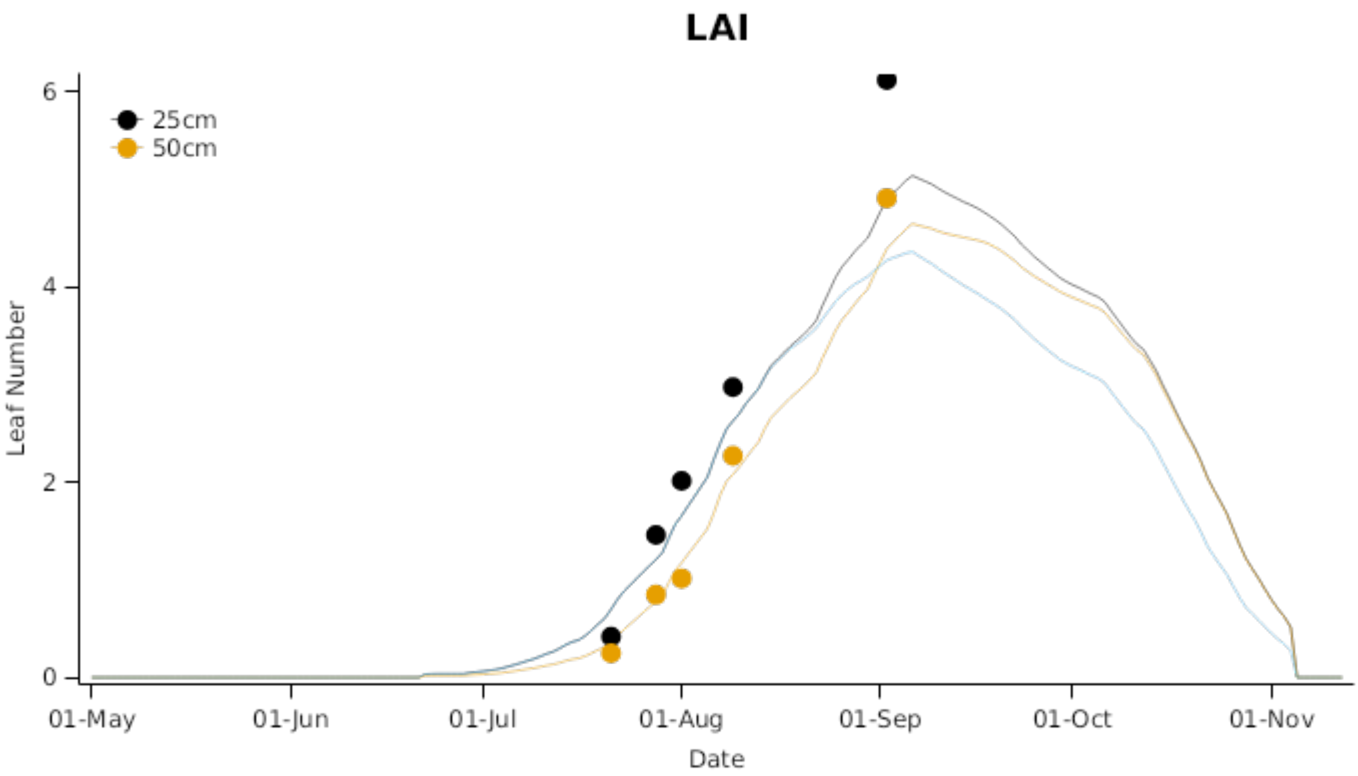


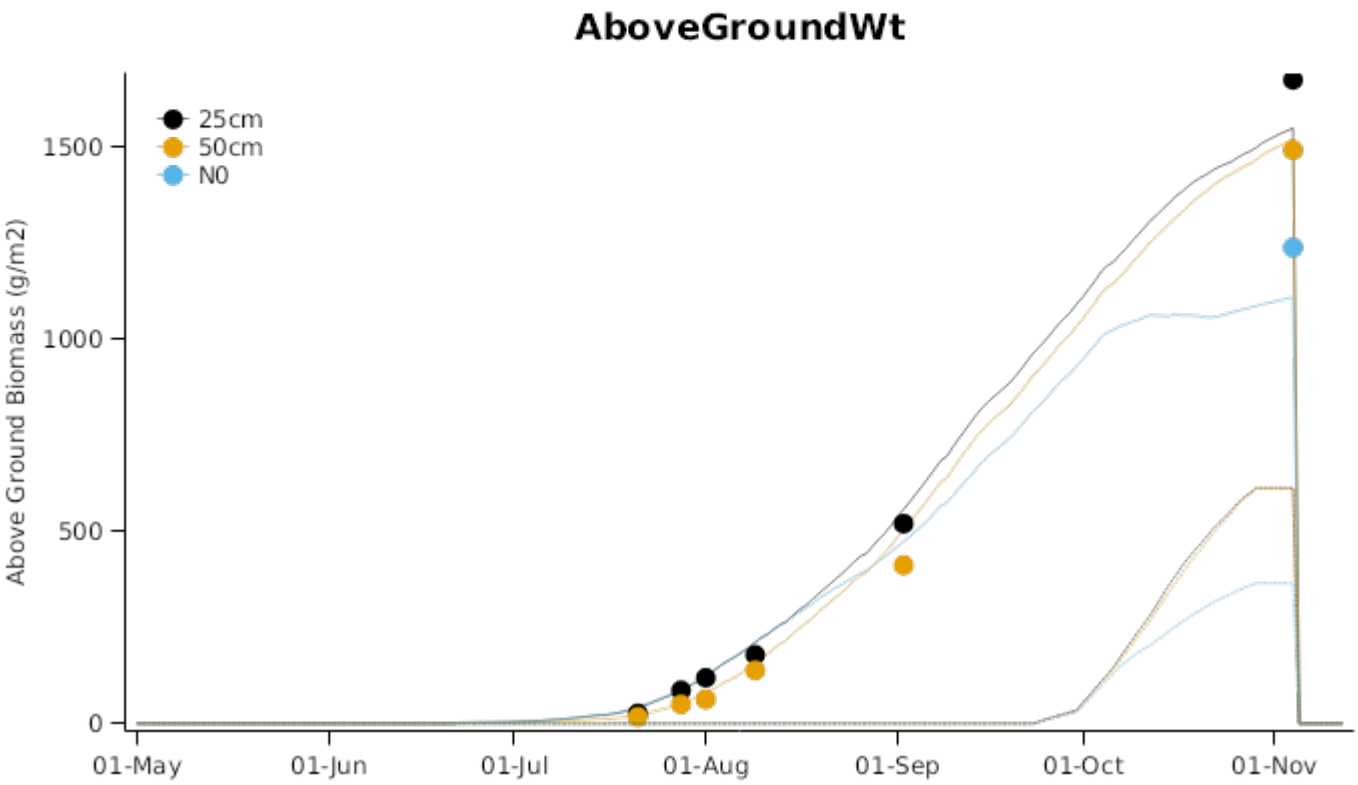
3.2.5 GattonRowSpacing

This simple experiment was conducted to investigate the light interception and subsequent growth of wheat under different populations invoked using row spacing. Wheat was sown at Gatton on 15th of June 2011 at 25cm row spacing. Soon after emergence, alternate rows were removed from selected plots to produce half populations at 50cm row spacing. A zero N treatment was used to identfy the inherent fertility of the site to assist in model parameterisation. Data were collected on light interception, canopy development, biomass accumulation and yield.



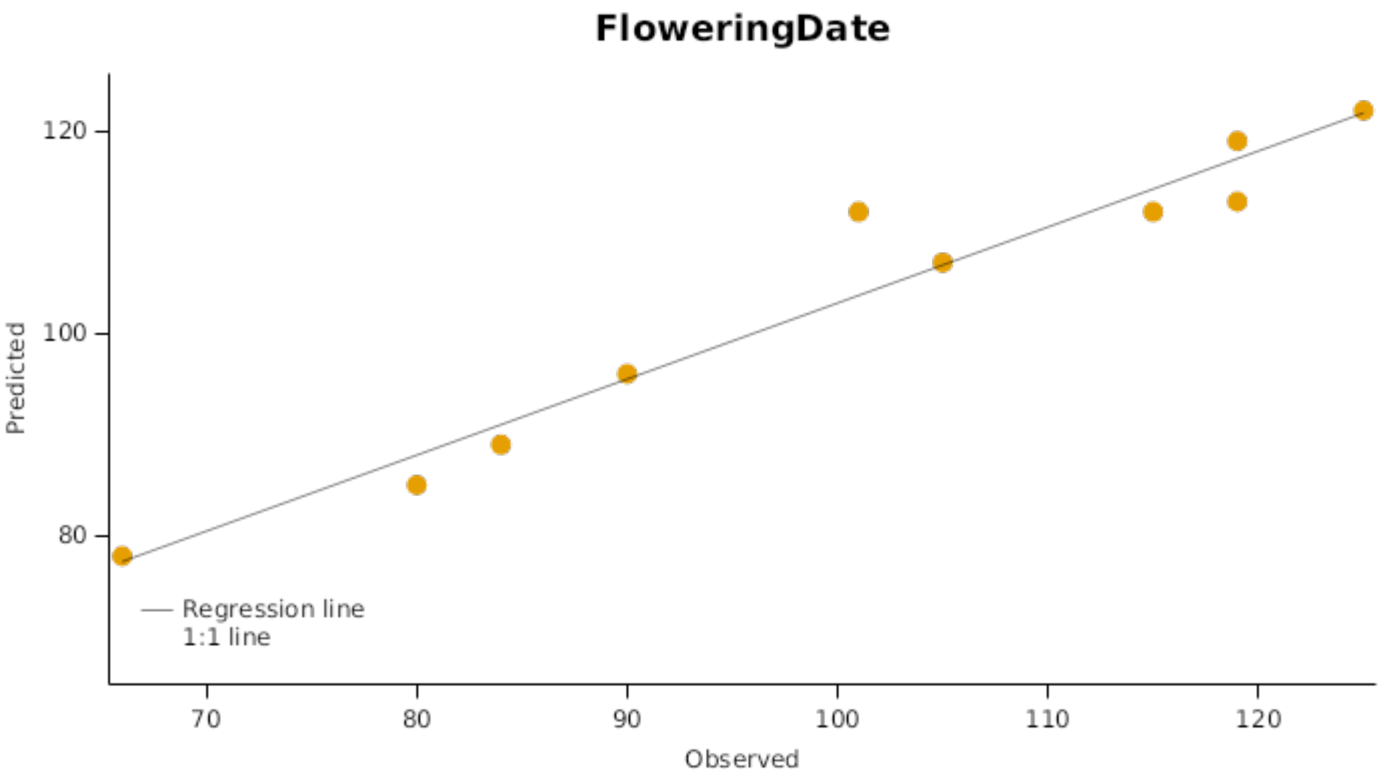

TillerNumber
25cm
50cm
N0
Leaf Number
800
600
400
200
0
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
Date

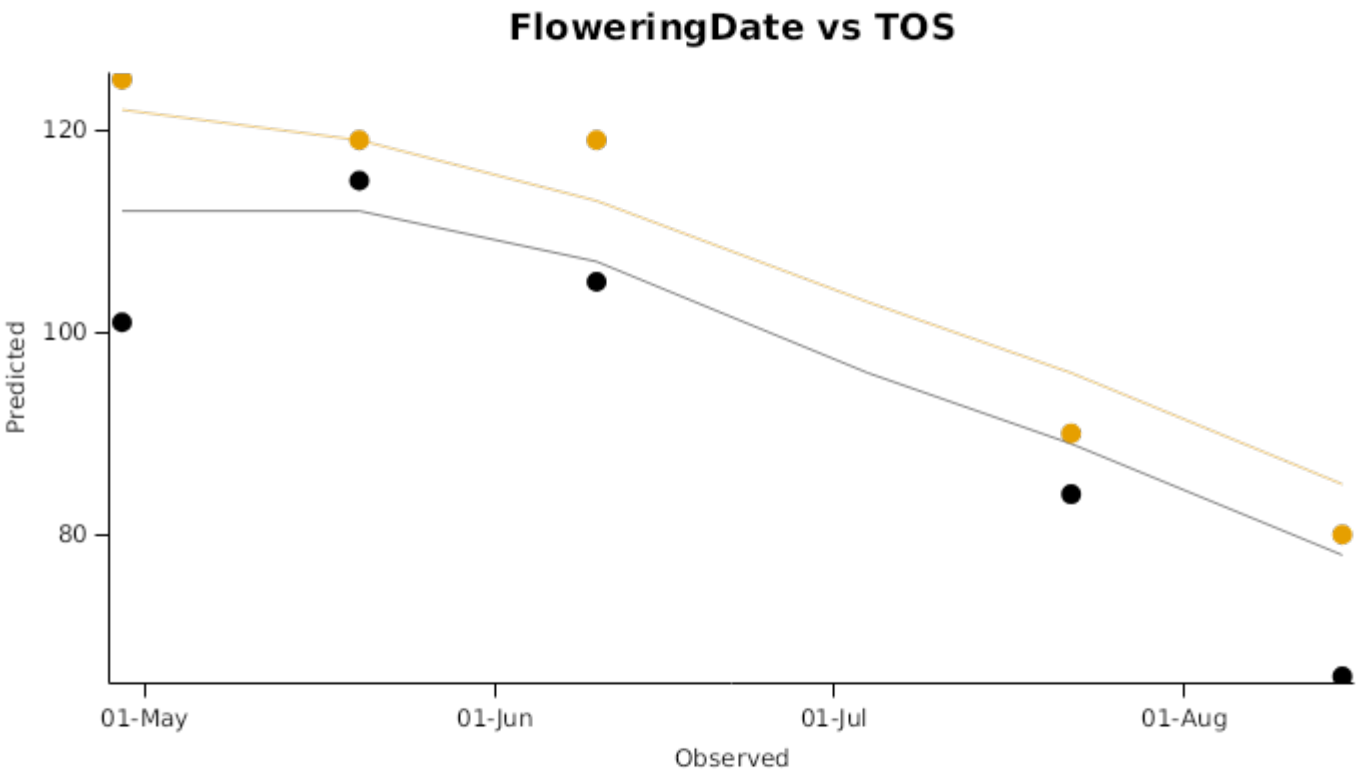

LAI
25cm
50cm
Leaf Number
6
4
2
0
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
Date



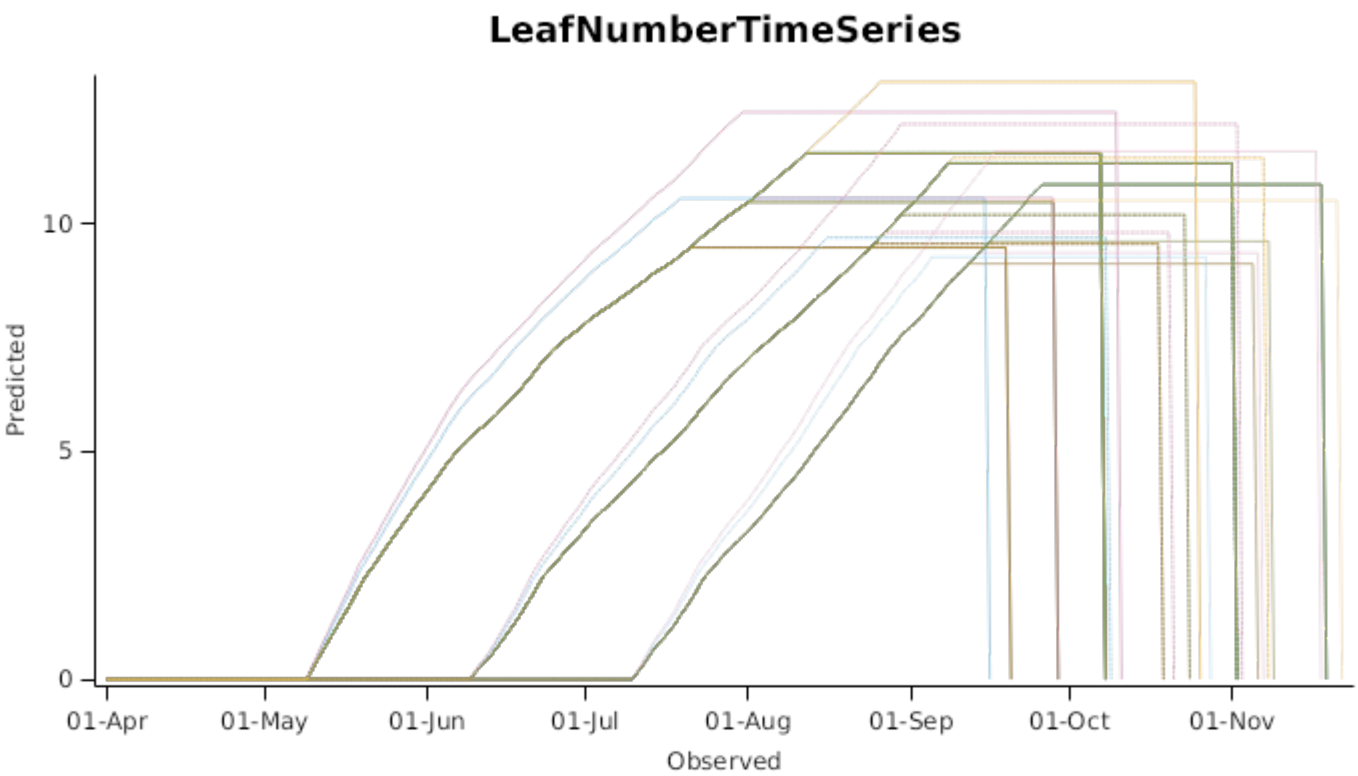
3.2.6 Gatton94

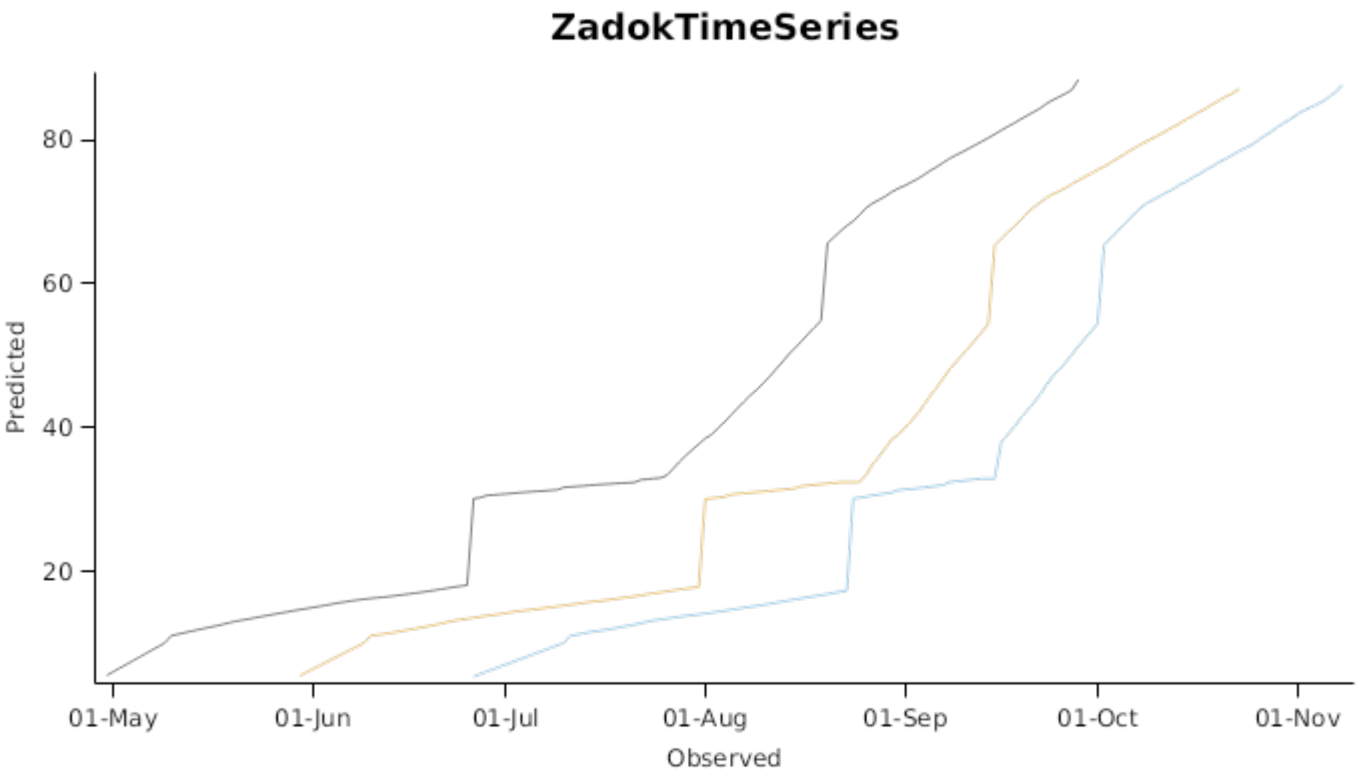
This simple experiment was conducted to investigate the impact of time of sowing on wheat. Wheat (cv. Hartog and Batavia) was sown at Gatton on six dates during 1994. Various data were collected. However final growth data was compromised by mouse damage. The dataset is used here to study the impact of sowing time on phenological development.



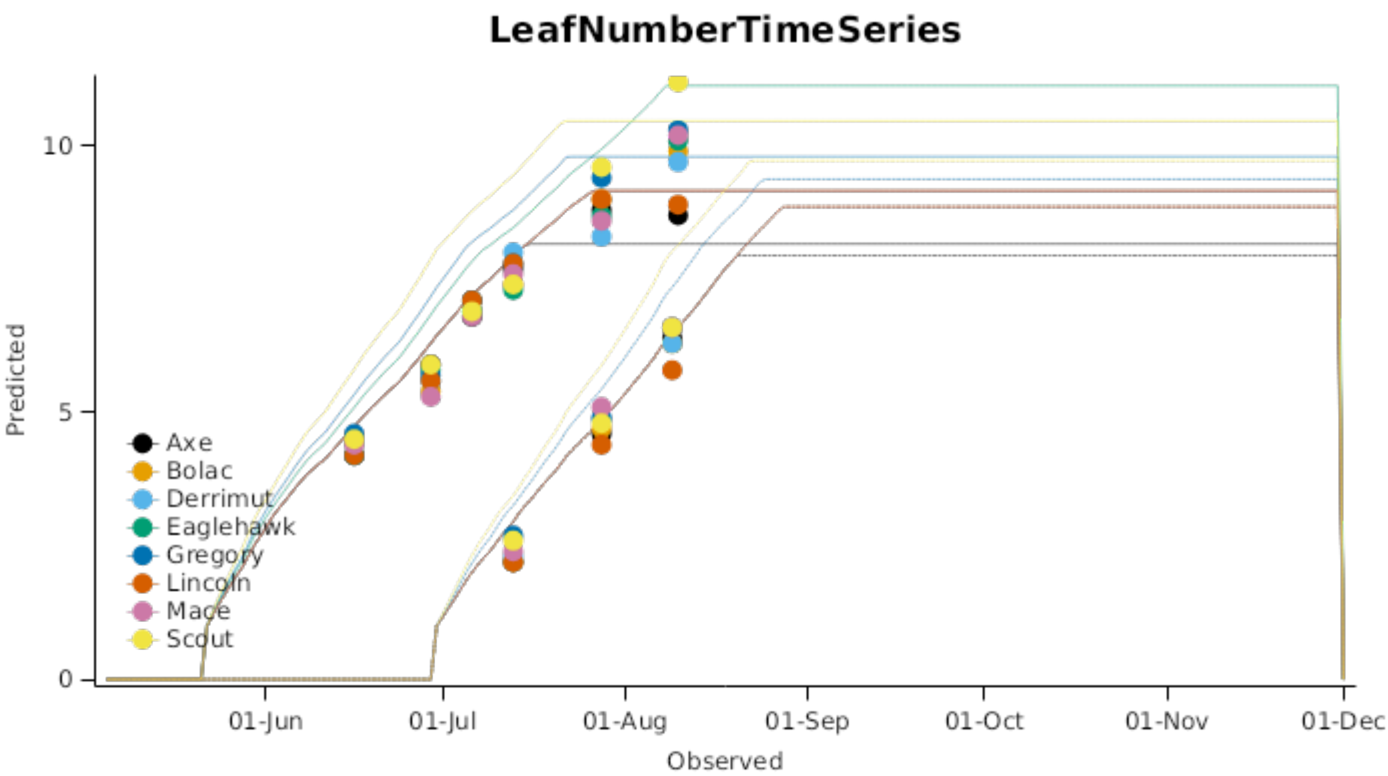


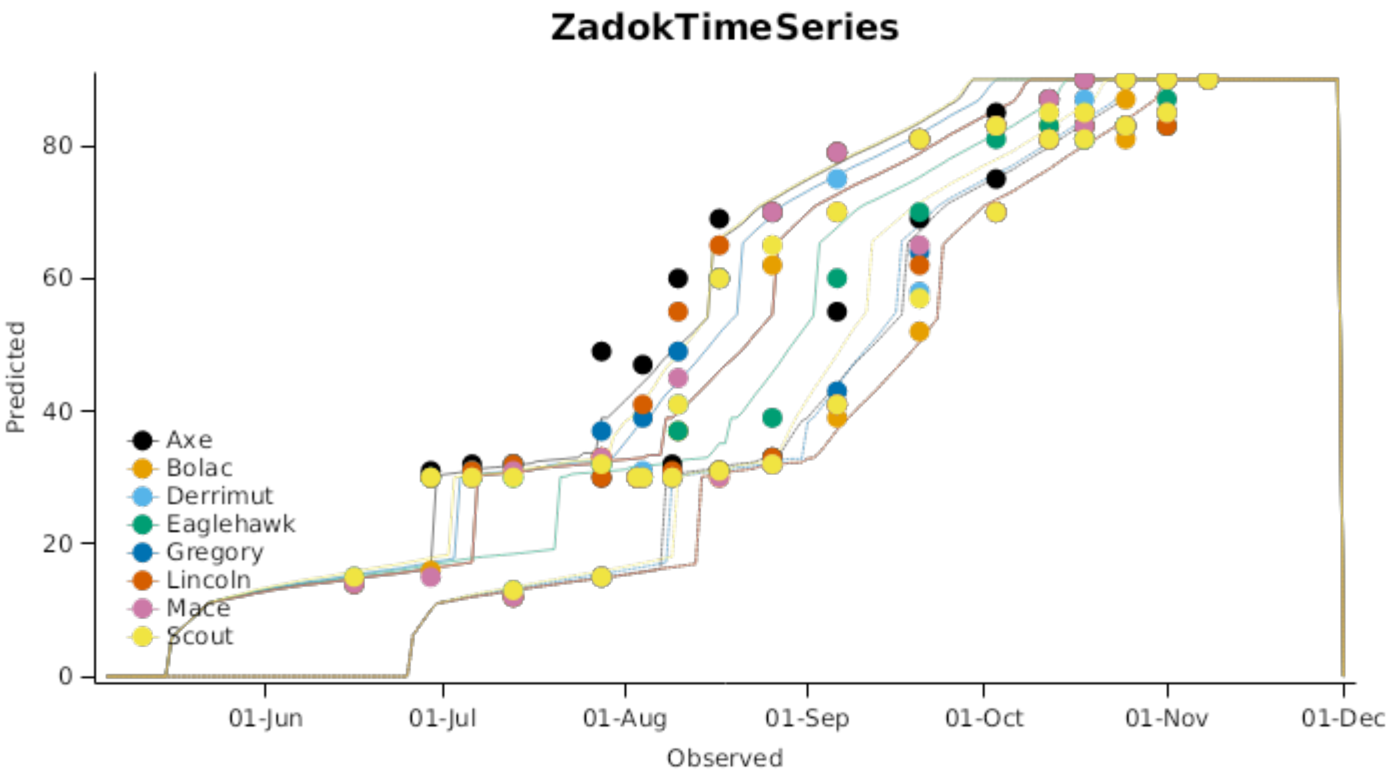
3.2.7 Gatton2009

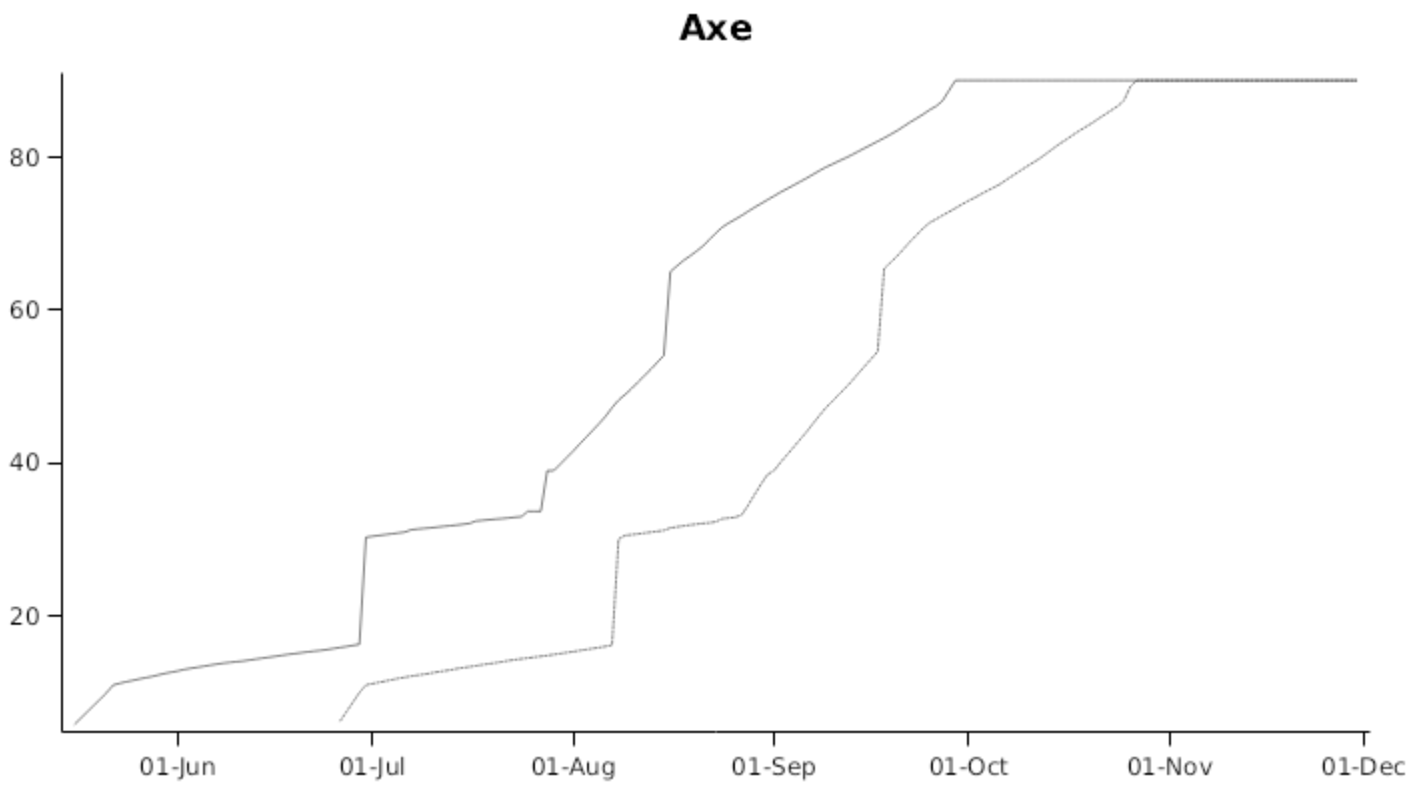


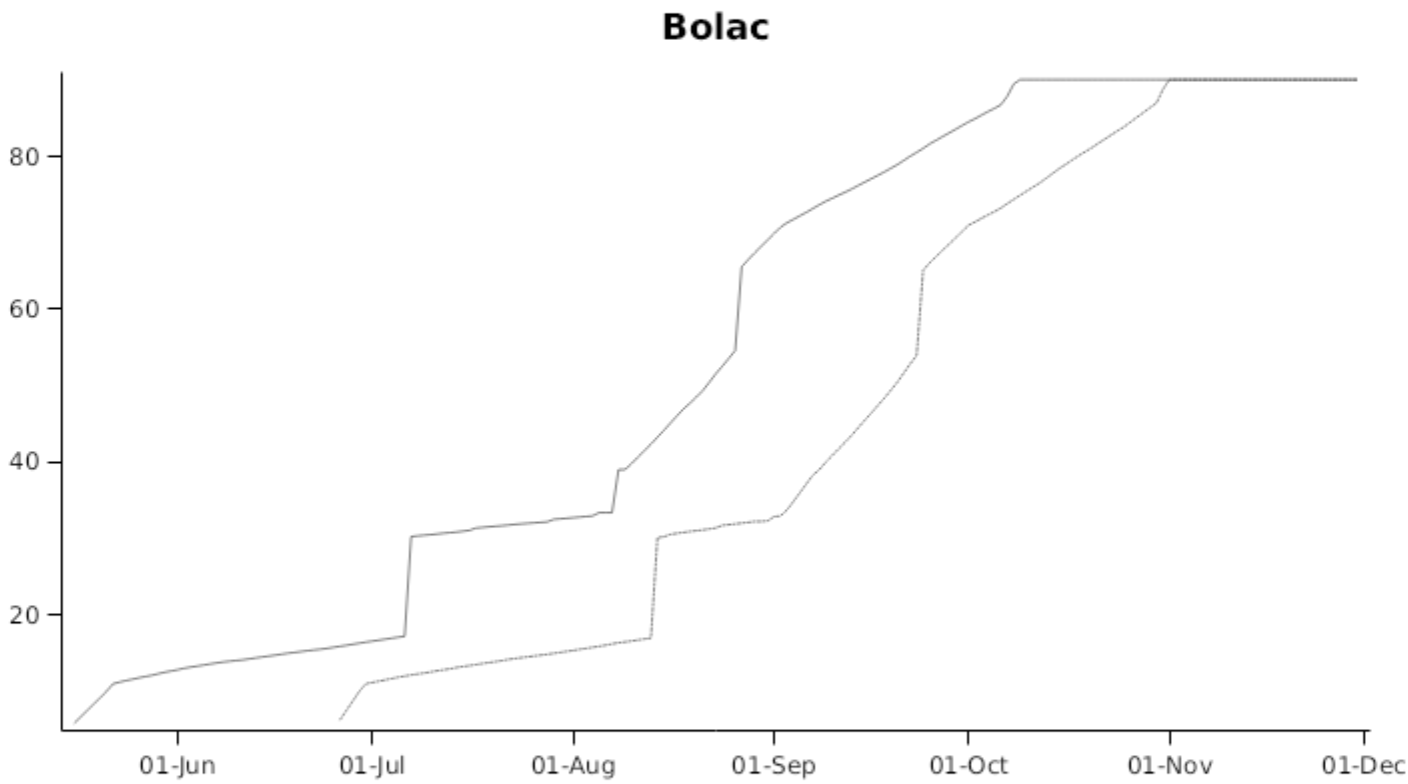


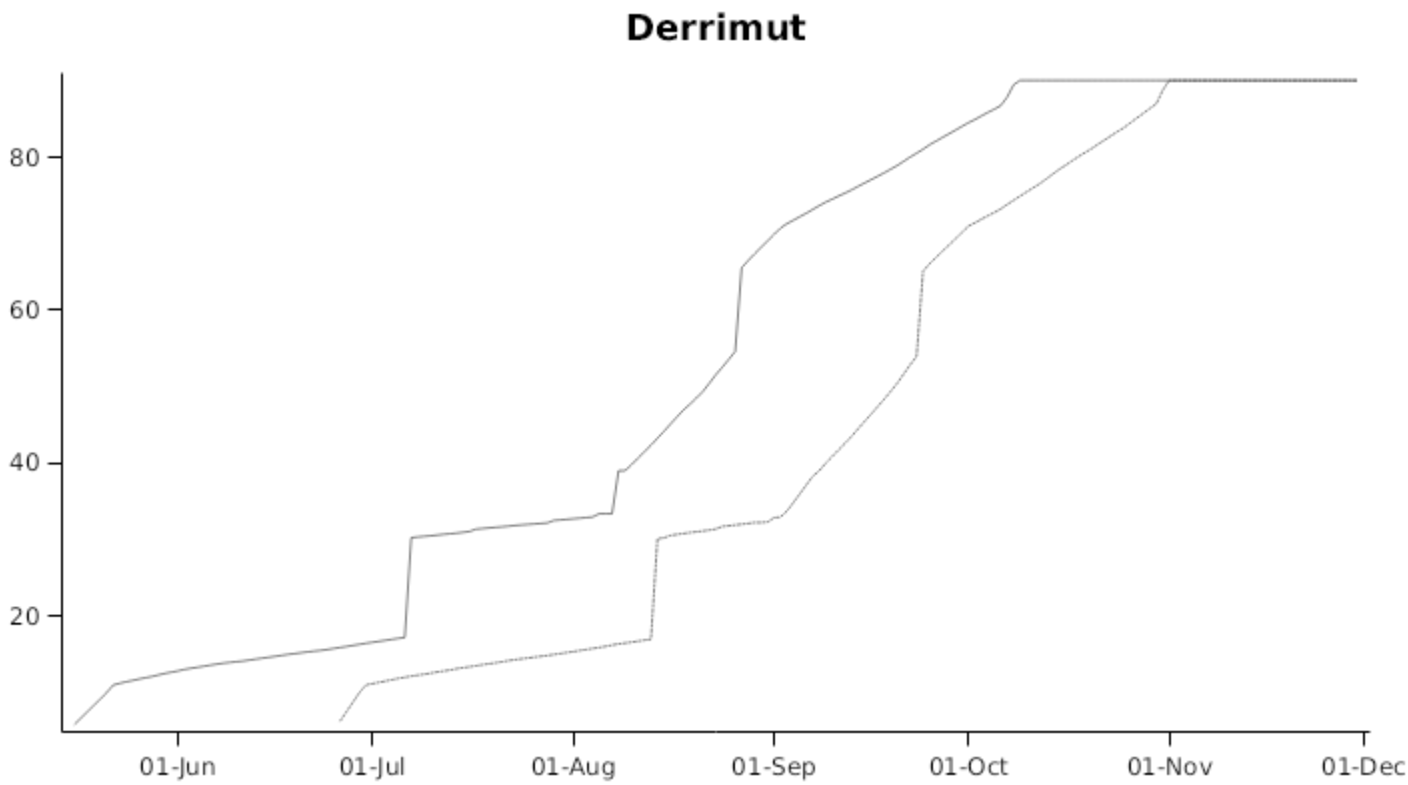
3.2.8 Gatton2011



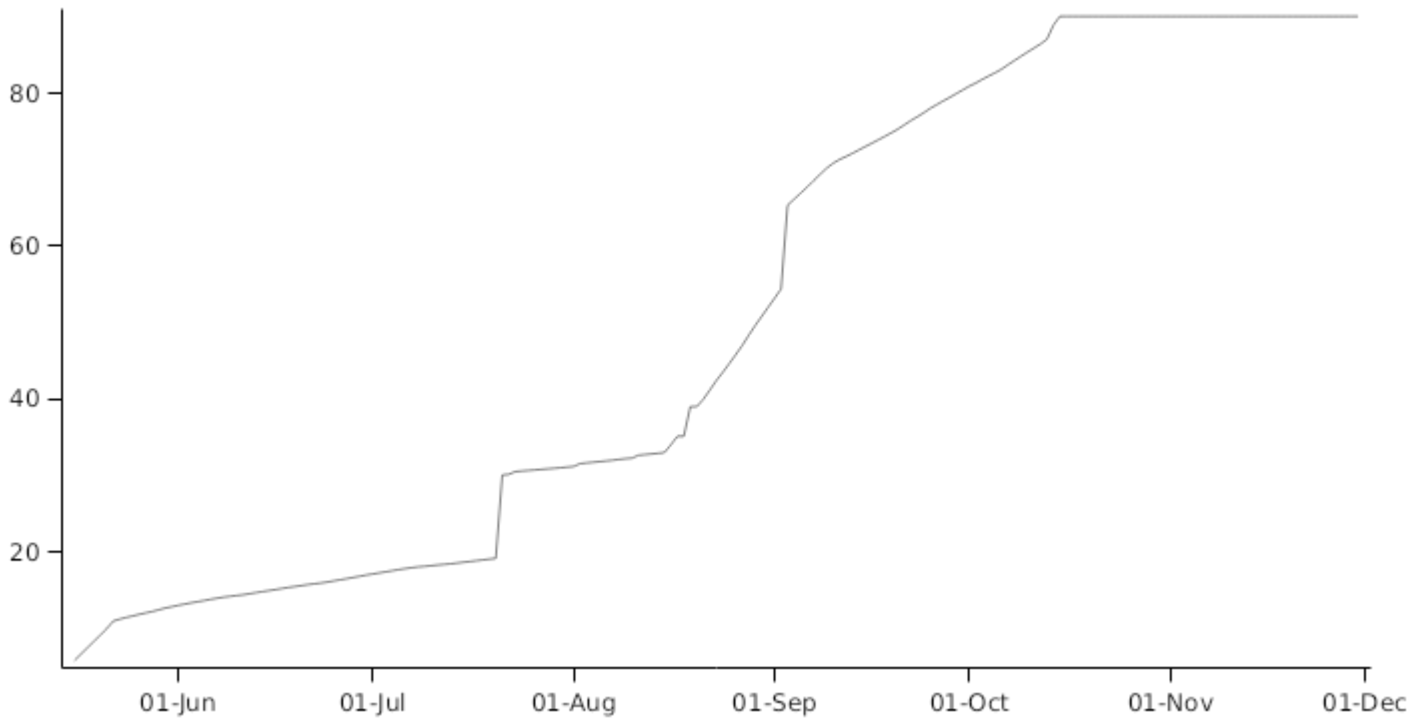

ZadokTimeSeries
Predicted
Observed
0
20
40
60
80
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Axe
Bolac
Derrimut
Eaglehawk
Gregory
Lincoln
Mace
Scout


Axe
20
40
60
80
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

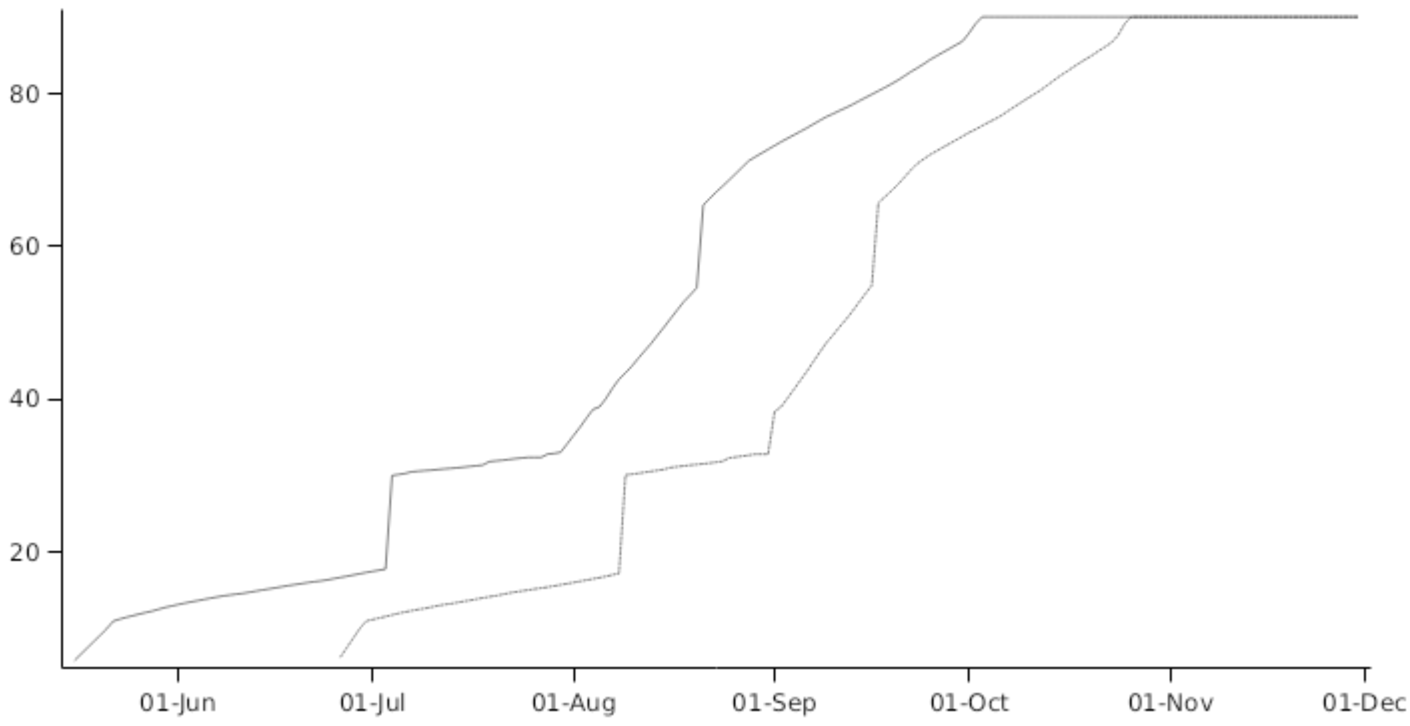

Bolac
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


Derrimut
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

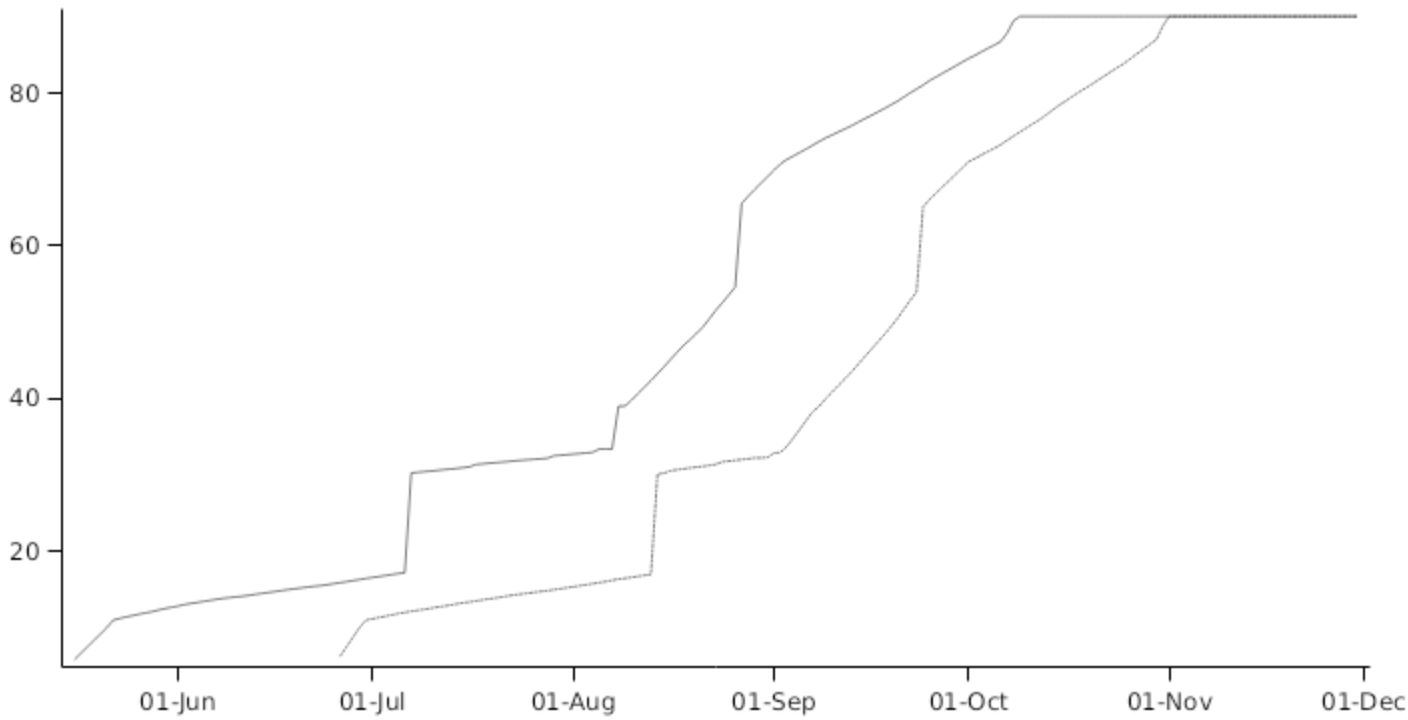
EagleHawk



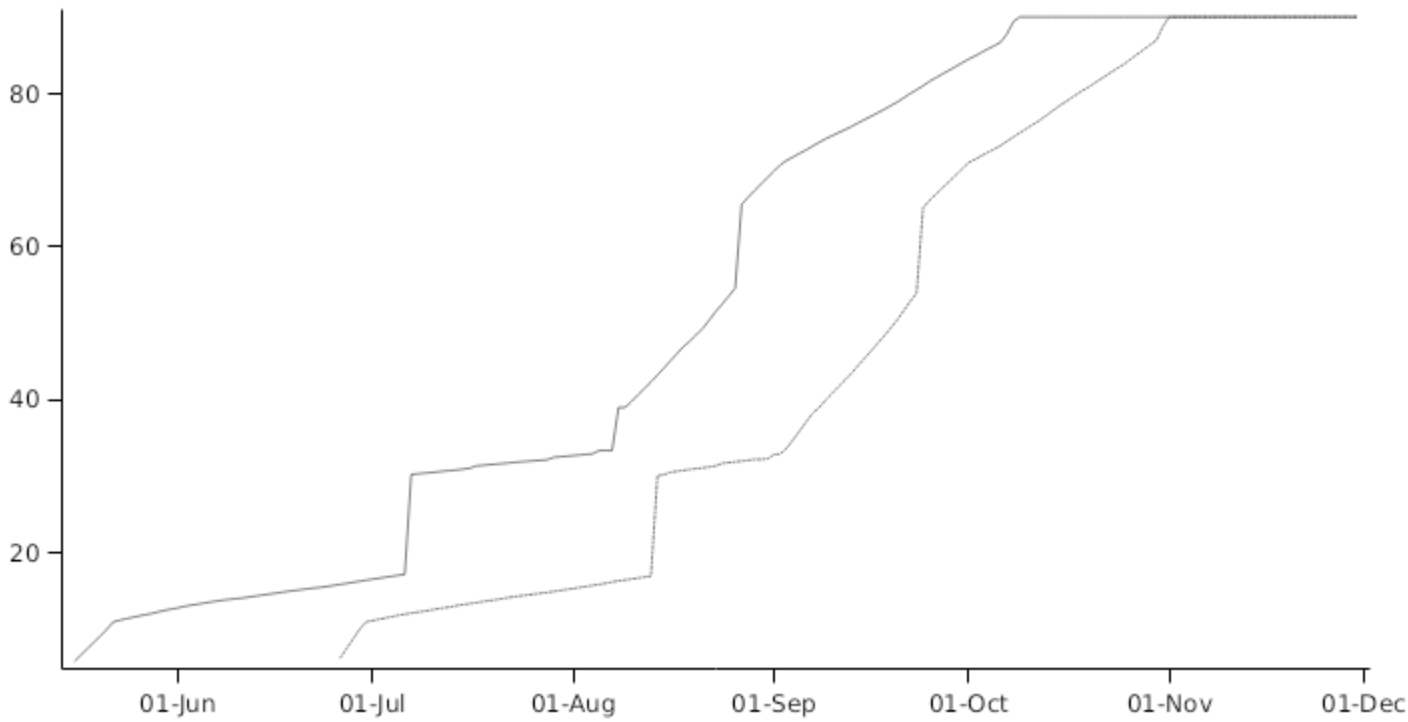
Gregory

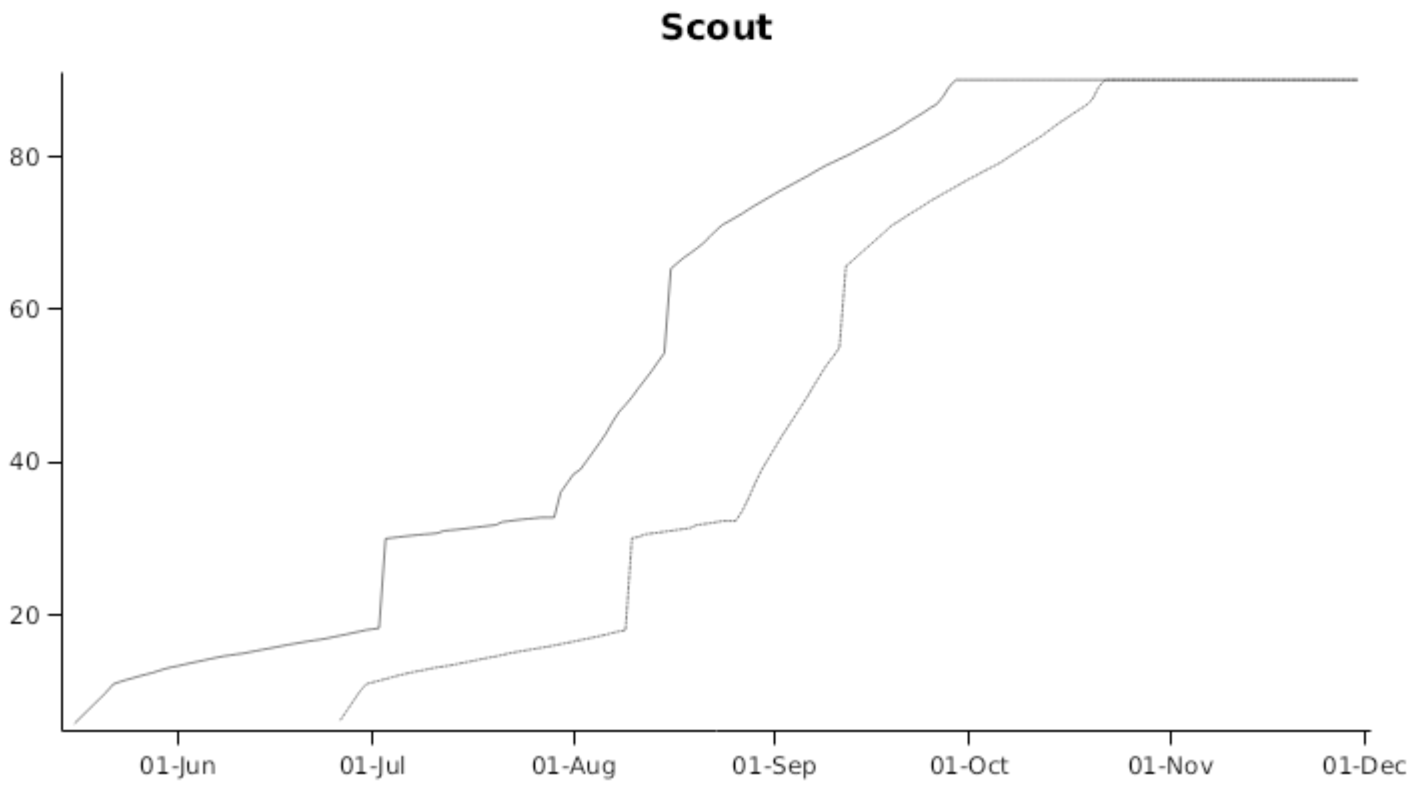


Mace

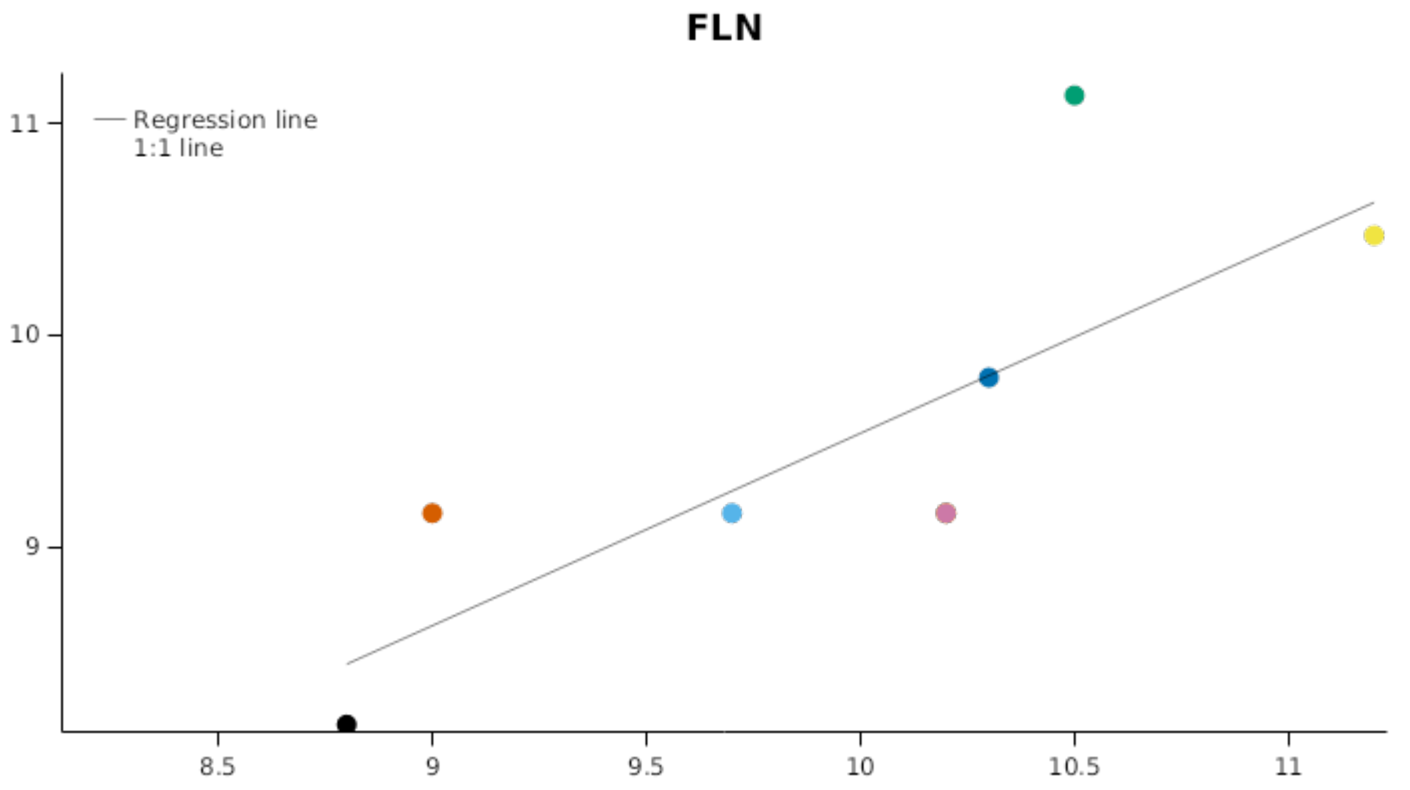


Lincoln





Scout
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

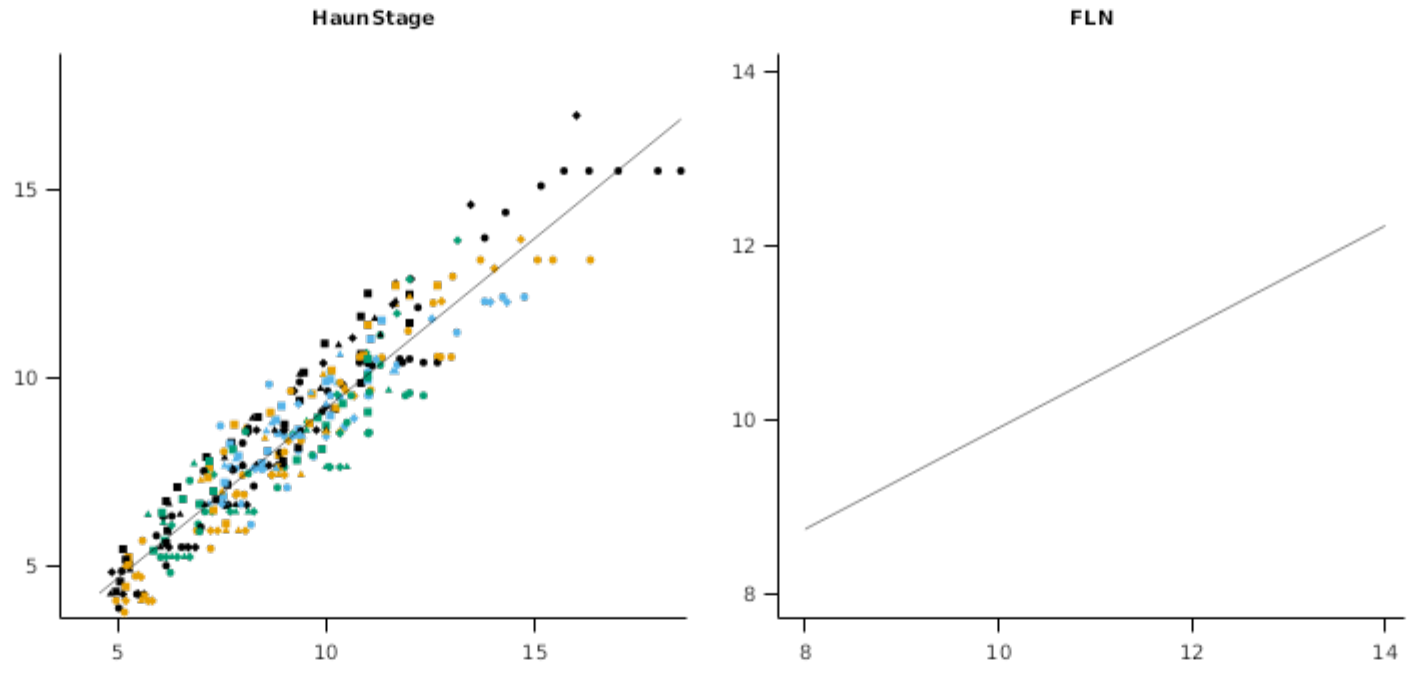


FLN
Regression line
1:1 line
11
10
9
8.5
9
9.5
10
10.5
11

ZadokTimeSeries1

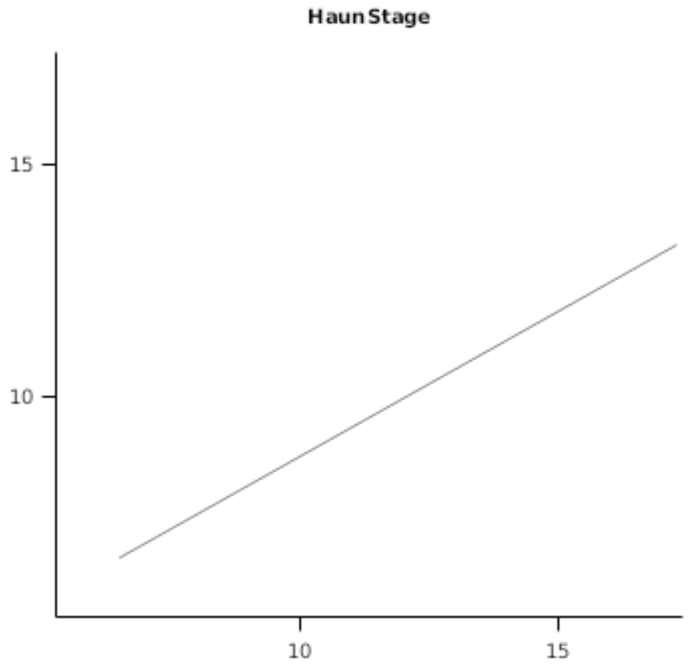
3.2.9 Gatton2014

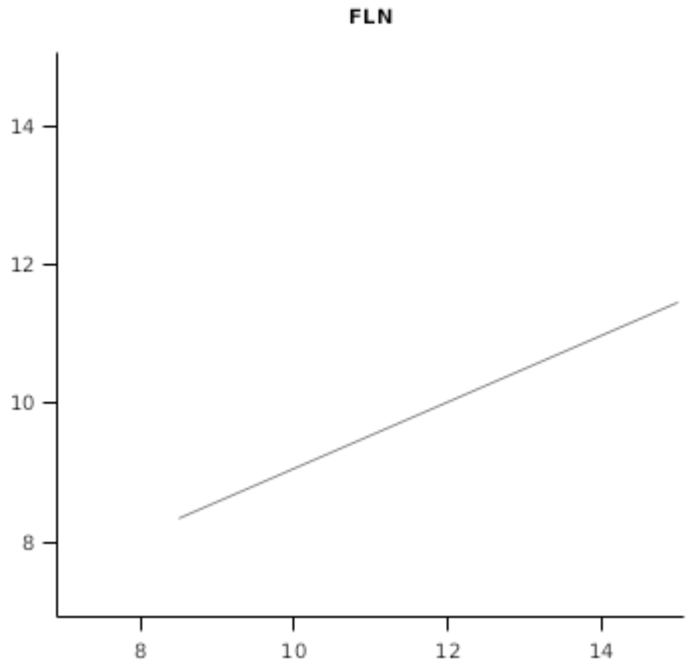
3.2.9.1 PredObs



3.2.10 Gatton2014AE

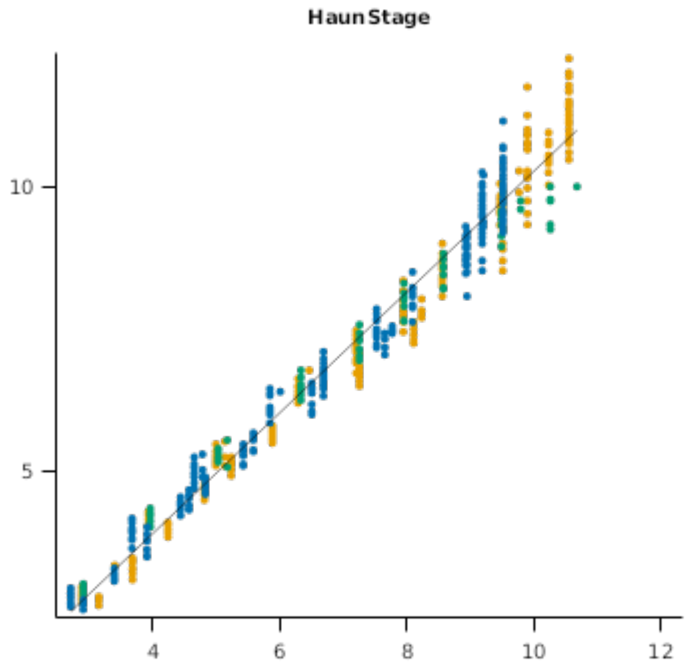
3.2.10.1 PredObs





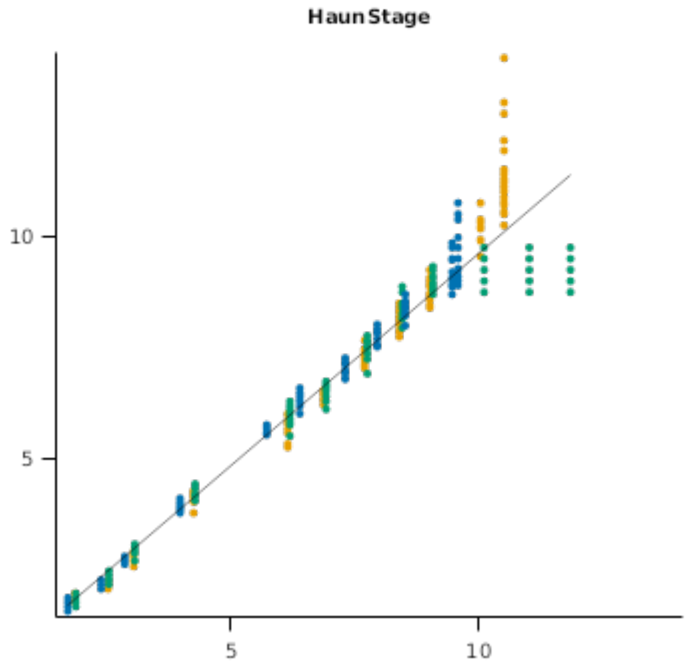
3.2.11 TraitMod2015

3.2.11.1 PredObs



3.2.12 TraitMod2016

3.2.12.1 PredObs



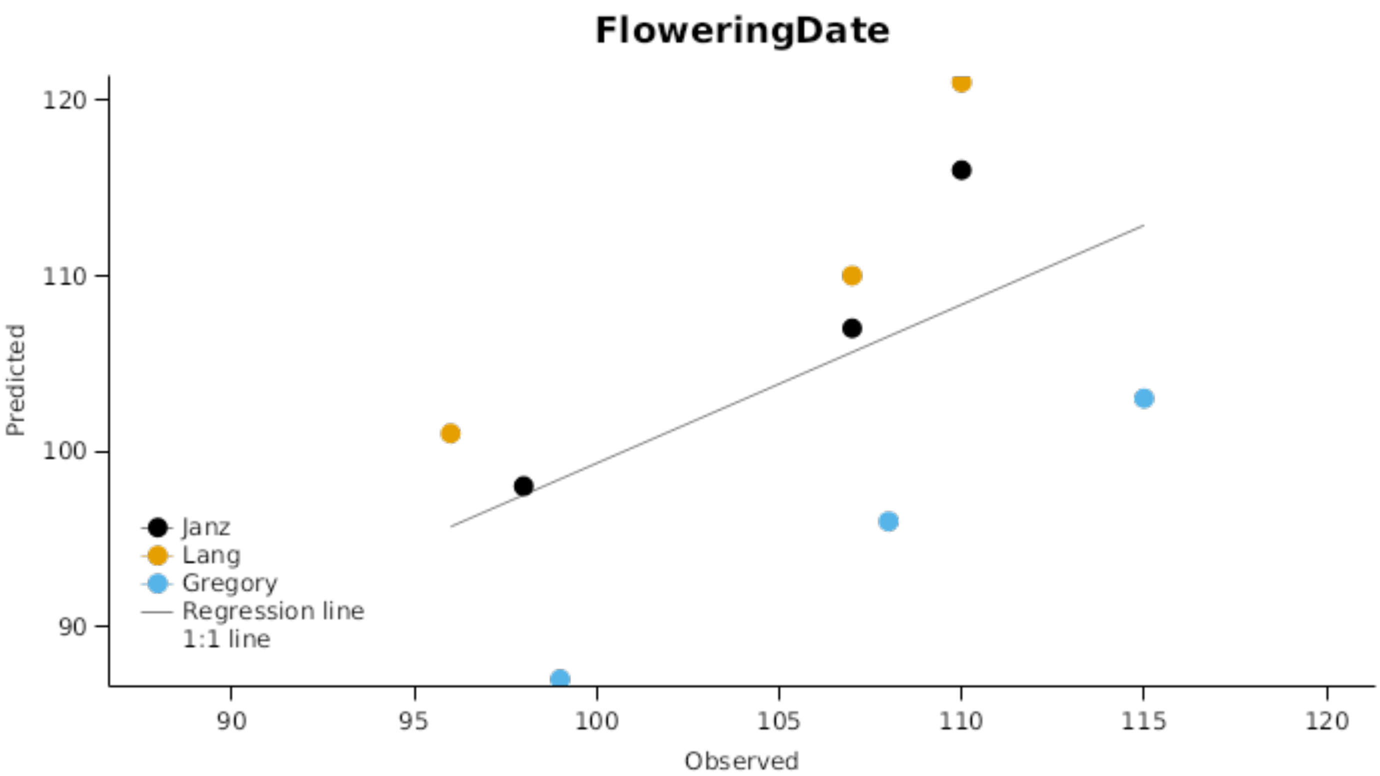
3.2.13 AddingValueToNVT

The "Adding Value to the National Variety Trials" project aimed to use measurement and modelling to explain GeneXEnvironmentXManagement interactions for Australian Wheat cultivars. A description of this national trial can be found in R.A. Lawes et al., 2016. Here we include some of the data from south-eastern Queensland.

List of experiments.

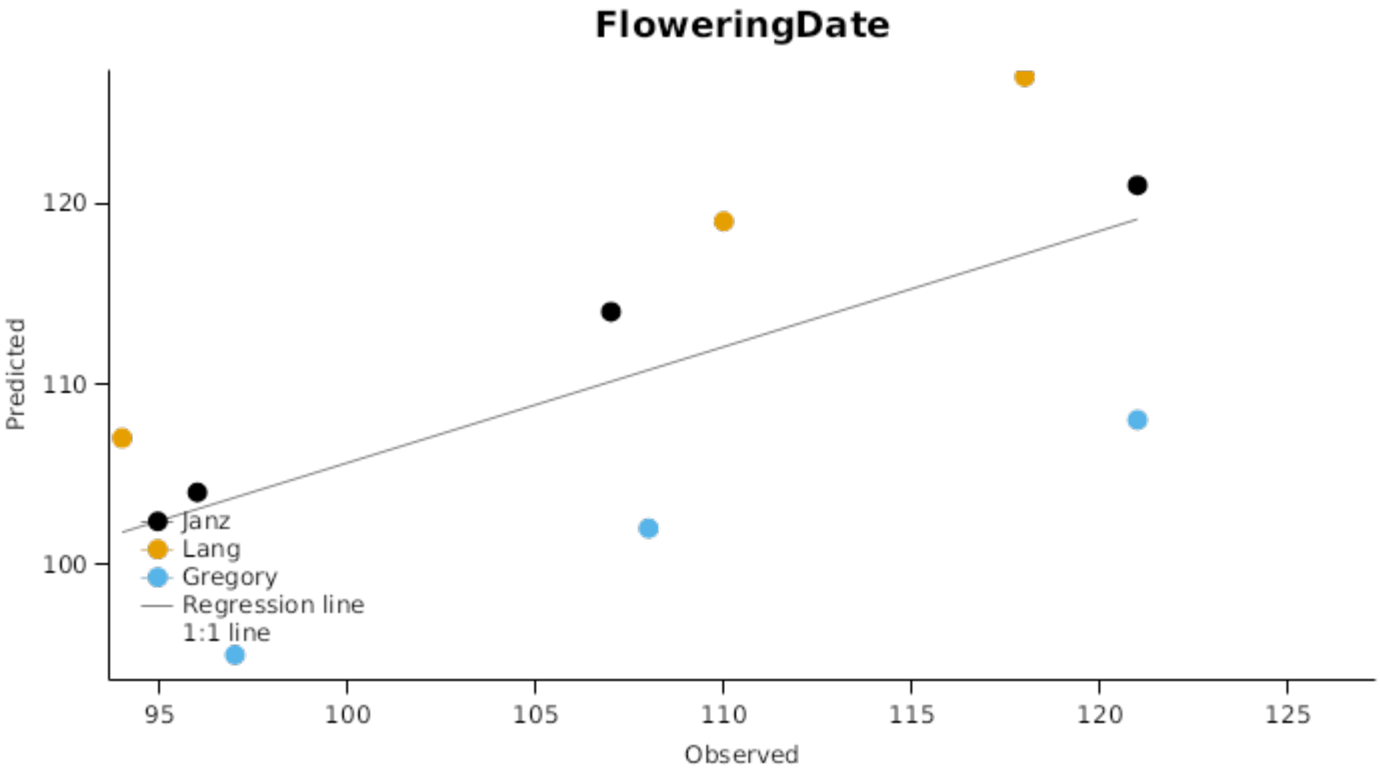
Experiment Name	Design (Number of Treatments)
Goondiwindi2011	Cv x TOS (9)
Nagwee2012	Cv x TOS (9)
Bungunya2012	Cv x TOS (9)

3.2.13.1 Goondiwindi2011



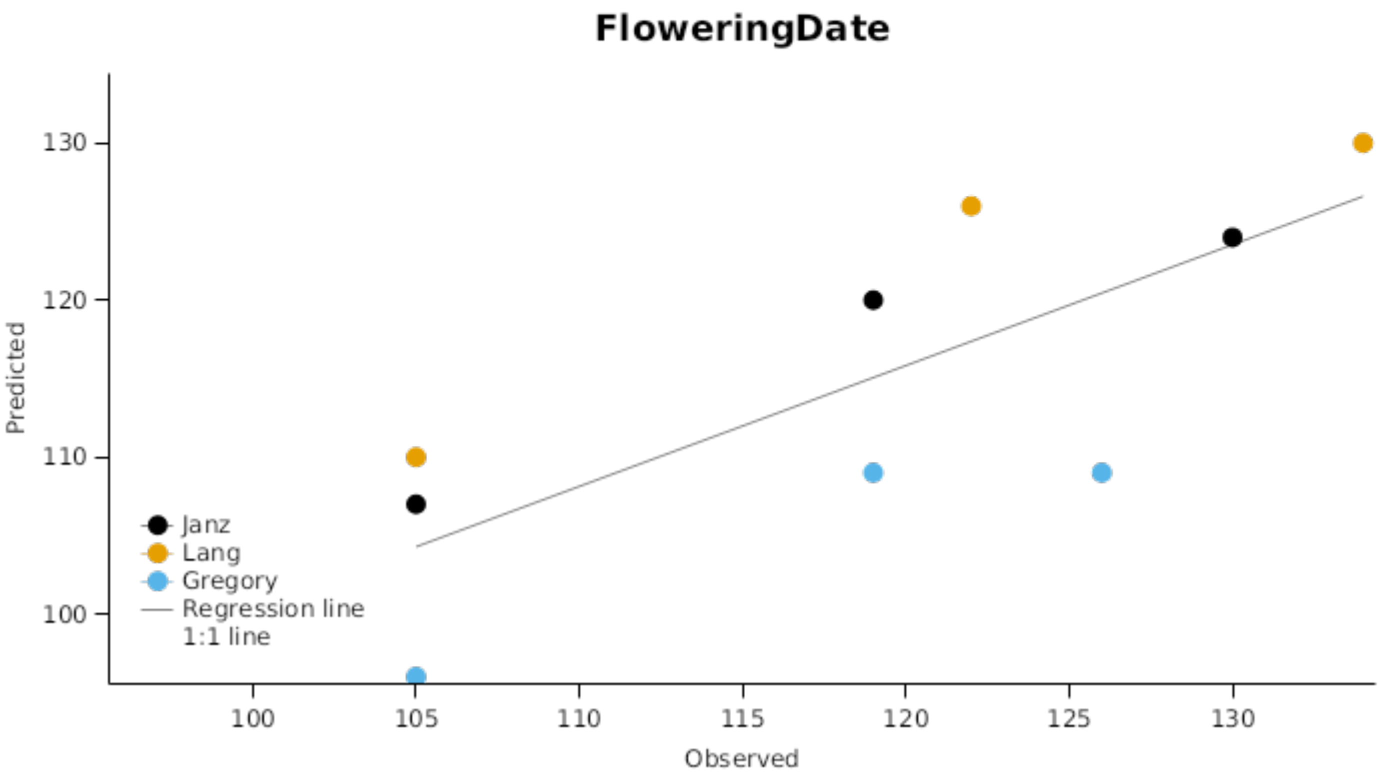
3.2.13.2 Nagwee2012

INSERT TEXT HERE



3.2.13.3 Bungunya2012

INSERT TEXT HERE



3.2.14 Phenology1996

This dataset includes observed heading date for six cultivars (Batavia, Cunningham, Hartog, Janz, Sunbri, Suneca) for a range of locations and planting dates in the northern grain-growing region of Australia.

List of experiments.

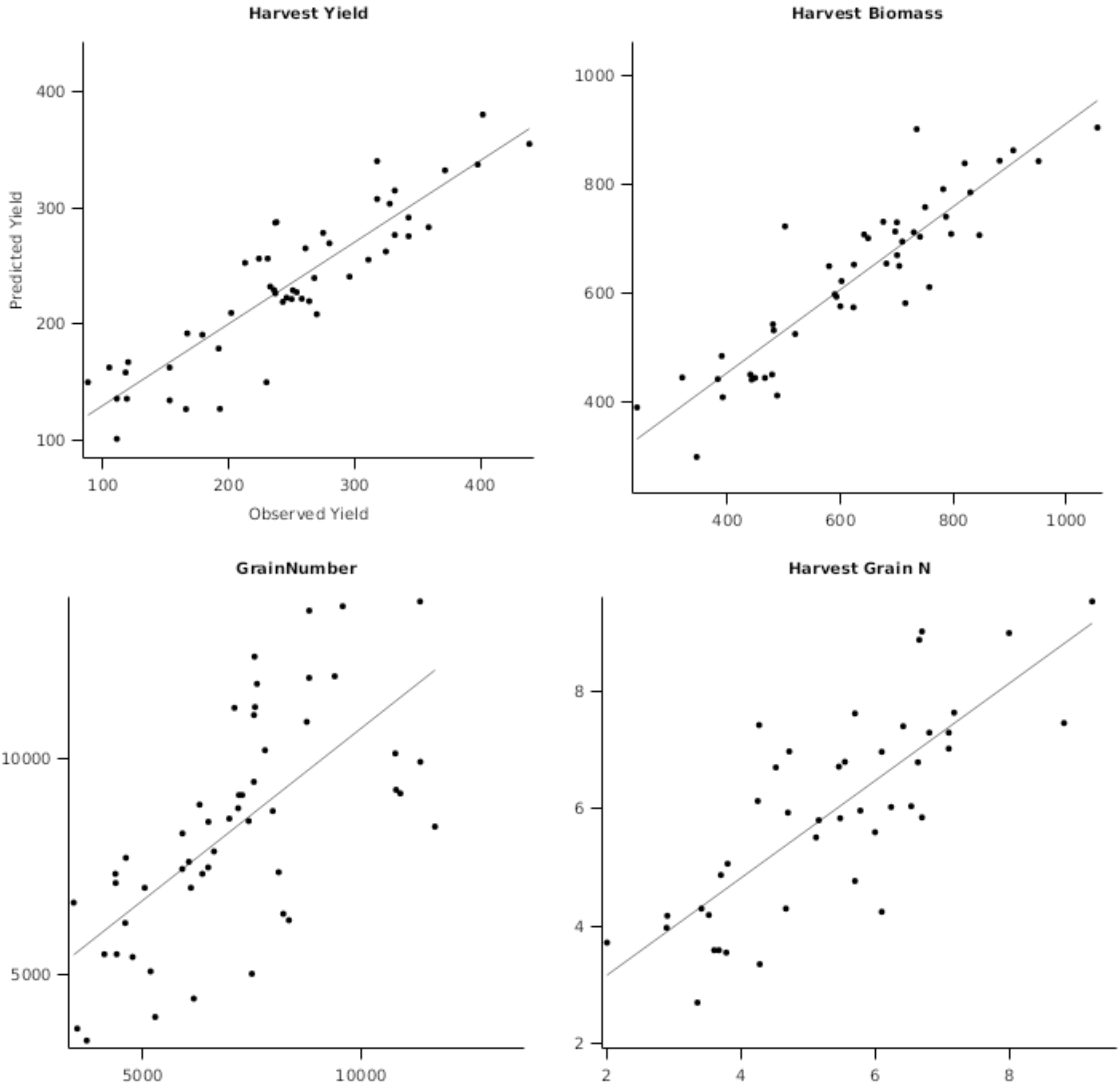
Experiment Name	Design (Number of Treatments)
Goondiwindi1996	Cv x TOS (18)
Miles1996	Cv x TOS (30)
Emerald1996	Cv x TOS (24)
Biloela1996	Cv x TOS (30)
Moree1996	Cv x TOS (18)

3.3 Western Australia

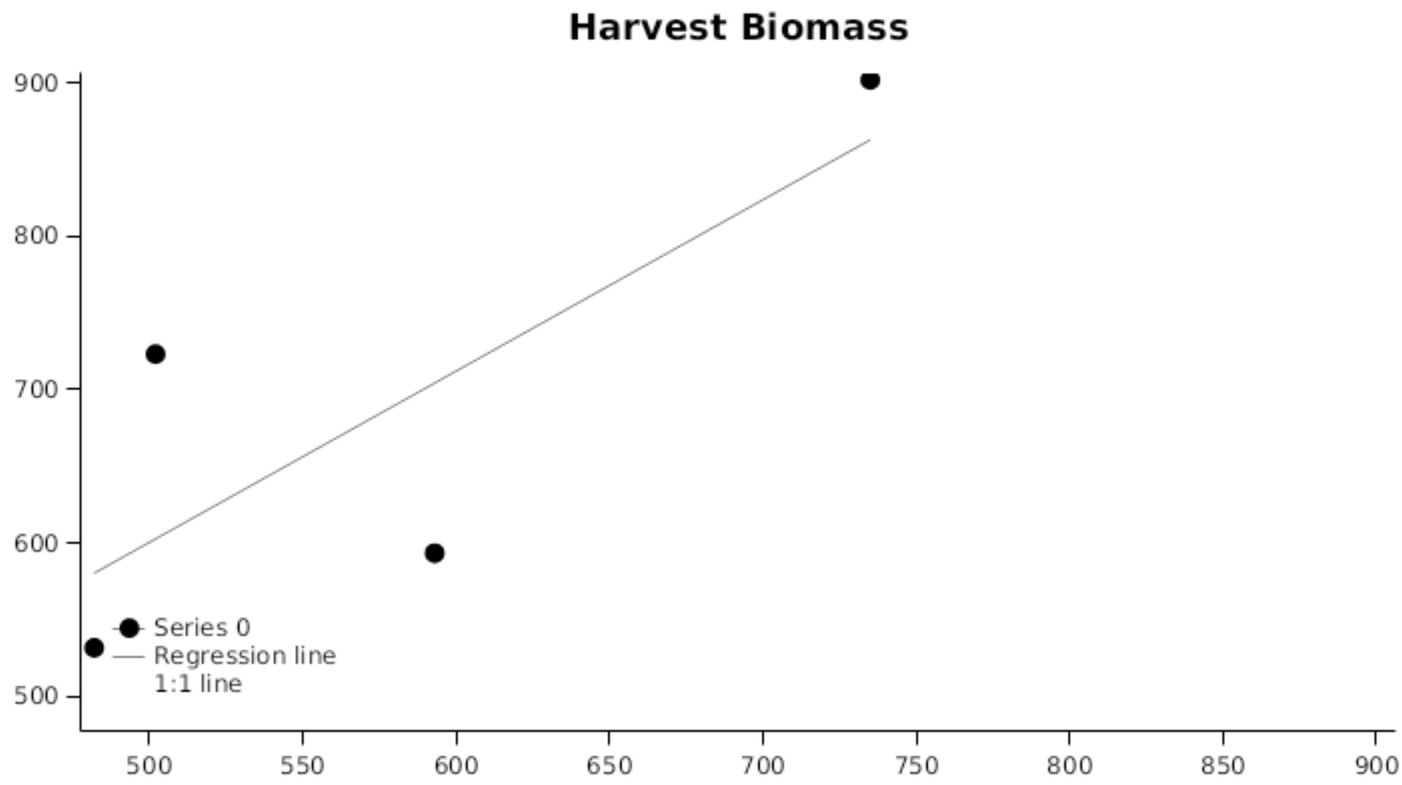
The wheat belt of Western Australia has a Mediteranean climate (winter dominant rainfall patterns) with mostly sandy soils. Data from S Asseng et al., 1998. and some more recent studies have been included to extend the range of conditions studied and to include more modern cultivars.

List of experiments.

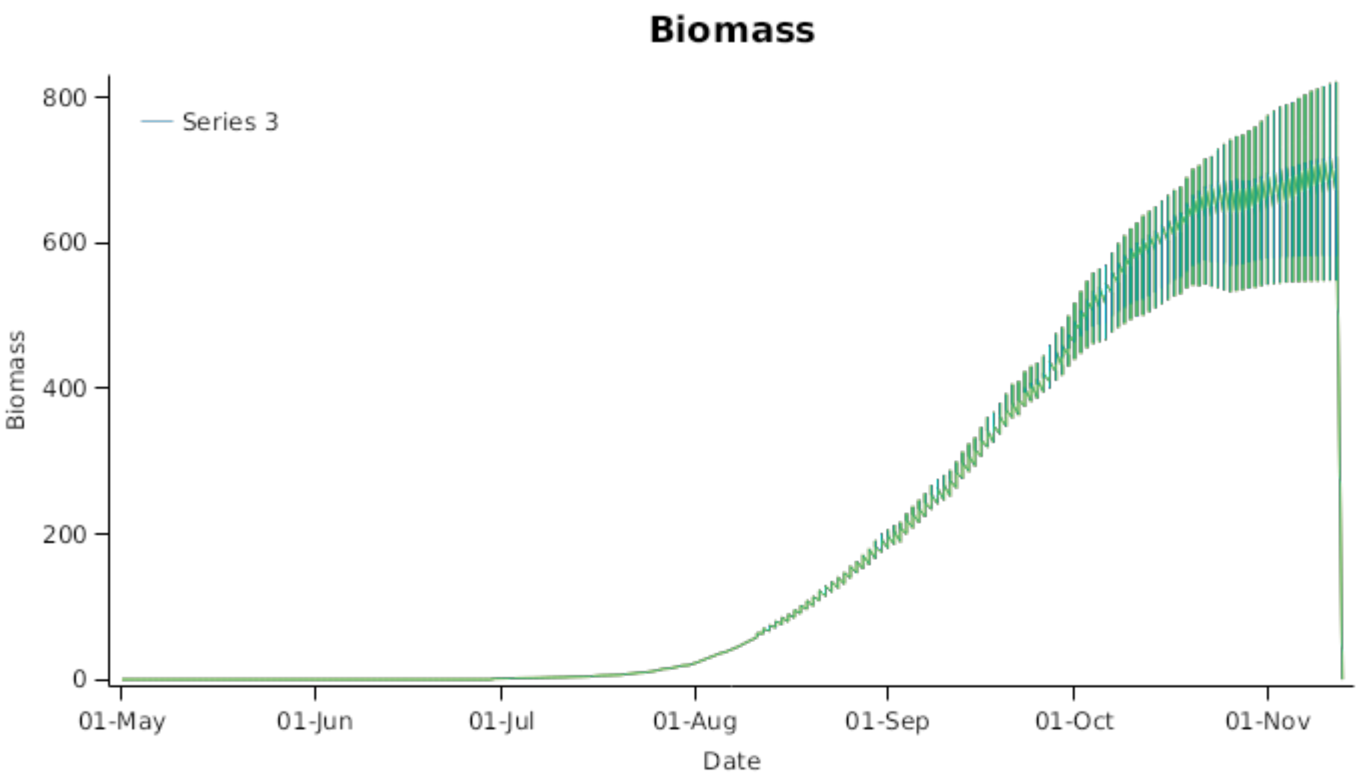
Experiment Name	Design (Number of Treatments)
Mer86	NRate x Water (4)
Mer73	NRate x Water (6)
Cunderdin97	Sow x SowN x TopN x Irr (40)
Wongan83	Soil x N (10)

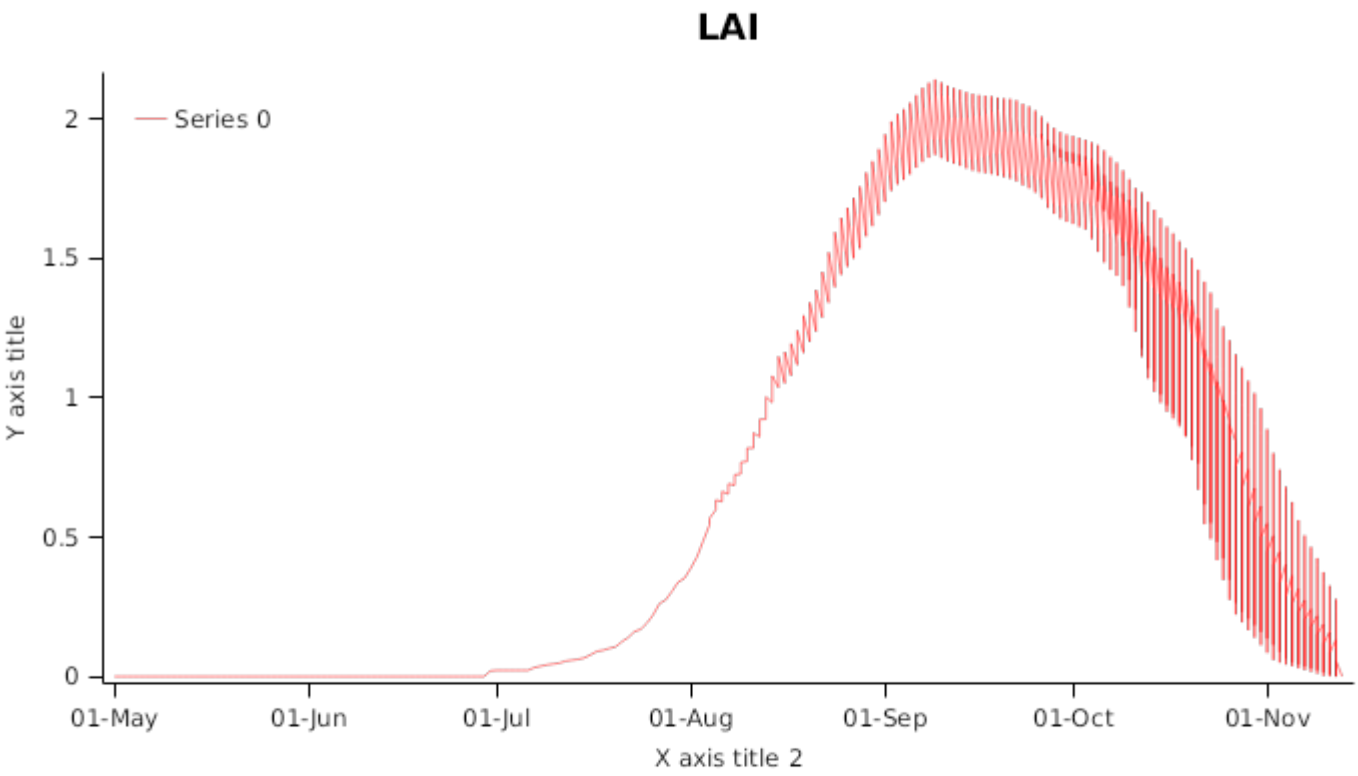

Harvest Yield
Predicted Yield
Observed Yield
100
200
300
400
Harvest Biomass
400
600
800
1000
GrainNumber
5000
10000
Harvest Grain N
2
4
6
8

3.3.1 Mer86

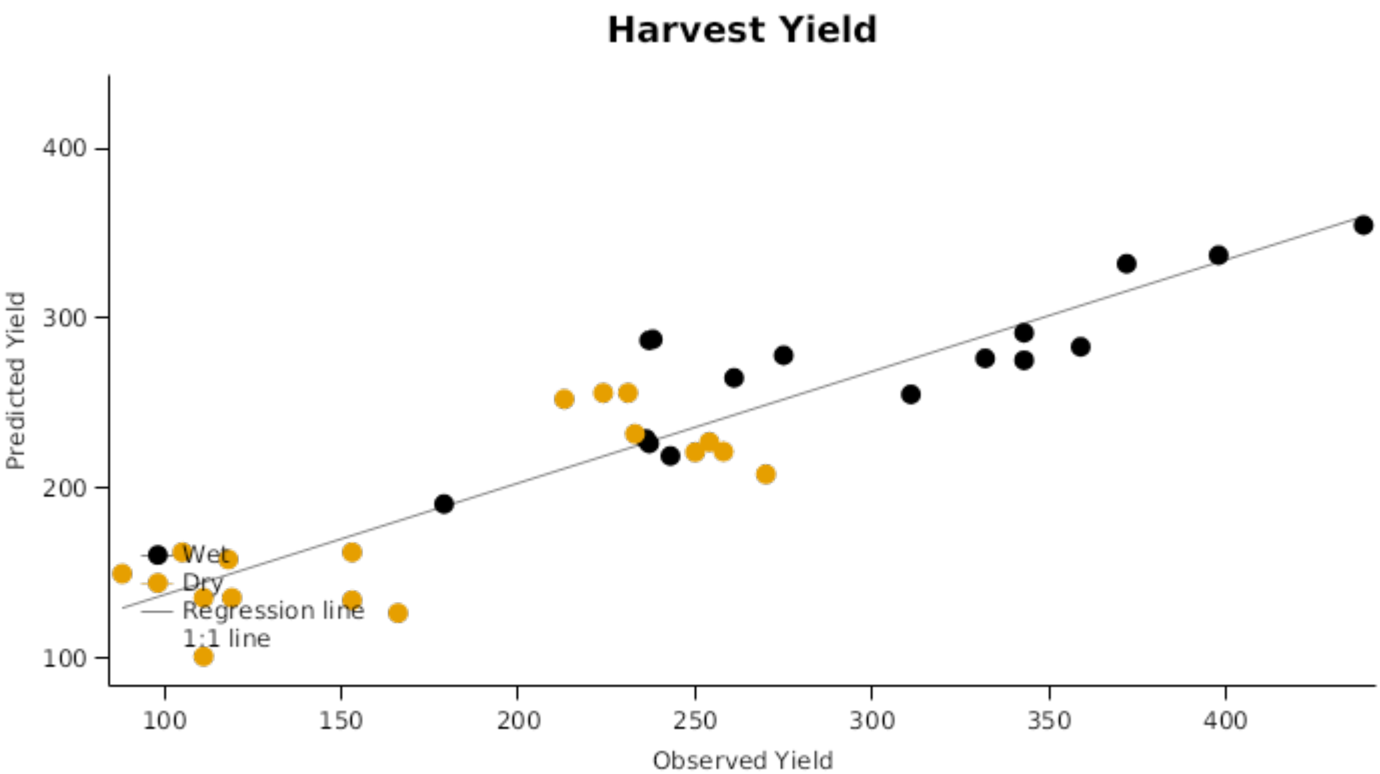

Harvest Biomass
900
800
700
600
500
Series 0
Regression line
1:1 line
500
550
600
650
700
750
800
850
900

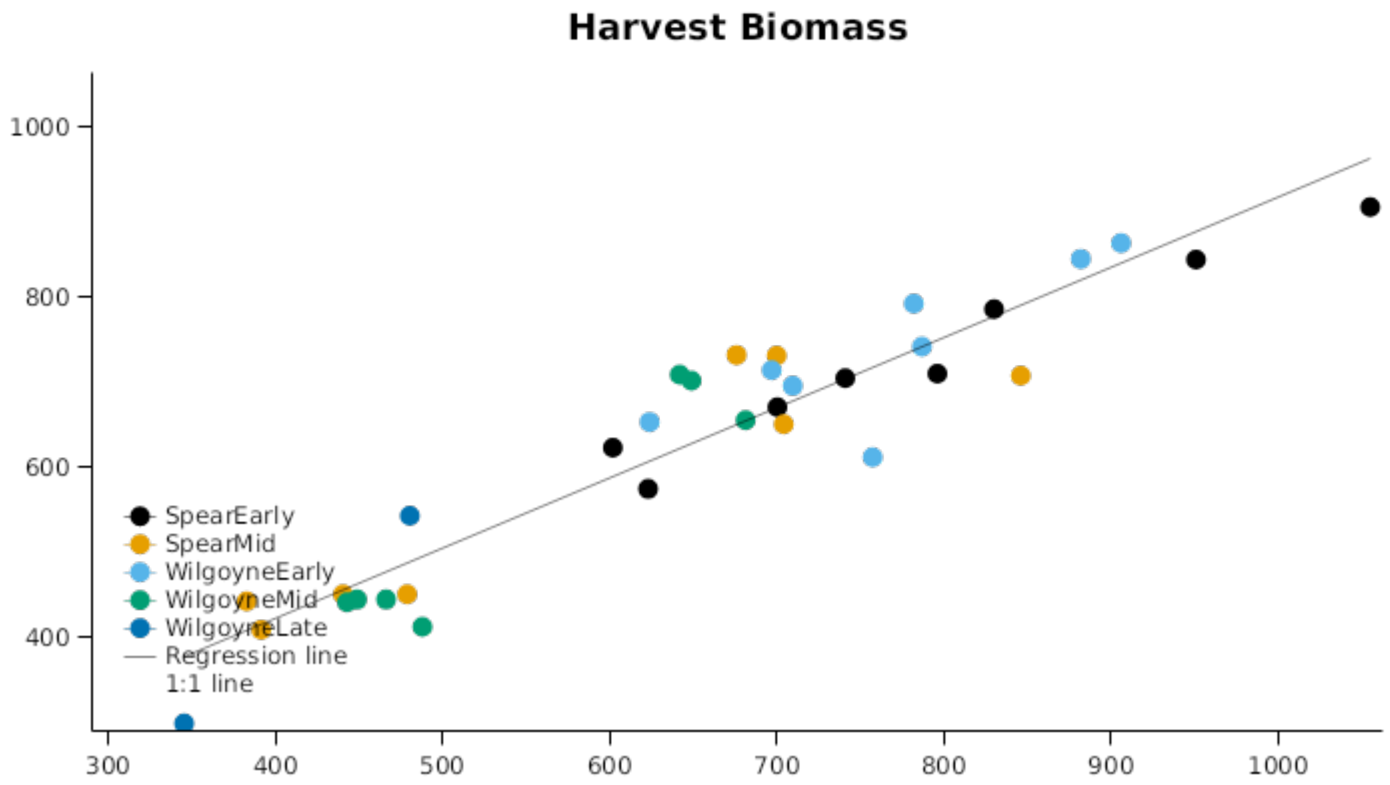
3.3.2 Mer73

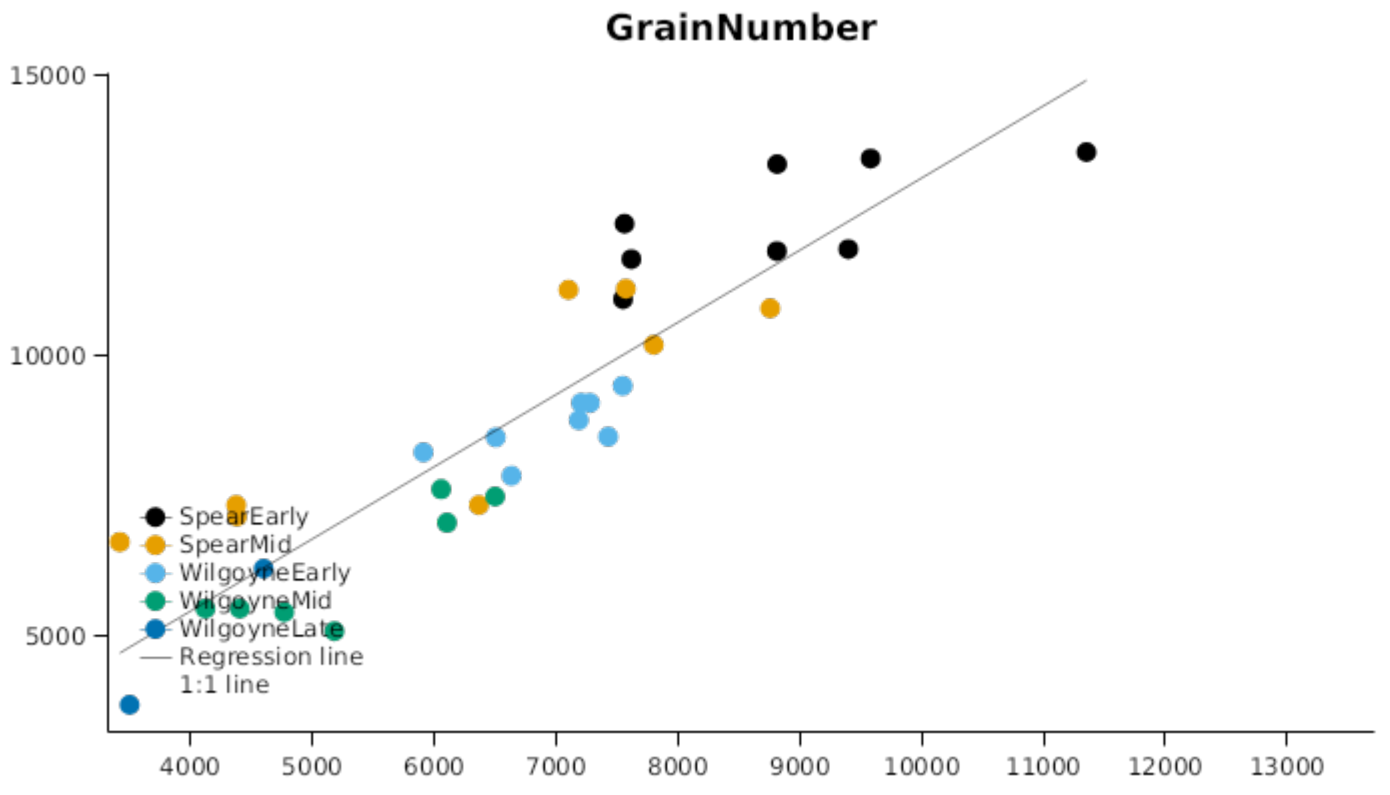

Biomass
800
600
400
200
0
Biomass
Series 3
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
Date

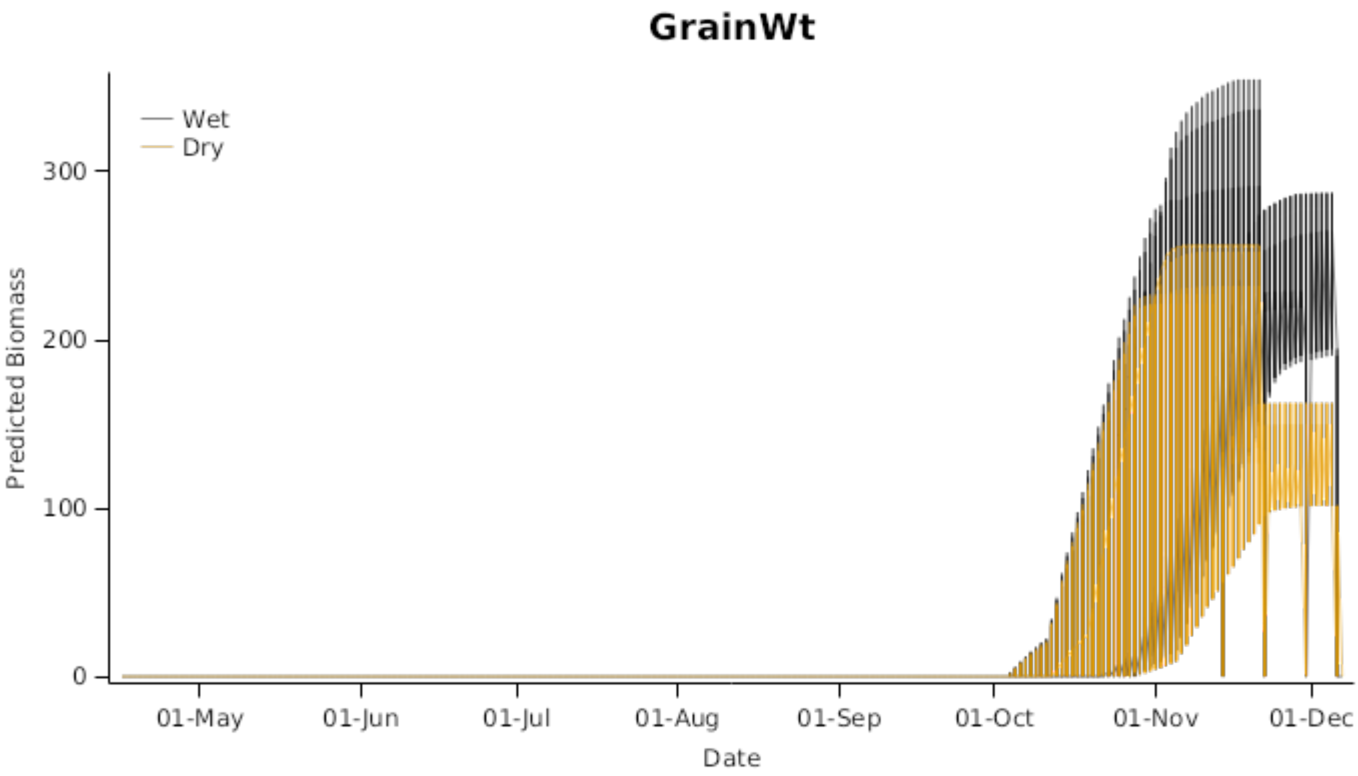


3.3.3 Cunderdin97

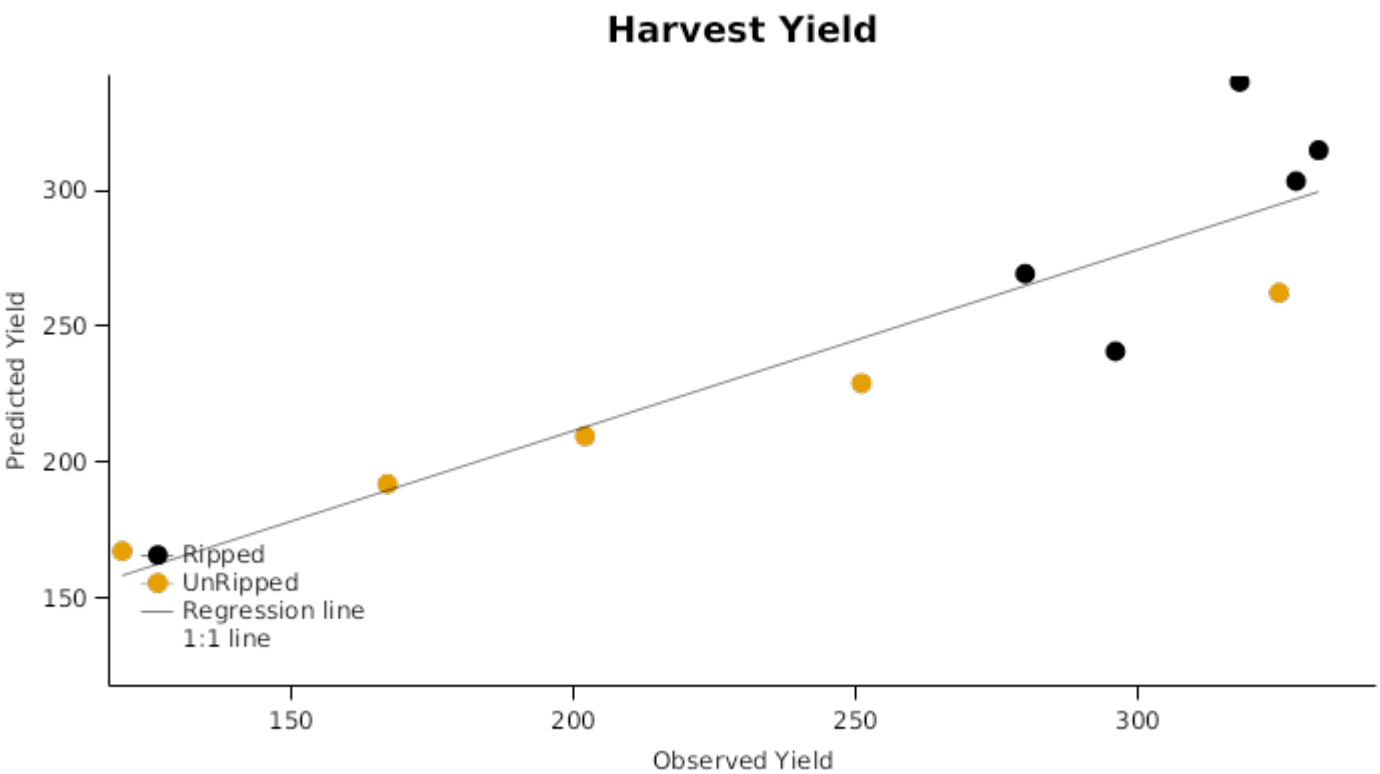


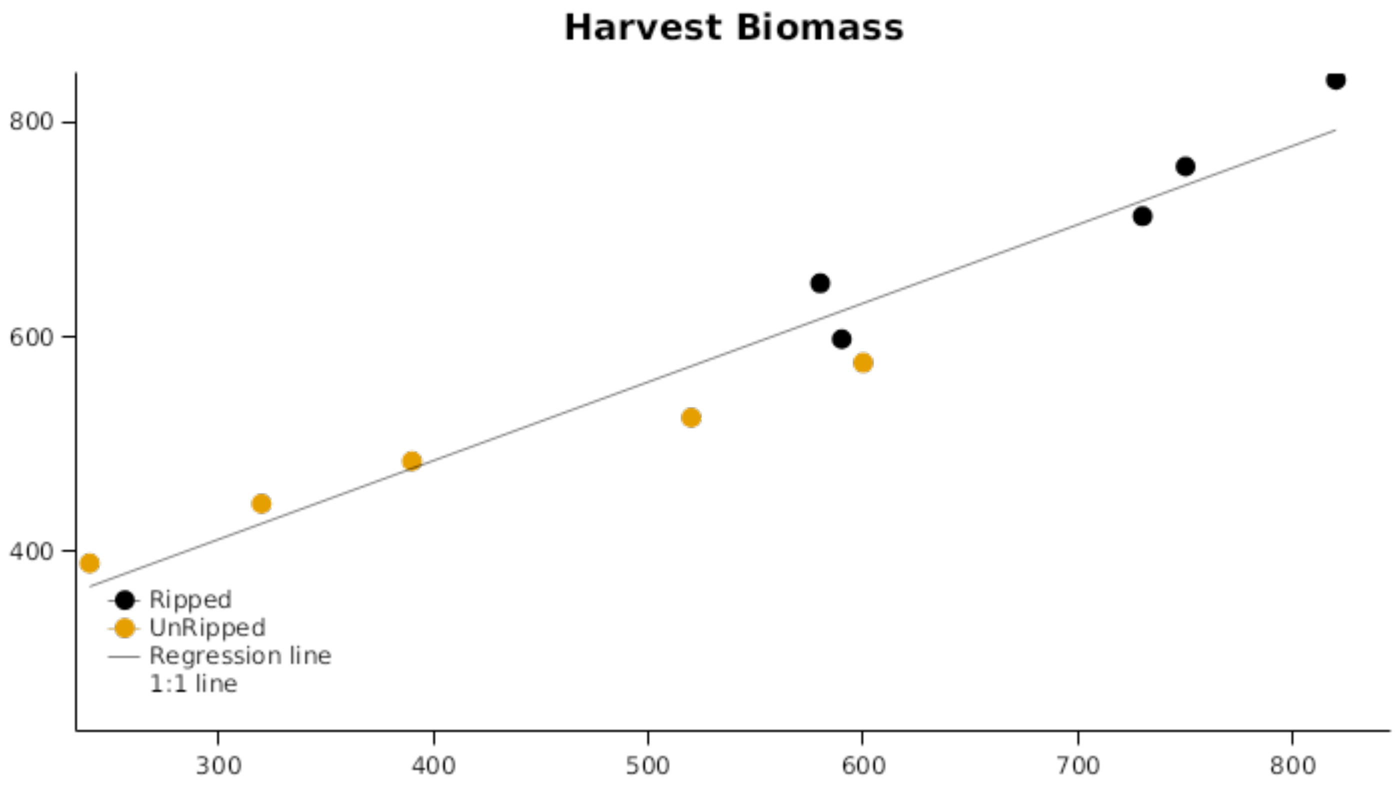

Harvest Biomass
1000
800
600
400
300
400
500
600
700
800
900
1000
SpearEarly
SpearMid
WilgoyneEarly
WilgoyneMid
WilgoyneLate
Regression line
1:1 line


GrainNumber
15000
10000
5000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
SpearEarly
SpearMid
WilgoyneEarly
WilgoyneMid
WilgoyneLate
Regression line
1:1 line

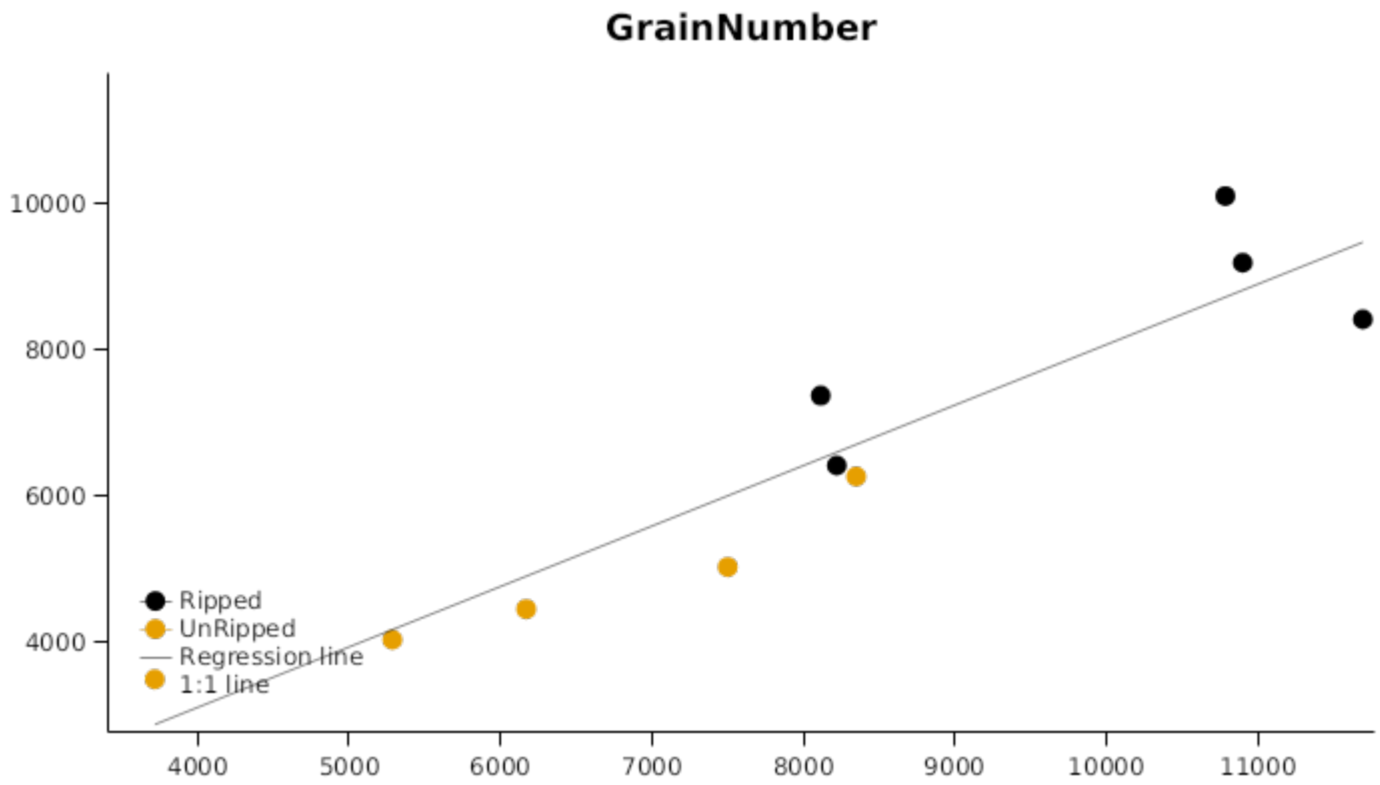


3.3.4 Wongan83

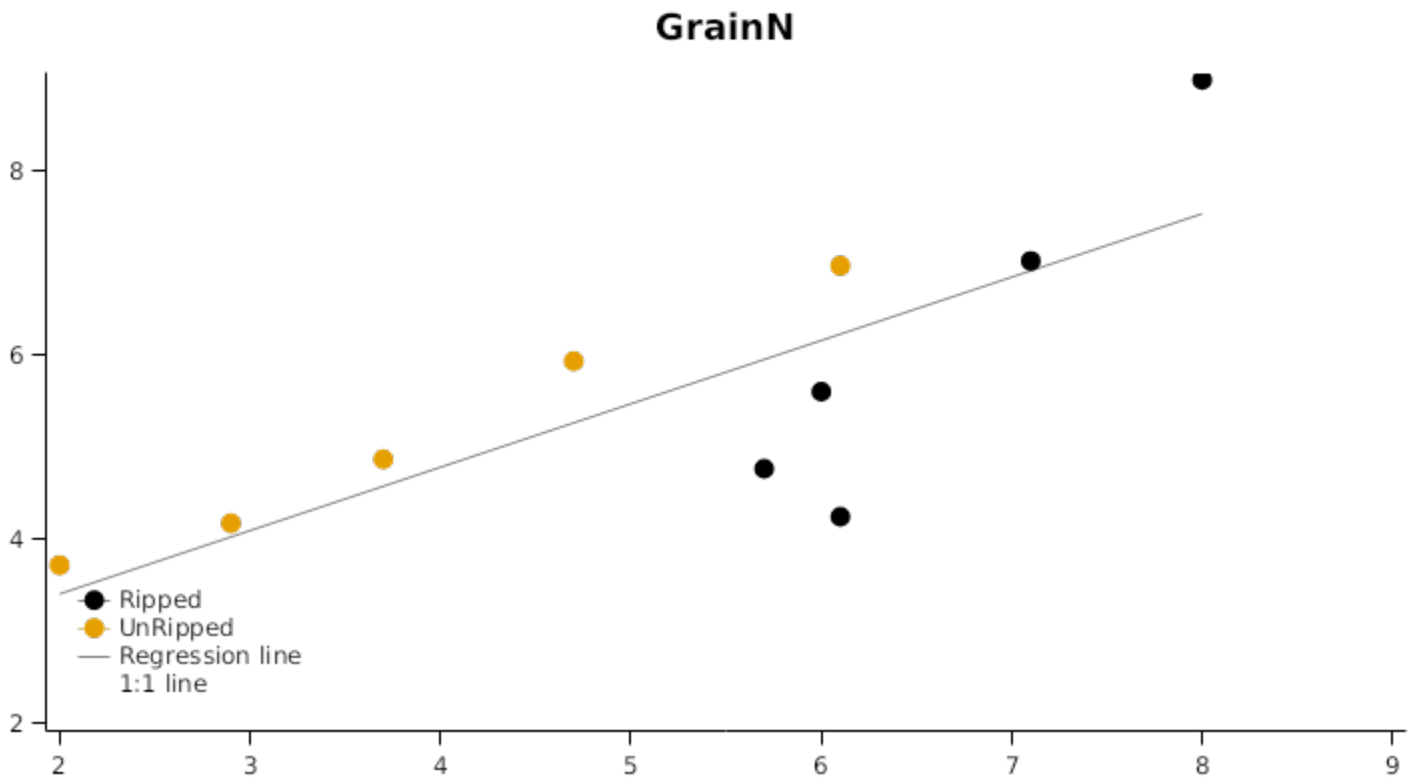


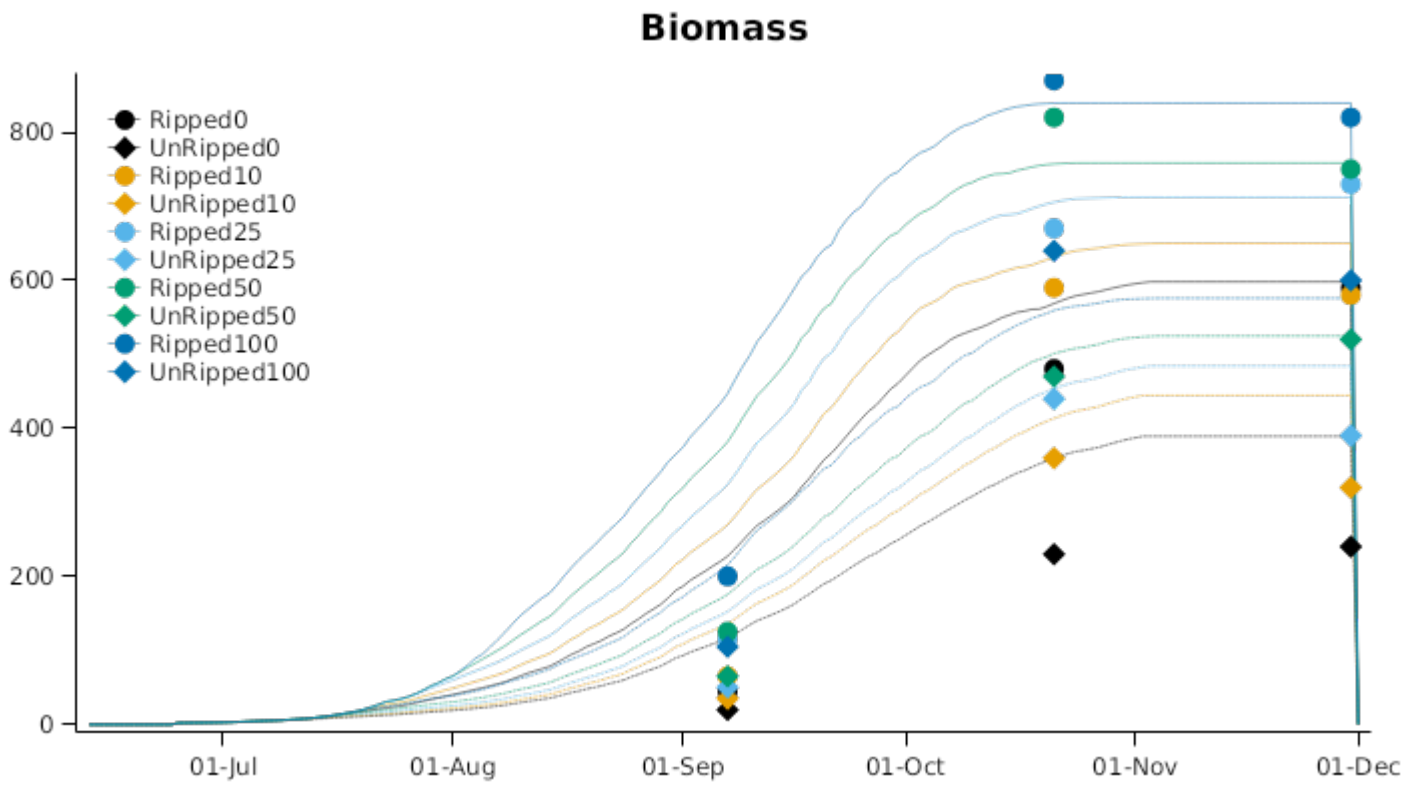


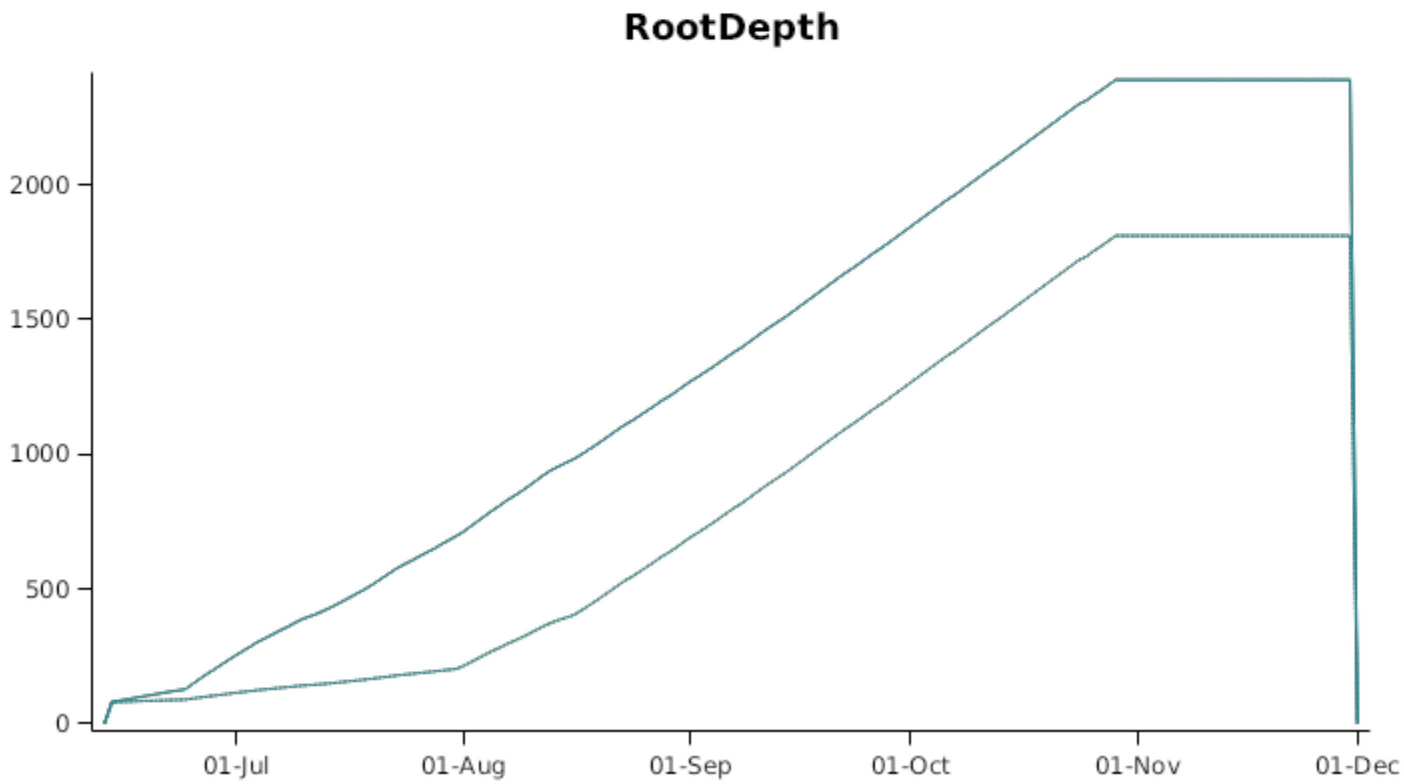
Harvest Biomass
800
600
400
300
400
500
600
700
800
Ripped
UnRipped
Regression line
1:1 line

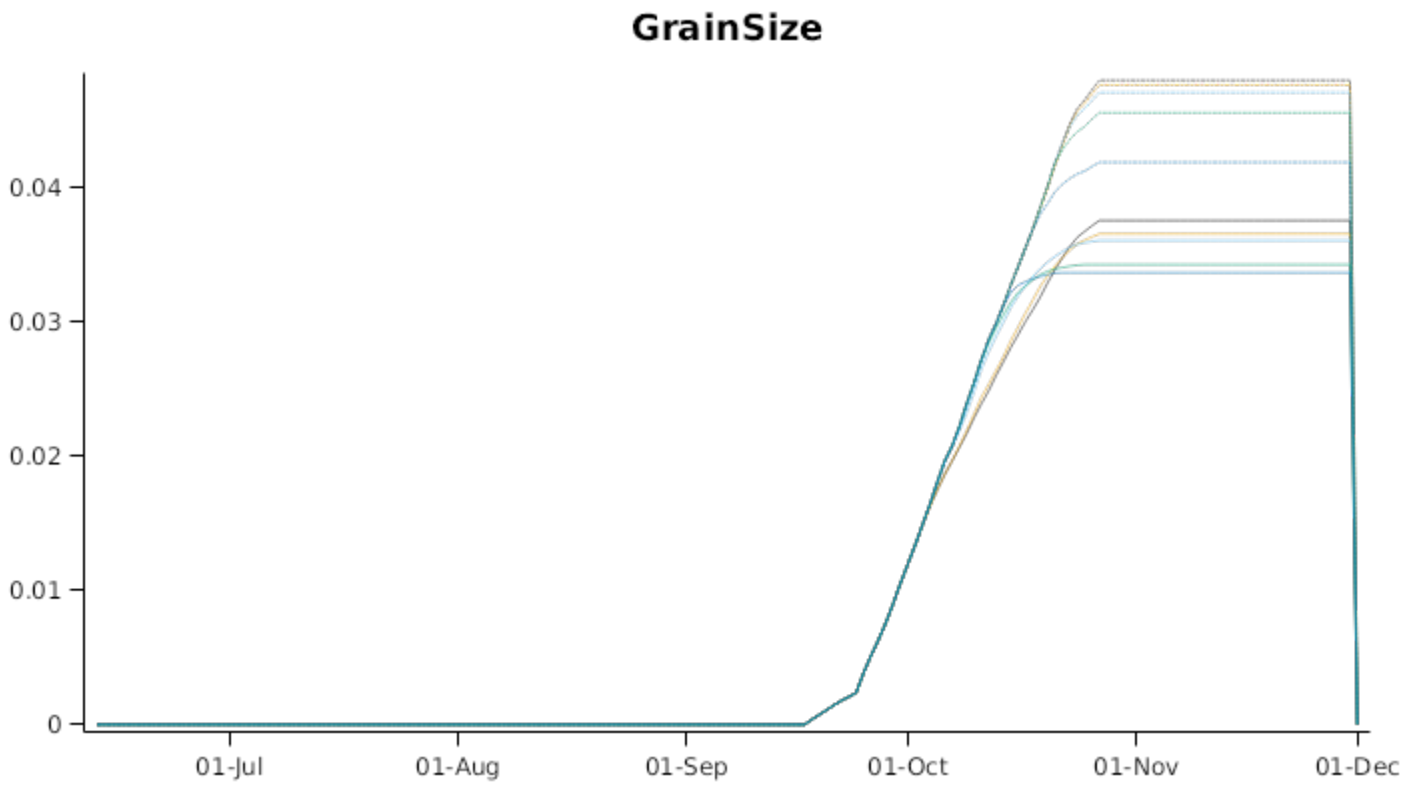


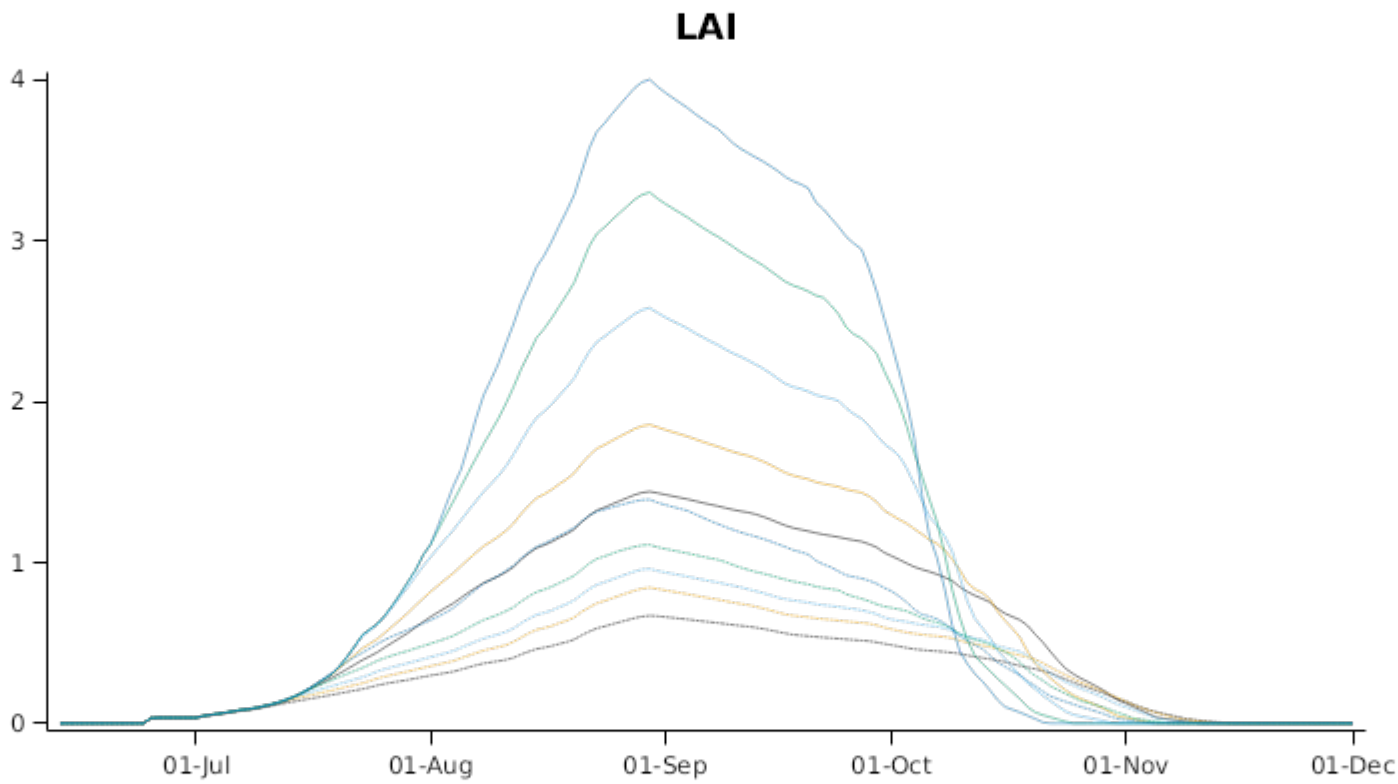
GrainNumber
10000
8000
6000
4000
4000
5000
6000
7000
8000
9000
10000
11000
Ripped
UnRipped
Regression line
1:1 line

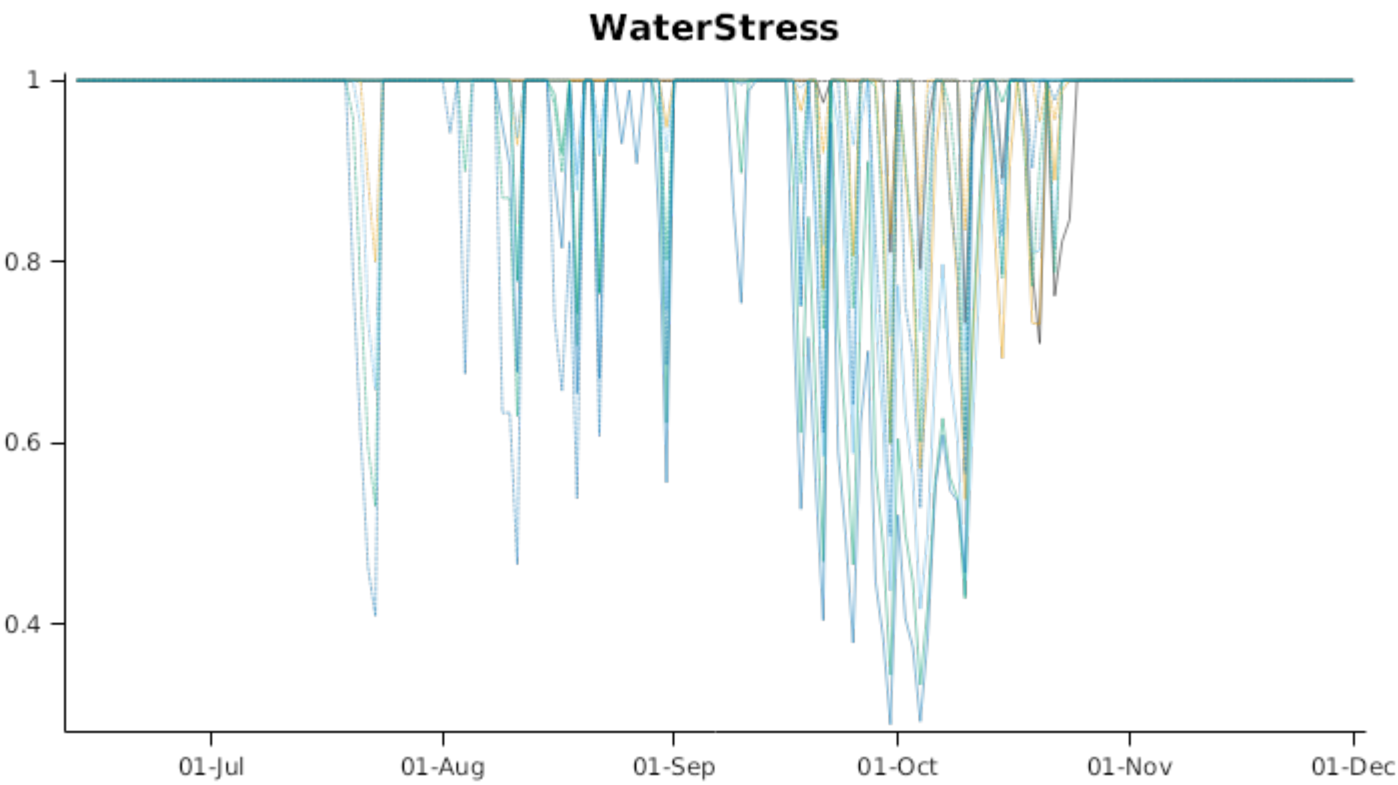

GrainN
Ripped
UnRipped
Regression line
1:1 line
2
4
6
8
2
3
4
5
6
7
8
9

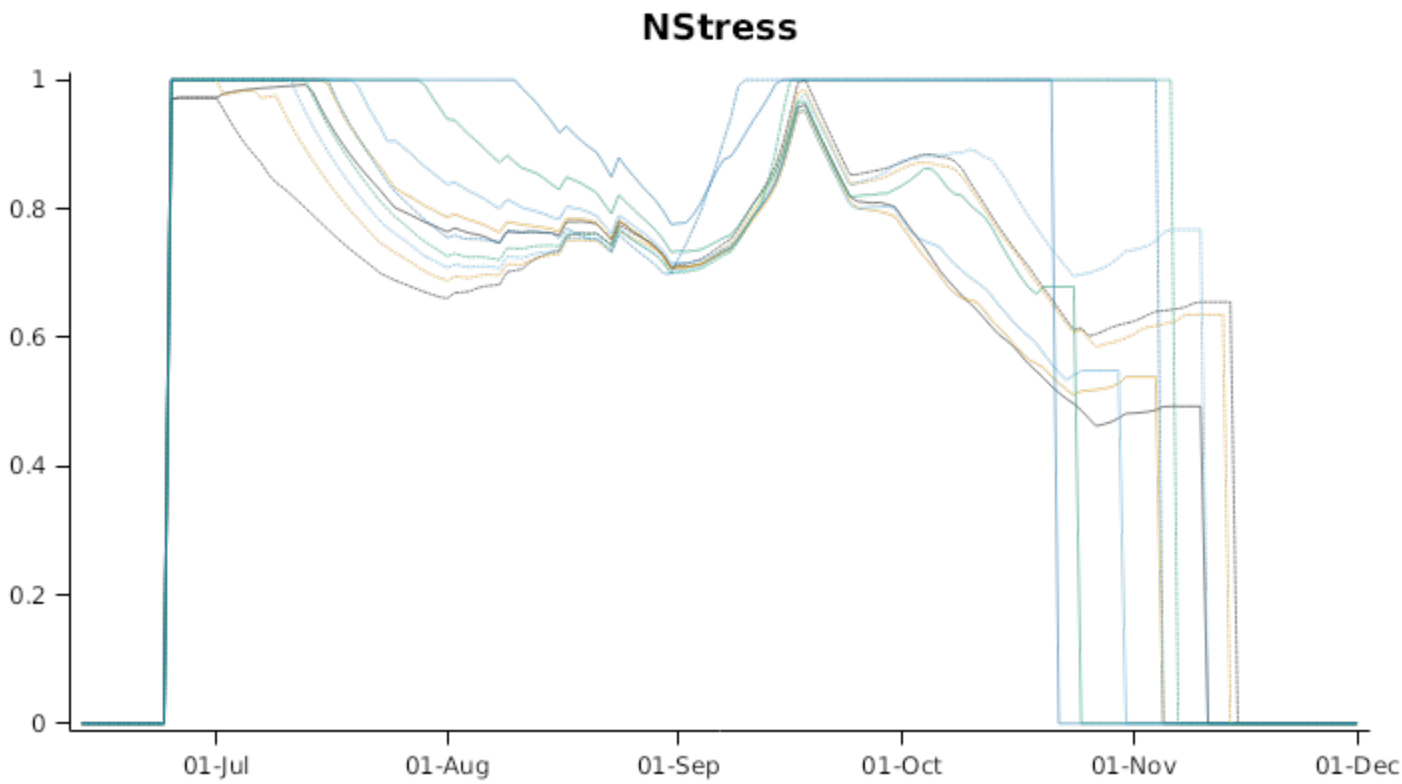

Biomass
Ripped0
UnRipped0
Ripped10
UnRipped10
Ripped25
UnRipped25
Ripped50
UnRipped50
Ripped100
UnRipped100
0
200
400
600
800
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


RootDepth
2000
1500
1000
500
0
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


GrainSize
0.04
0.03
0.02
0.01
0
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


LAI
4
3
2
1
0
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


WaterStress
1
0.8
0.6
0.4
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

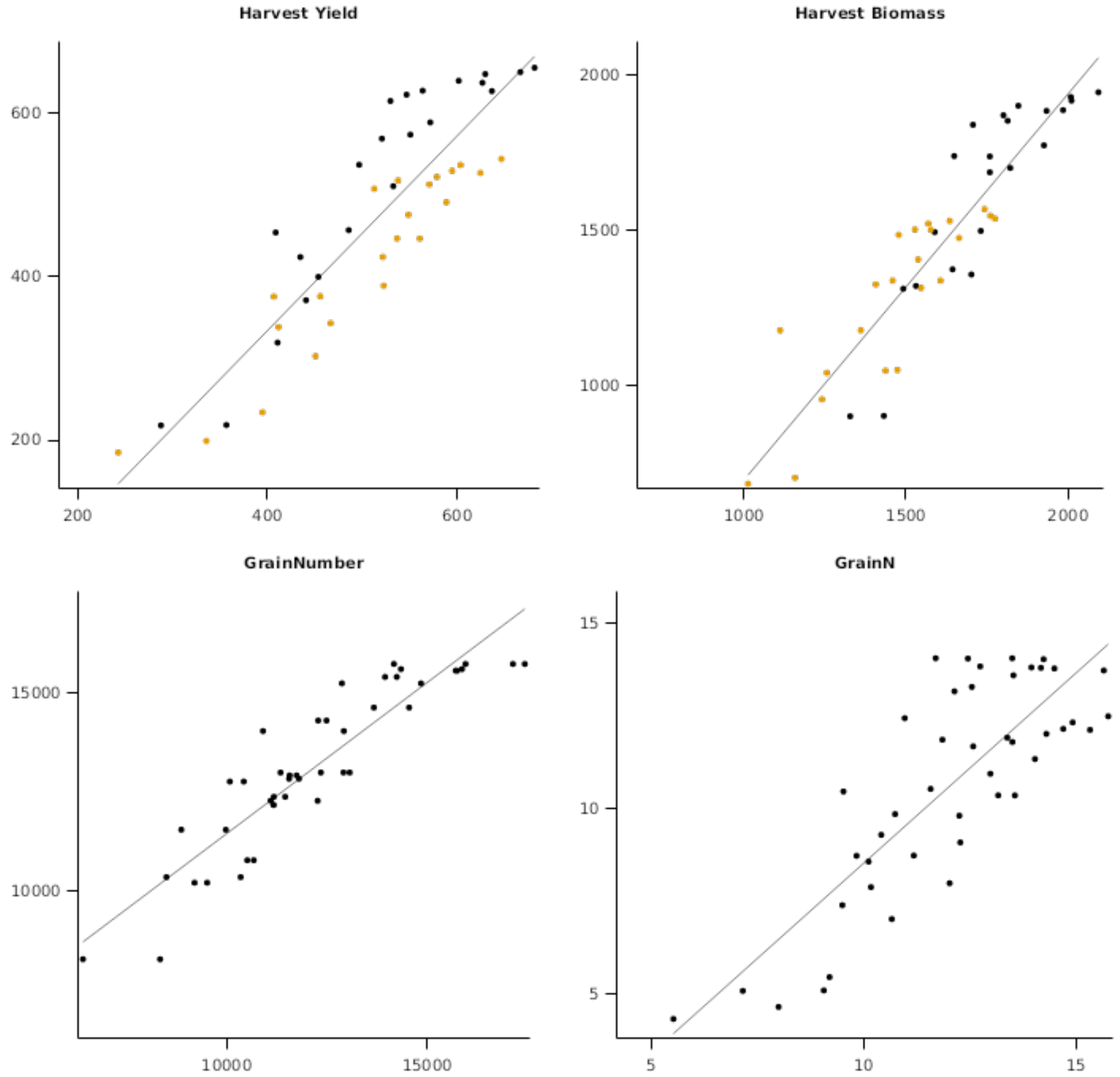


3.4 Turkey

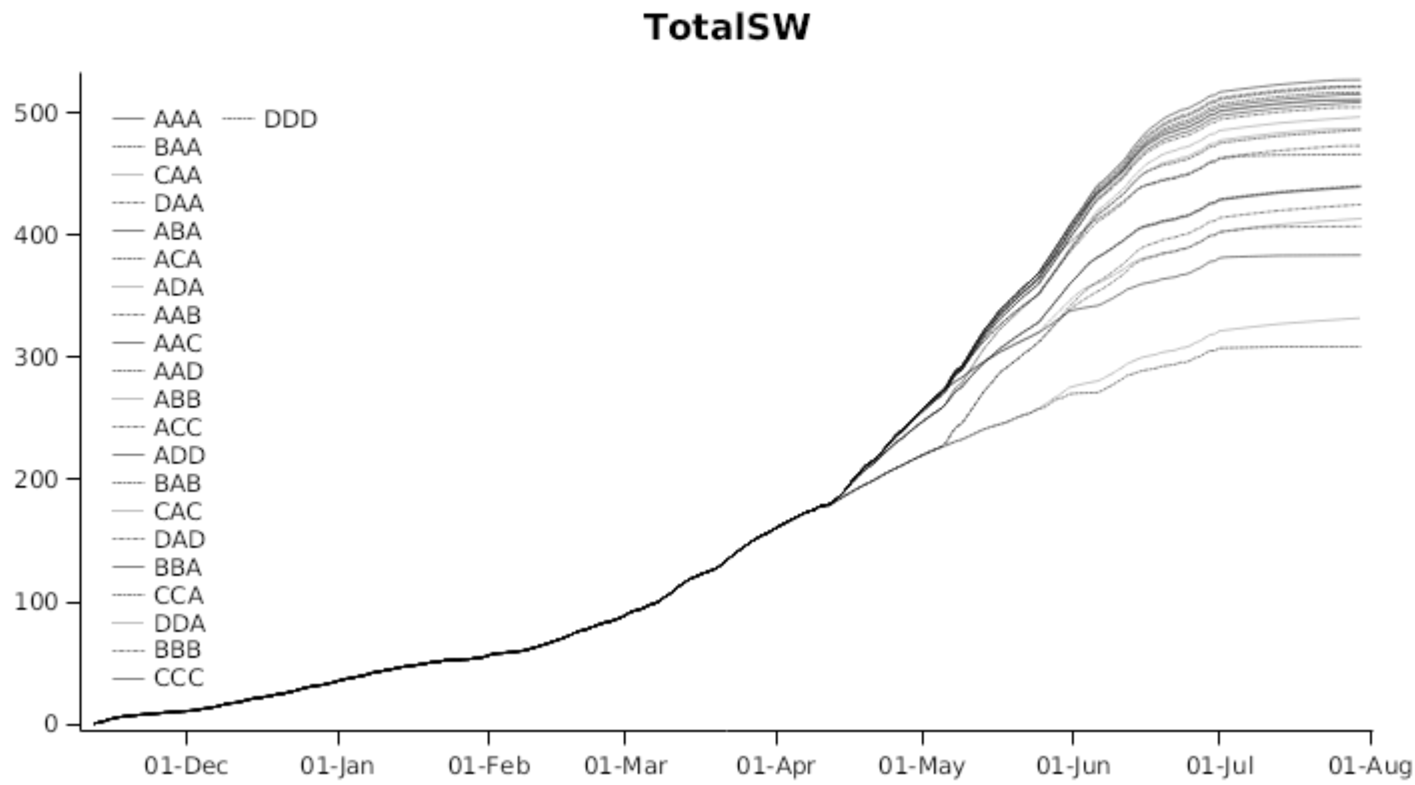
The dataset of Ali Fuat Tari, 2016 includes 4 irrigation deficit treatments applied at each of 3 plant growth stages. The experiment was conducted at Konya in the Central Anatolia region of Turkey. Yields ranged from 2.88 t/ha to 6.82 t/ha. These treatments were reproduced over two growing seasons, resulting in 44 individual wheat crops including differing levels of water stress at different stages of development. Soil data have been estimated from that provided within the original publication.

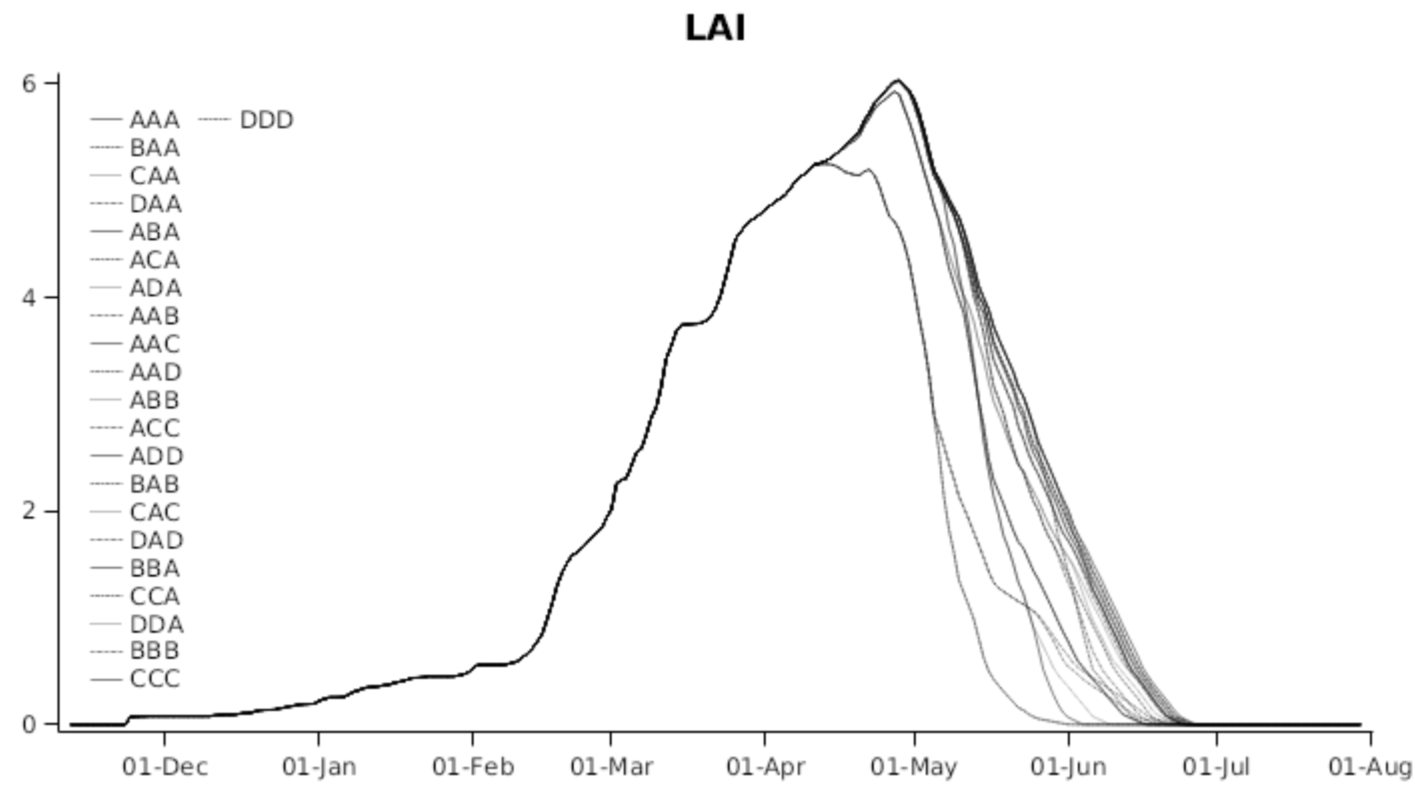
List of experiments.

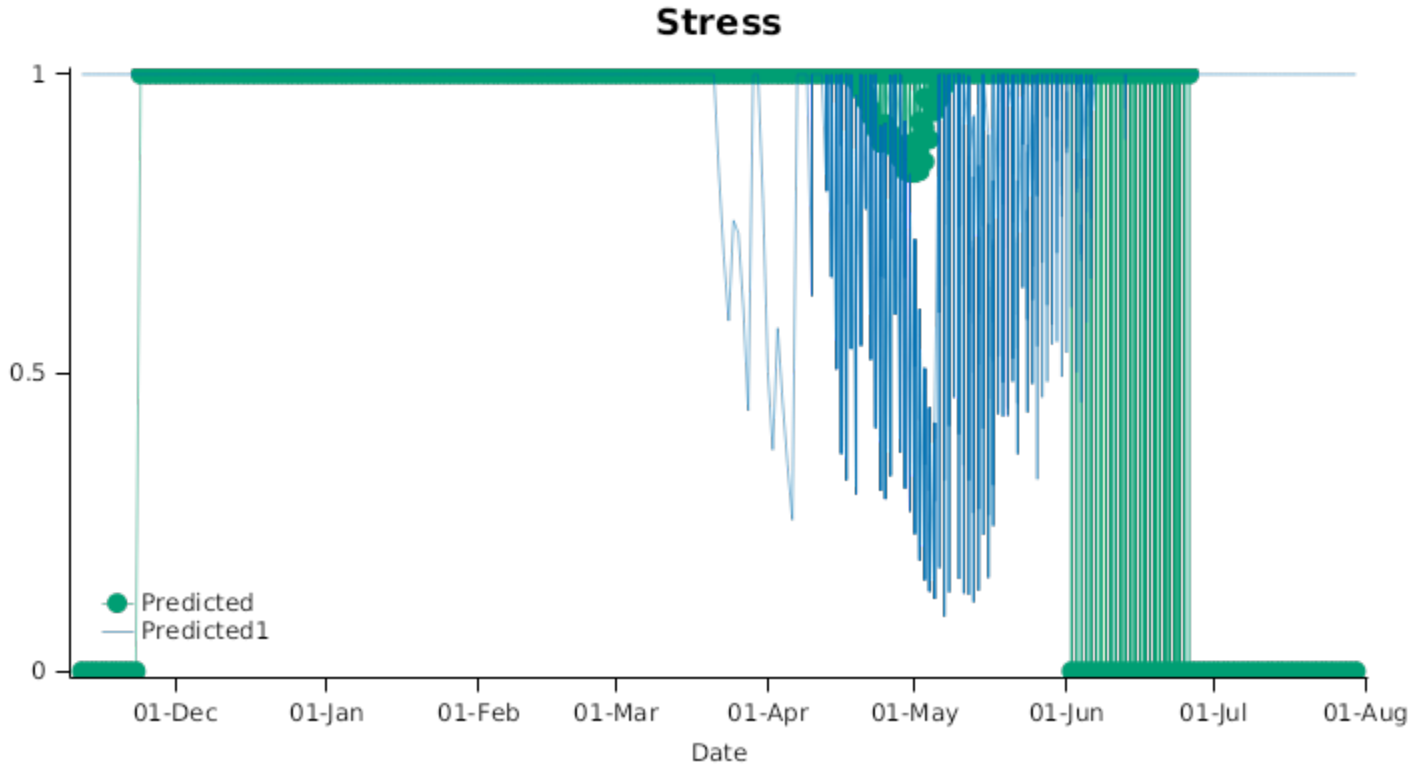
Experiment Name	Design (Number of Treatments)
Konya09	Water (22)
Konya11	Water (22)

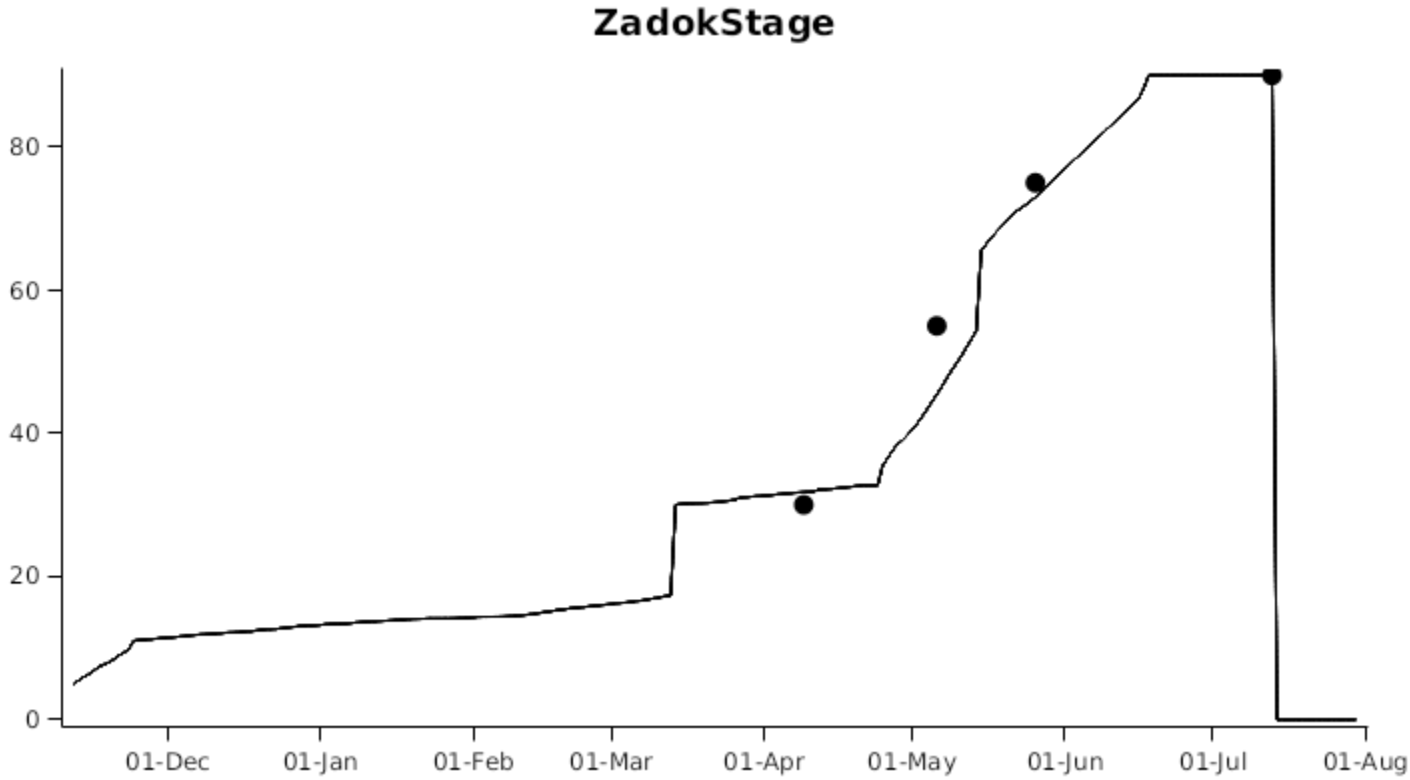

Harvest Yield
600
400
200
200
400
600
Harvest Biomass
2000
1500
1000
1000
1500
2000
GrainNumber
15000
10000
10000
15000
GrainN
15
10
5
5
10
15

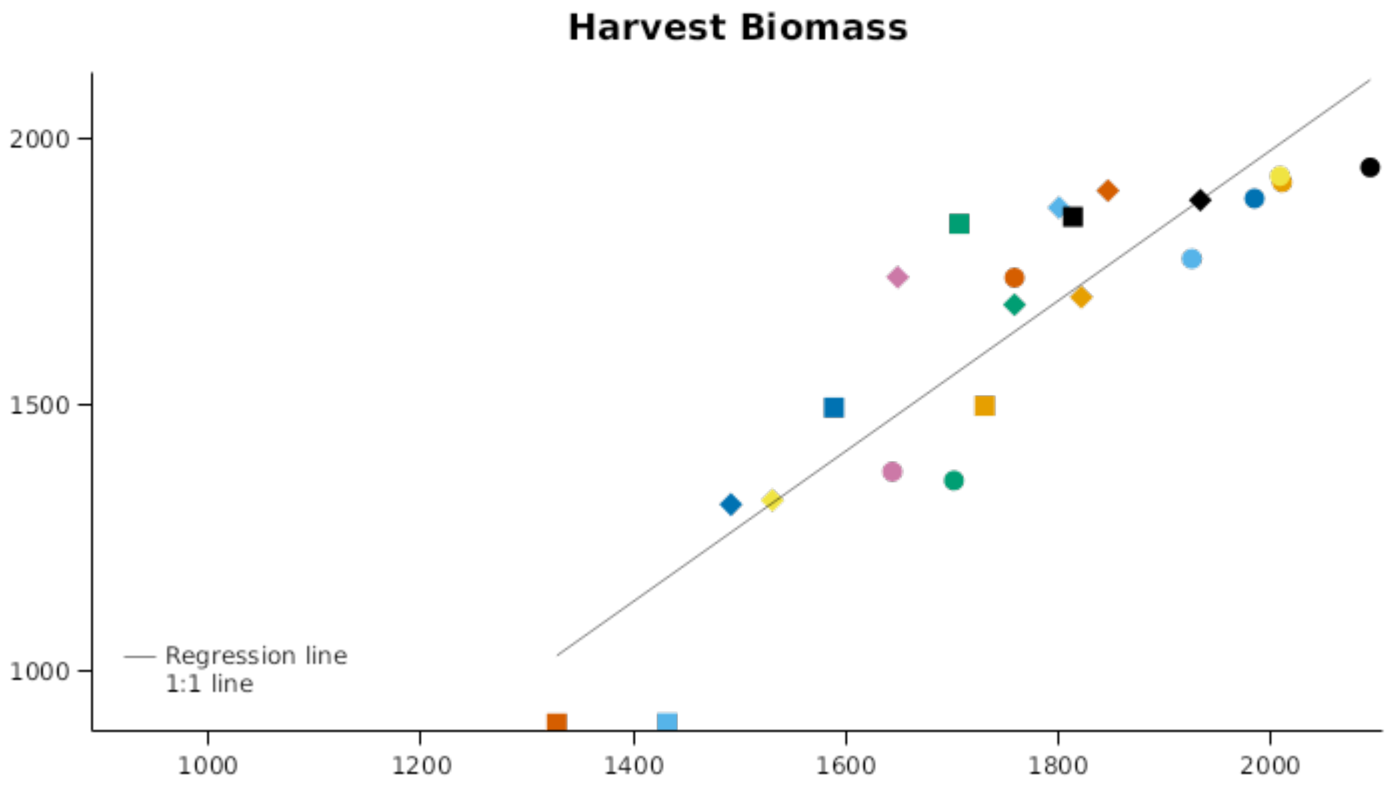
3.4.1 Konya09

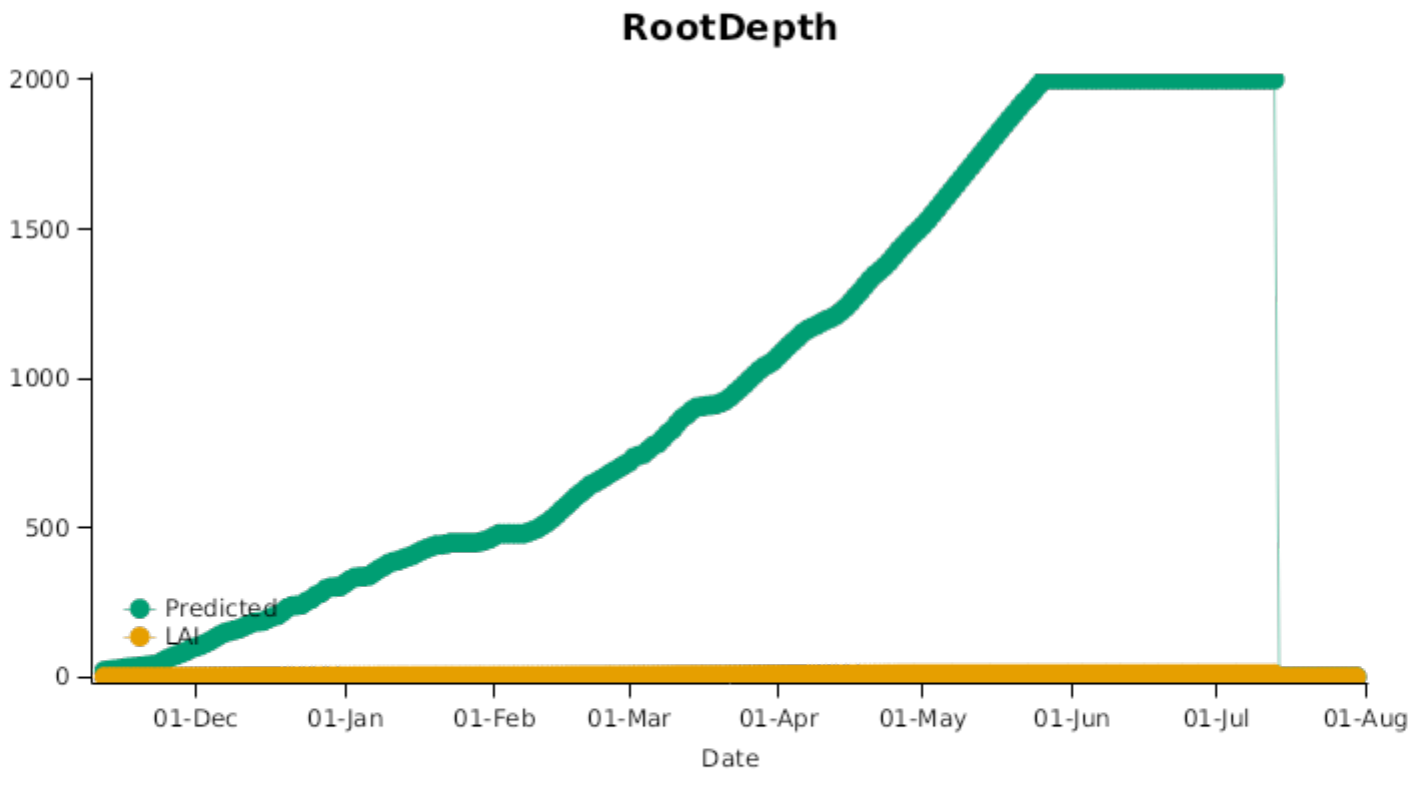

TotalSW
AAA
BAA
CAA
DAA
ABA
ACA
ADA
AAB
AAC
AAD
ABB
ACC
ADD
BAB
CAC
DAD
BBA
CCA
DDA
BBB
CCC
DDD
500
400
300
200
100
0
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug


LAI
AAA
BAA
CAA
DAA
ABA
ACA
ADA
AAB
AAC
AAD
ABB
ACC
ADD
BAB
CAC
DAD
BBA
CCA
DDA
BBB
CCC
DDD
6
4
2
0
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug

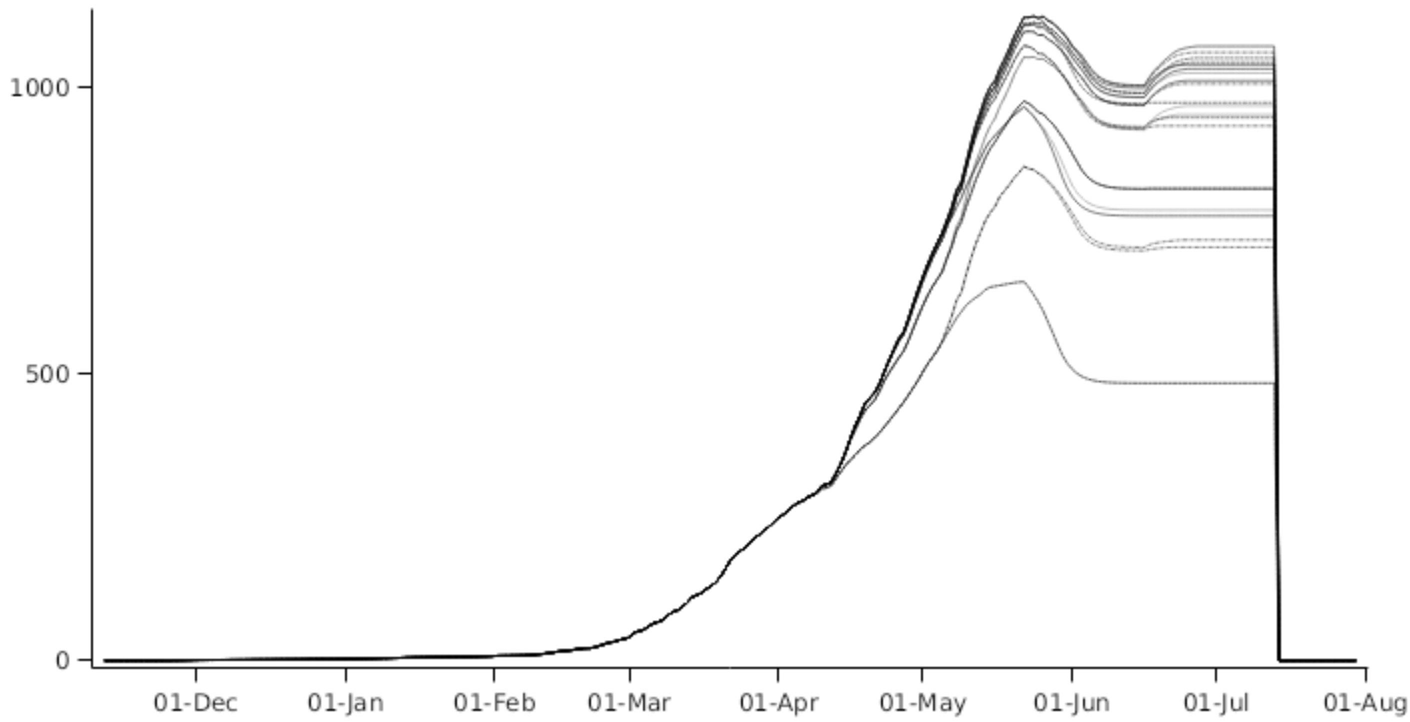

Stress
1
0.5
0
Predicted
Predicted1
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
Date


ZadokStage
80
60
40
20
0
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug

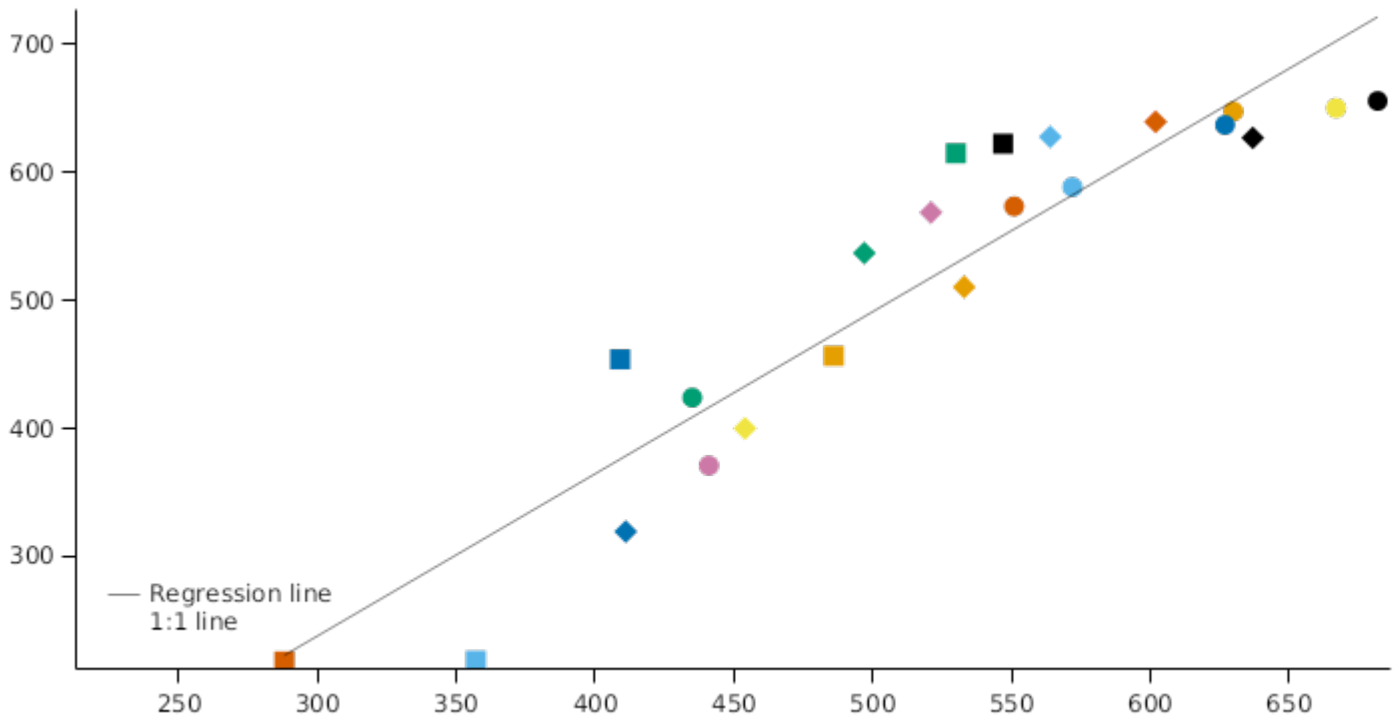

Harvest Biomass
2000
1500
1000
Regression line
1:1 line
1000
1200
1400
1600
1800
2000

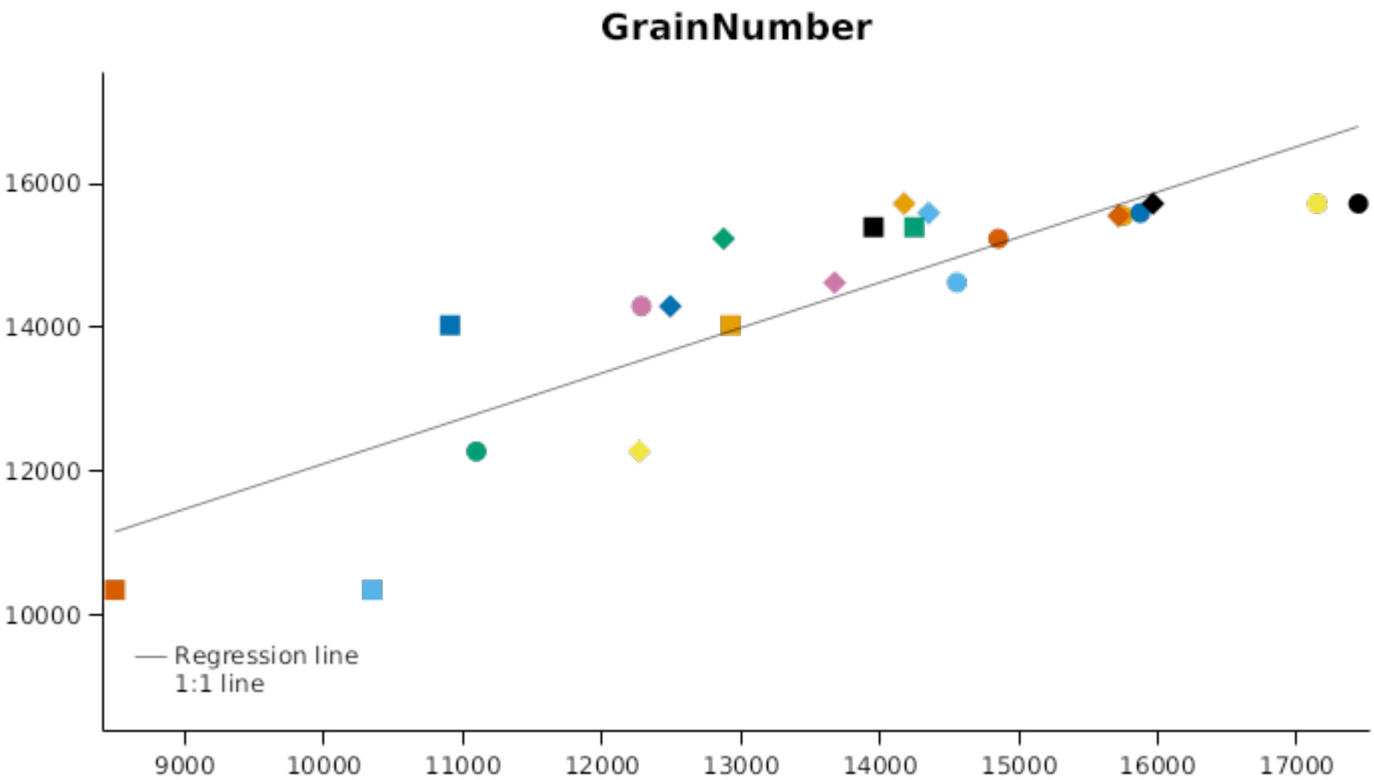

RootDepth
2000
1500
1000
500
0
Predicted
LAI
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
Date

StemWt



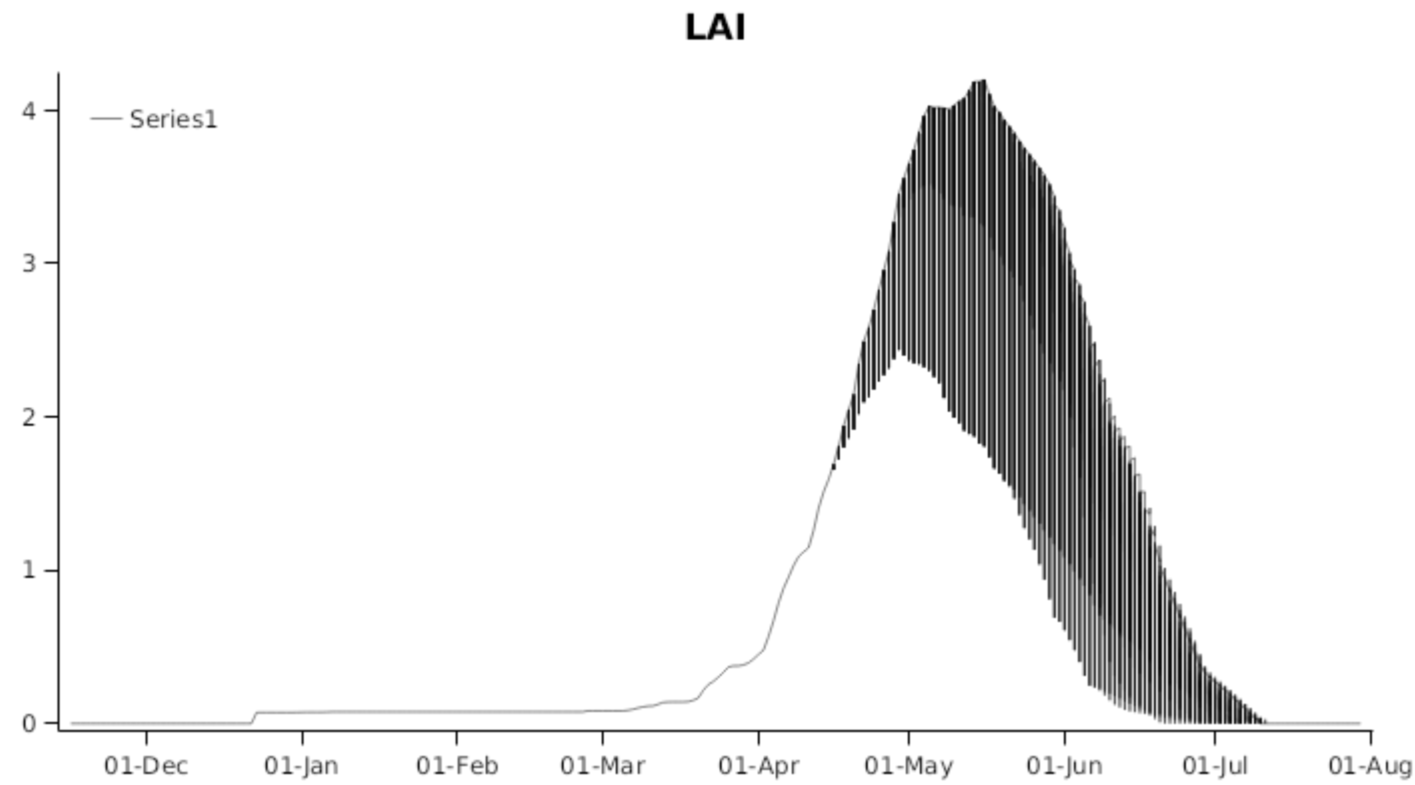
Harvest Grain

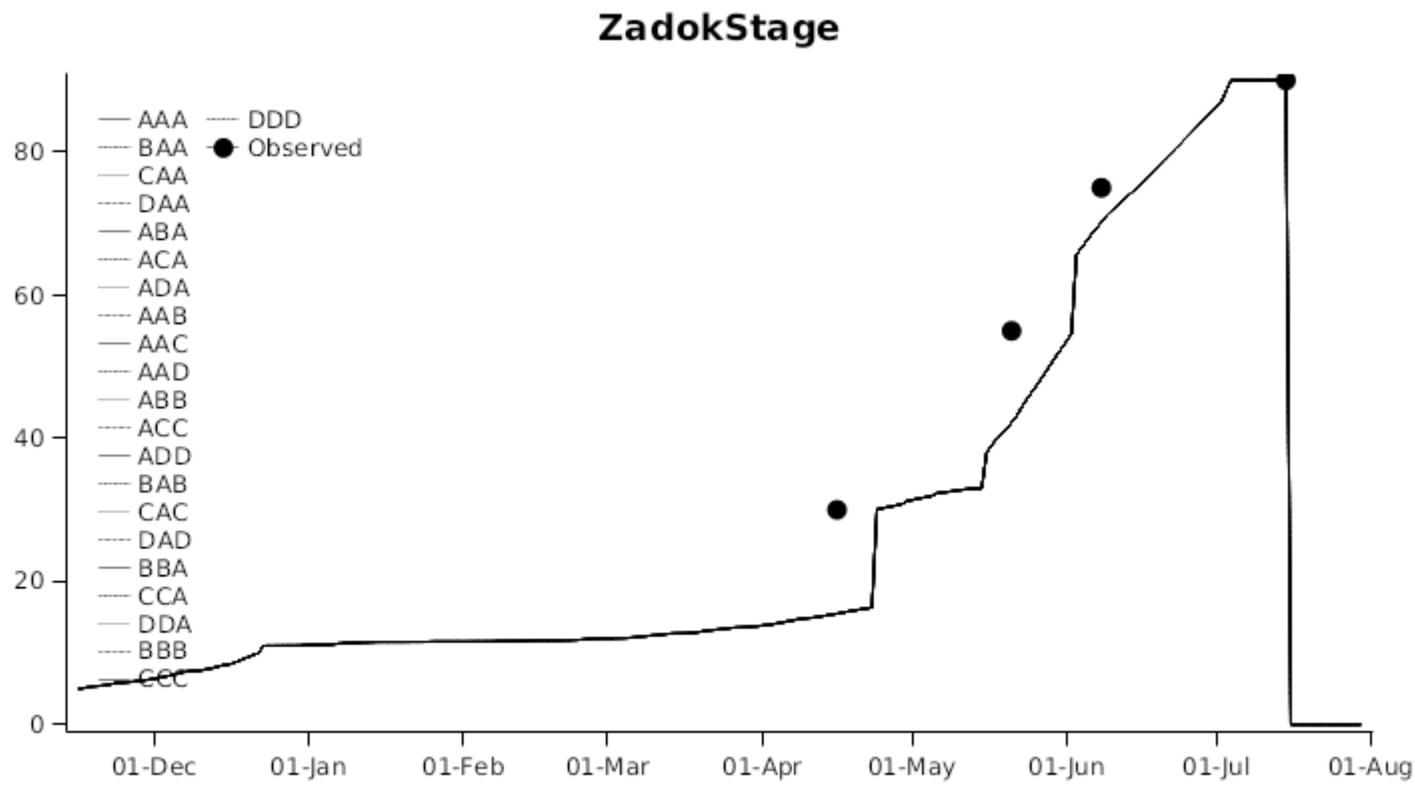




3.4.2 Konya11

TotalSW



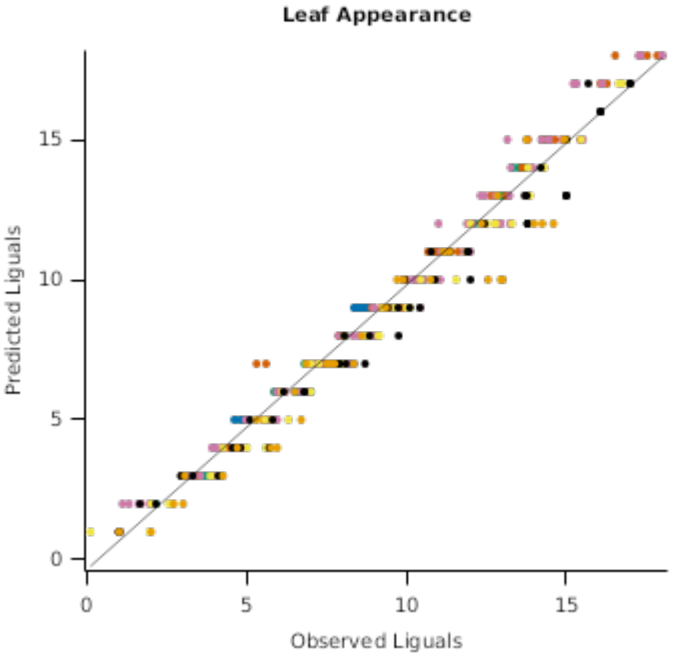


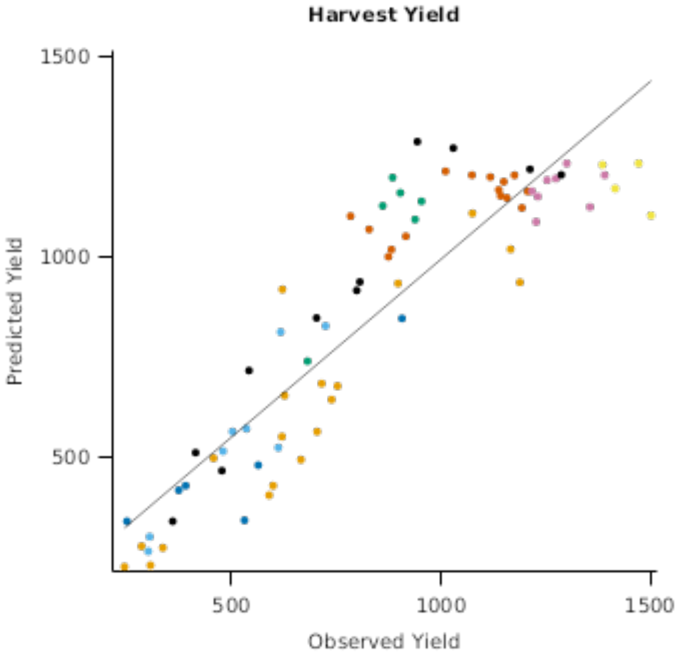
3.5 New Zealand

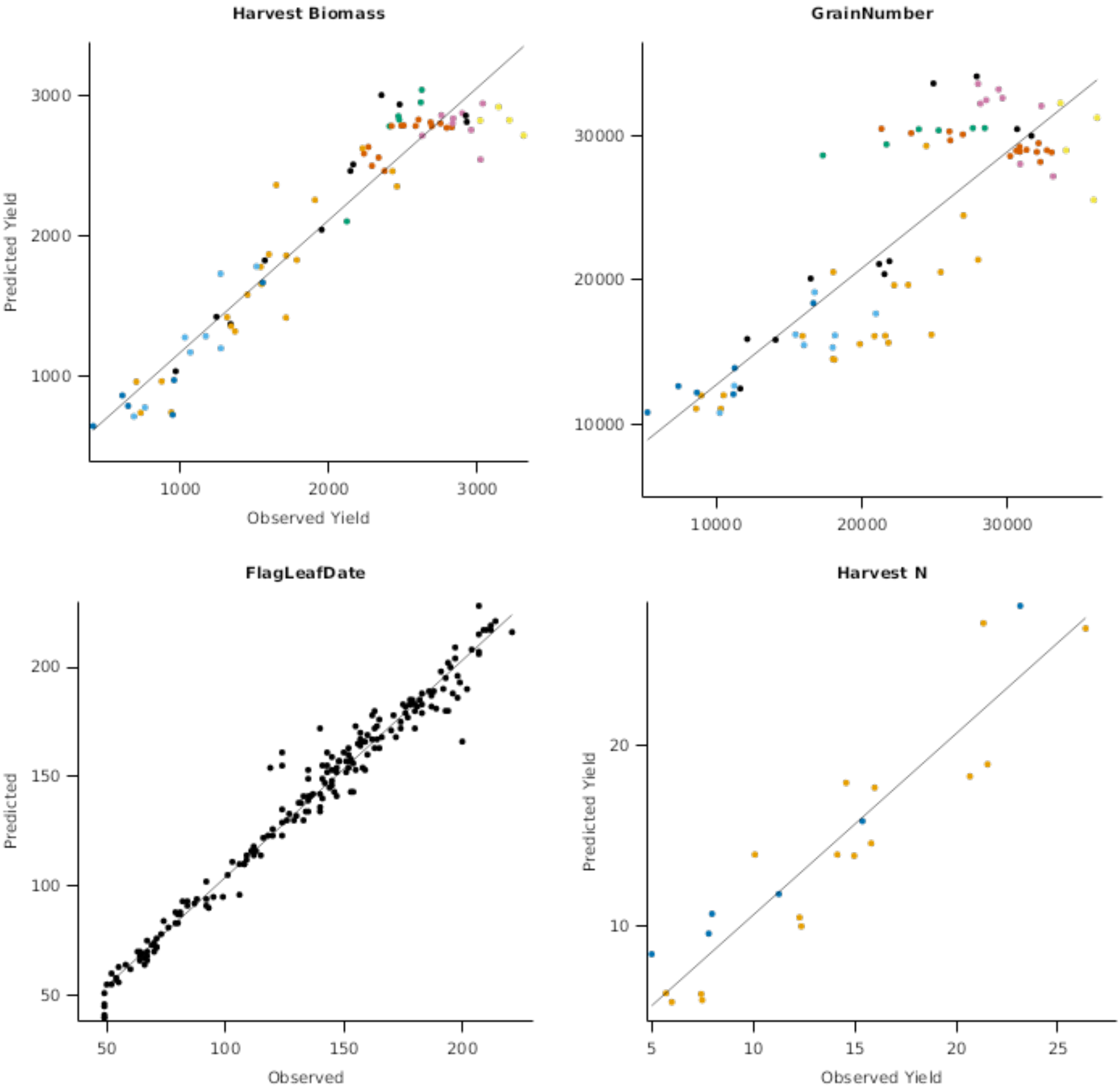
List of experiments.

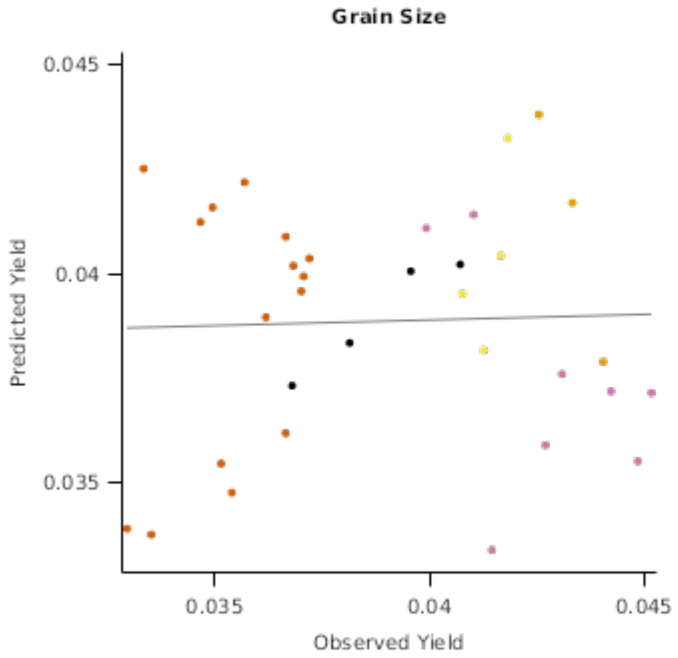
Experiment Name	Design (Number of Treatments)
Lincoln9192	Irrig (7)
Lincoln1992	Sow x Irr x Nit (16)
Lincoln2010	Sow x Irr (8)
Lincoln2014	Irrig (6)

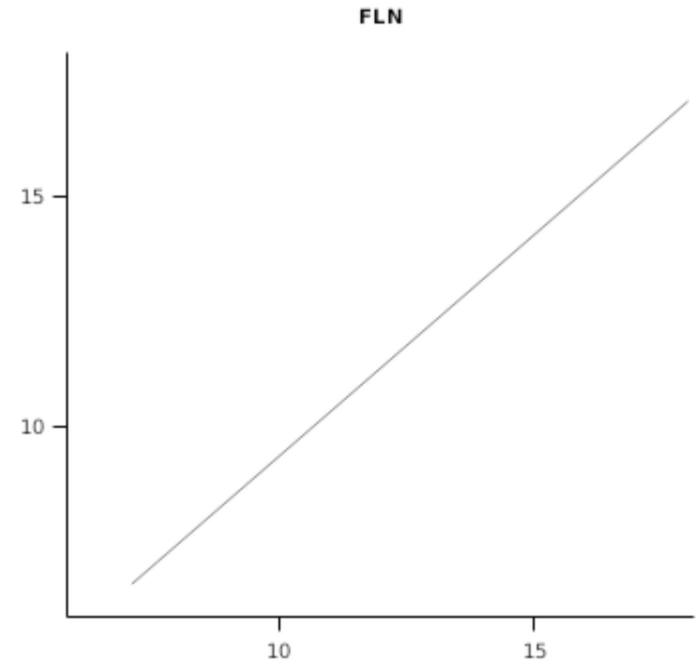
Experiment Name	Design (Number of Treatments)
Lincoln2015	Nit x Irr (6)
Leeston2013	Sow x Popn (15)
Leeston2014	Sow x Popn (8)
Wakanui2015	Sow x Cm (4)
Wakanui2016	Sow x Cm (4)
Wakanui2017	Sow x Cm (3)
PalmerstonNorth1989	Sow x Cv (18)
Lincoln1994	Sow x Cv (10)






Harvest Biomass
Predicted Yield
Observed Yield
1000
2000
3000
1000
2000
3000
GrainNumber
10000
20000
30000
10000
20000
30000
FlagLeafDate
Predicted
Observed
50
100
150
200
50
100
150
200
Harvest N
Predicted Yield
Observed Yield
10
20
5
10
15
20
25



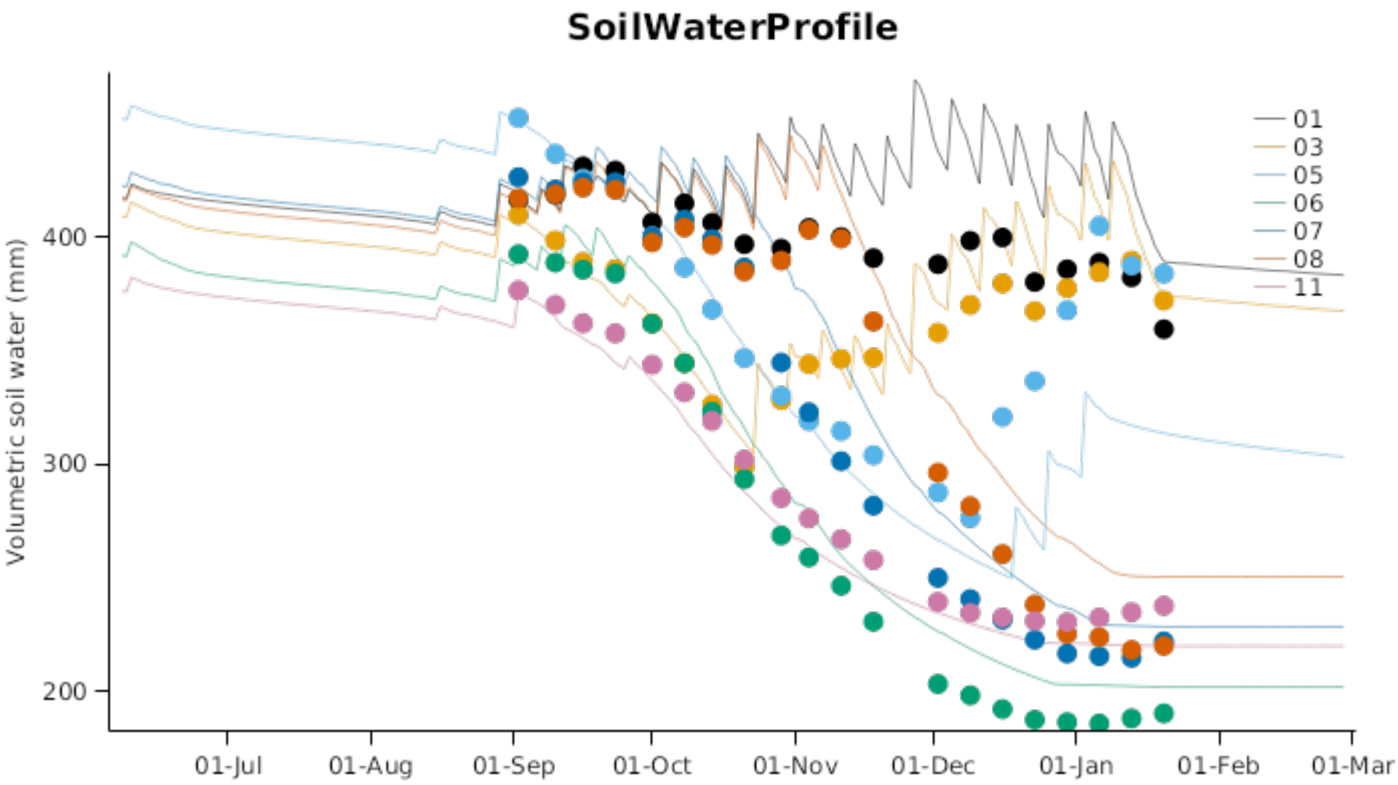


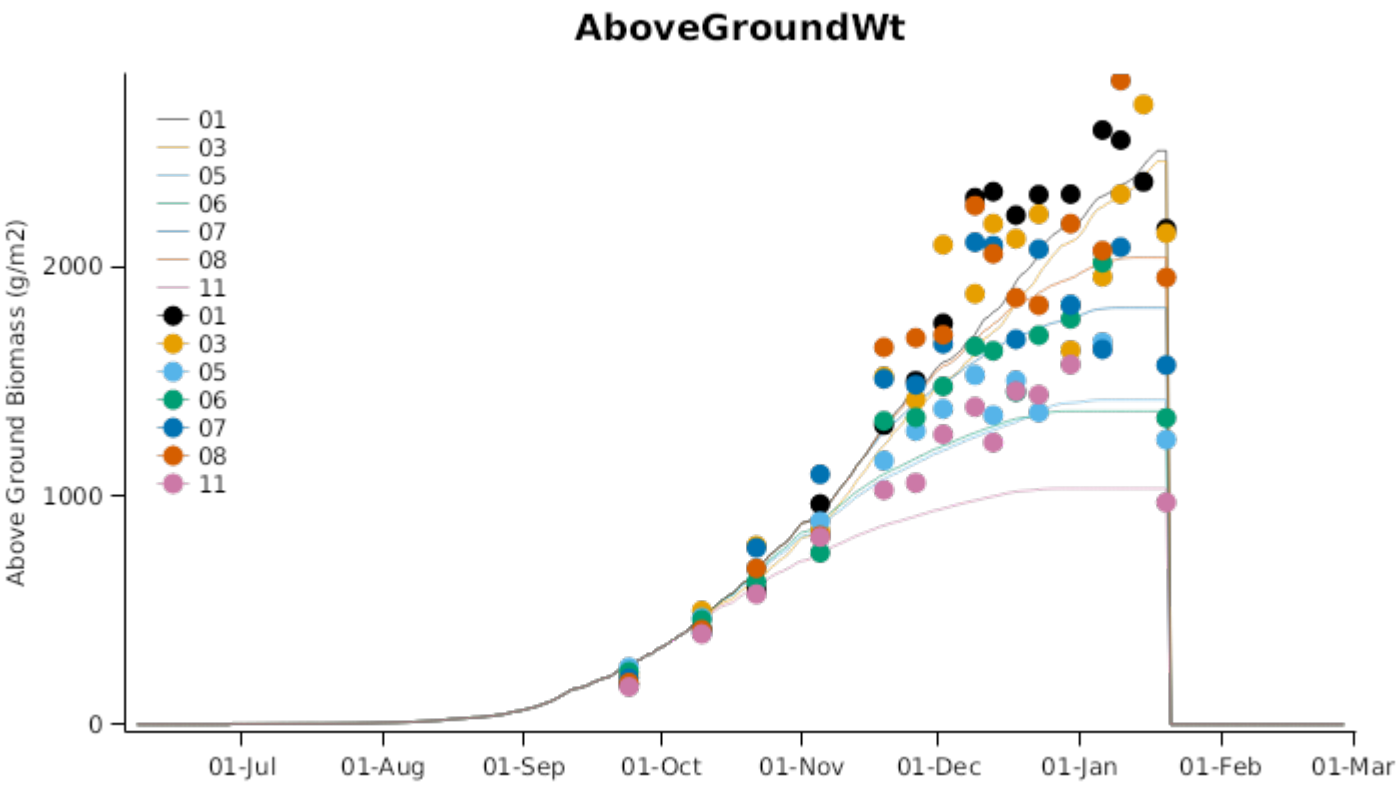
3.5.1 Lincoln9192

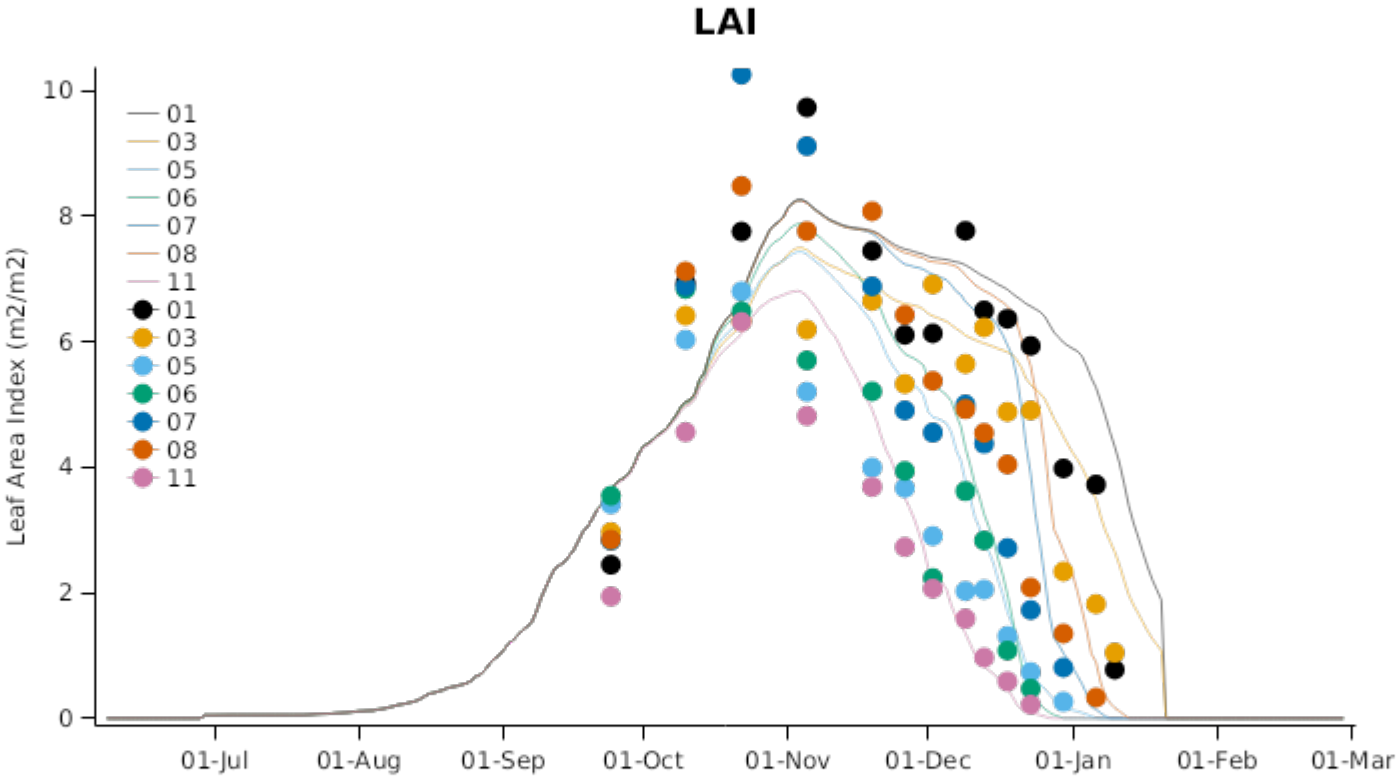
This is a water response trial run in the rain out shelter at Plant and Food Research in Lincoln, New Zealand. It is described in full by Jamieson et al., 1995 but briefly. A winter crop of 'Batten' wheat was sown at 300 plants/m^2 on the 8th of June 1991 and range of irrigation amount and timing treatments were applied. Six of these treatments have been included in this validation:

1. Full irrigation where measured ET was replaced weekly
2. Short Early Drought where irrigation was withheld from sowing until late October then full irrigation was applied
3. Long Early Drought where irrigation was withheld from sowing until mid December then full irrigation was applied
4. Long Late Drought where full irrigation was applied from sowing until mid September then withheld for the rest of the season
5. Moderate Late Drought where full irrigation was applied from sowing until mid October then withheld for the rest of the season
6. Short Late Drought where full irrigation was applied from sowing until Early November then withheld for the rest of the season
7. Nil where no water was applied and the crop grew on soil stored water only.

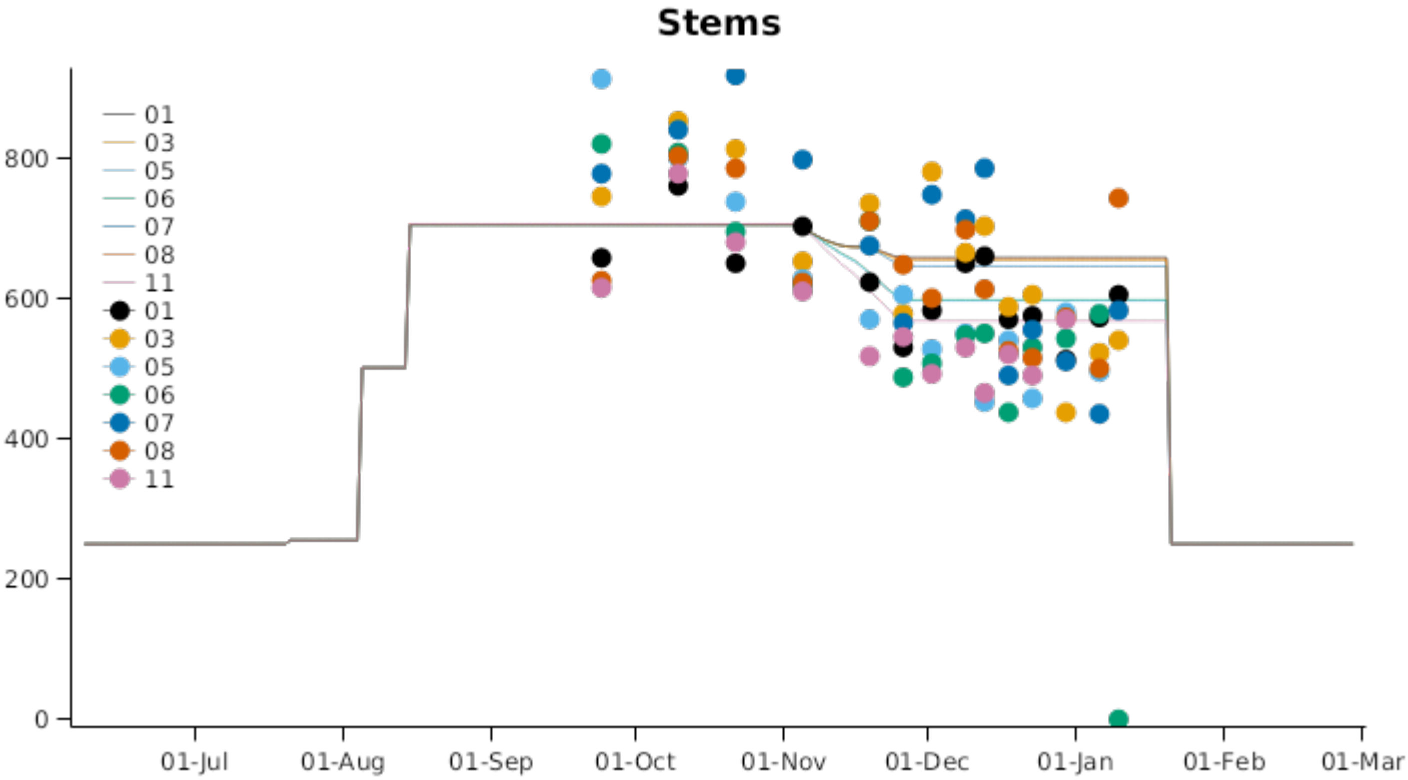
Irrigation was applied at weekly intervals through and assemply of low rate drip emitters on each plot. Soil water content was measured weekly with a neutron probe and biomass was measured at 10 - 14 day intervals. Samples throughtout the crop were from two 0.1m^2 quatrants and the final harvest sample was from a 1 m^2 quadrant. Each treatment was replicated twice and there was considerable soil variation from plot to plot so each treatment was initianilised with unique soil parameters which best described the soil they were growing on.


SoilWaterProfile
Volumetric soil water (mm)
200
300
400
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01
03
05
06
07
08
11

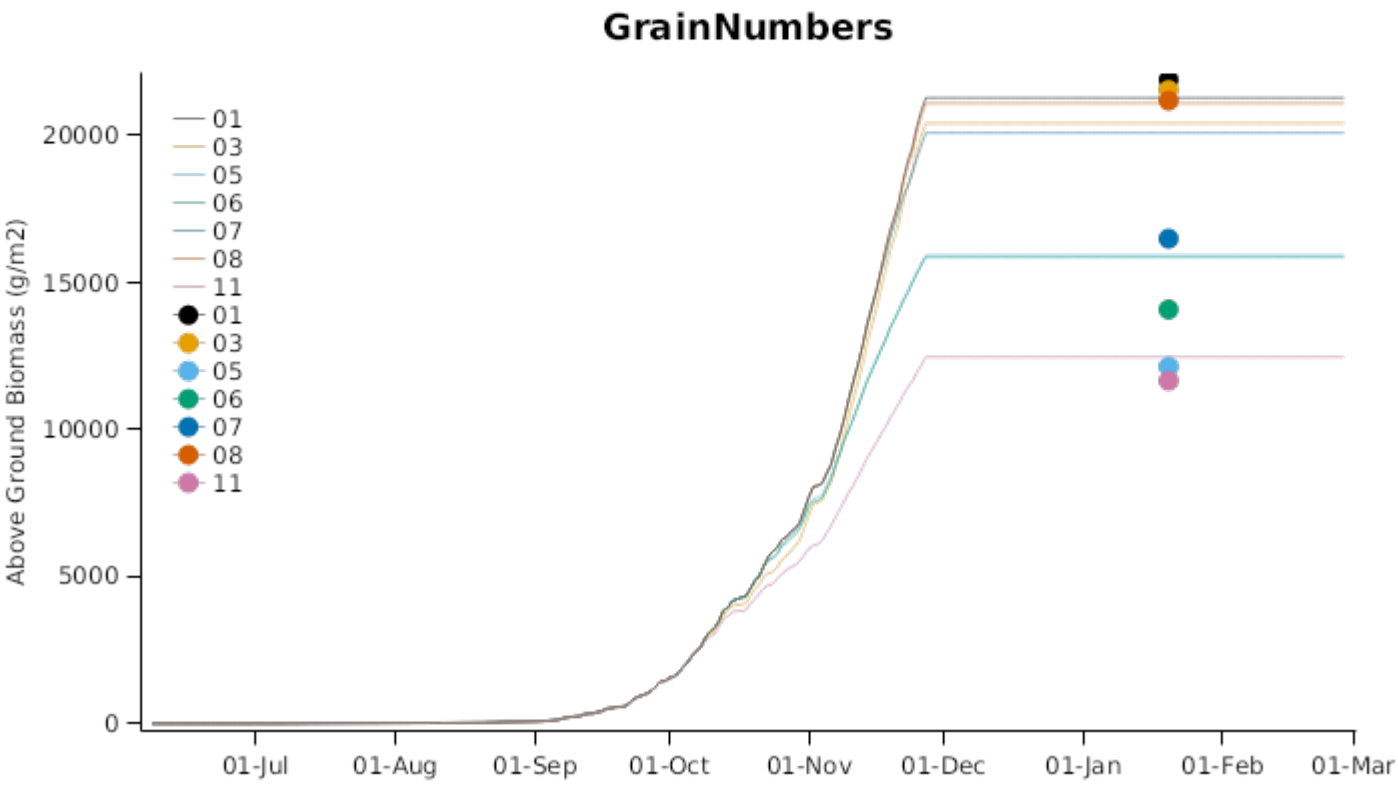

AboveGroundWt
Above Ground Biomass (g/m2)
0
1000
2000
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01
03
05
06
07
08
11
01
03
05
06
07
08
11

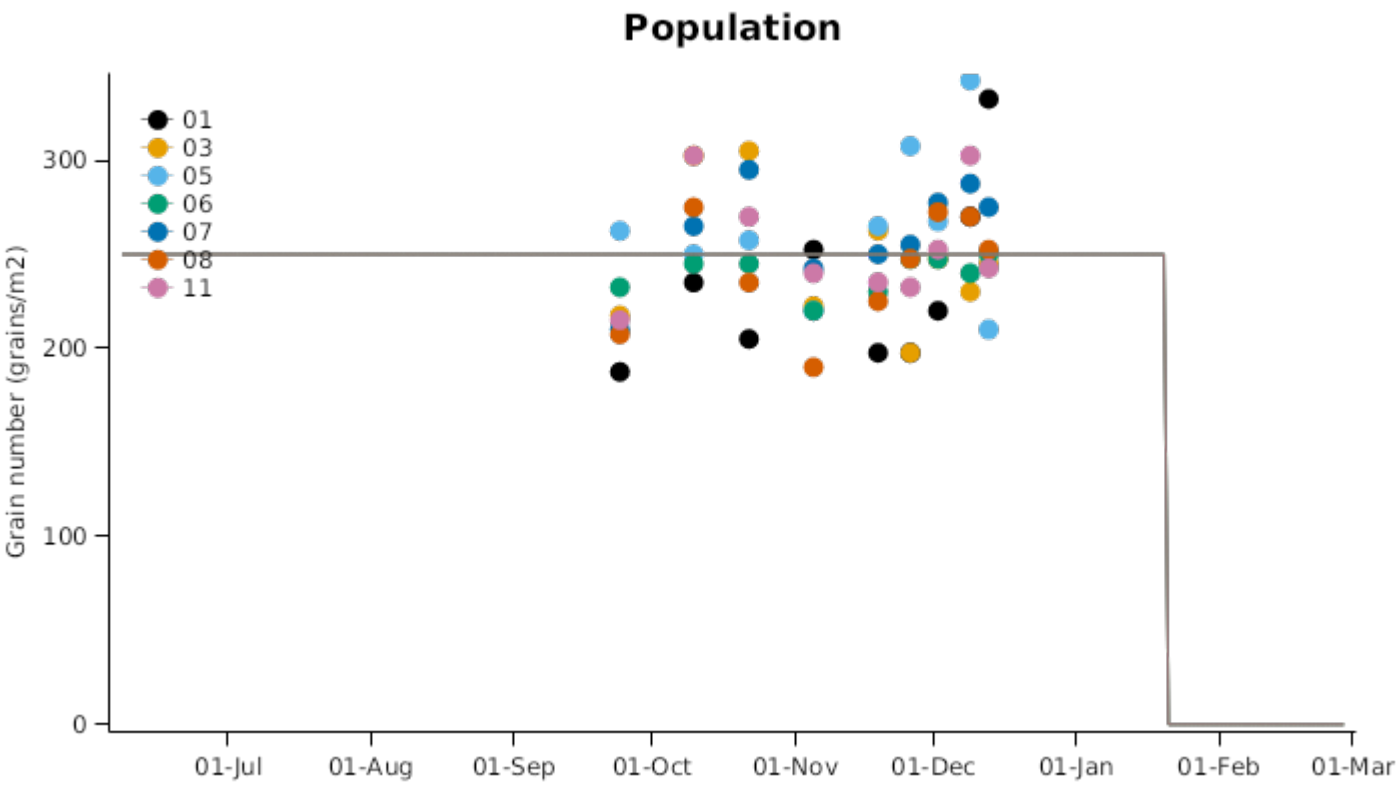


LAI
Leaf Area Index (m2/m2)
01
03
05
06
07
08
11
01
03
05
06
07
08
11
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar



Stems
01
03
05
06
07
08
11
01
03
05
06
07
08
11
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar





3.5.2 Lincoln1992

This trial has never been formally written up. It was conducted at Plant and Foods A Block, Lincoln, New Zealand with 'Batten' Wheat grown on a Templeton silt loam (160mm AWC/m). It was a 2 x 2 x 4 factorial with the following treatments:

1. Sowing Date (5 May 1992 and 5 Aug 1992)
2. Irrigation (Nil and 120 mm)
3. Nitrogen (0, Low, Medium and High)

The N applied to the Low, Medium and High N treatments was 100, 150 and 250 kg/ha, respectively, for the May sowing and 50, 100 and 150, respectively, for the August sowing.

Could not find informaiton confirming sowing rate so assumed typical values of 300 plants per m/2 for the spring sowing 100 plants per m/2 for May sowing. Emergence was recorded as the 28th of May for the first planting. The model was predicting this early so delayed sowing date to get emergence date correct..

3.5.3 Lincoln2010

- Could not find informaiton confirming sowing rate. Protocole said aim for 300 plants per m/2 which is usual for a spring sowing but very high for an Autumn sowing. Assumed 100 plants per m/2 for May sowing and 300 for August.
- Emergence was recorded as the 28th of May for the first planting. The model was predicting this early so delayed sowing date to get emergence date correct..

This is a water response trial run in the rain out shelter at Plant and Food Research in Lincoln, New Zealand. It is described in full by E. Chakwizira et al., 2014 but briefly. An Autumn crop of 'Wakanui' wheat was sown at 165 plants/m^2 on the 28th of March 2013 and 6 irrigation timing treatments were applied:

1. Full irrigation where measured ET was replaced weekly .
2. Nill irrigation.
3. Very Early Drought where irrigation was withheld from sowing until the beginning of stem extension.
4. Early Drought where irrigation was withheld between Flag leaf and the beginning of grain fill.
5. Middle Drought where irrigation was withheld between Flag leaf and 1 week into grain fill.
6. Late Drought where irrigation was withheld from heading until harvest.

Irrigation was applied at weekly intervals through and assemply of low rate drip emitters on each plot. Soil water content was measured weekly with a neutron probe and biomass was measured on 5 occasions throughout the crop. Samples throughtout the crop were from a 0.43m^2 quatrant and the final harvest sample was from a 1 m^2 quadrant. Each treatment was replicated four times and there was considerable soil variation from plot to plot so each treatment was initianilised with unique soil parameters which best described the soil they were growing on.

3.5.4 Lincoln2014

This is a water response trial run in the rain out shelter at Plant and Food Research in Lincoln, New Zealand. It is described in full by E. Chakwizira et al., 2014 but briefly. An Autumn crop of 'Wakanui' wheat was sown at 165 plants/m^2 on the 28th of March 2013 and 6 irrigation timing treatments were applied:

1. Full irrigation where measured ET was replaced weekly .
2. Nill irrigation.
3. Very Early Drought where irrigation was withheld from sowing until the beginning of stem extension.
4. Early Drought where irrigation was withheld between Flag leaf and the beginning of grain fill.
5. Middle Drought where irrigation was withheld between Flag leaf and 1 week into grain fill.
6. Late Drought where irrigation was withheld from heading until harvest.

Irrigation was applied at weekly intervals through and assemply of low rate drip emitters on each plot. Soil water content was measured weekly with a neutron probe and biomass was measured on 5 occasions throughout the crop. Samples throughtout the crop were from a 0.43m^2 quatrant and the final harvest sample was from a 1 m^2 quadrant. Each treatment was replicated four times and there was considerable soil variation from plot to plot so each treatment was initianilised with unique soil parameters which best described the soil they were growing on.

3.5.5 Lincoln2015

3.5.5.1 Lincoln2012 (Rain-Shelter Trail)

Testing of APSIM Maize under New Zealand conditions was undertaken using the 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 growth and nitrogen content of individual organs, soil water contents, leaf area index, phenology and yield components. 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.

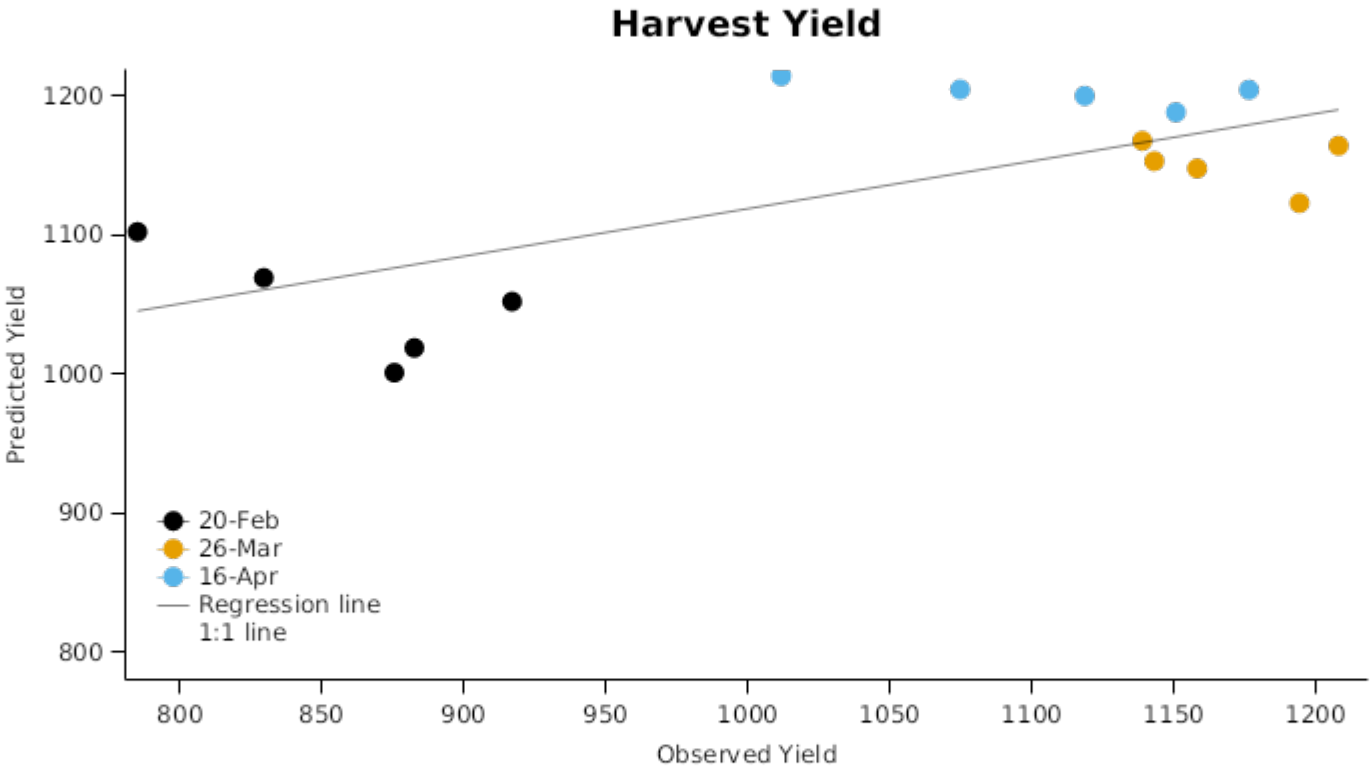
3.5.6 Leeston2013

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.



3.5.7 Leeston2014

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.

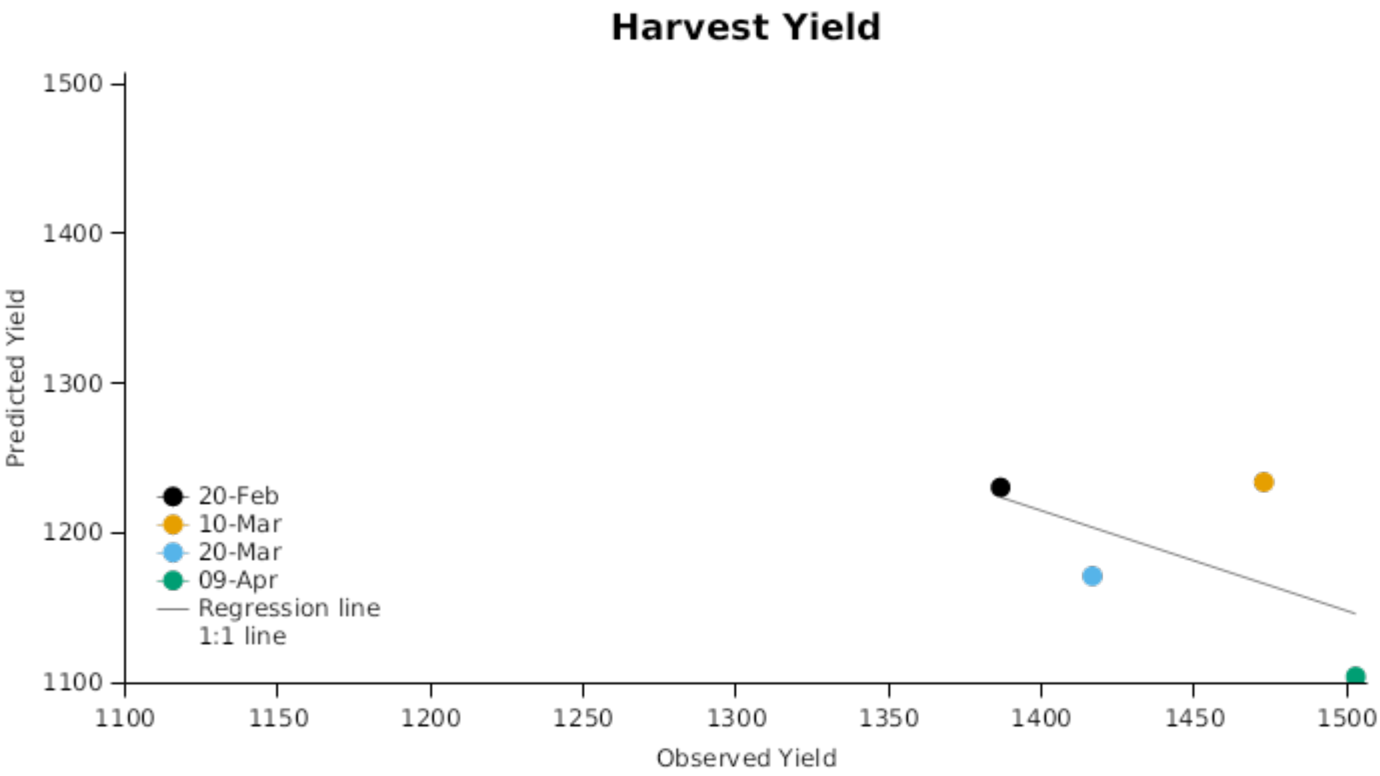
3.5.8 Wakanui2015

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.



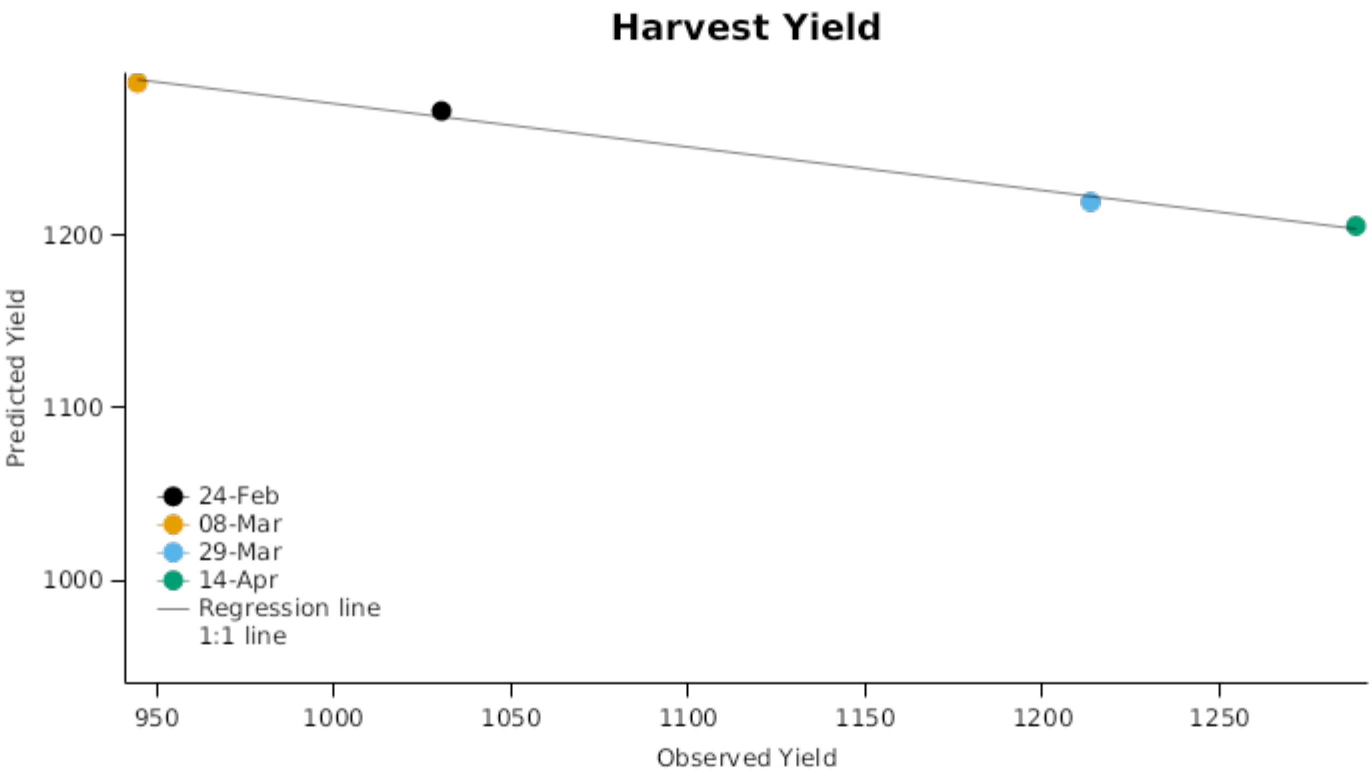
3.5.9 Wakanui2016

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.



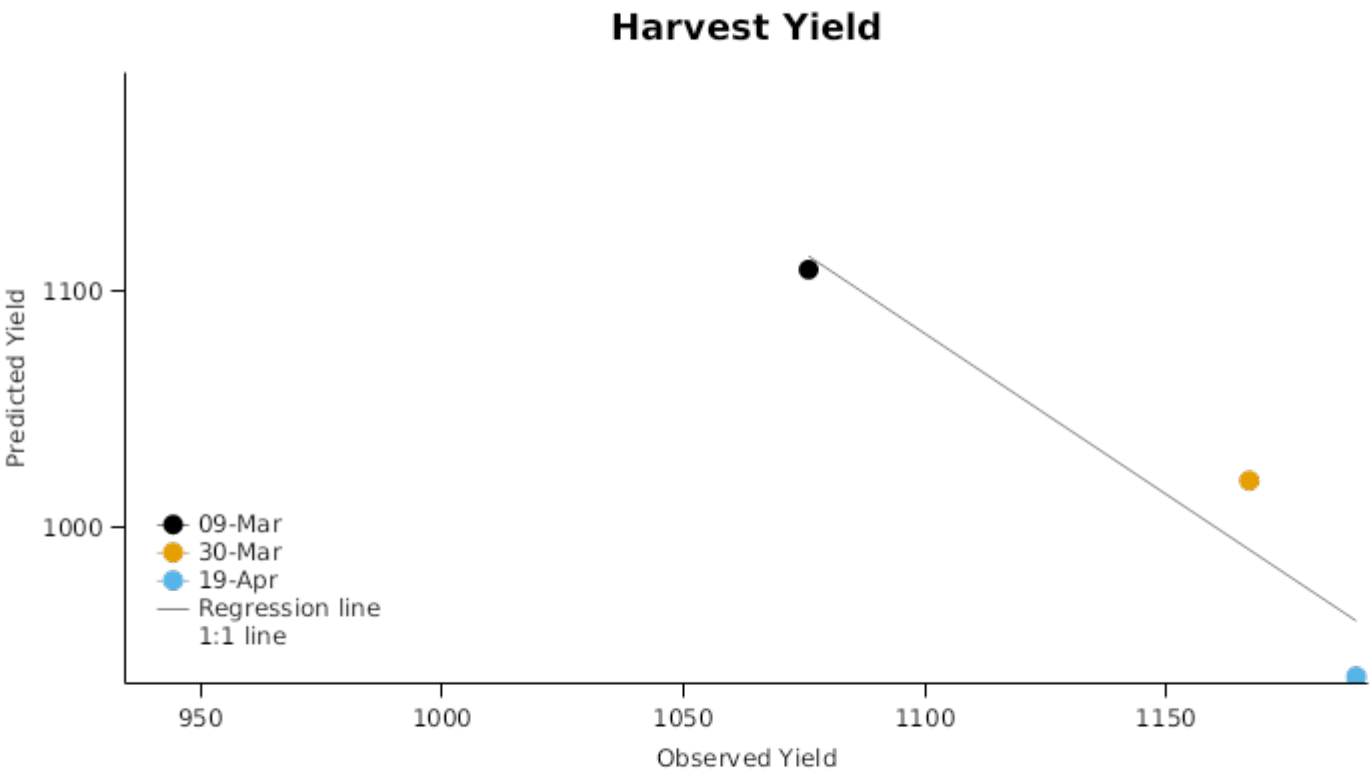
3.5.10 Wakanui2017

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.



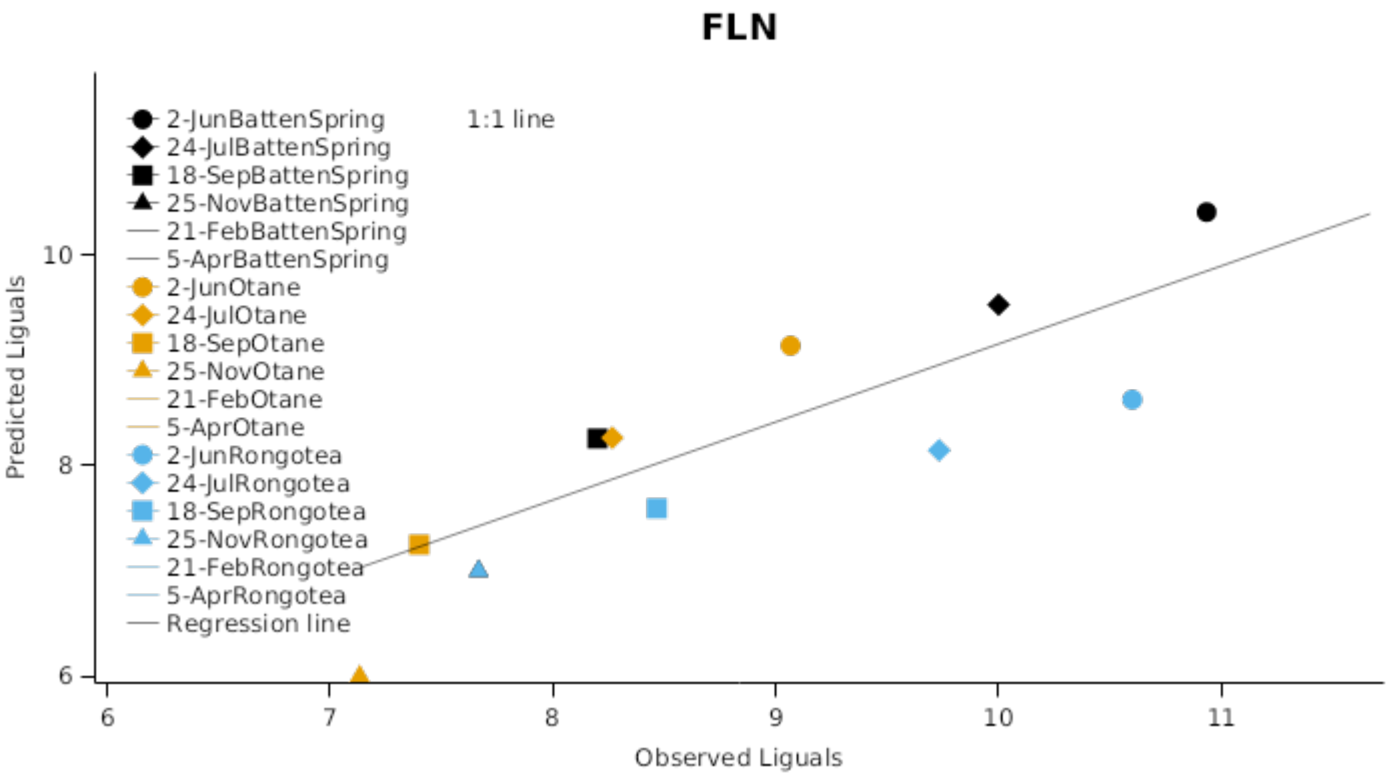
3.5.11 PalmerstonNorth1989

The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.



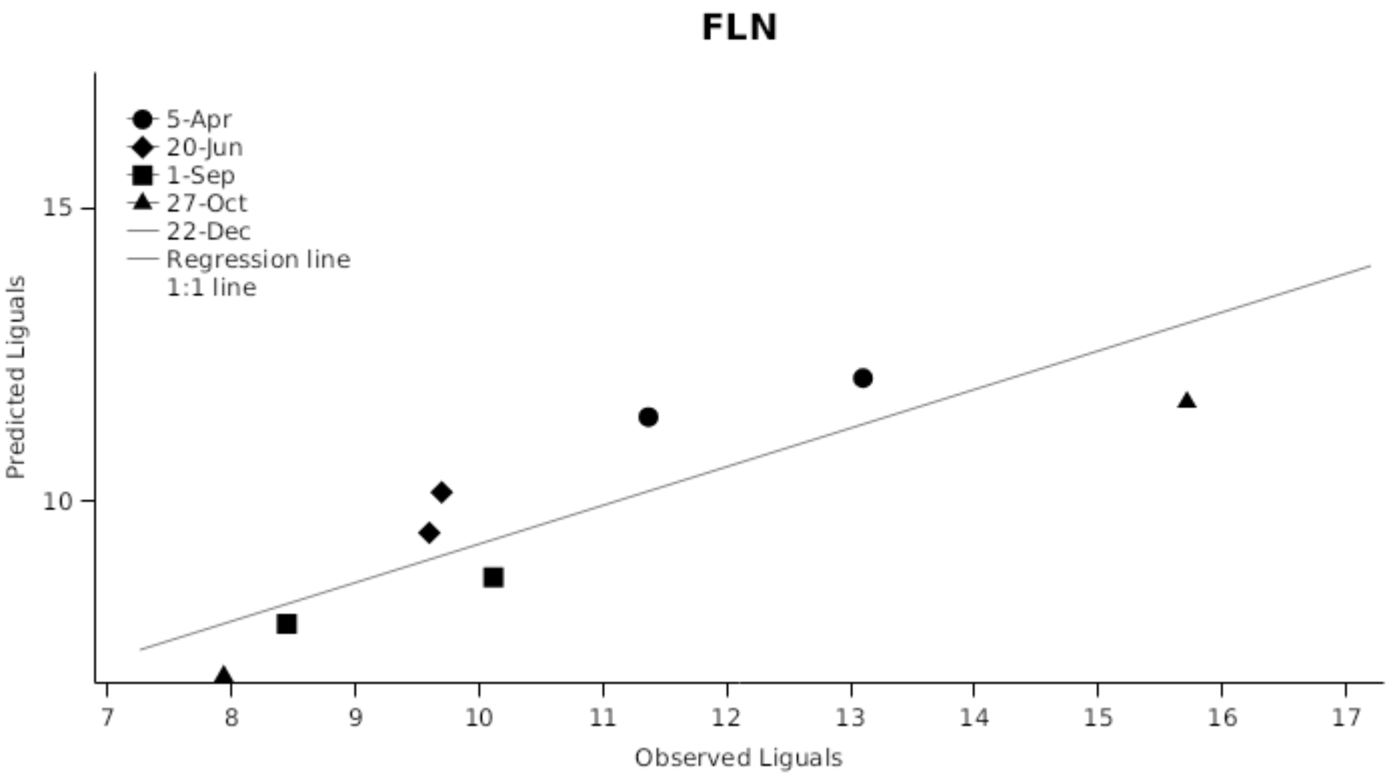
3.5.12 Lincoln1994

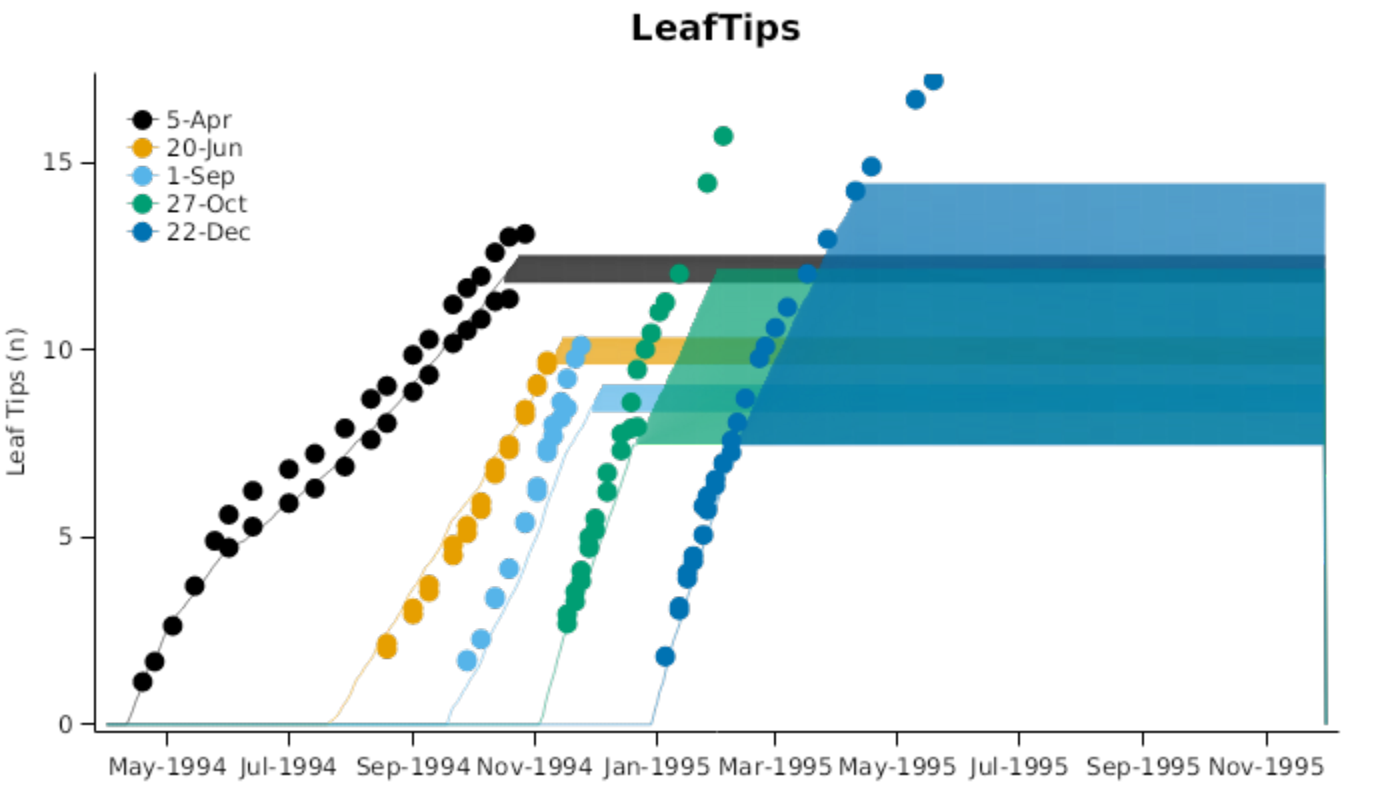
The design, management and yield results of this trial have been described in full by [Craigie_Wheat_2015]. In brief, this trial was conducted to assess the impact of earlier sowing on potential yields of 'Wakanui' wheat grown at Wakanui (the cultivar was named after the area) in Mid Canterbury, New Zealand. it was a 4 x 4 factorial with 4 replicates of the following treatments:

1. Sowing date (20 February, 10 March, 28 March, 23 April)
2. Sowing density (50,100,150 and 200 plants/m^2

In addition to yield, measurements of leaf appearance and senescence and canopy cover (measured with NDVI) were measured at 10 - 14 day intervals and biomass measurements were taken at growth stages 32 and 65.

Considerable canopy decay was observed during the winter for the early sown treatments and we have not introduced mechanisms into the model to capture this yet so there is a genral over prediction of canopy size and biomass in these first sowing dates.





3.5.13 CPTPhenology

A range of soon to be released cultivars have their phenology assesed each year at Plant and Food Research in Lincoln, New Zealand. Each cultivar is planted on 4 sowing dates representing Autumn, Winter, Early Spring and Late Spring sowings. (approx April, June, Aug, Nov). Each cultivar is observed for 3 years but a number of standards are included each year or for more than 3 years bacause of the value of the data they provided.

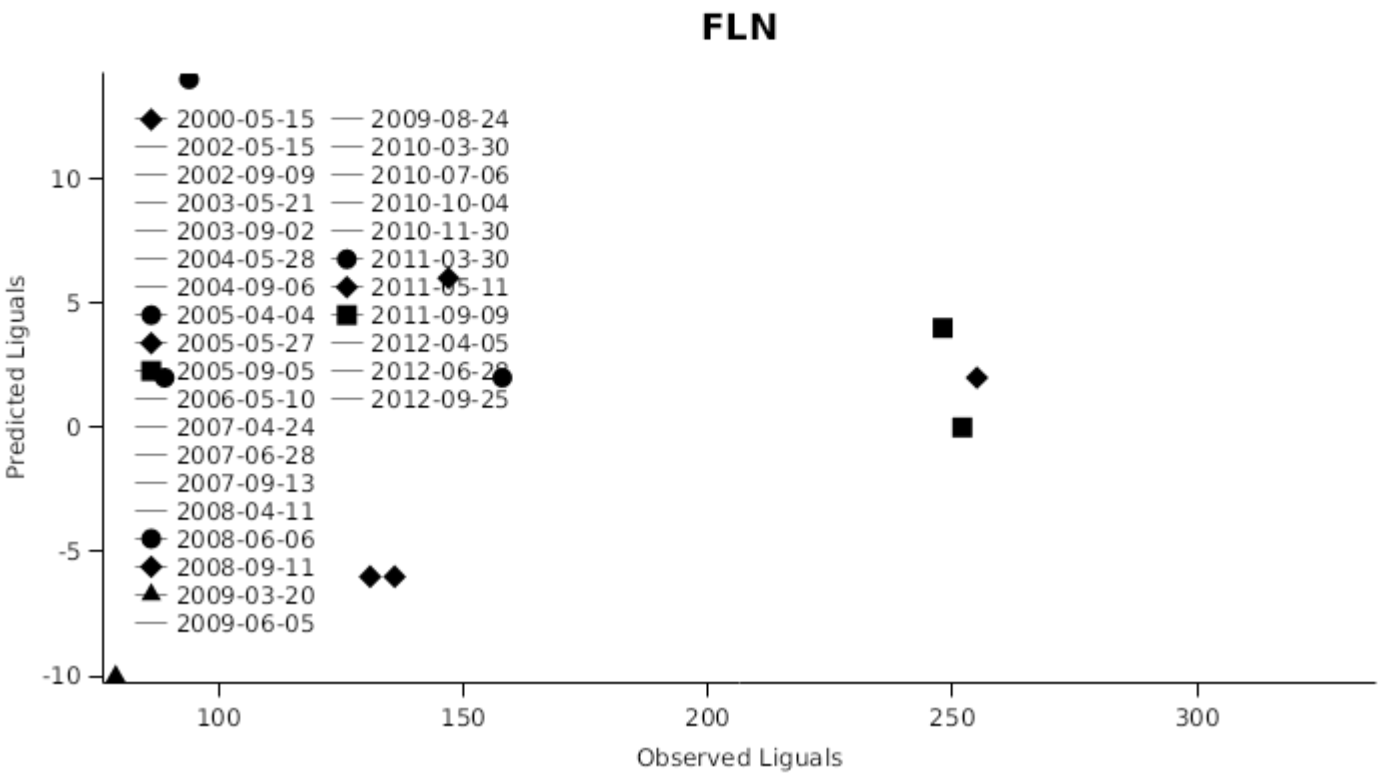
List of experiments.

Experiment Name	Design (Number of Treatments)
CPTCultOtane	Sow (40)

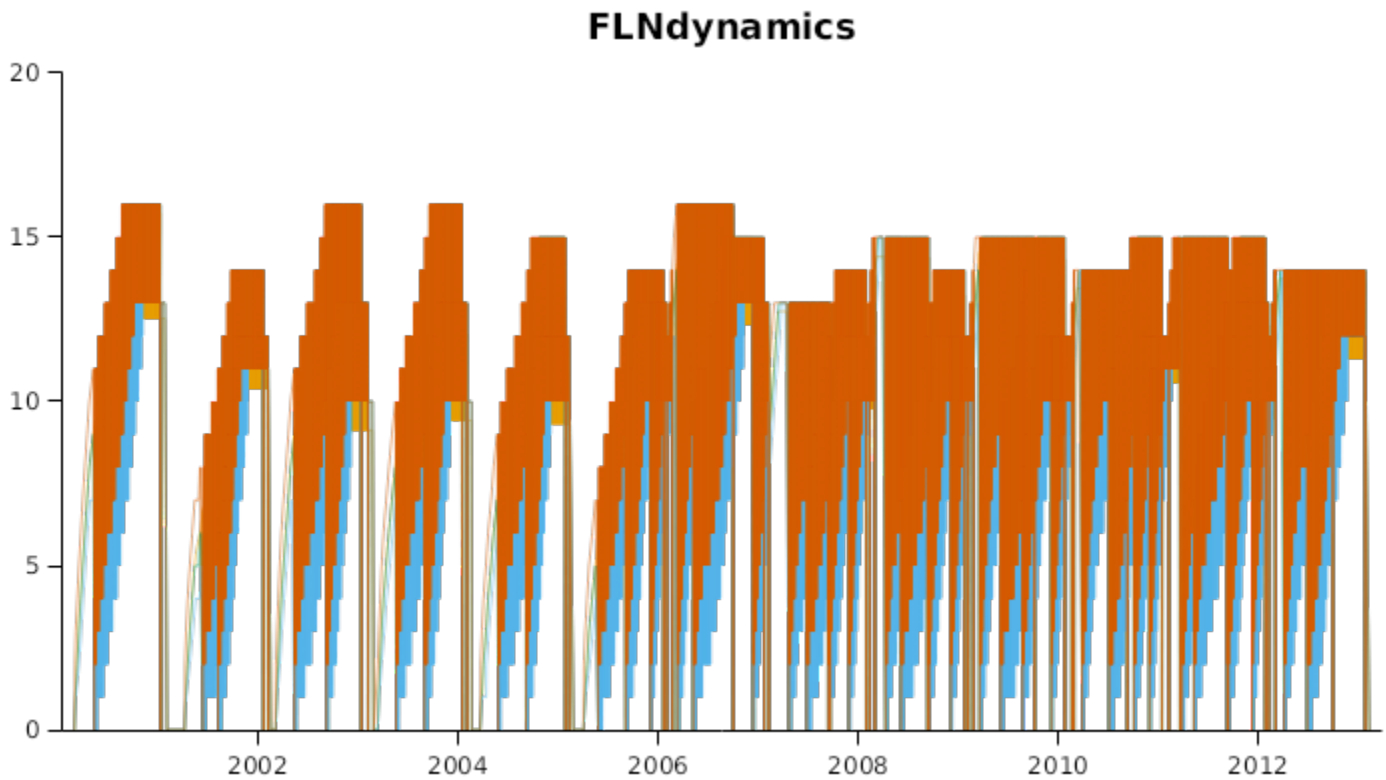
Experiment Name	Design (Number of Treatments)
CPTCultAmarok	Sow (26)
CPTCultClaire	Sow (43)
CPTCultWakanui	Sow (6)
CPTCultBattenSpring	Sow (13)
CPTCultBattenWinter	Sow (12)
CPTCultYitpi	Sow x Cv (13)
CPTCultSunco	Sow (13)
CPTCultMcCubbin	Sow (13)
CPTCultMacKellar	Sow (13)
CPTCultJanz	Sow x Cv (13)
CPTCultLang	Sow (13)
CPTCultH45	Sow (13)

3.5.13.1 CPTCultOtane

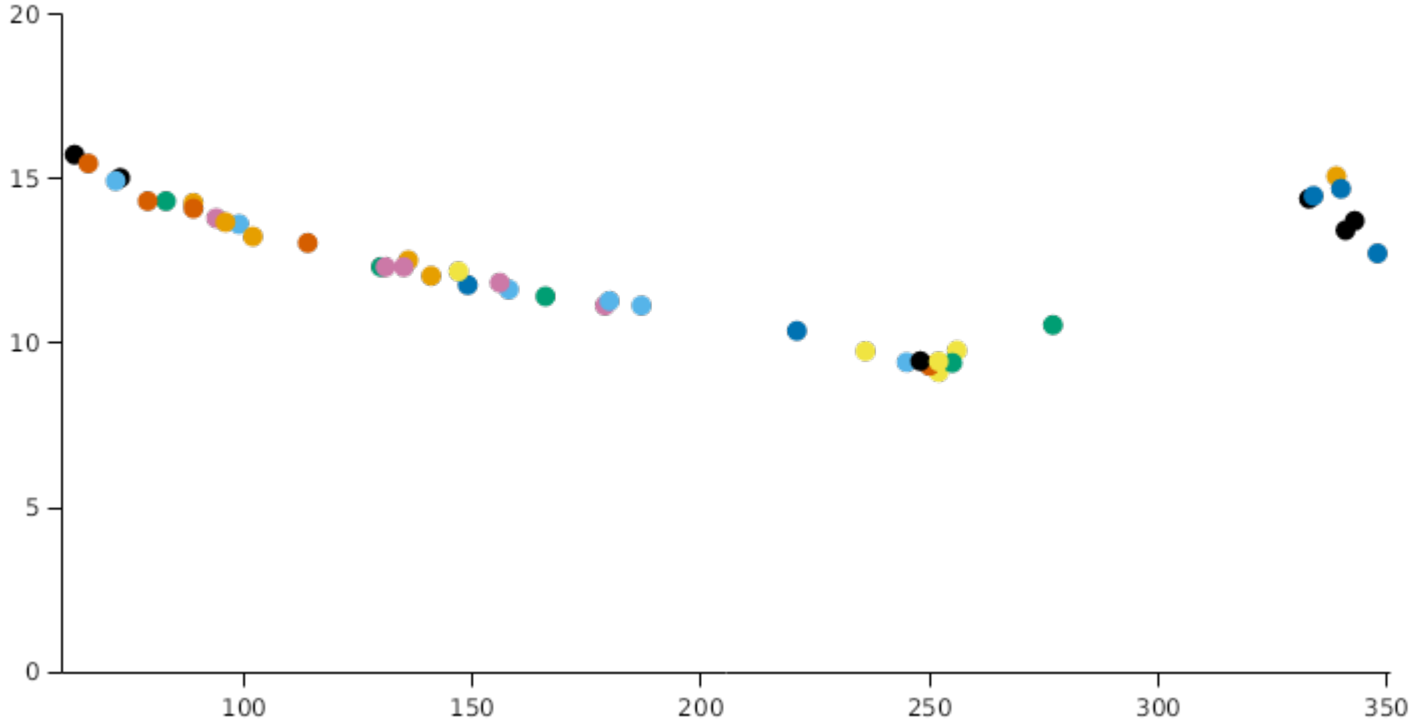
Graph1



3.5.13.2 CPTCultClaire



Graph1



HSTSDynamics

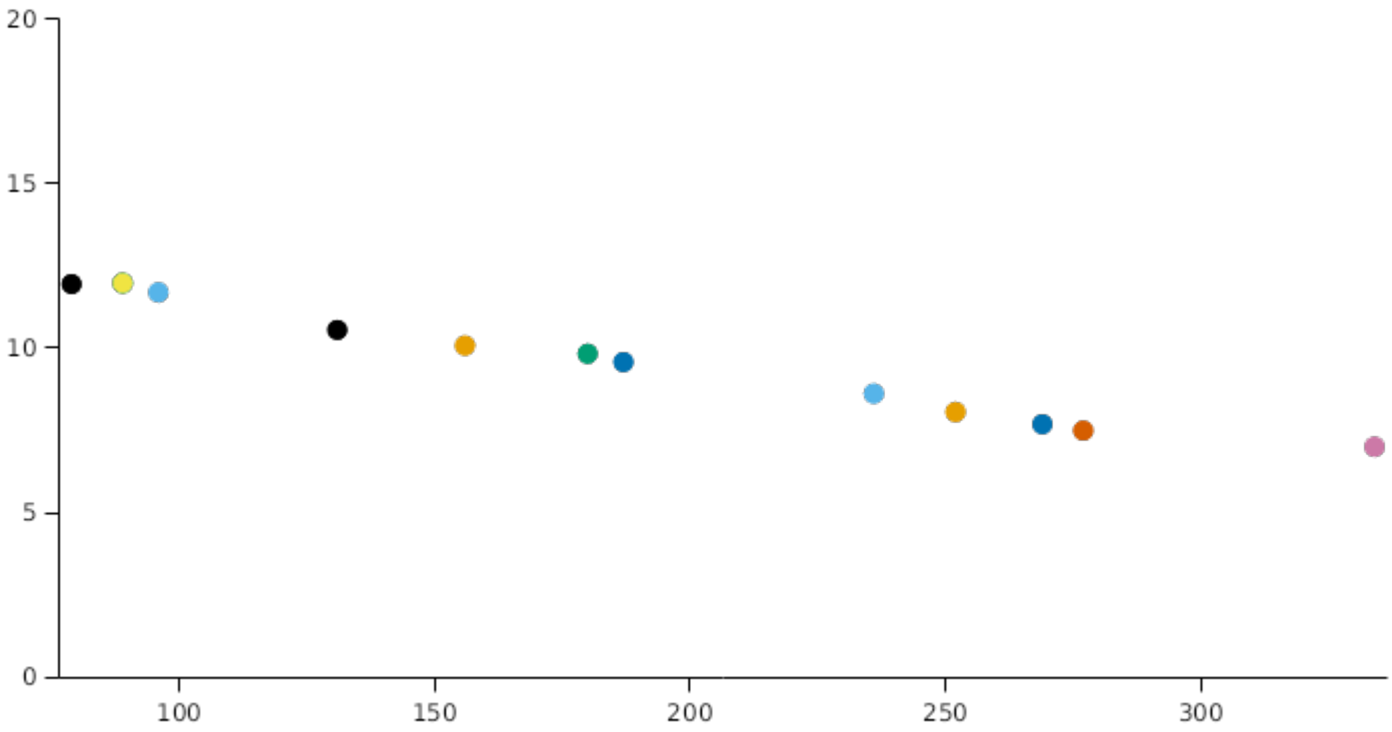
FLNdynamics1

Graph11

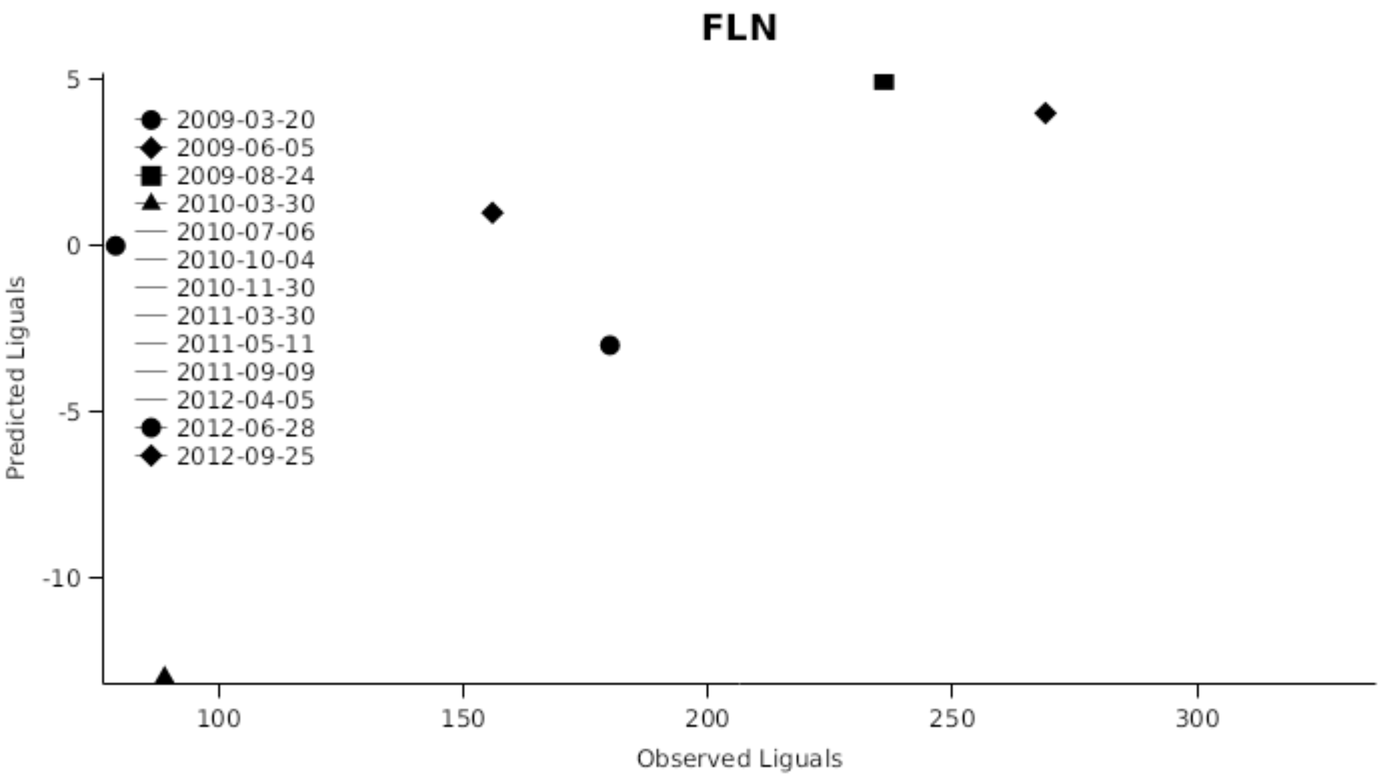
Graph111

3.5.13.3 CPTCultBattenSpring

Graph1



FLNdynamics1

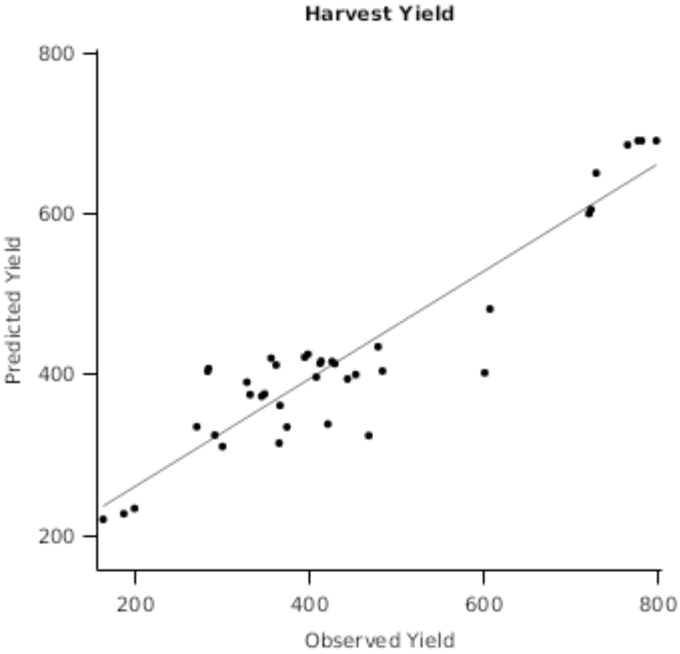


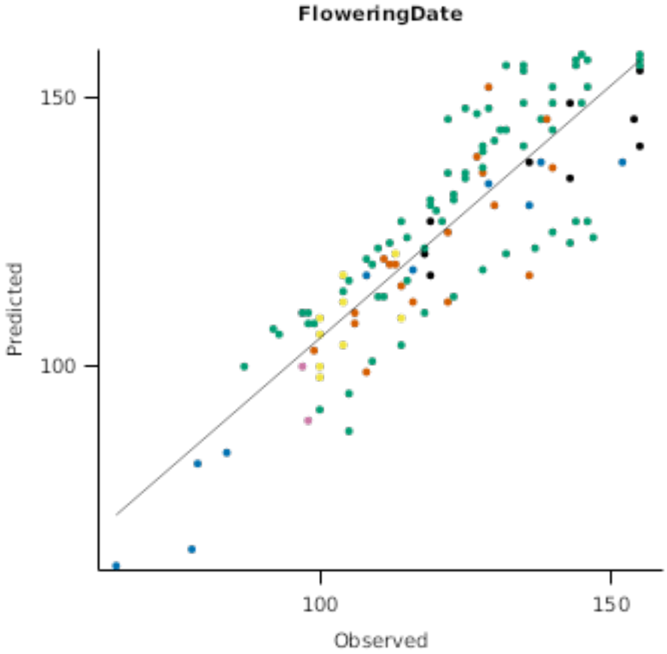
3.6 Southern Australia

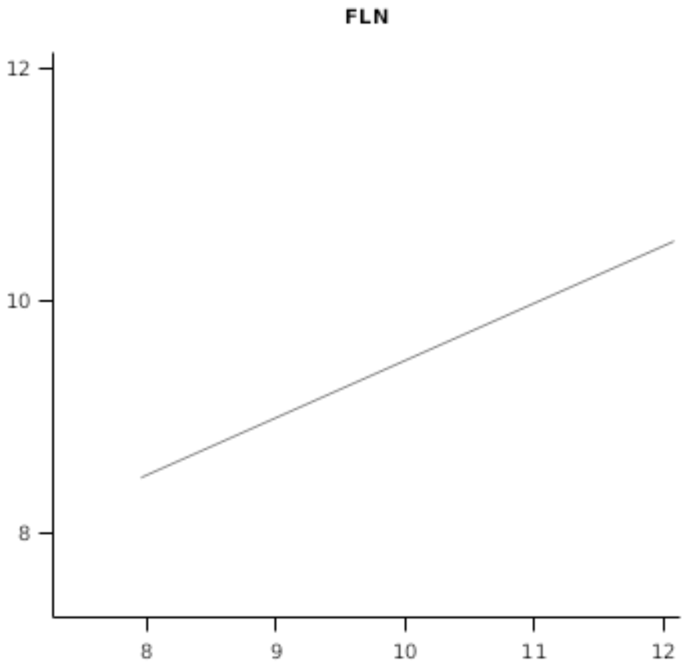
List of experiments.

Experiment Name	Design (Number of Treatments)
Mouse	Removal x Date (20)
Walpeup2011	Cv x TOS (12)
Walpeup2012	Cv x TOS (8)
Minnipa2012	Cv x TOS (9)

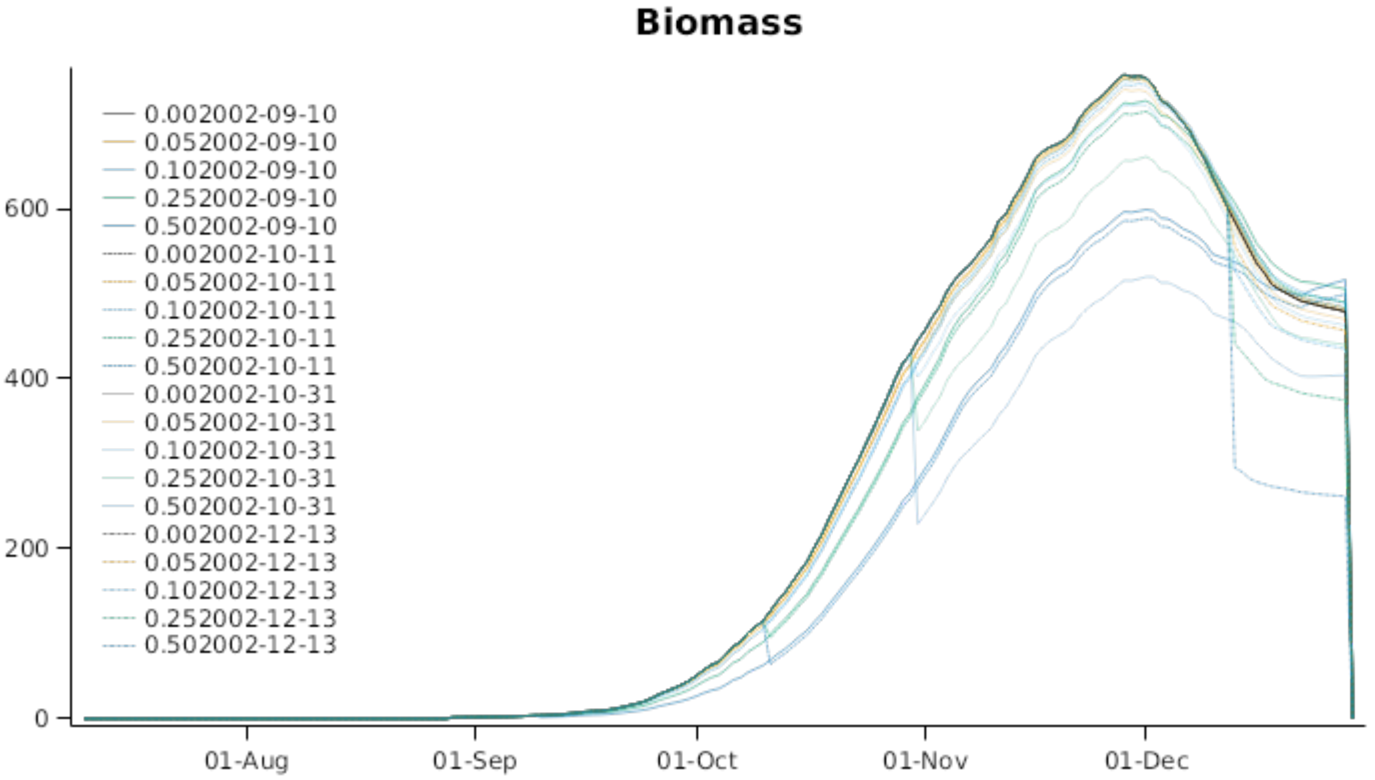
Experiment Name	Design (Number of Treatments)
Temora2012	Cv x TOS (9)
Birchip2011	TOS x Cv (16)
Tarlee2011	TOS x Cv (16)
Tamworth1992	Cv x TOS (75)

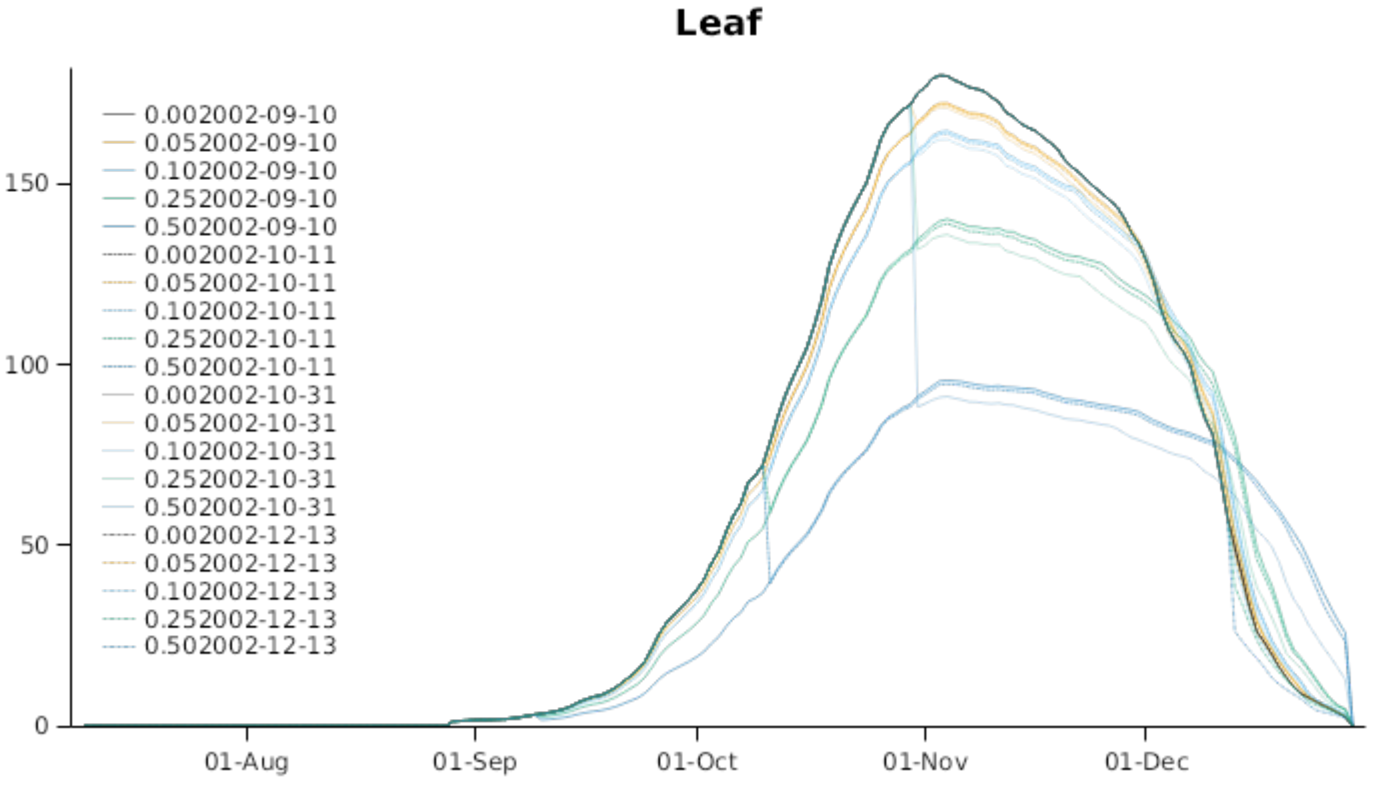






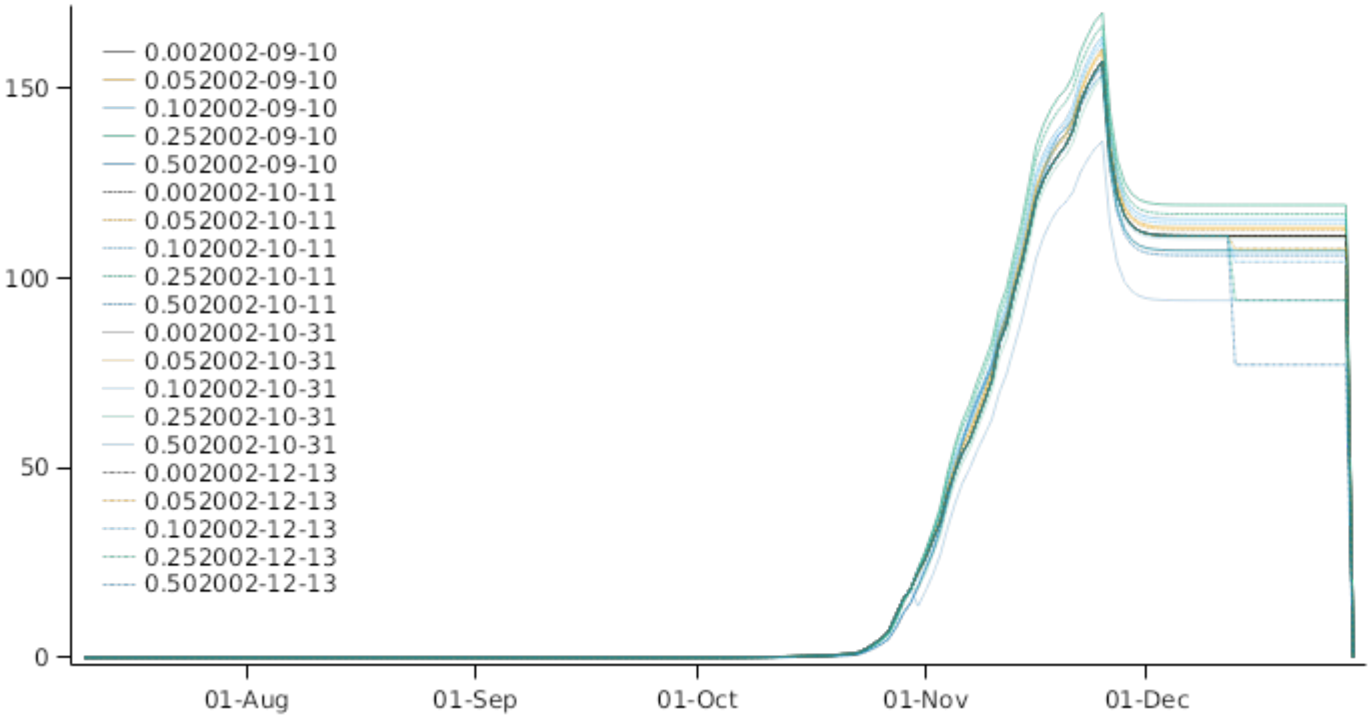
3.6.1 Mouse


Biomass
0.002002-09-10
0.052002-09-10
0.102002-09-10
0.252002-09-10
0.502002-09-10
0.002002-10-11
0.052002-10-11
0.102002-10-11
0.252002-10-11
0.502002-10-11
0.002002-10-31
0.052002-10-31
0.102002-10-31
0.252002-10-31
0.502002-10-31
0.002002-12-13
0.052002-12-13
0.102002-12-13
0.252002-12-13
0.502002-12-13
600
400
200
0
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

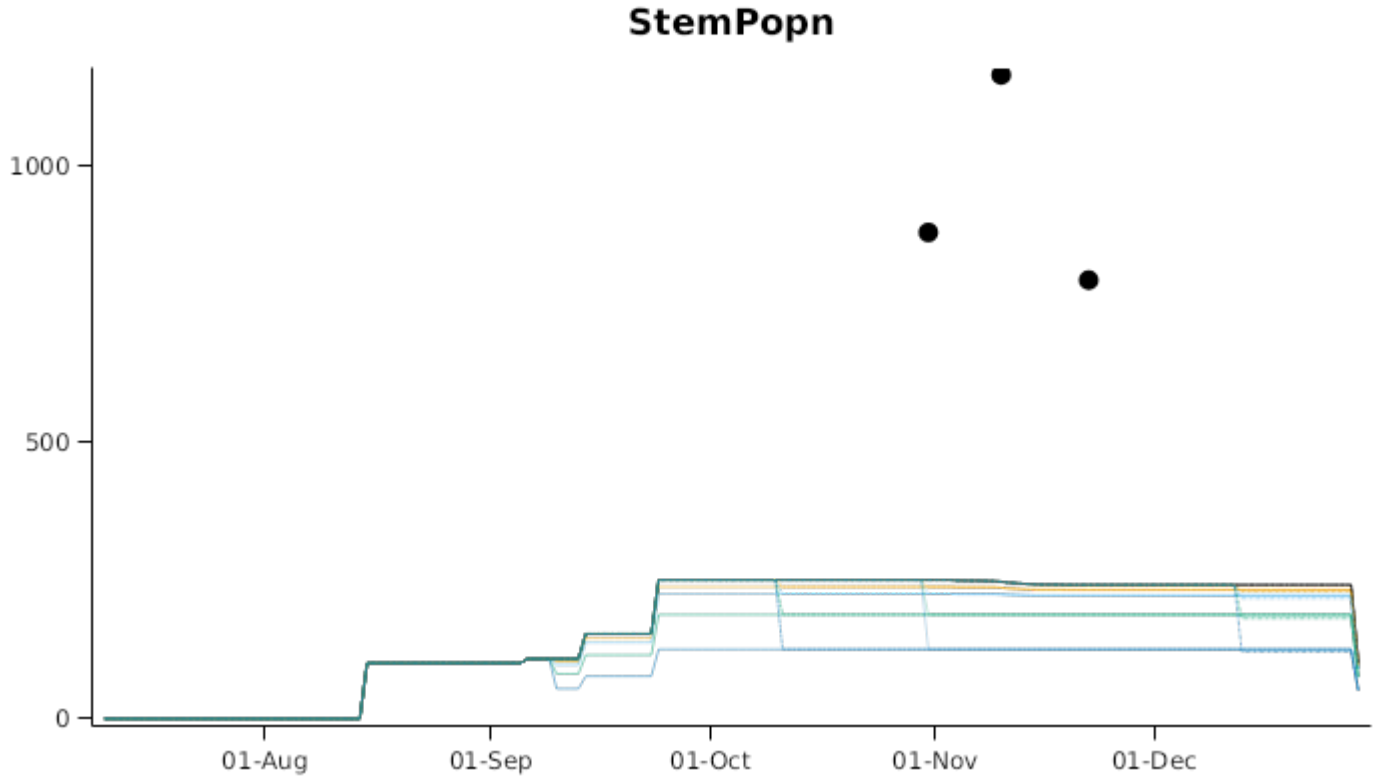

Leaf
0.002002-09-10
0.052002-09-10
0.102002-09-10
0.252002-09-10
0.502002-09-10
0.002002-10-11
0.052002-10-11
0.102002-10-11
0.252002-10-11
0.502002-10-11
0.002002-10-31
0.052002-10-31
0.102002-10-31
0.252002-10-31
0.502002-10-31
0.002002-12-13
0.052002-12-13
0.102002-12-13
0.252002-12-13
0.502002-12-13
150
100
50
0
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

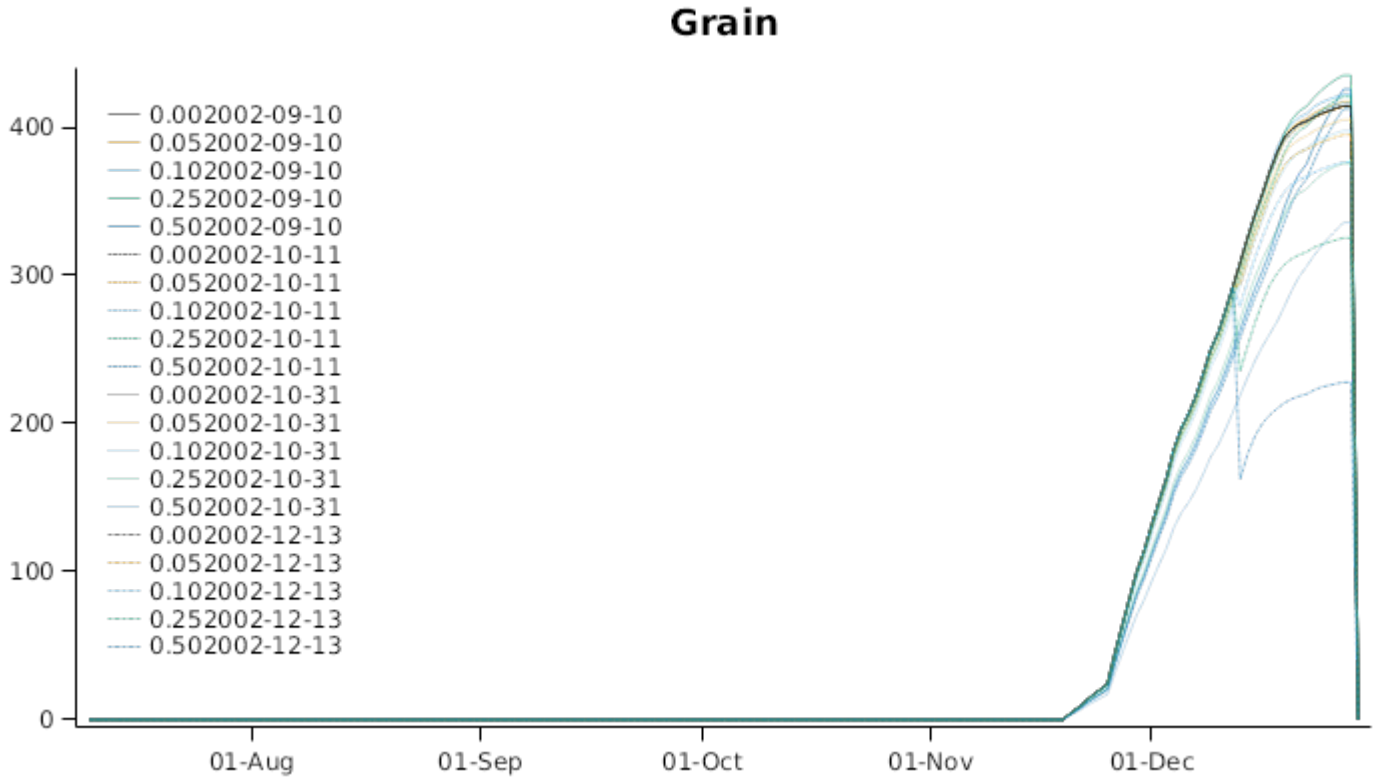
Stem

Spike

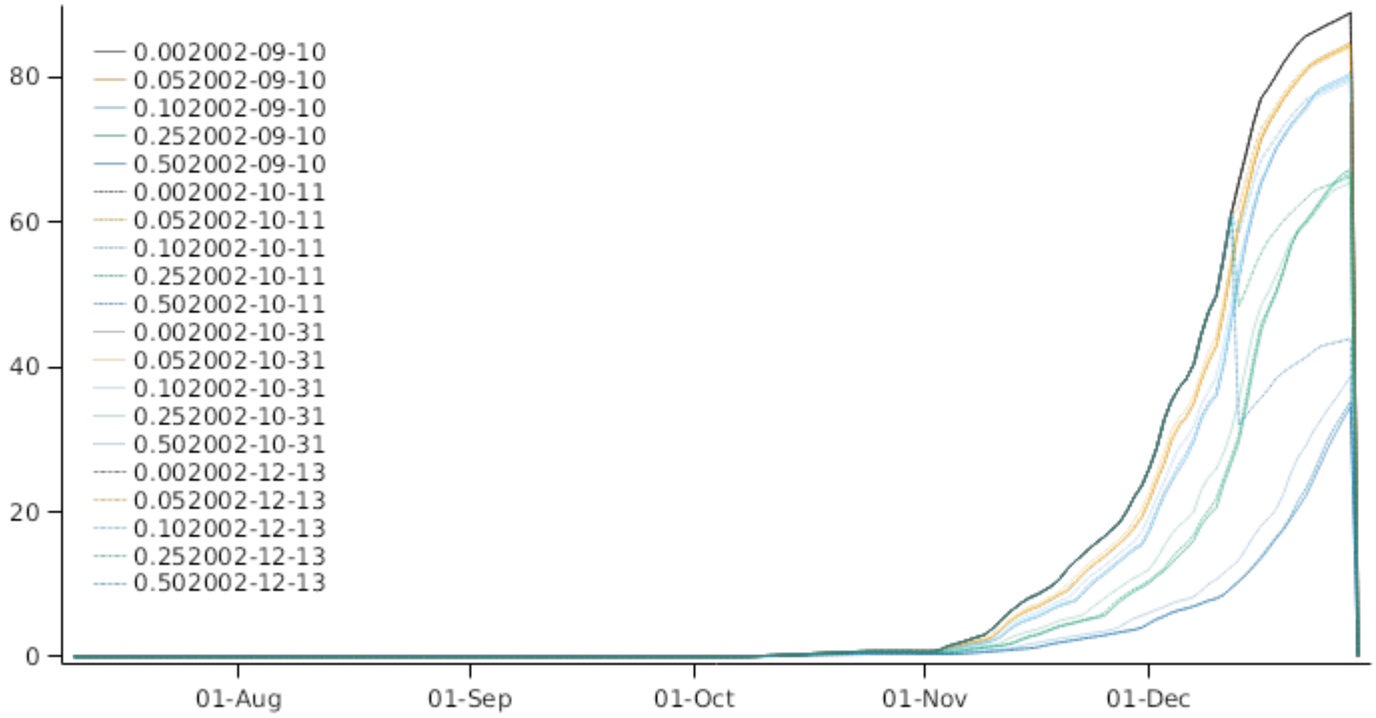


0.002002-09-10
0.052002-09-10
0.102002-09-10
0.252002-09-10
0.502002-09-10
0.002002-10-11
0.052002-10-11
0.102002-10-11
0.252002-10-11
0.502002-10-11
0.002002-10-31
0.052002-10-31
0.102002-10-31
0.252002-10-31
0.502002-10-31
0.002002-12-13
0.052002-12-13
0.102002-12-13
0.252002-12-13
0.502002-12-13
150
100
50
0
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

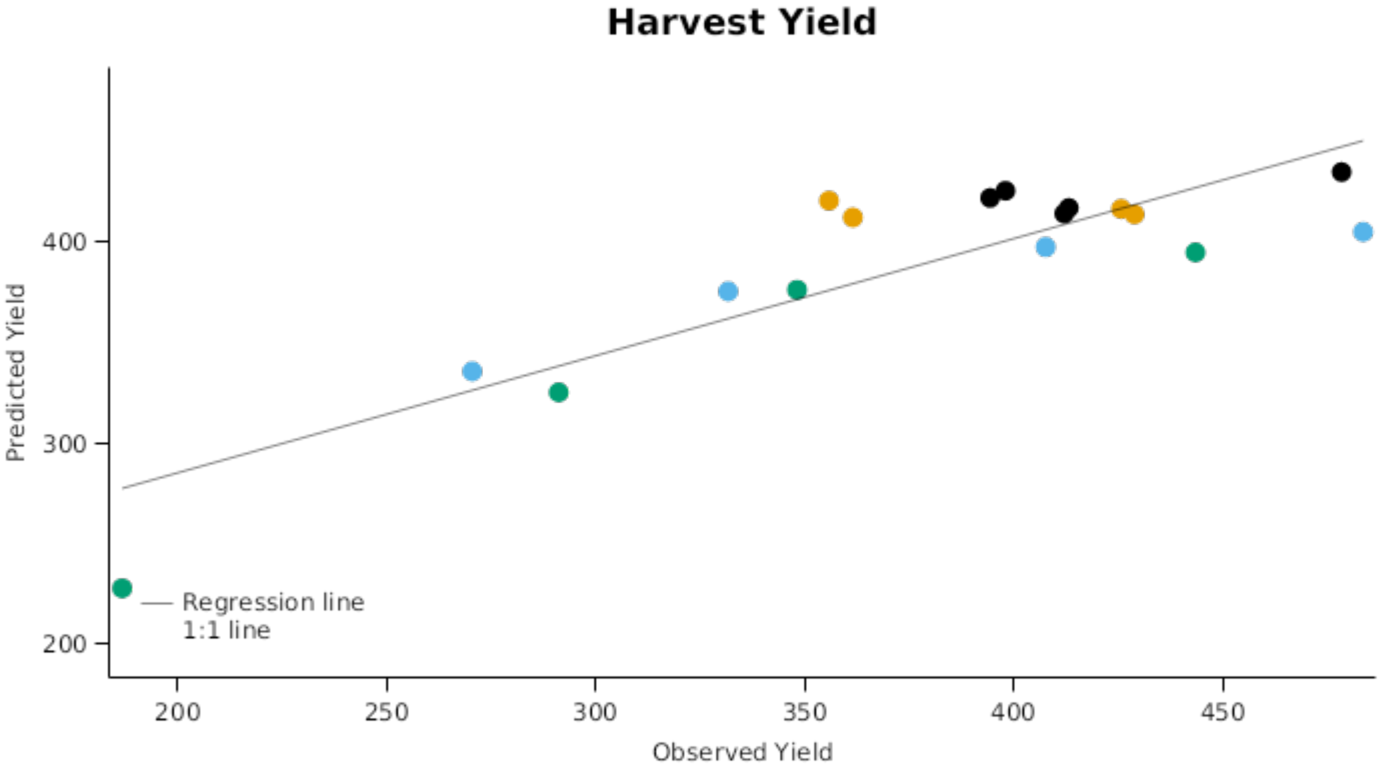

StemPopn
1000
500
0
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

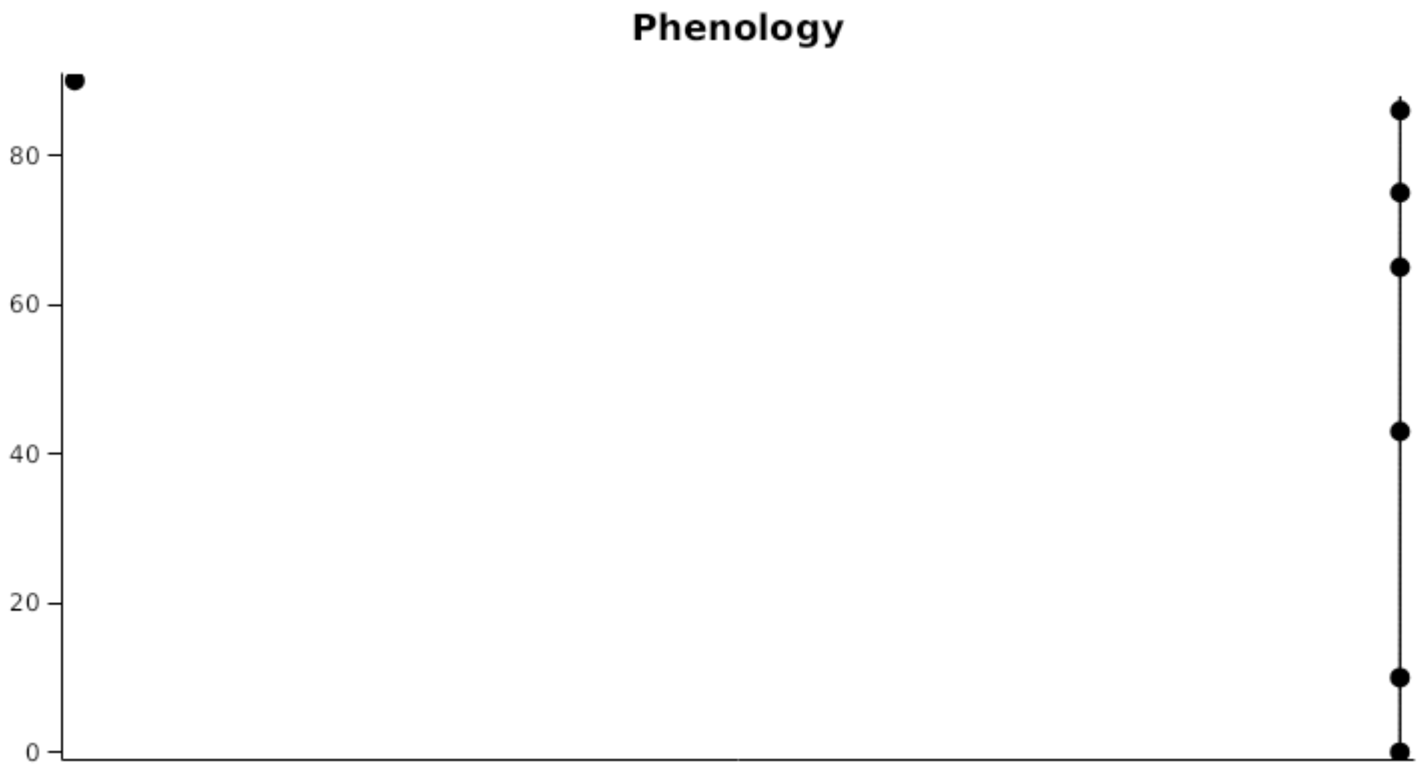

Grain
400
300
200
100
0
0.002002-09-10
0.052002-09-10
0.102002-09-10
0.252002-09-10
0.502002-09-10
0.002002-10-11
0.052002-10-11
0.102002-10-11
0.252002-10-11
0.502002-10-11
0.002002-10-31
0.052002-10-31
0.102002-10-31
0.252002-10-31
0.502002-10-31
0.002002-12-13
0.052002-12-13
0.102002-12-13
0.252002-12-13
0.502002-12-13
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

DeadLeaf



SurfaceOM





3.6.2 Walpeup2011

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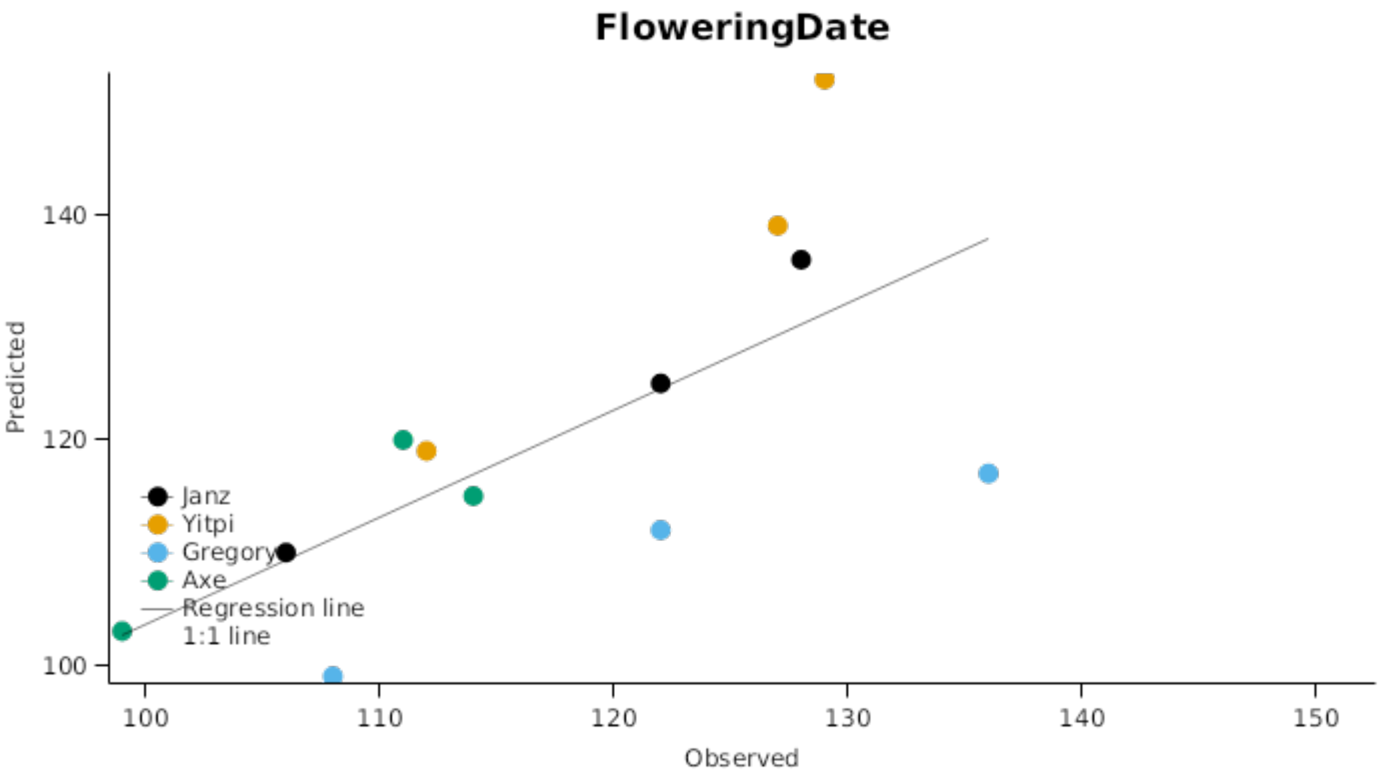

3.6.3 Walpeup2012

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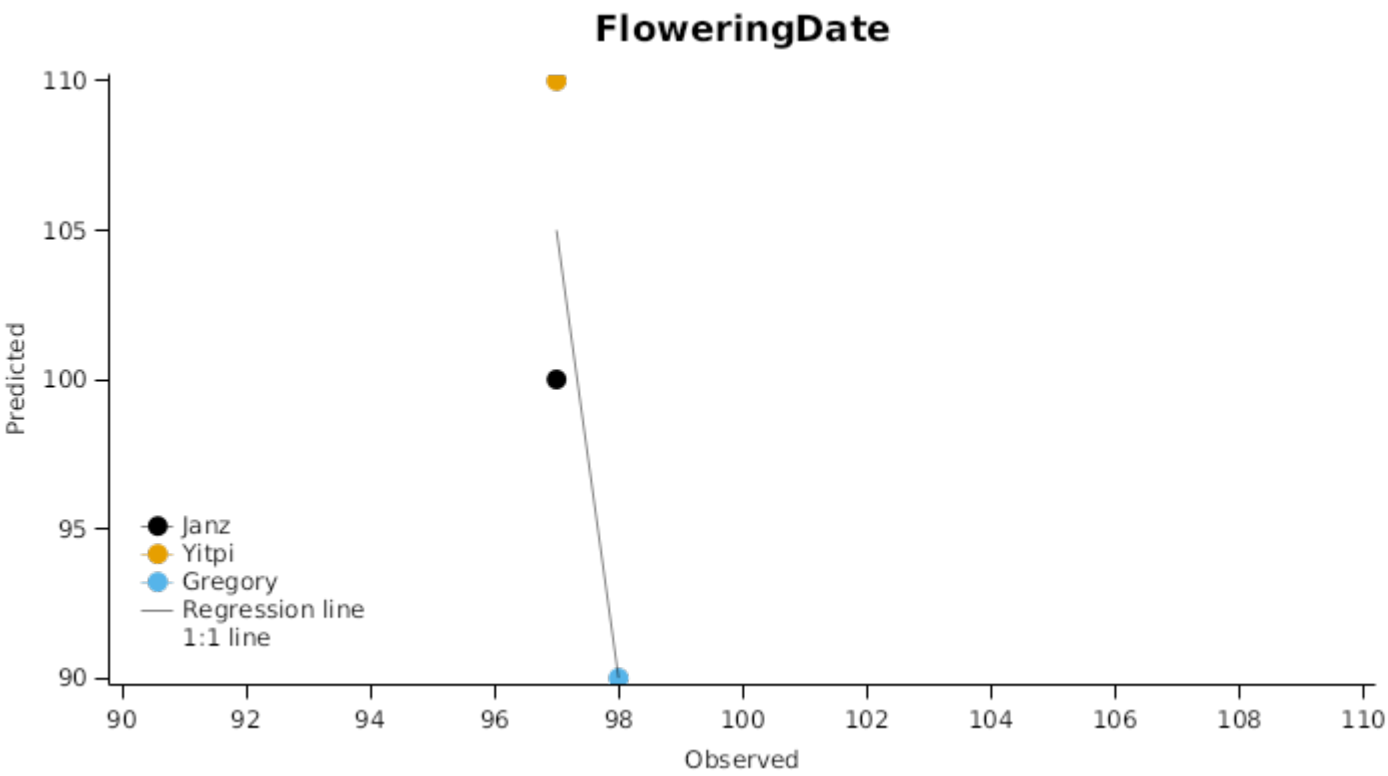
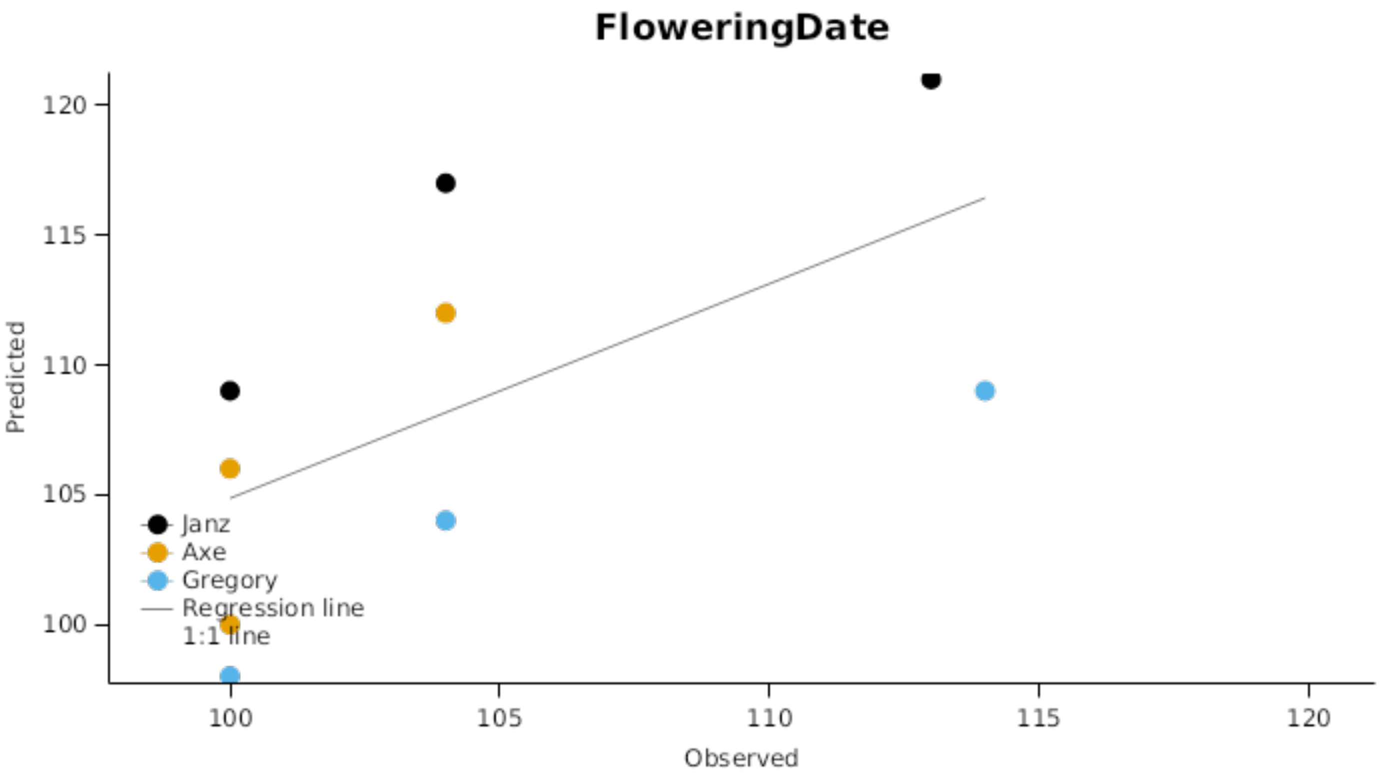


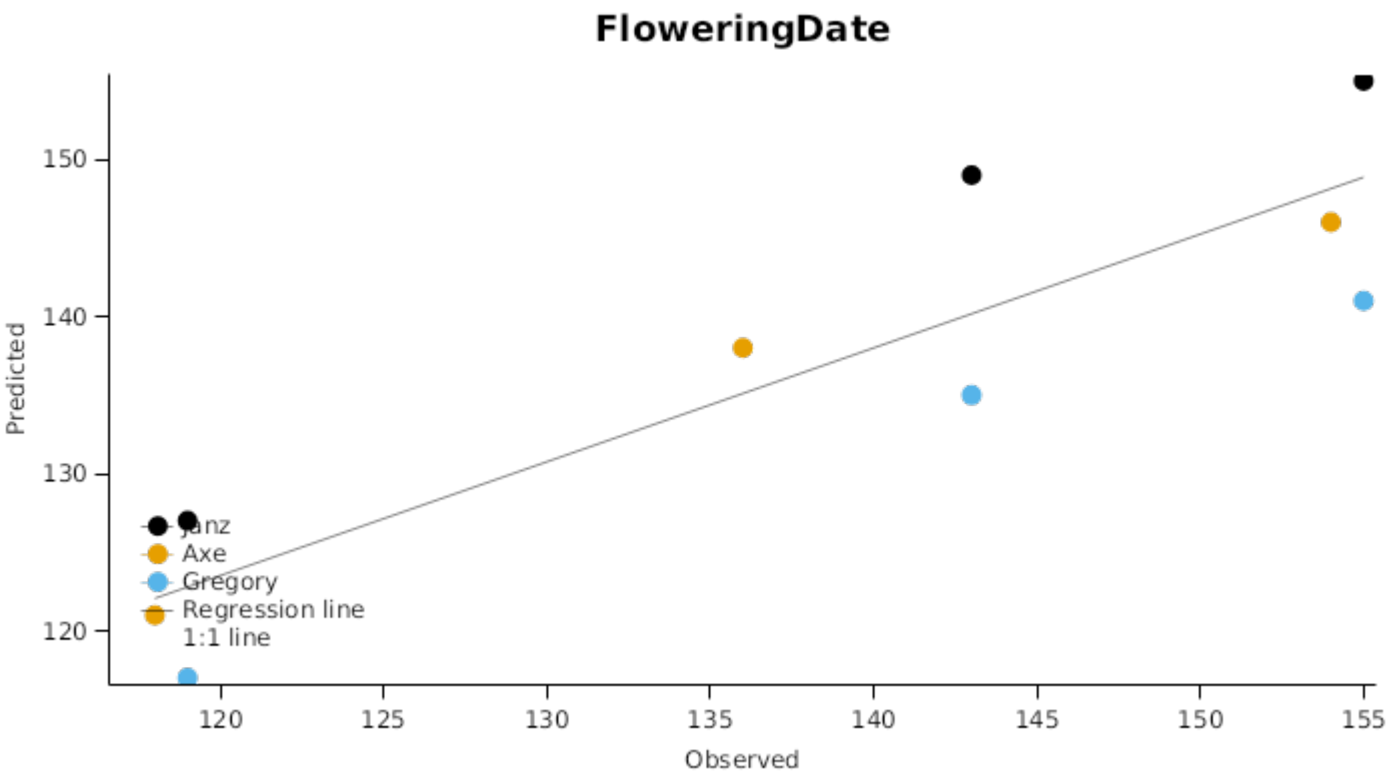
3.6.4 Minnipa2012

INSERT TEXT HERE

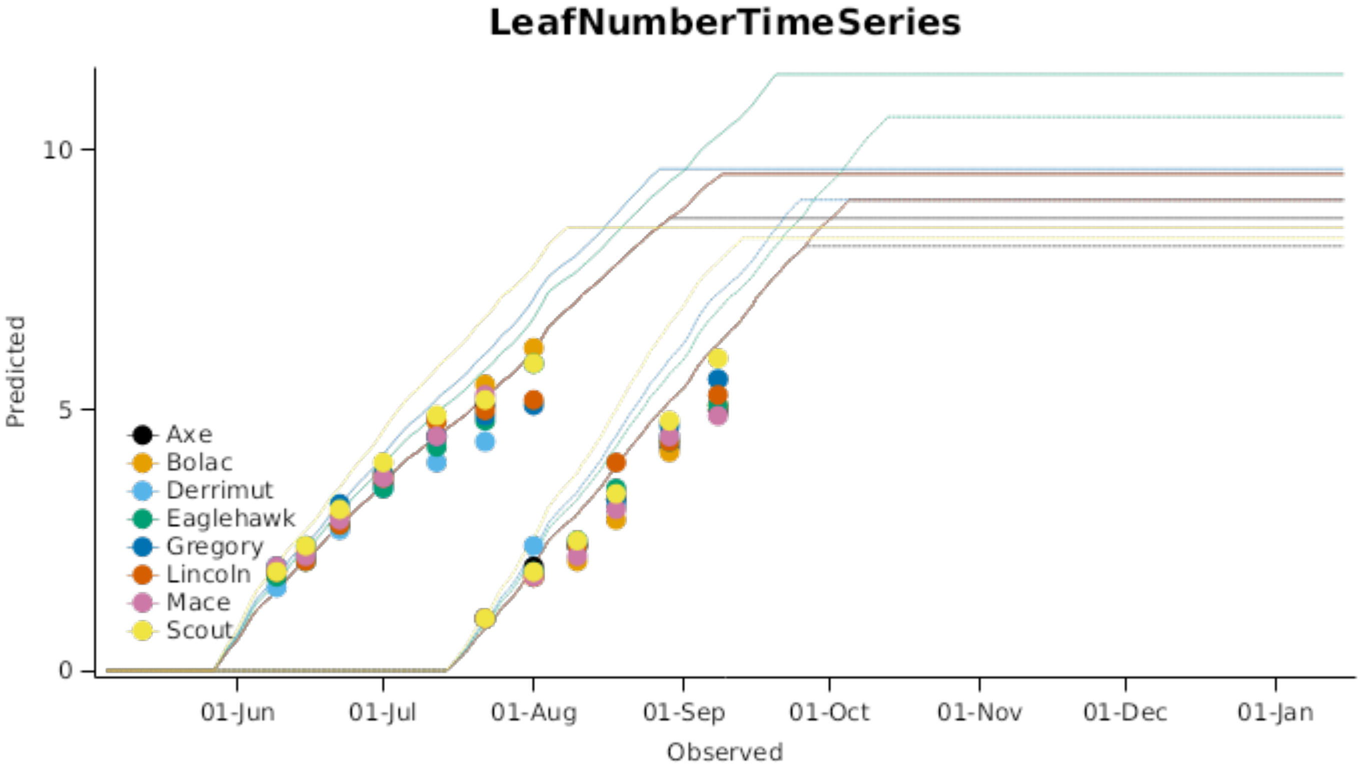


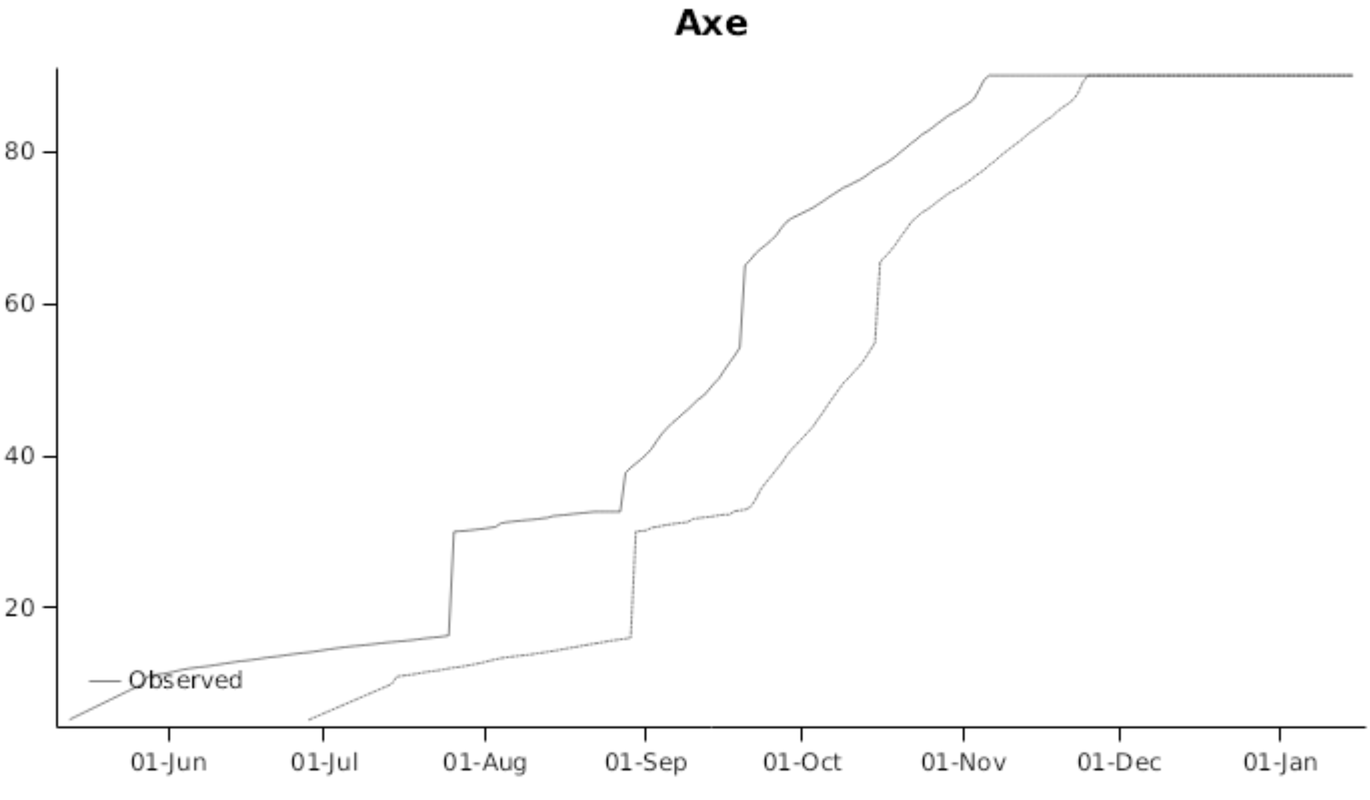
3.6.5 Temora2012

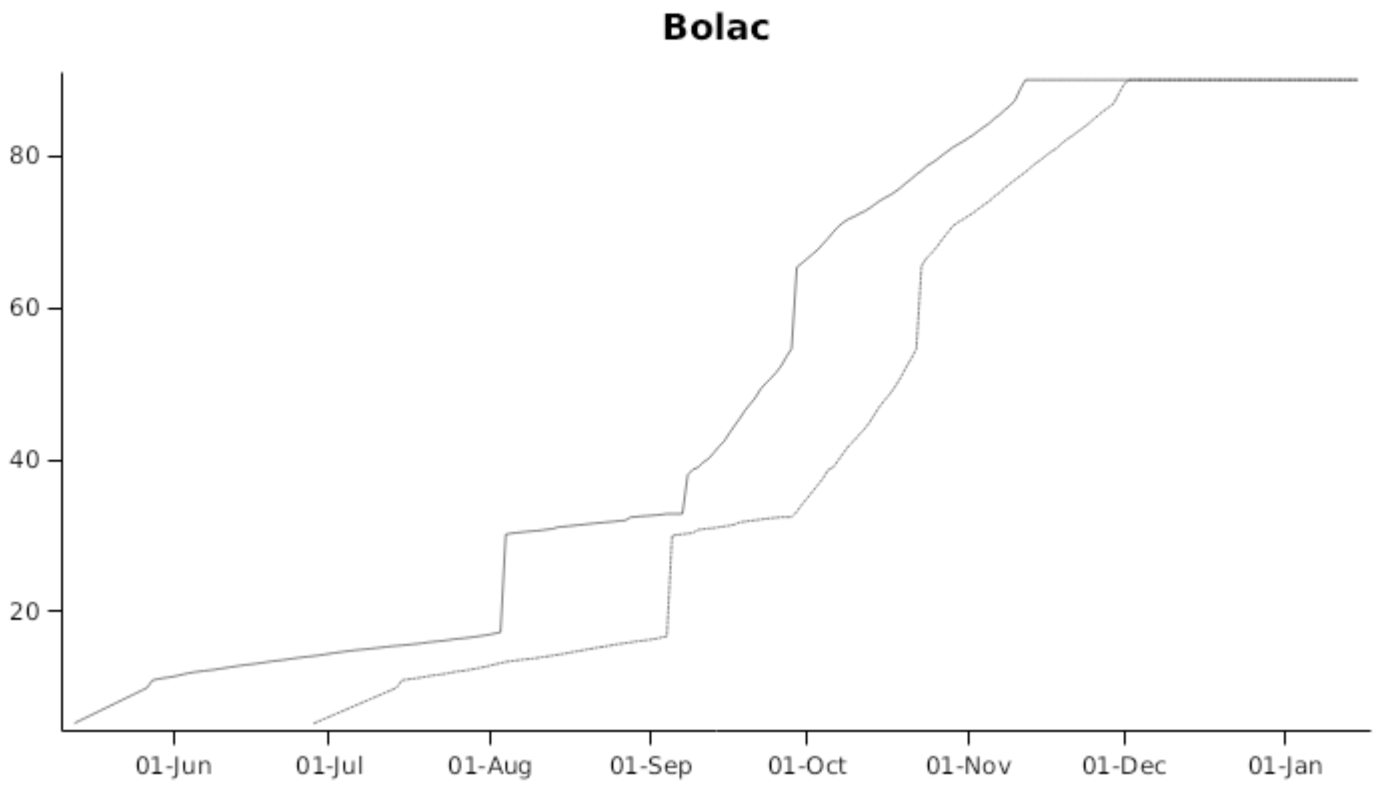
INSERT TEXT HERE

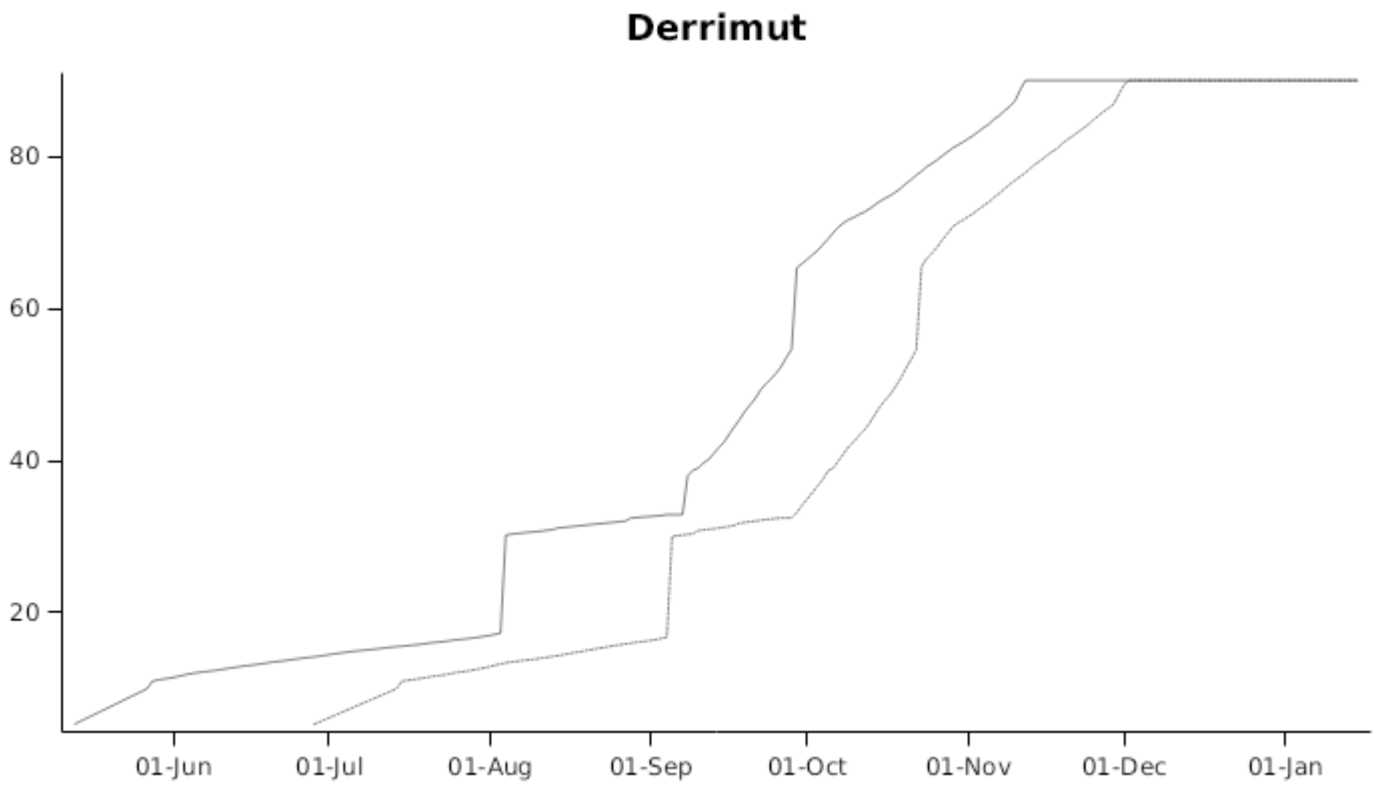


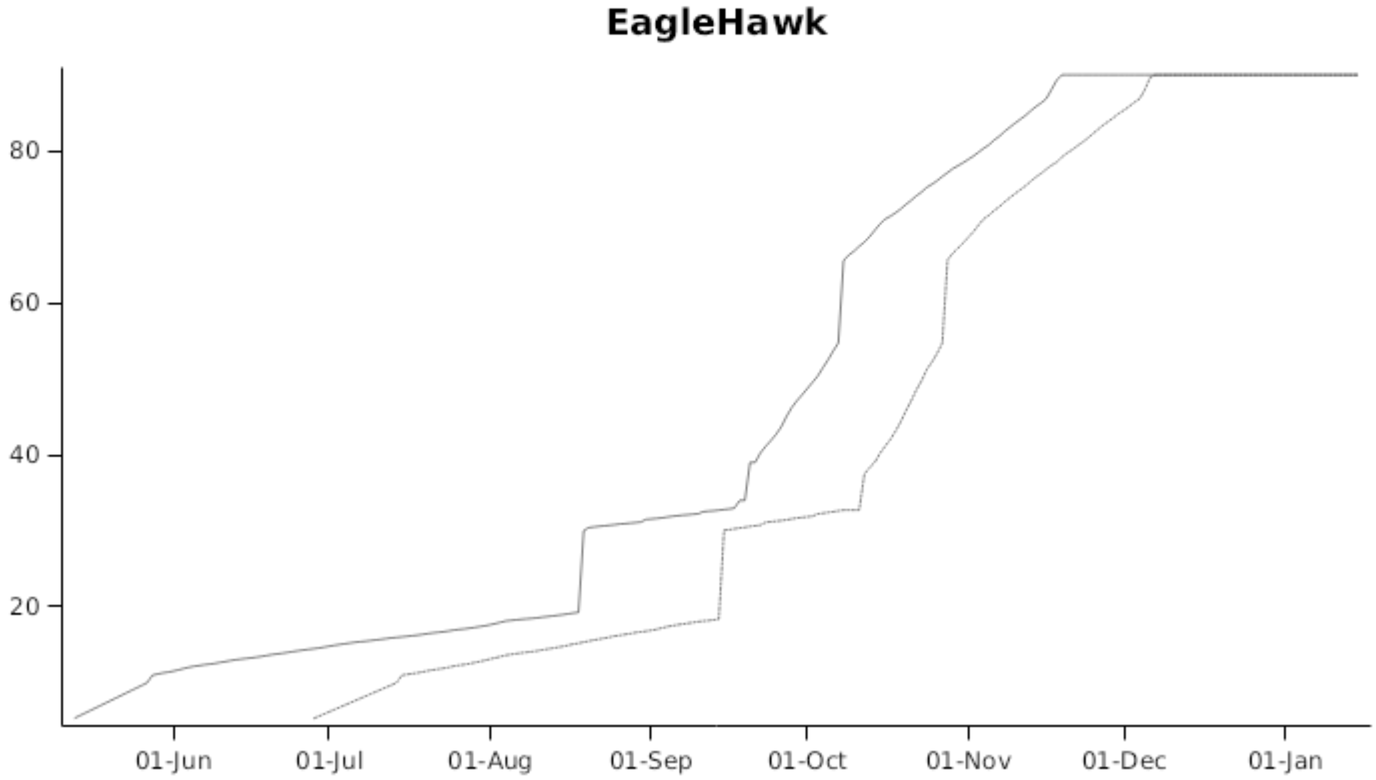
3.6.6 Birchip2011


LeafNumberTimeSeries
Predicted
Observed
Axe
Bolac
Derrimut
Eaglehawk
Gregory
Lincoln
Mace
Scout
0
5
10
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

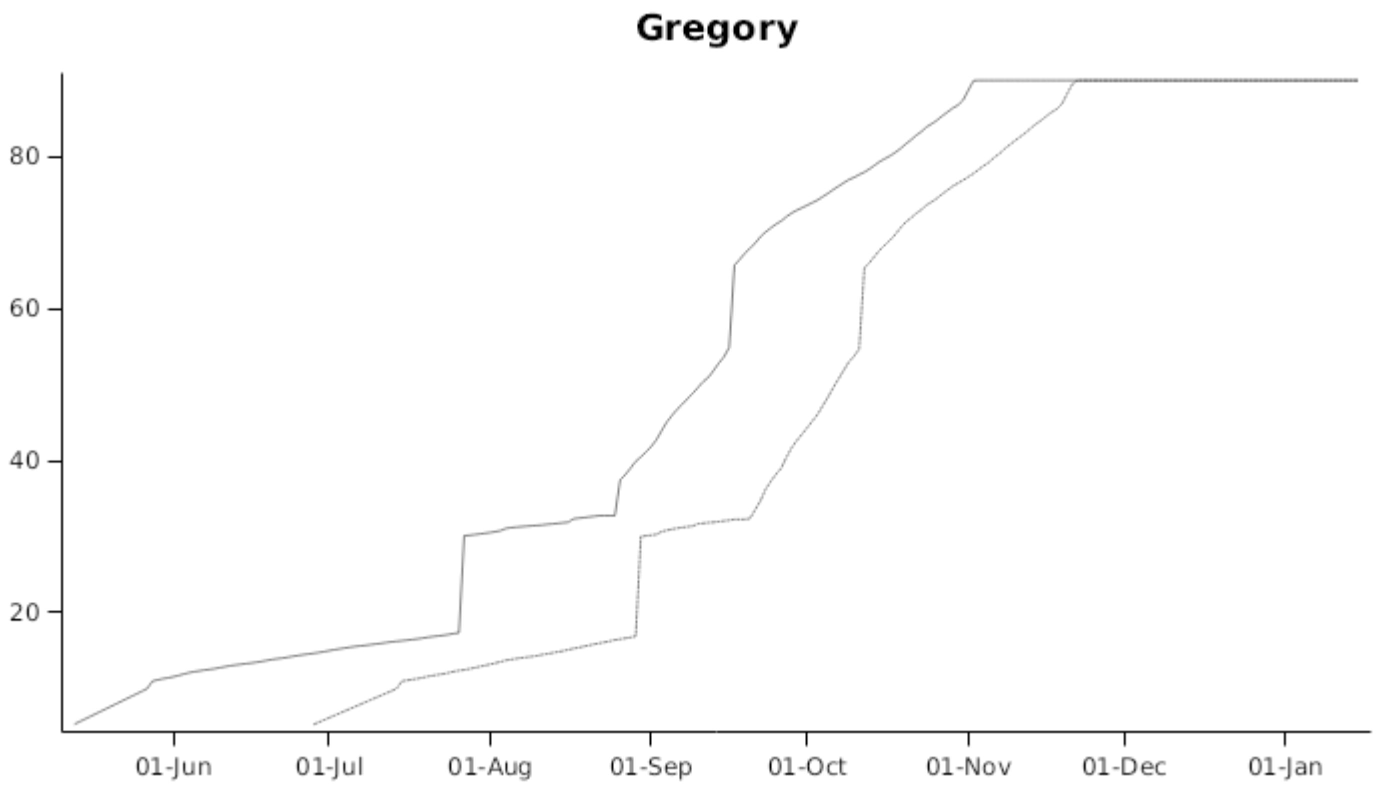

Axe
Observed
20
40
60
80
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan


Bolac
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan


Derrimut
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

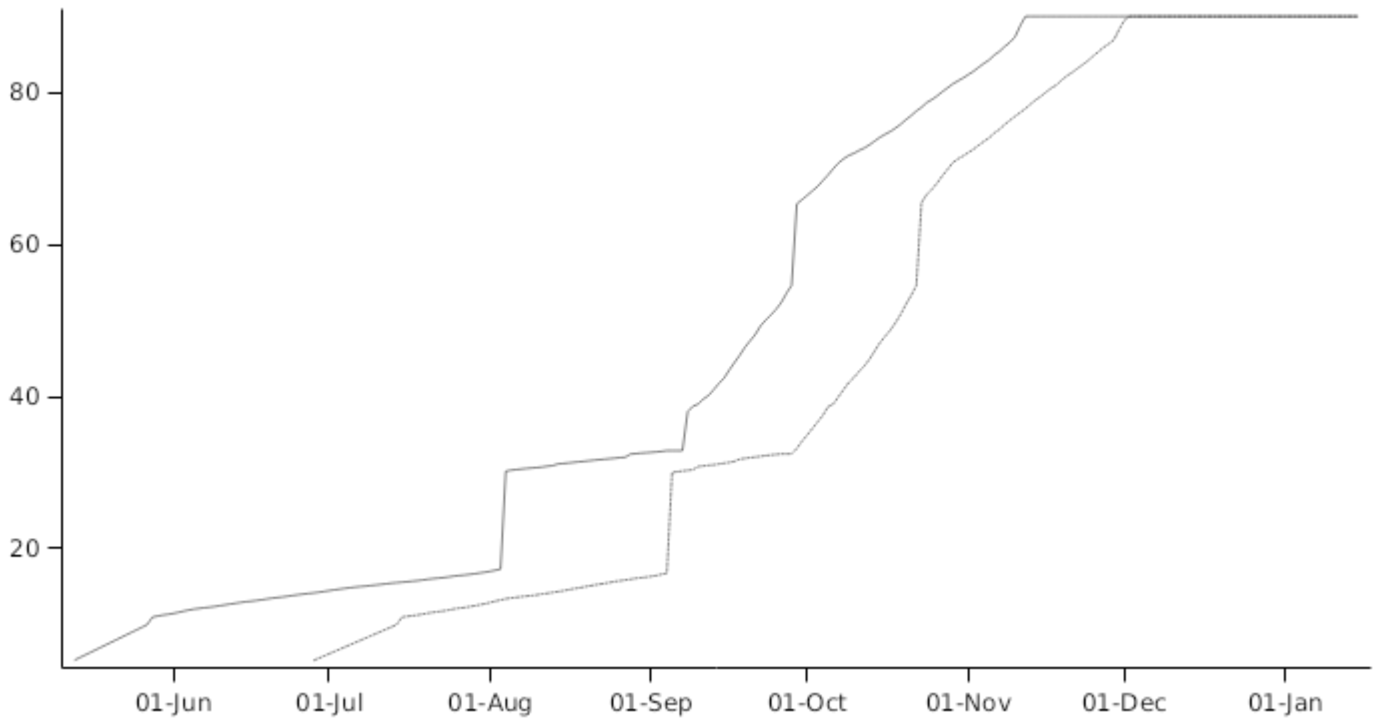


EagleHawk
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

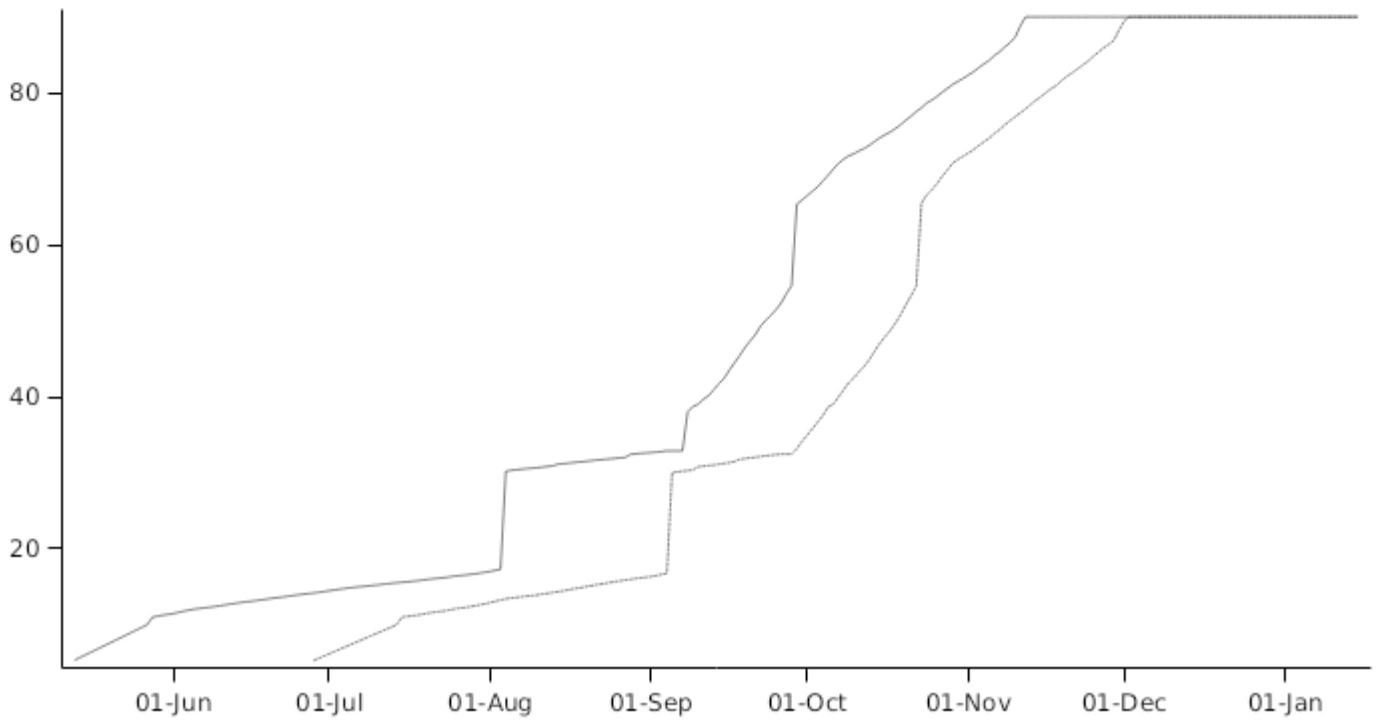


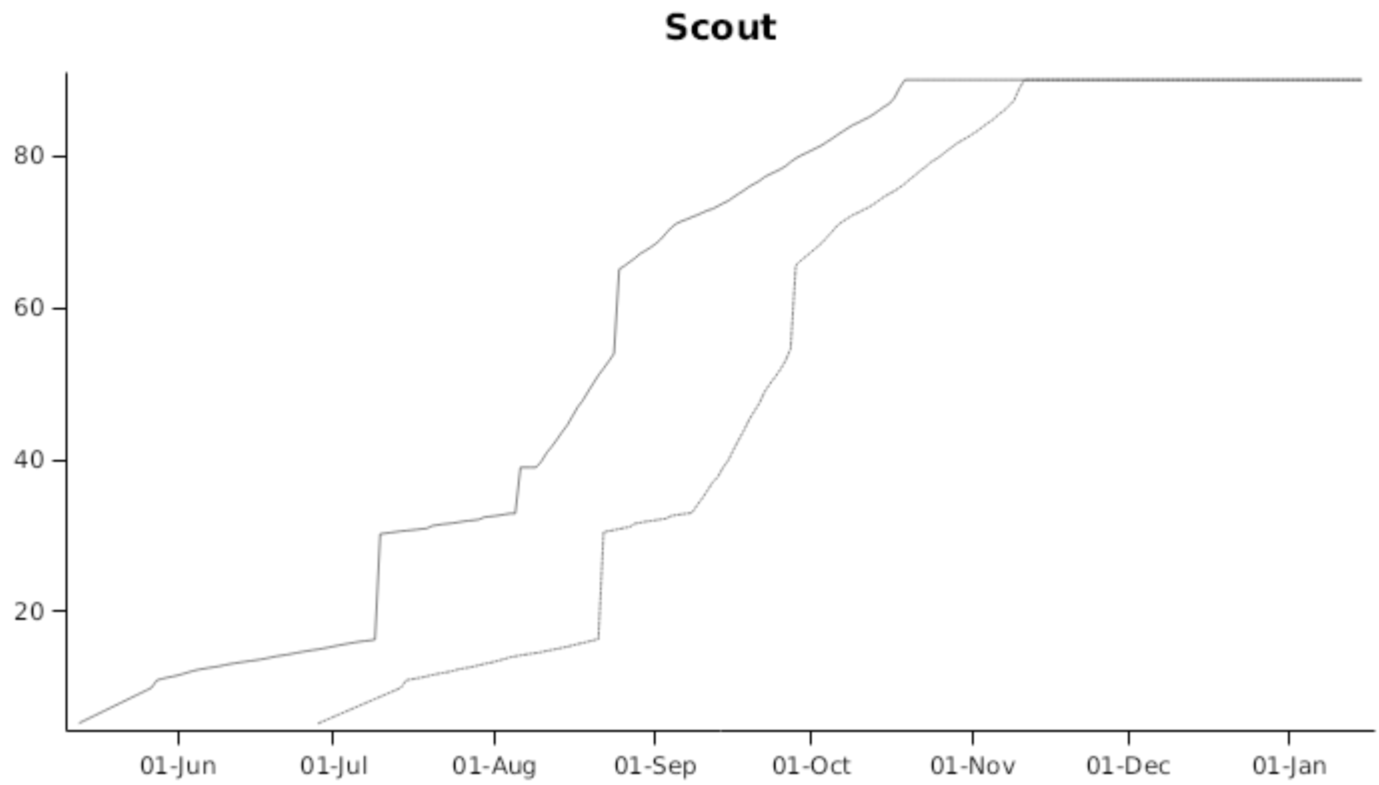
Gregory
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

Mace

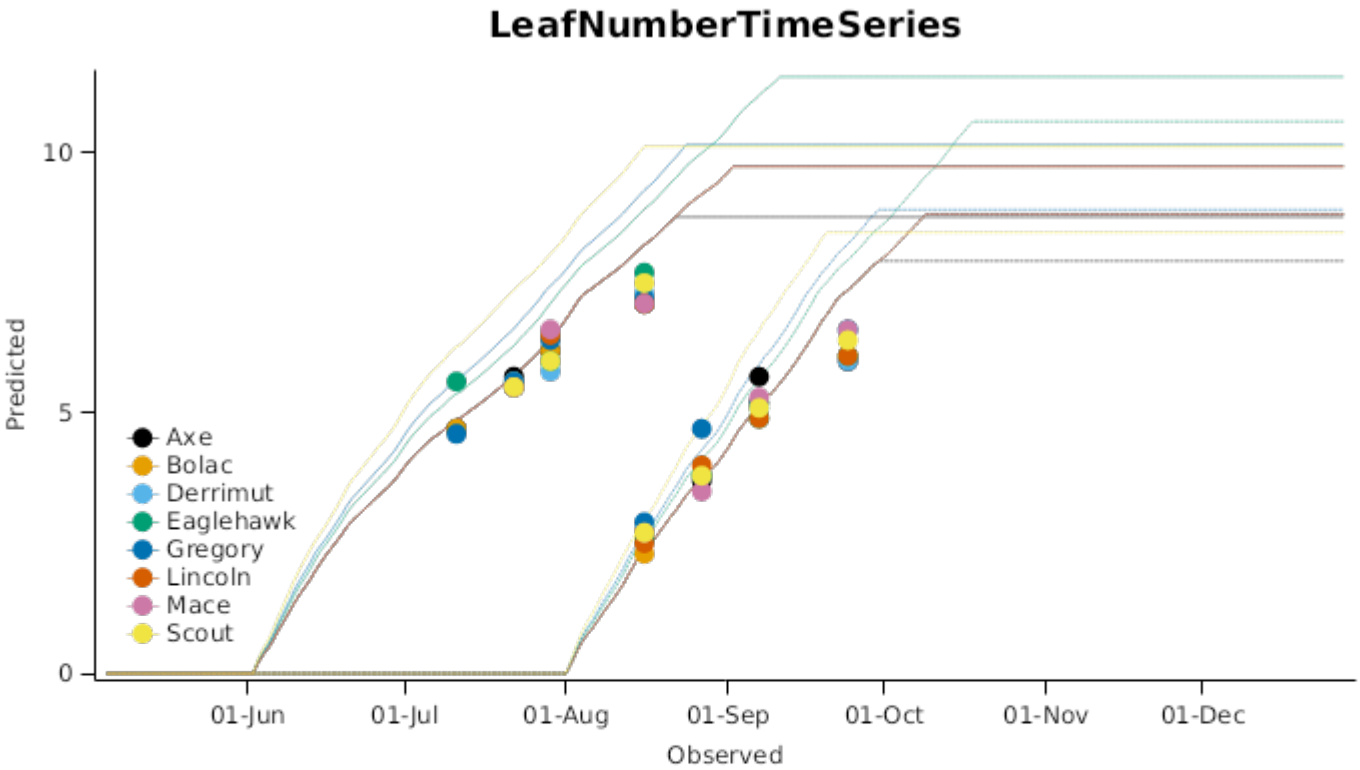


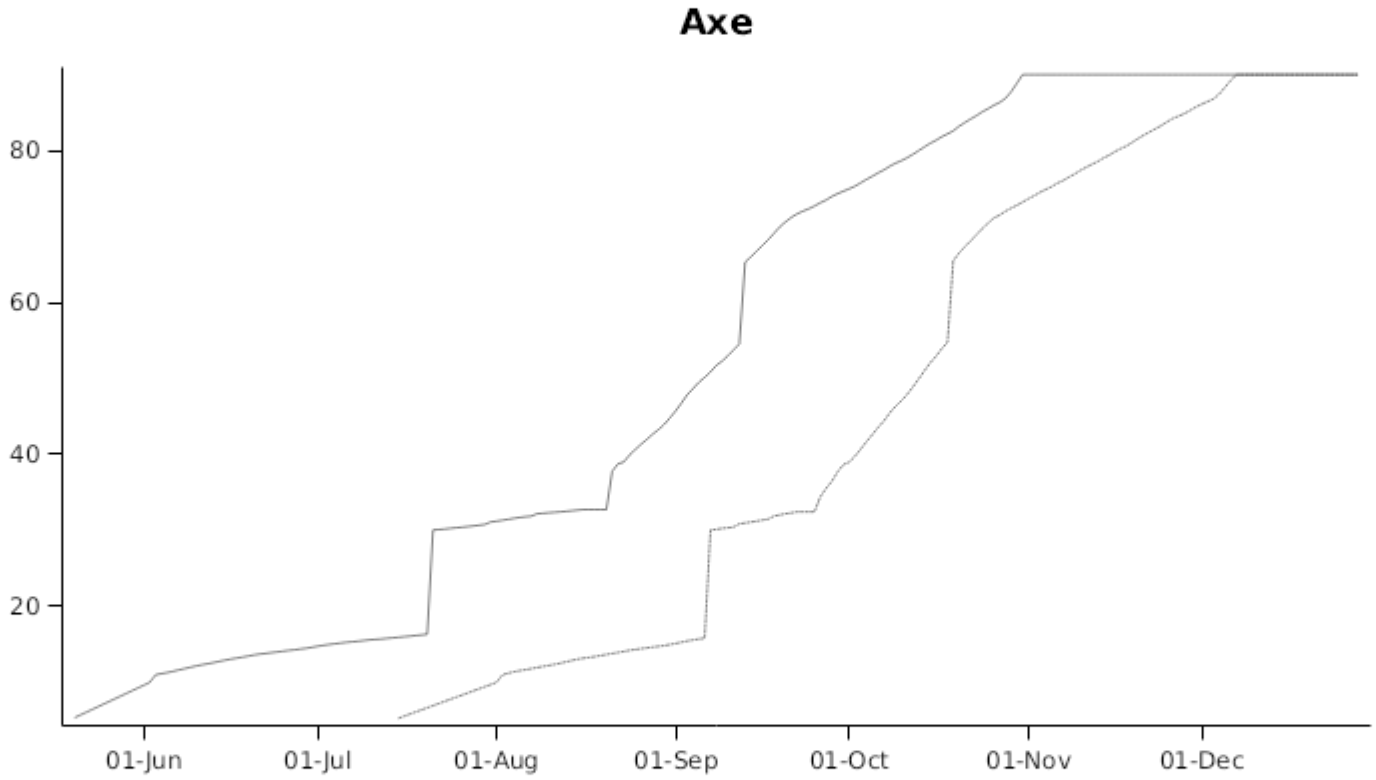
Lincoln

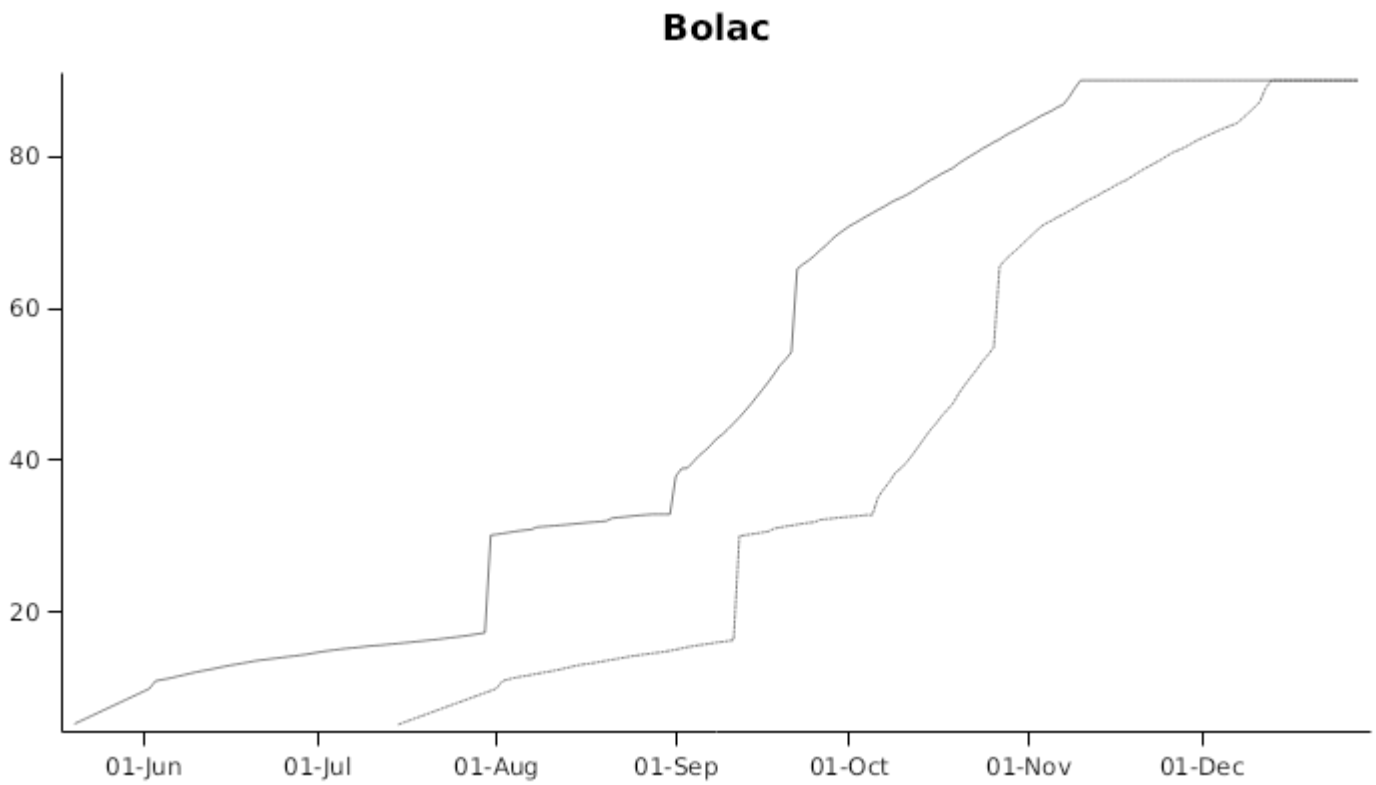


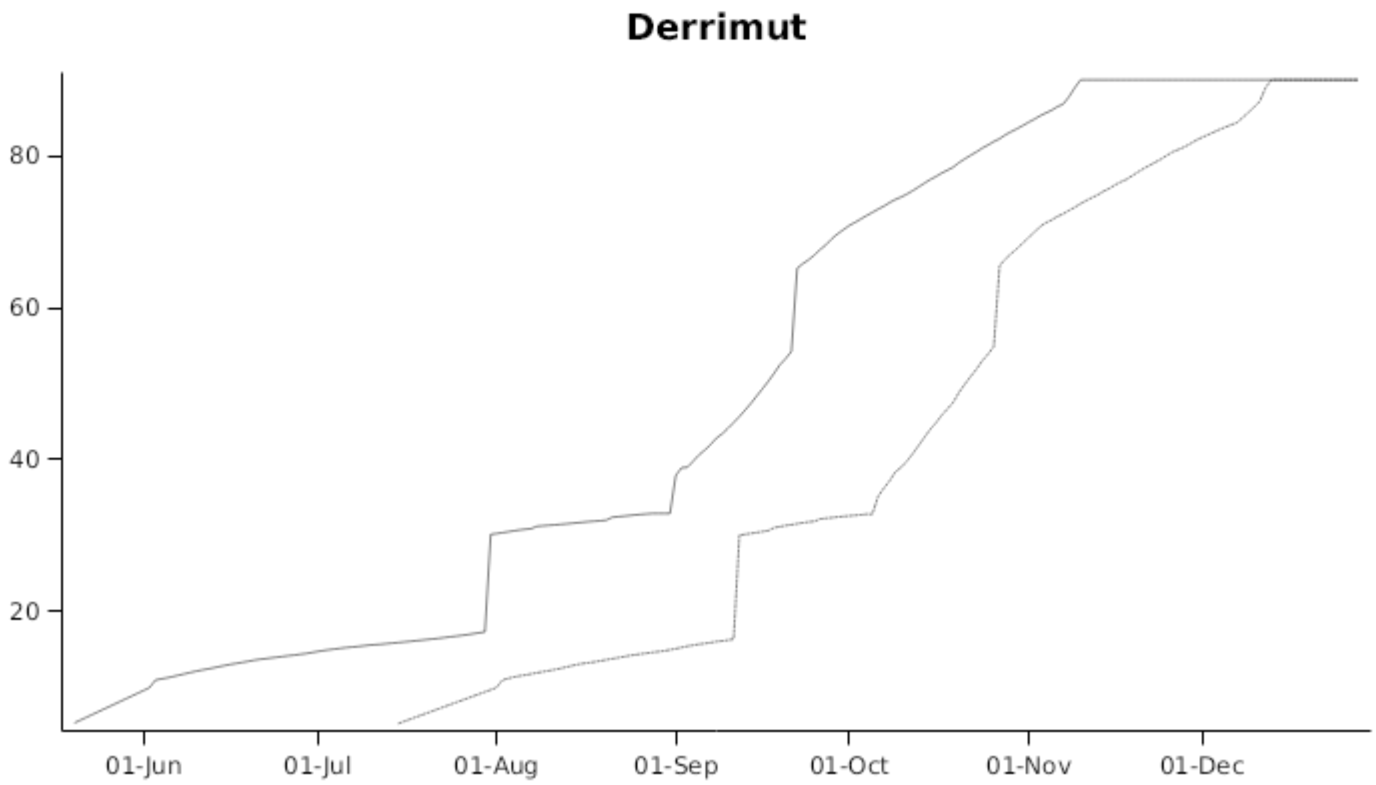


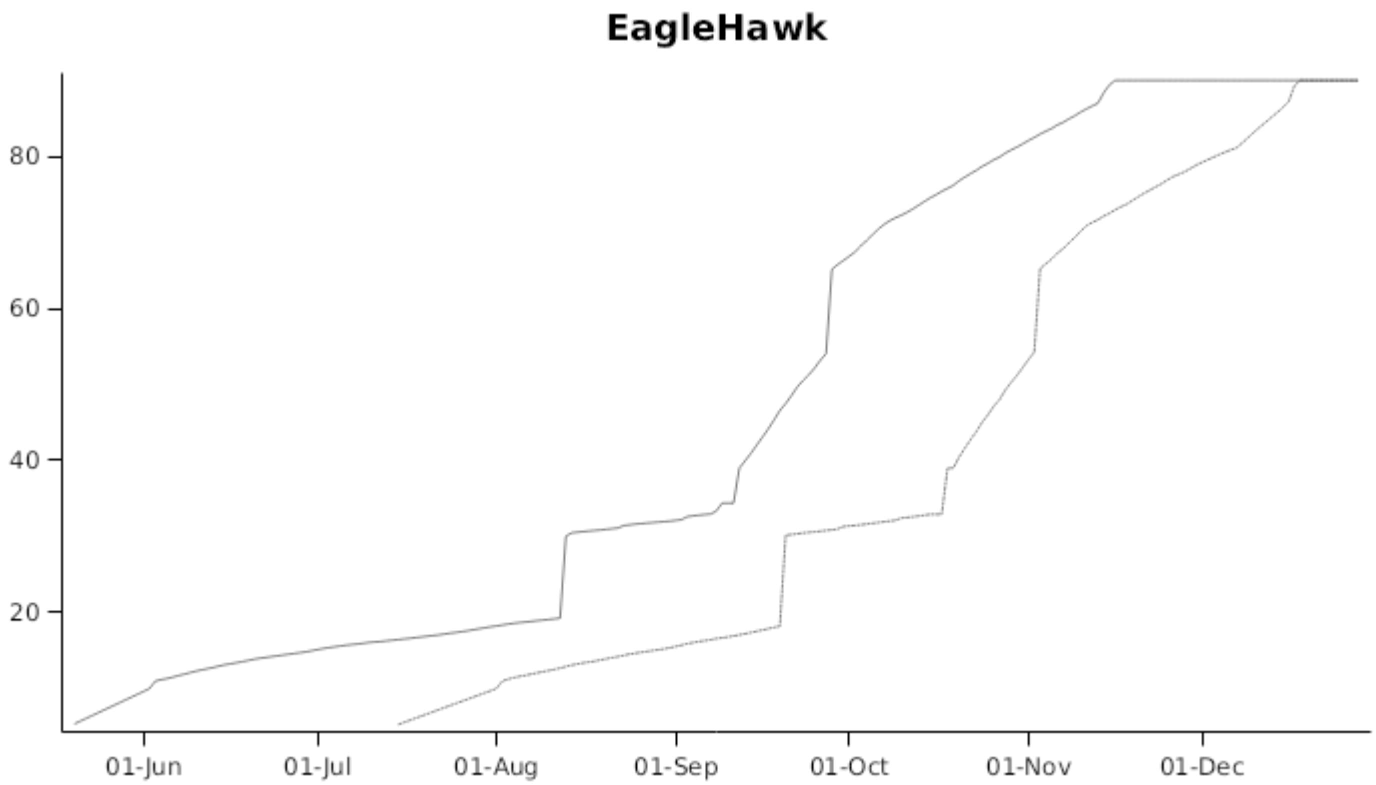
3.6.7 Tarlee2011



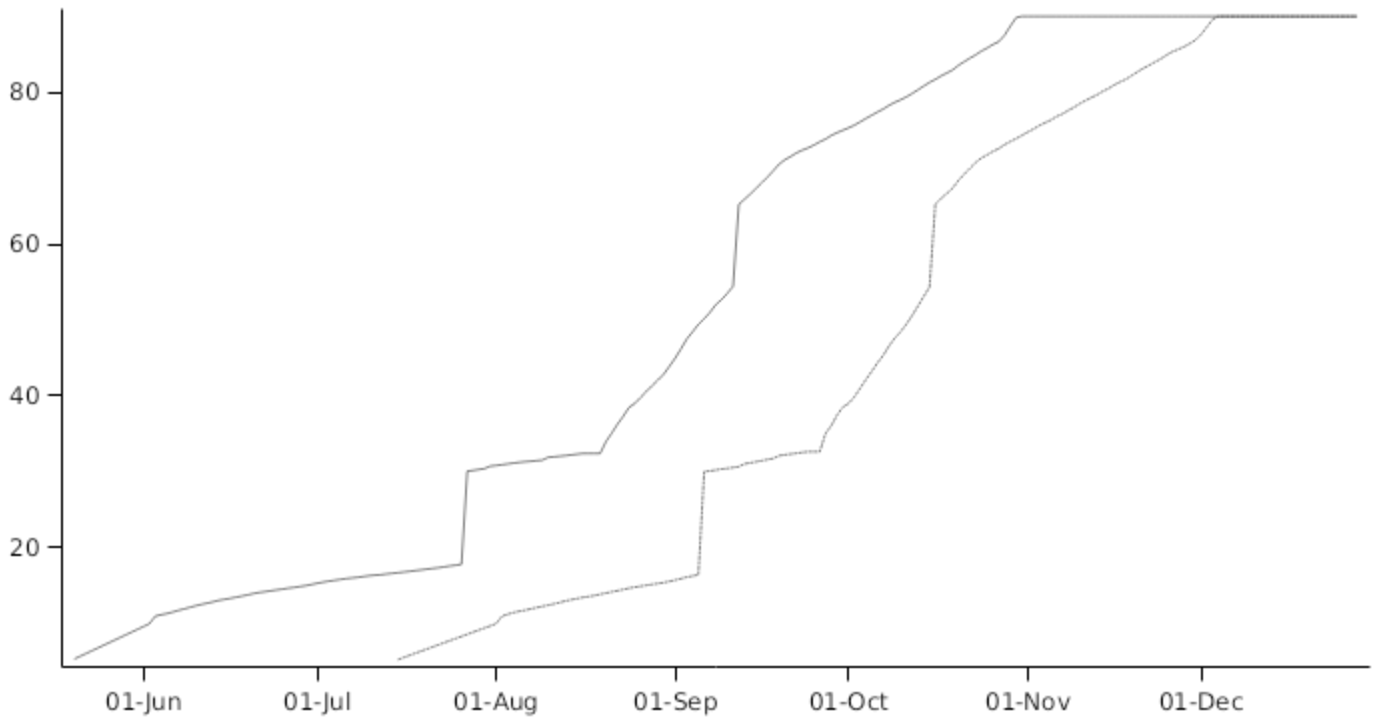

Axe
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


Bolac
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

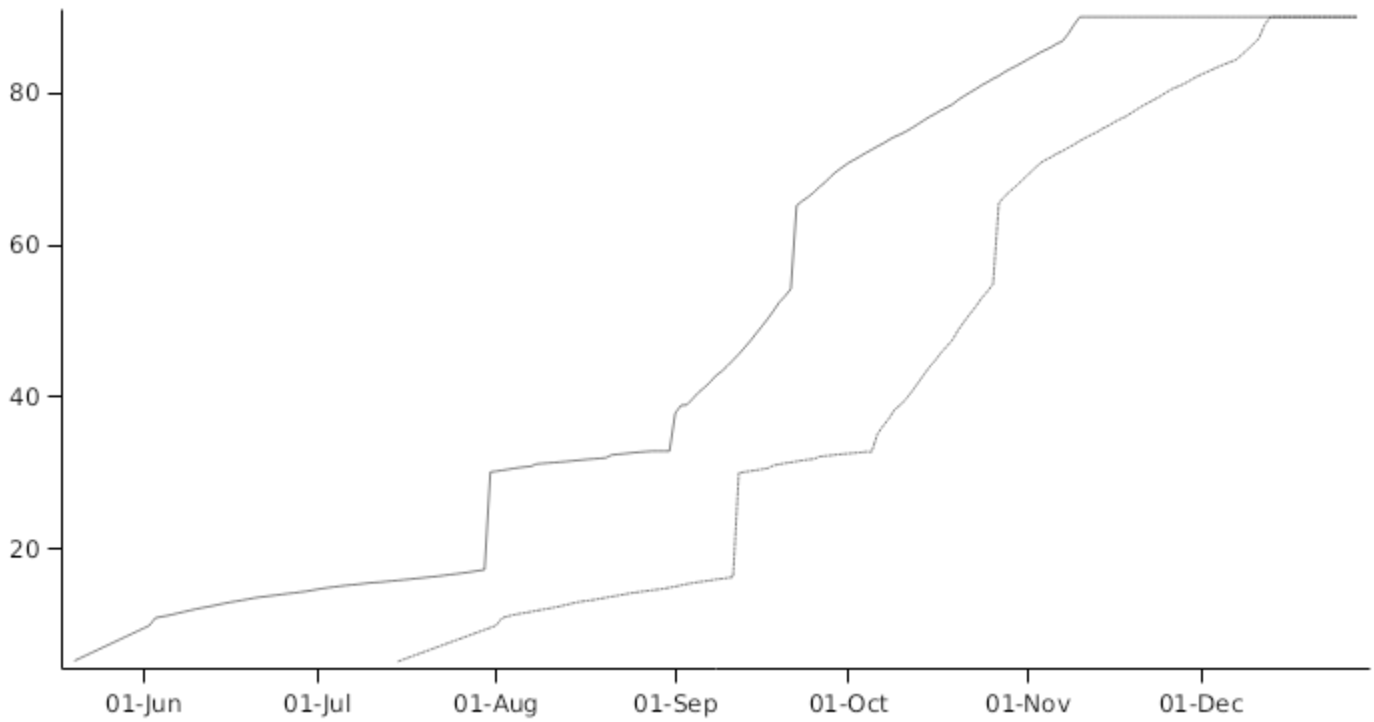

Derrimut
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

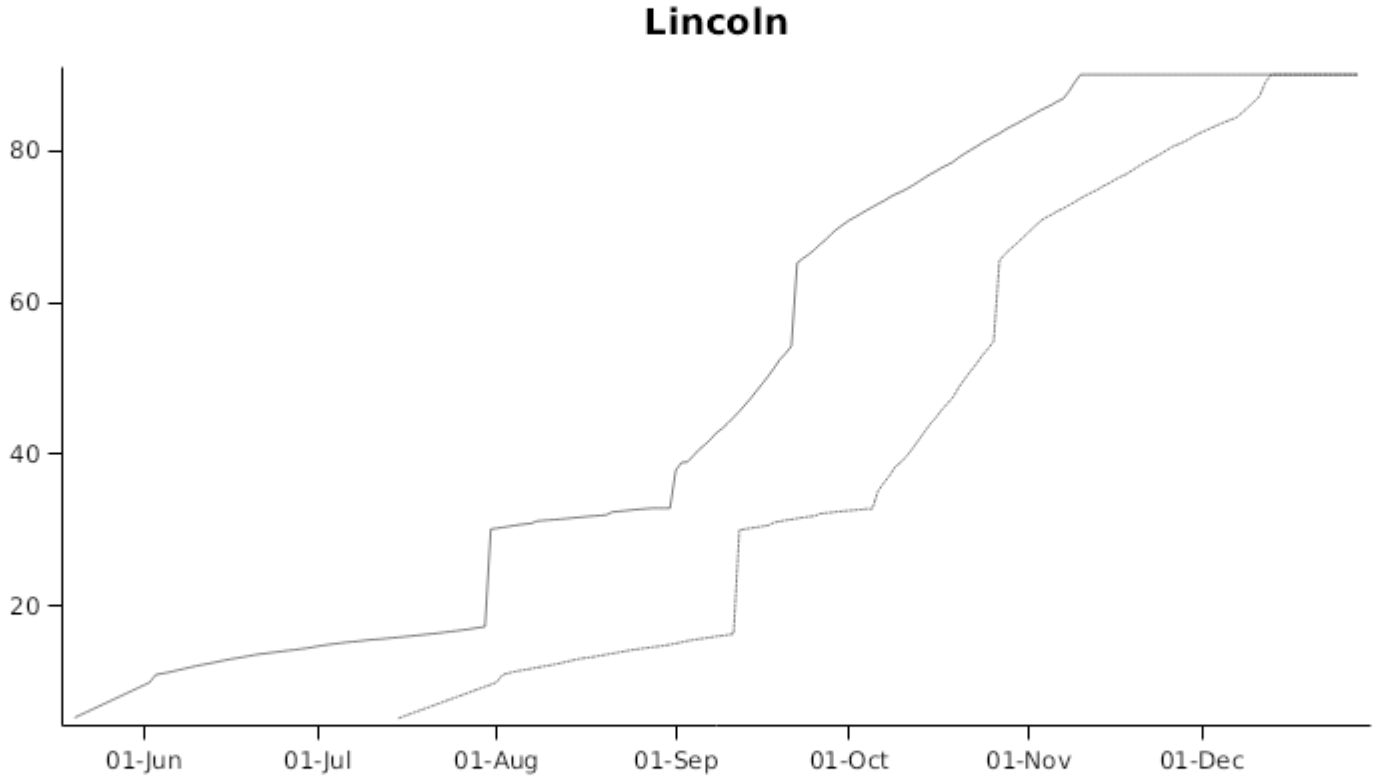

EagleHawk
80
60
40
20
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

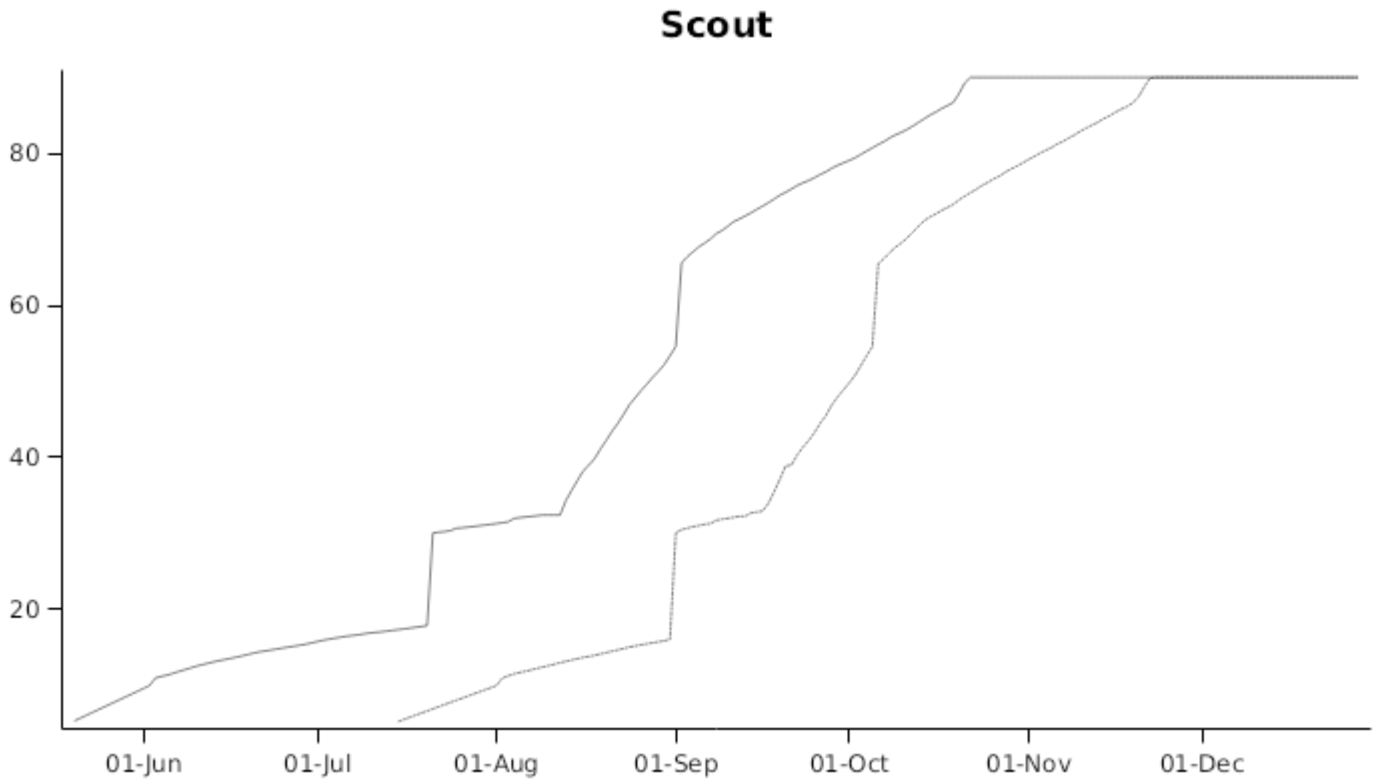
Gregory



Mace

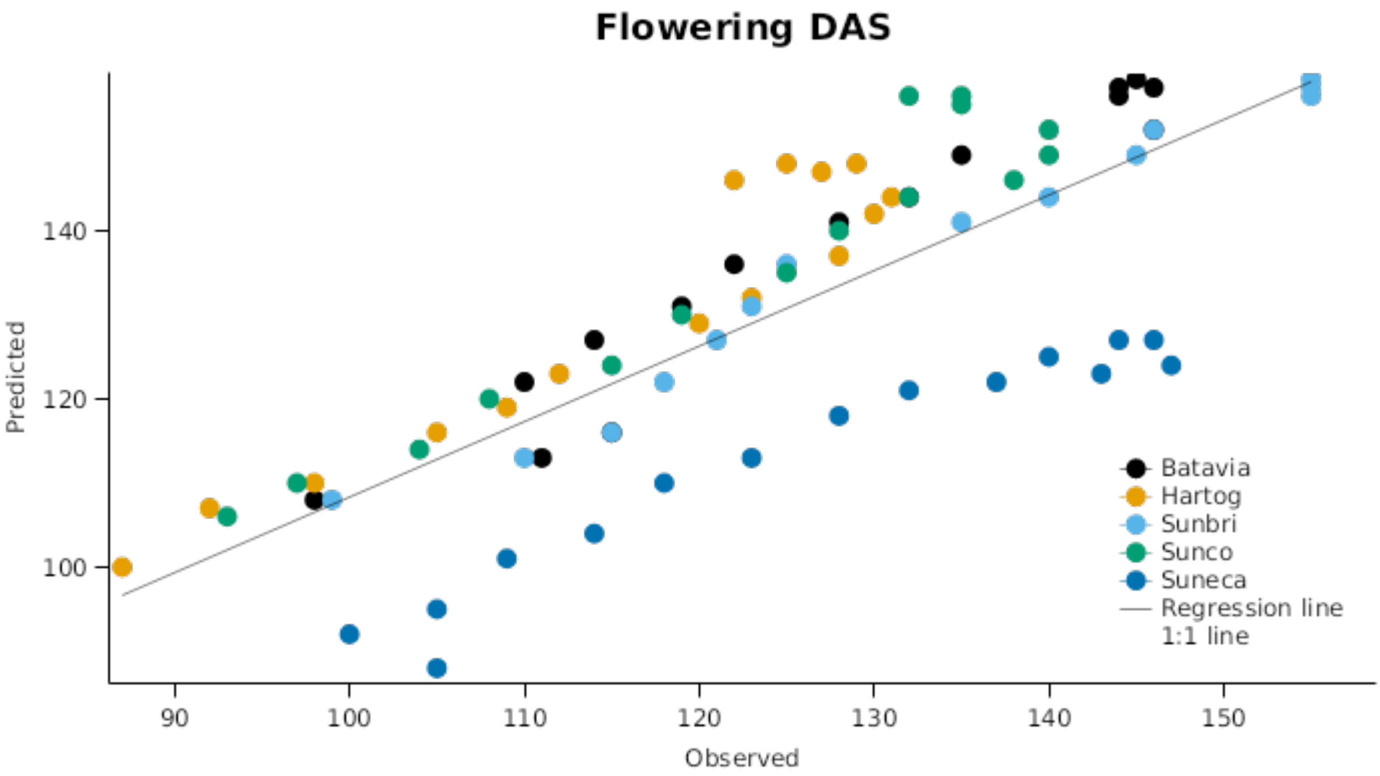


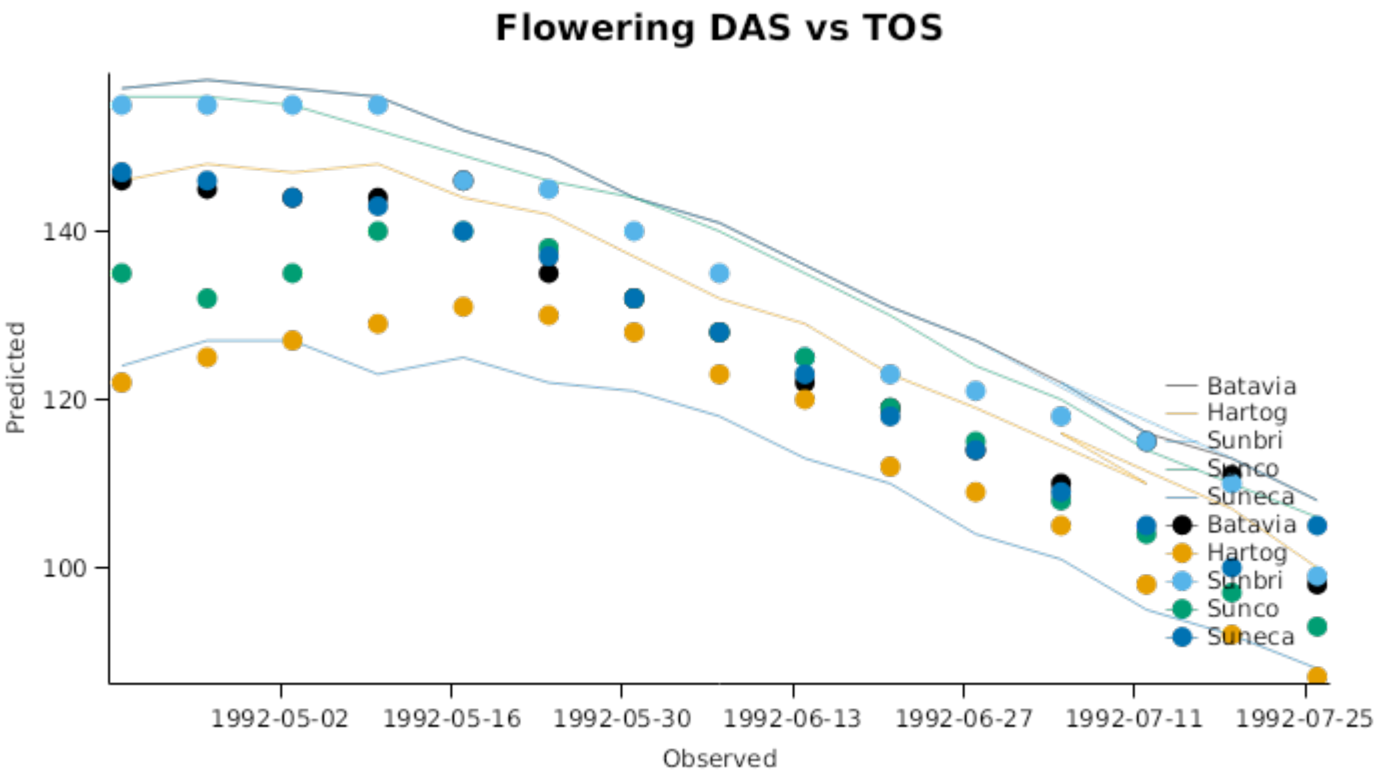




3.6.8 Tamworth1992

This dataset includes observed flowering date for five cultivars (Batavia, Hartog, Sunbri, Sunco, Suneca) for a range planting dates at Tamworth.



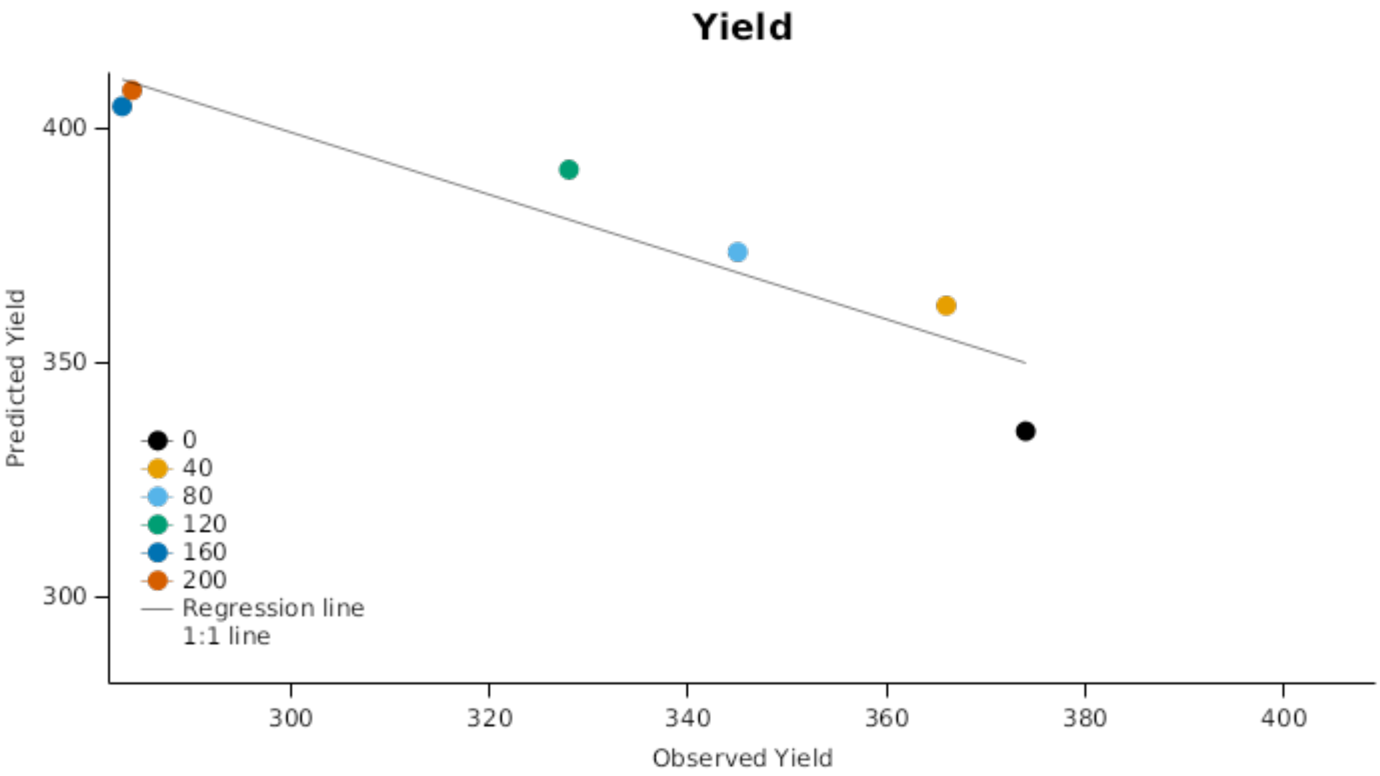


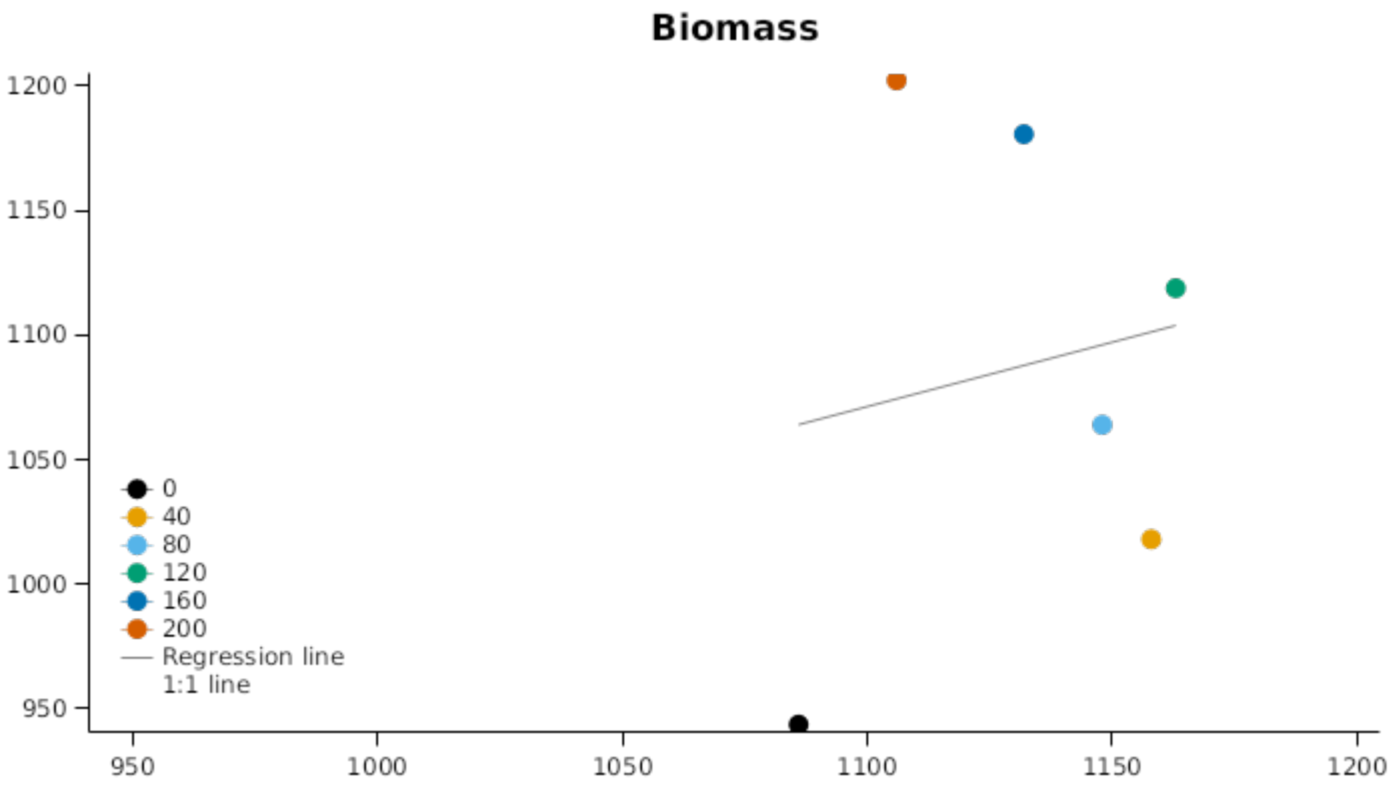
3.6.9 van Herwaarden et al 1998

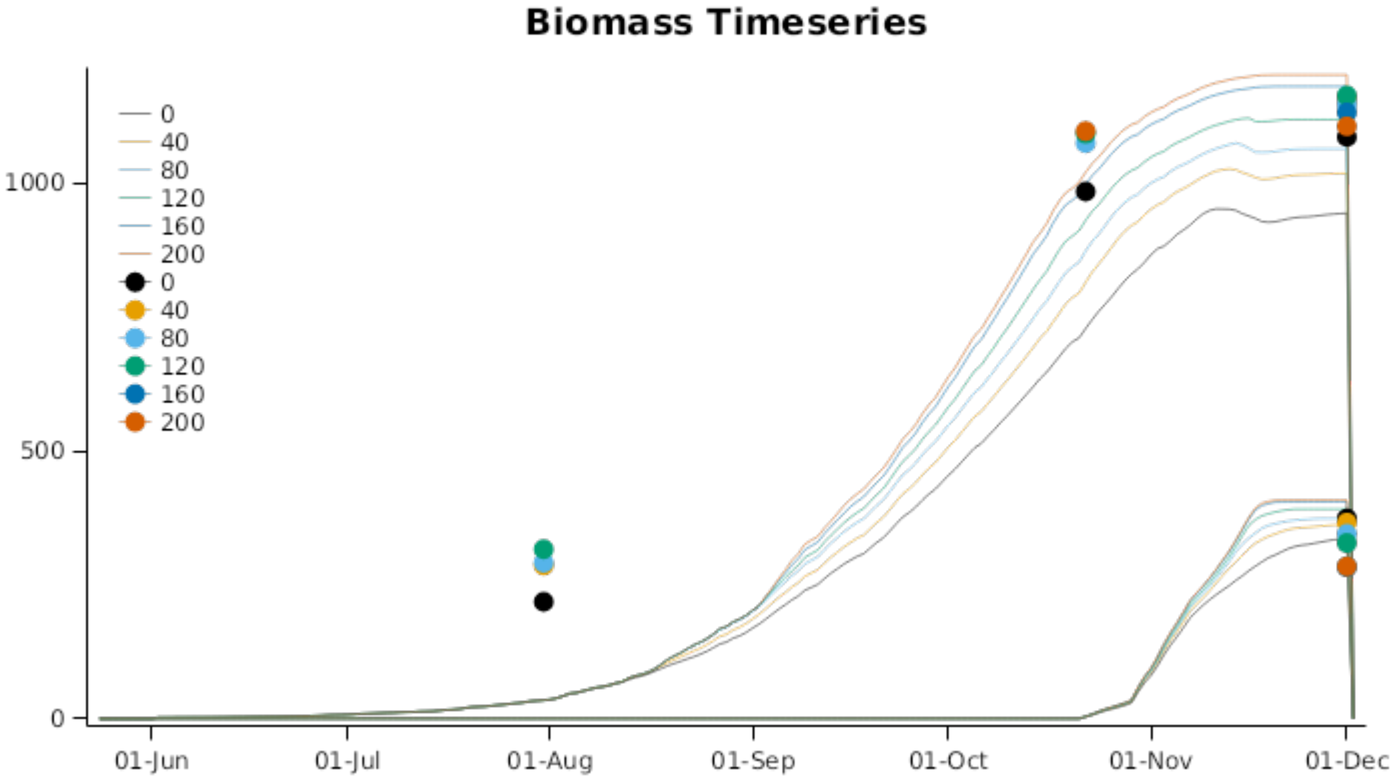
List of experiments.

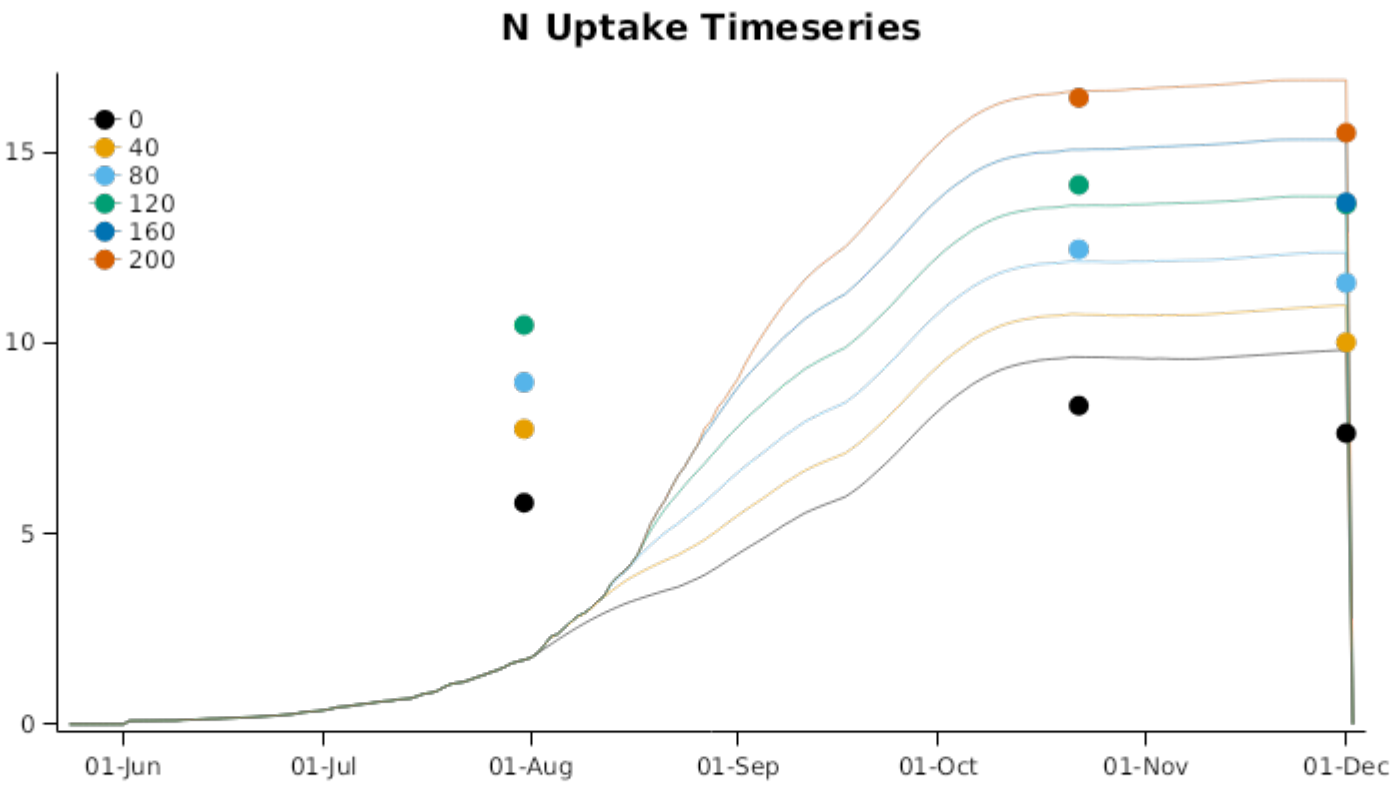
Experiment Name	Design (Number of Treatments)
Wagga1991	N (6)
Ginninderra1991	N x Cv (7)

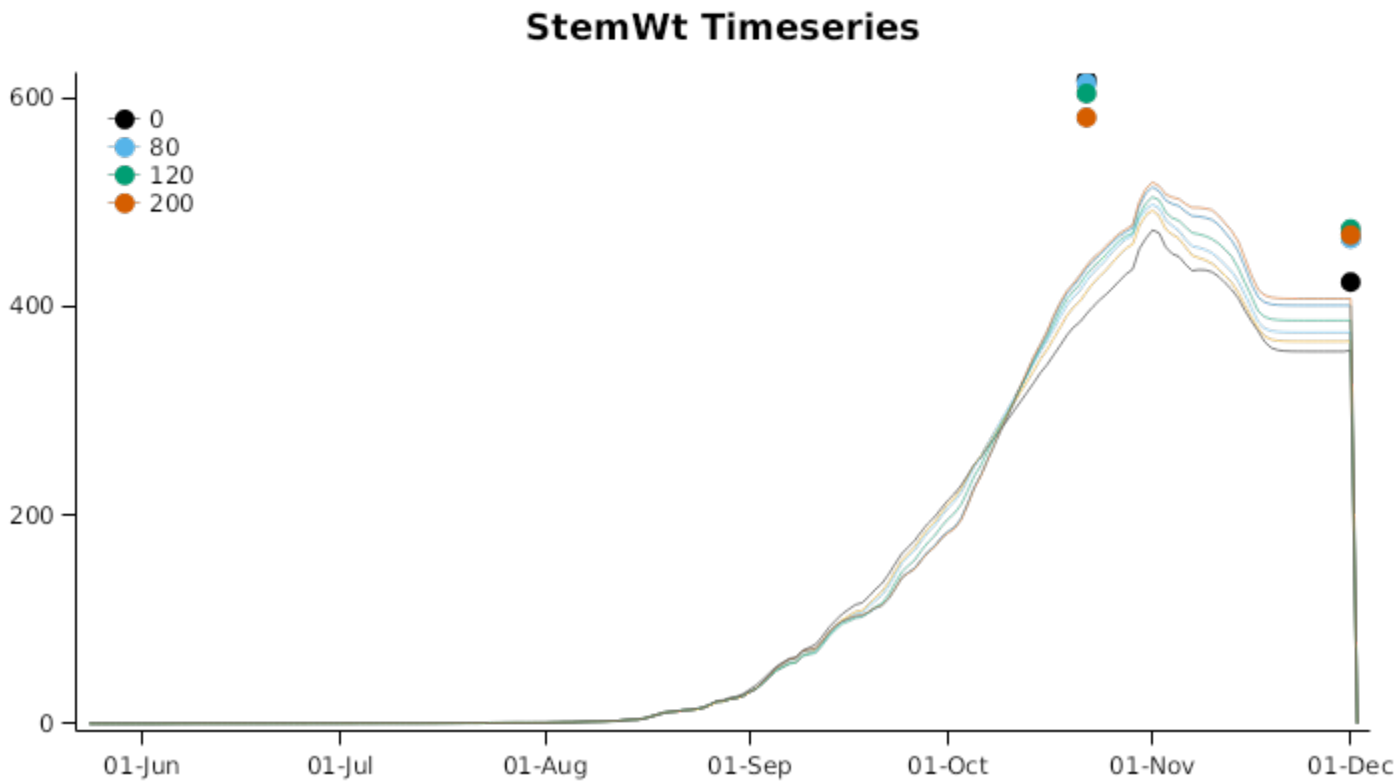
3.6.9.1 Wagga1991

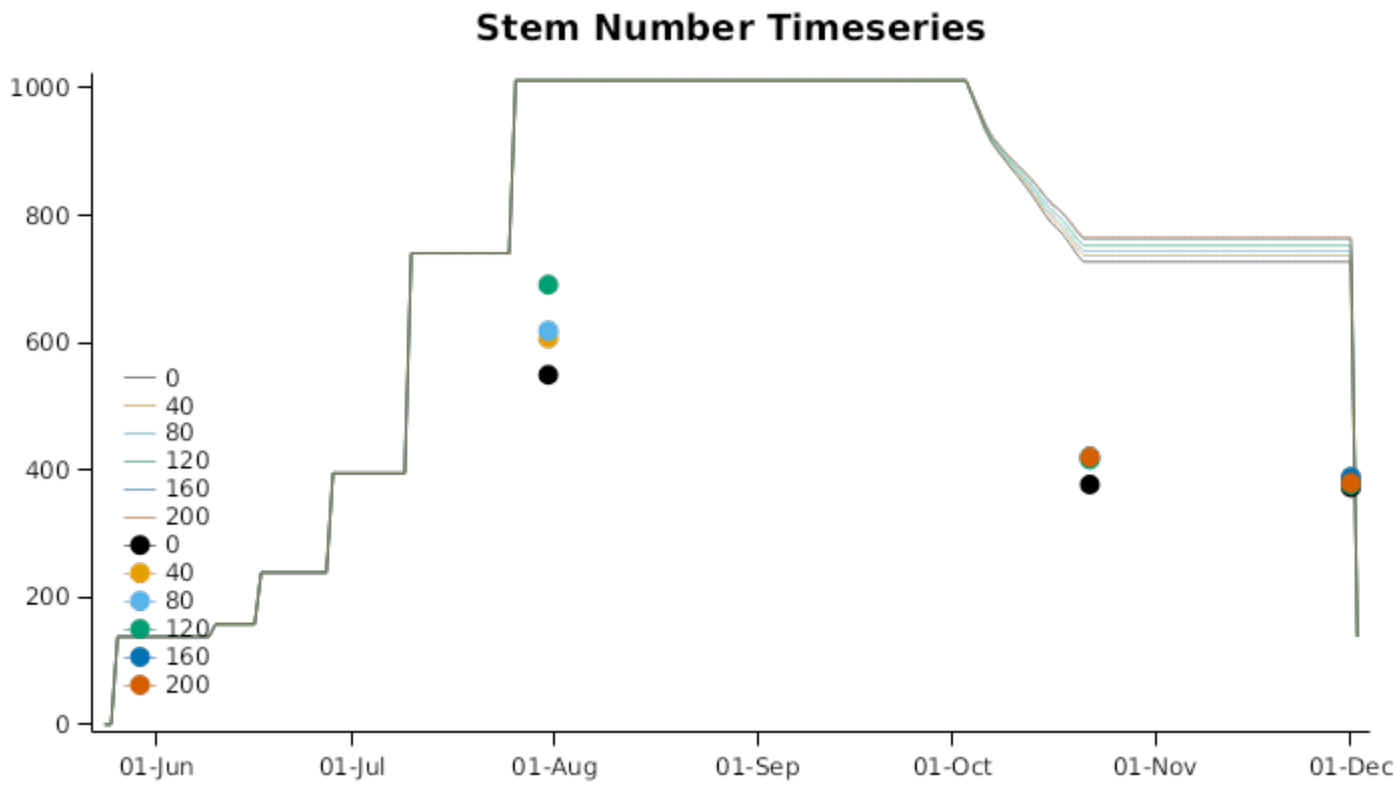

Yield
Predicted Yield
Observed Yield
400
350
300
300
320
340
360
380
400
0
40
80
120
160
200
Regression line
1:1 line

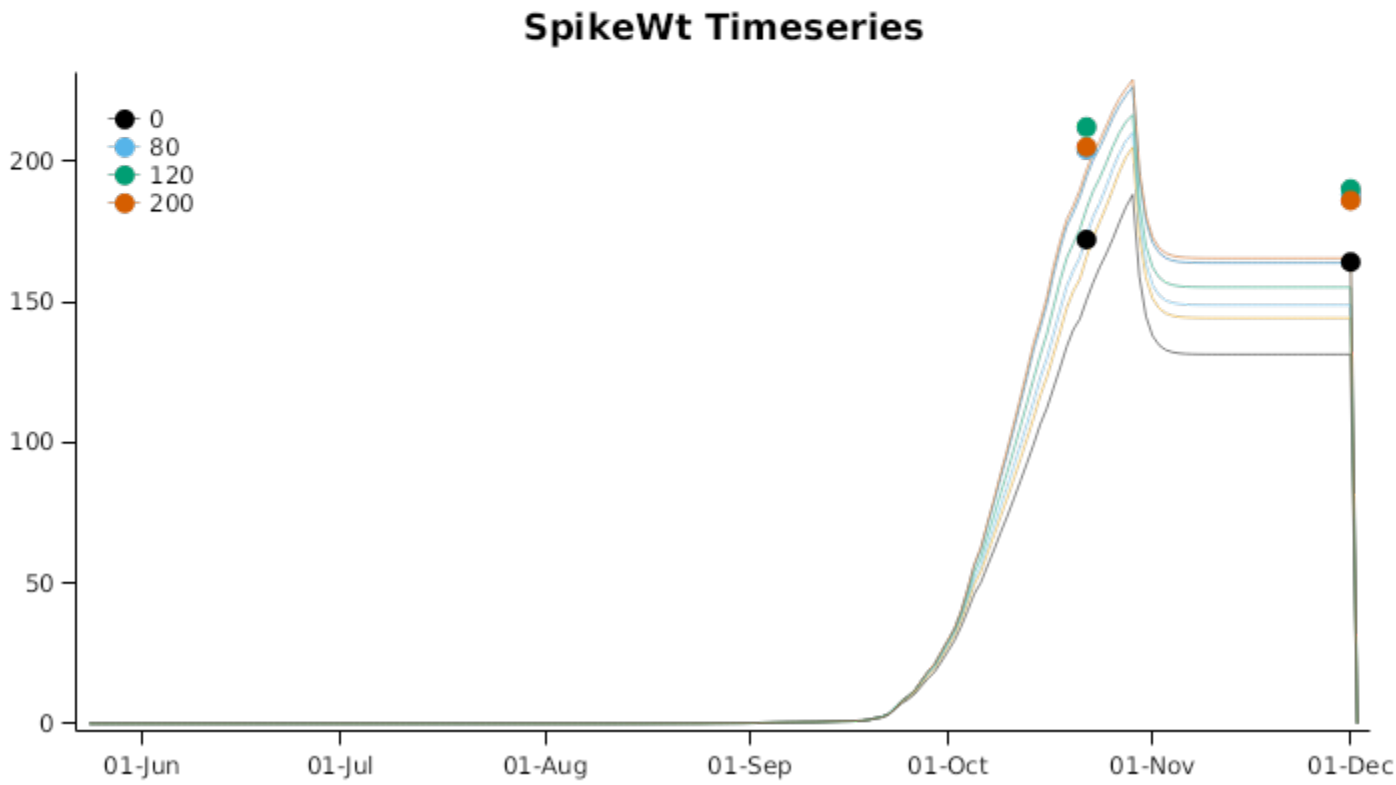

Biomass
1200
1150
1100
1050
1000
950
950
1000
1050
1100
1150
1200
0
40
80
120
160
200
Regression line
1:1 line

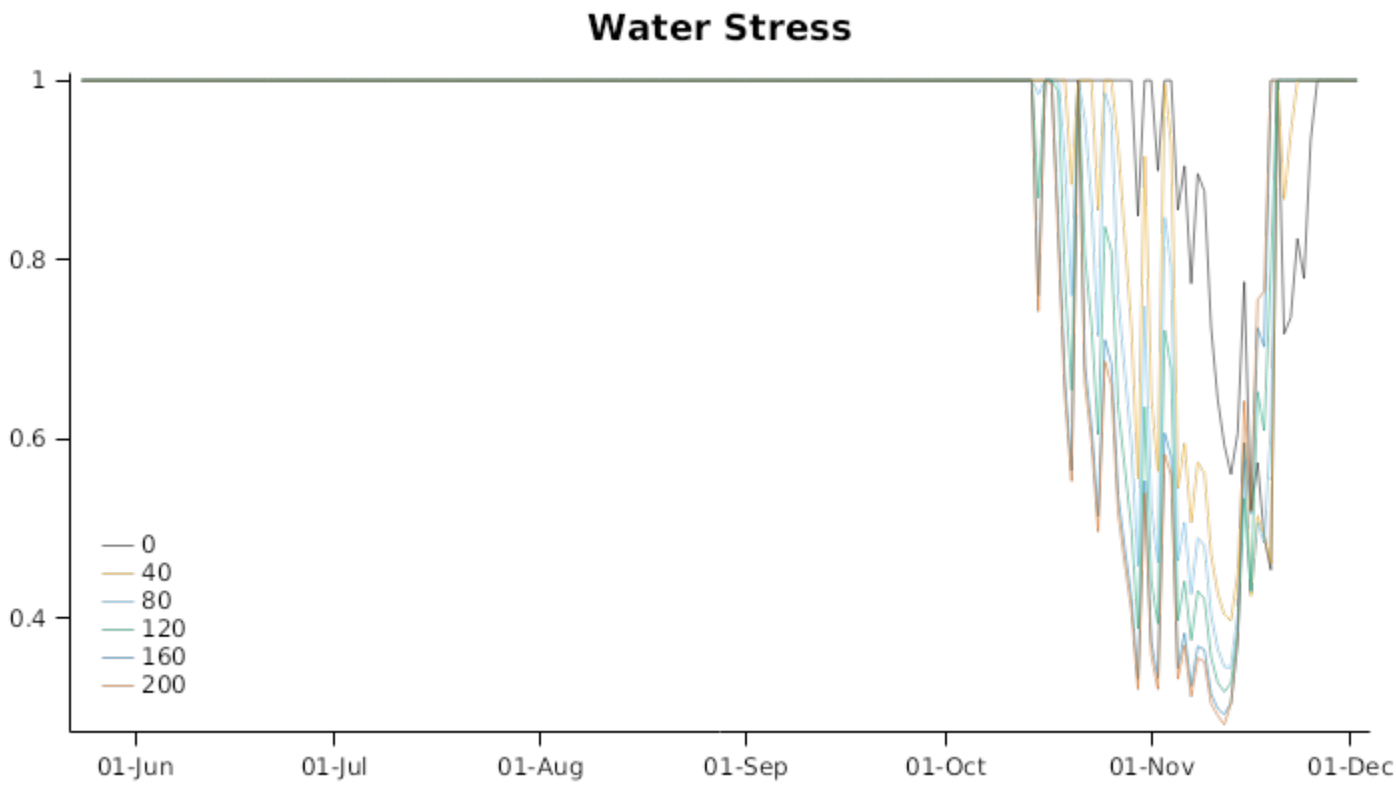

Biomass Timeseries
0
40
80
120
160
200
0
40
80
120
160
200
1000
500
0
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

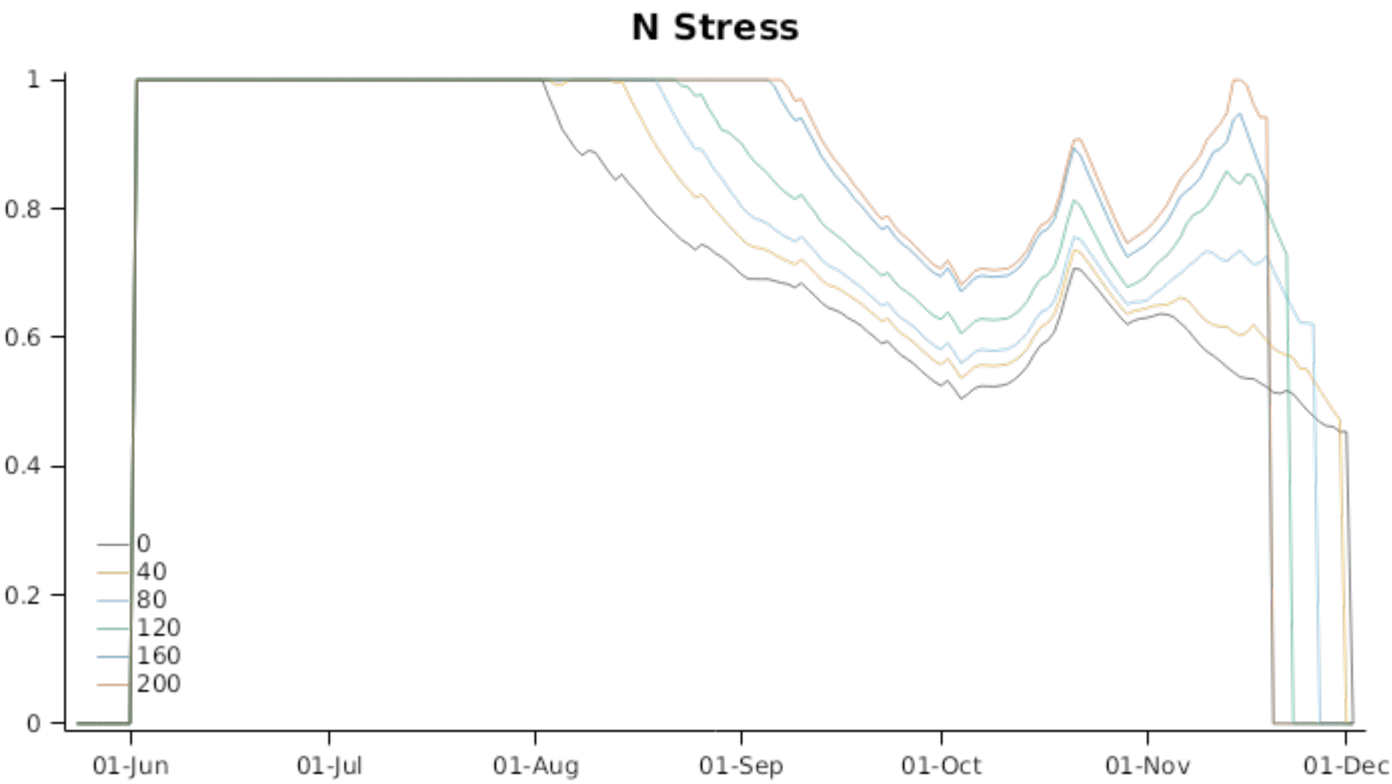

N Uptake Timeseries
0
40
80
120
160
200
15
10
5
0
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

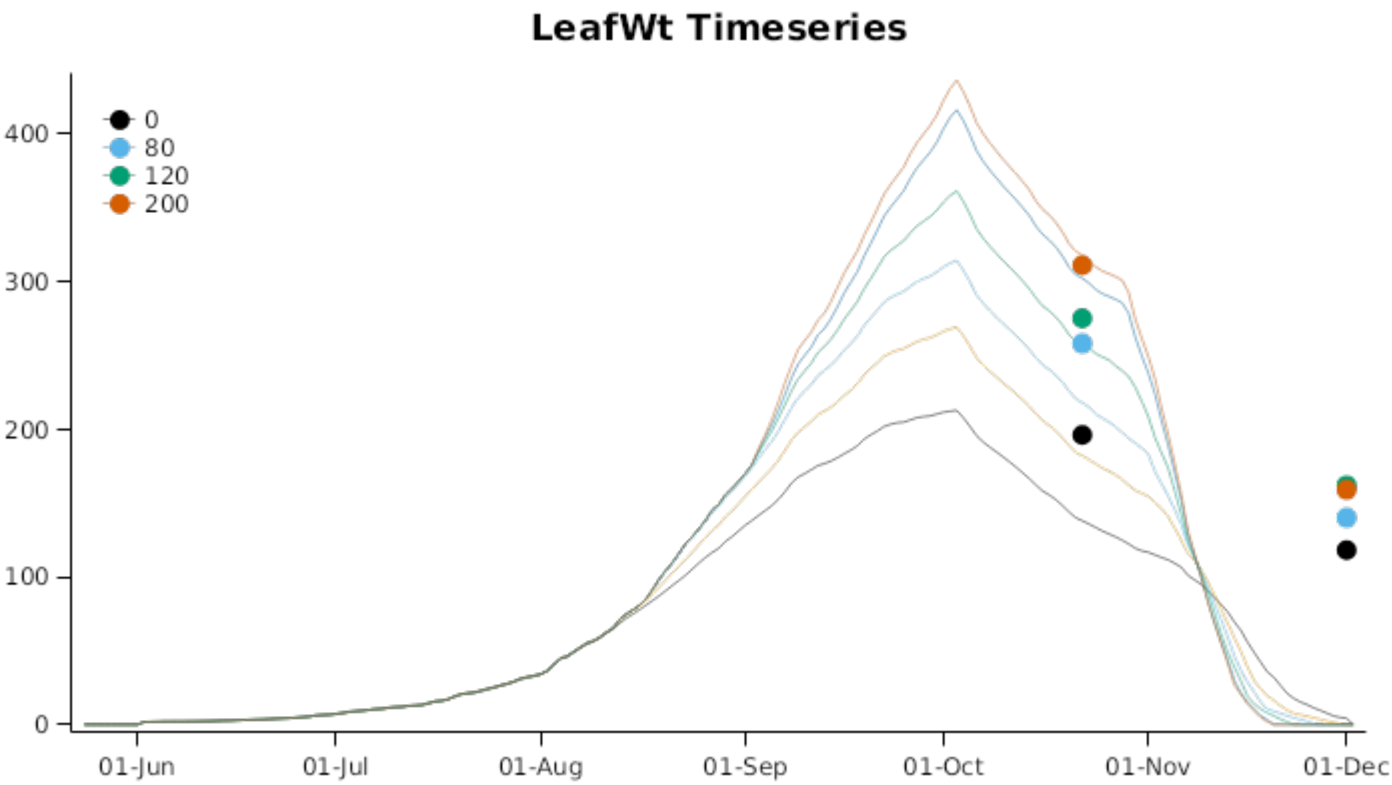

StemWt Timeseries
0
80
120
200
600
400
200
0
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

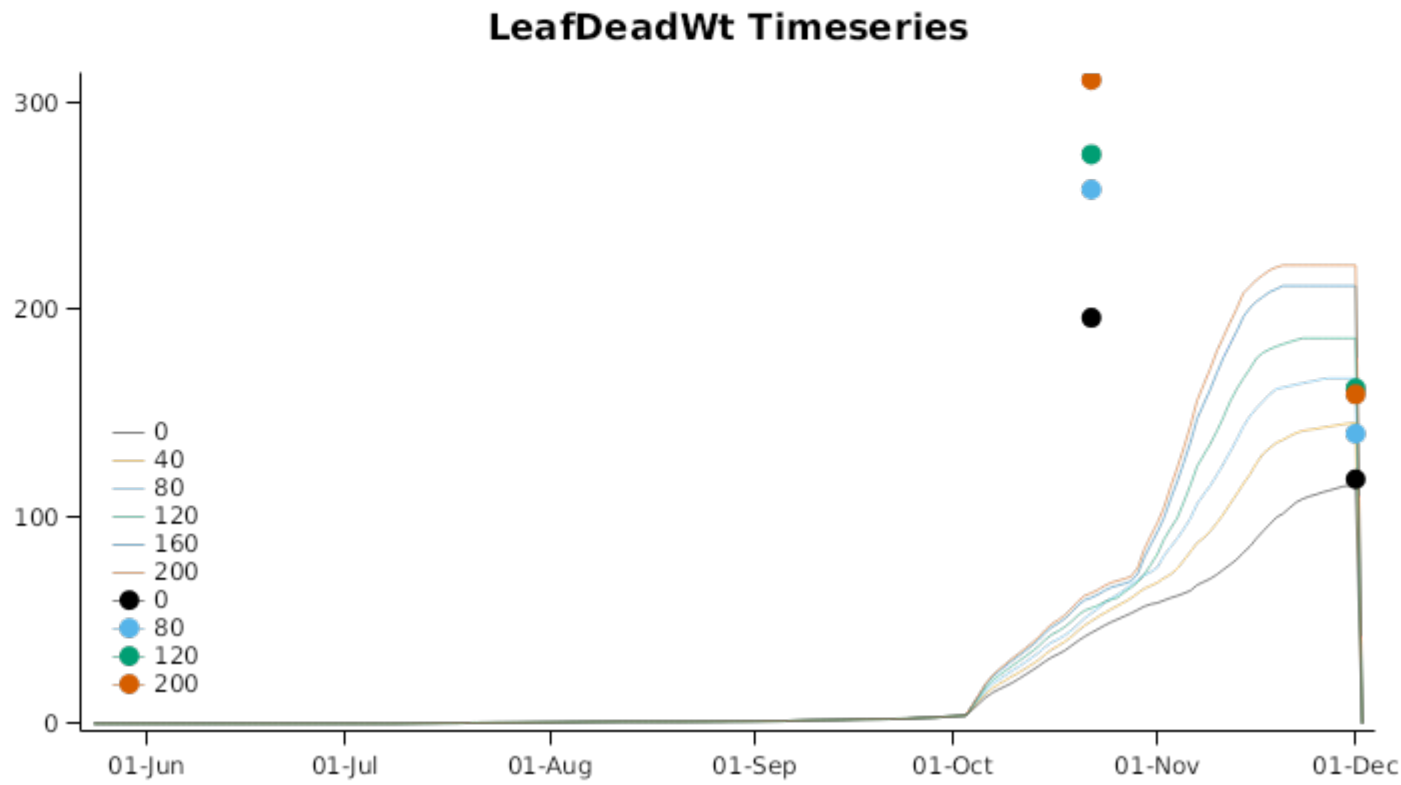

Stem Number Timeseries
0
40
80
120
160
200
0
40
80
120
160
200
1000
800
600
400
200
0
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

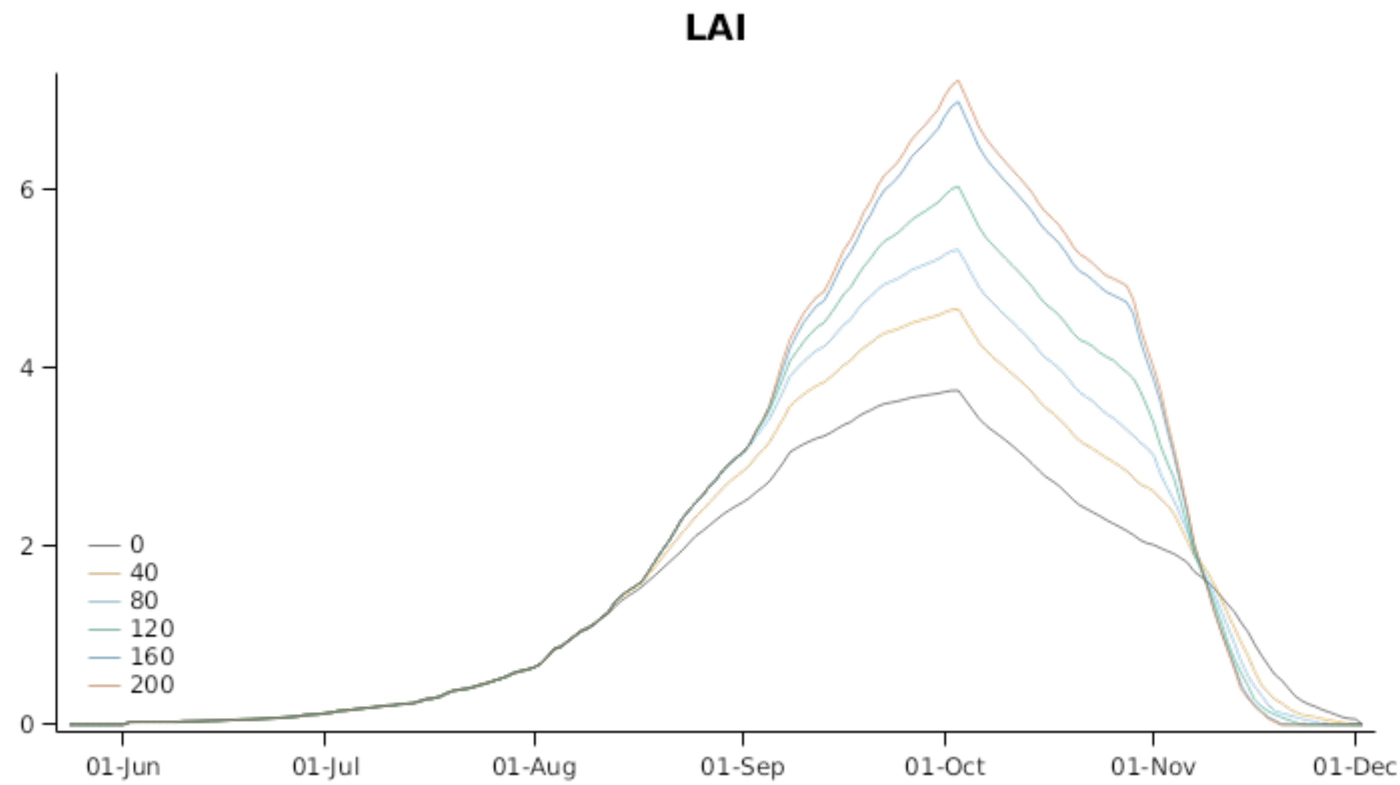

SpikeWt Timeseries
0
80
120
200
0
50
100
150
200
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


Water Stress
0
40
80
120
160
200
0.4
0.6
0.8
1
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

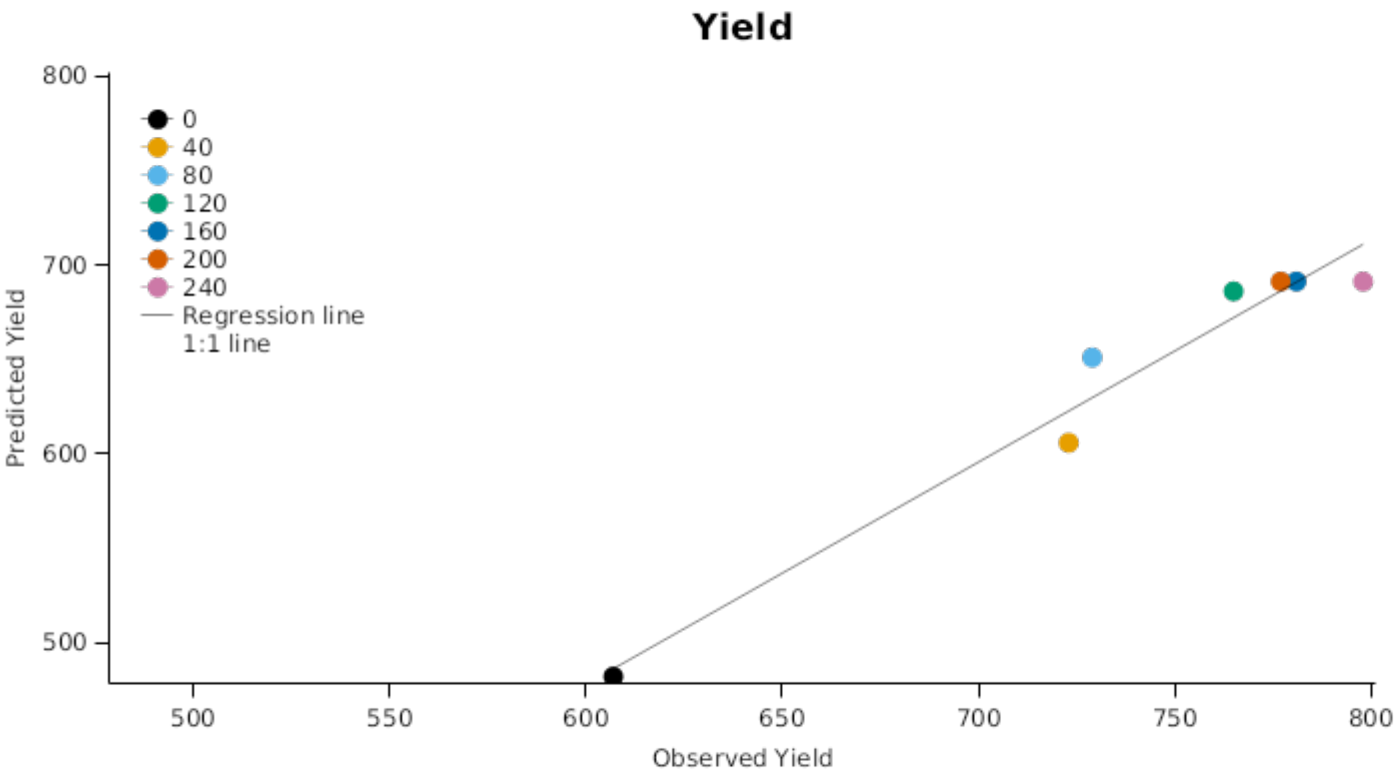

N Stress
1
0.8
0.6
0.4
0.2
0
0
40
80
120
160
200
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

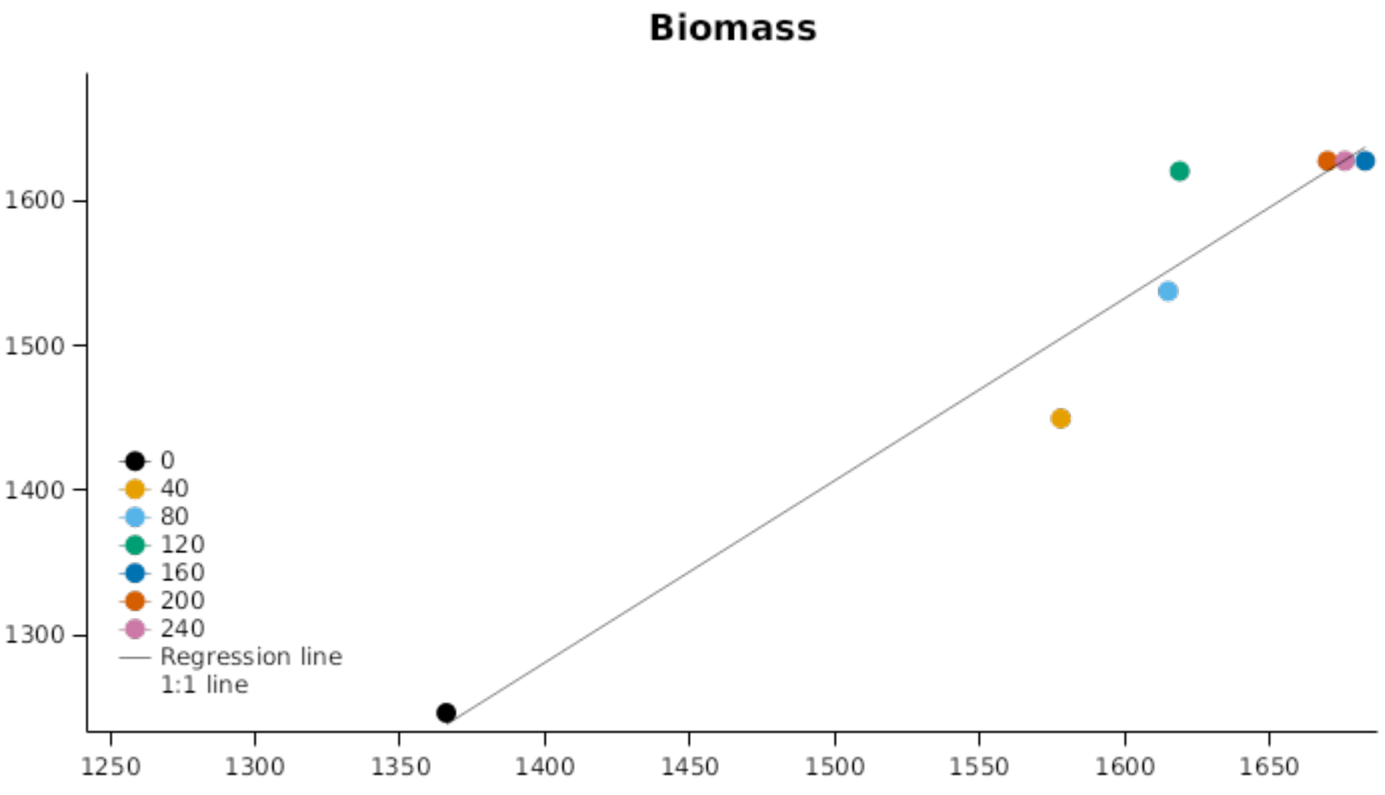

LeafWt Timeseries
400
300
200
100
0
0
80
120
200
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

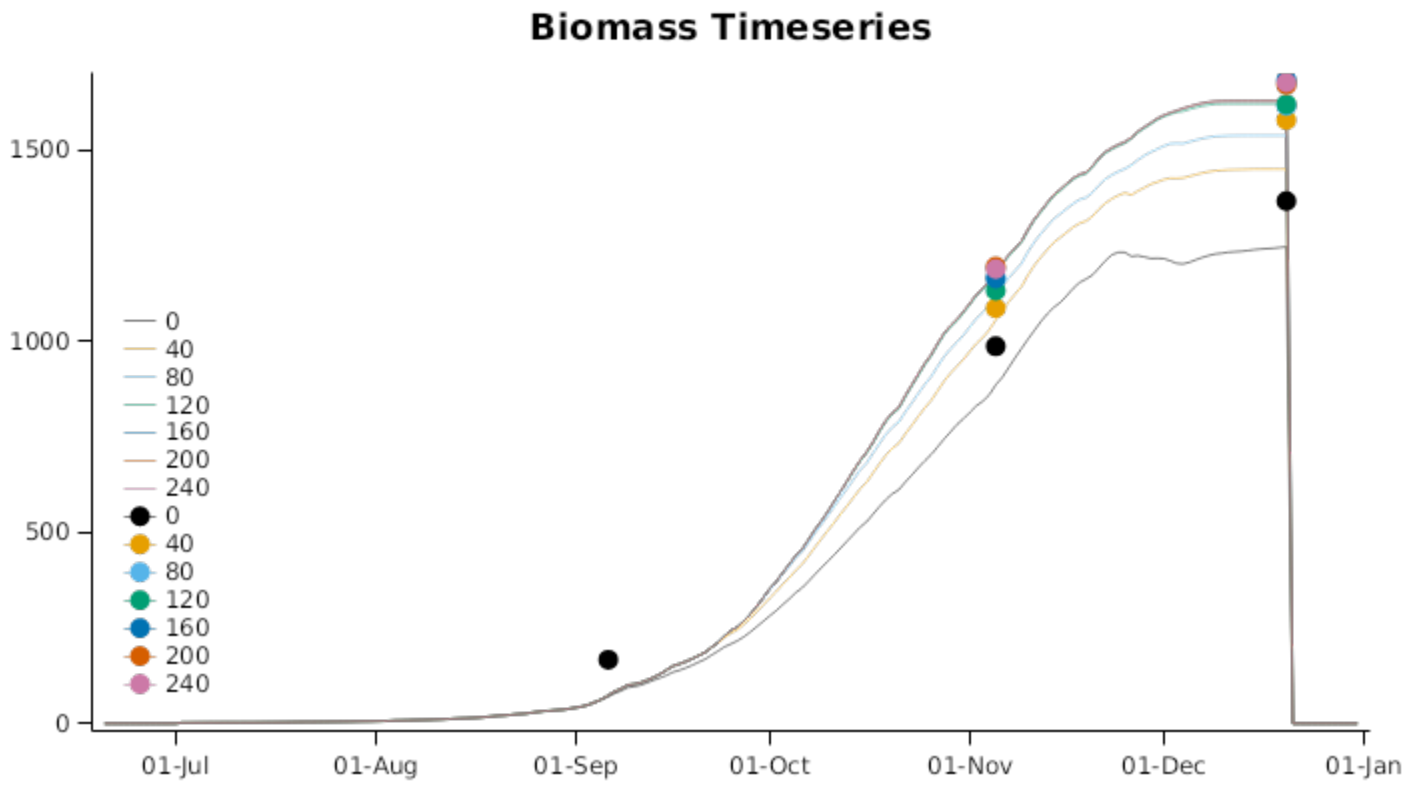


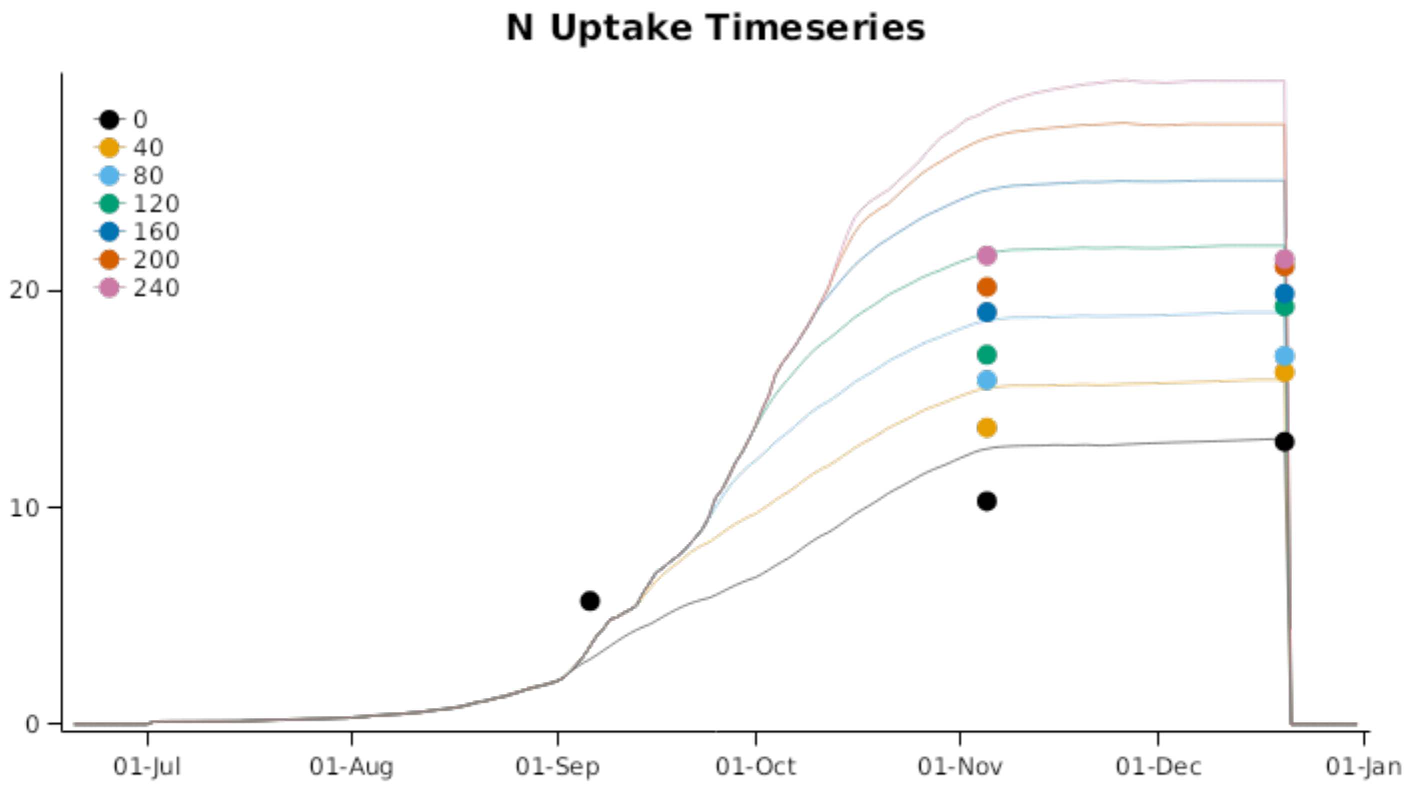


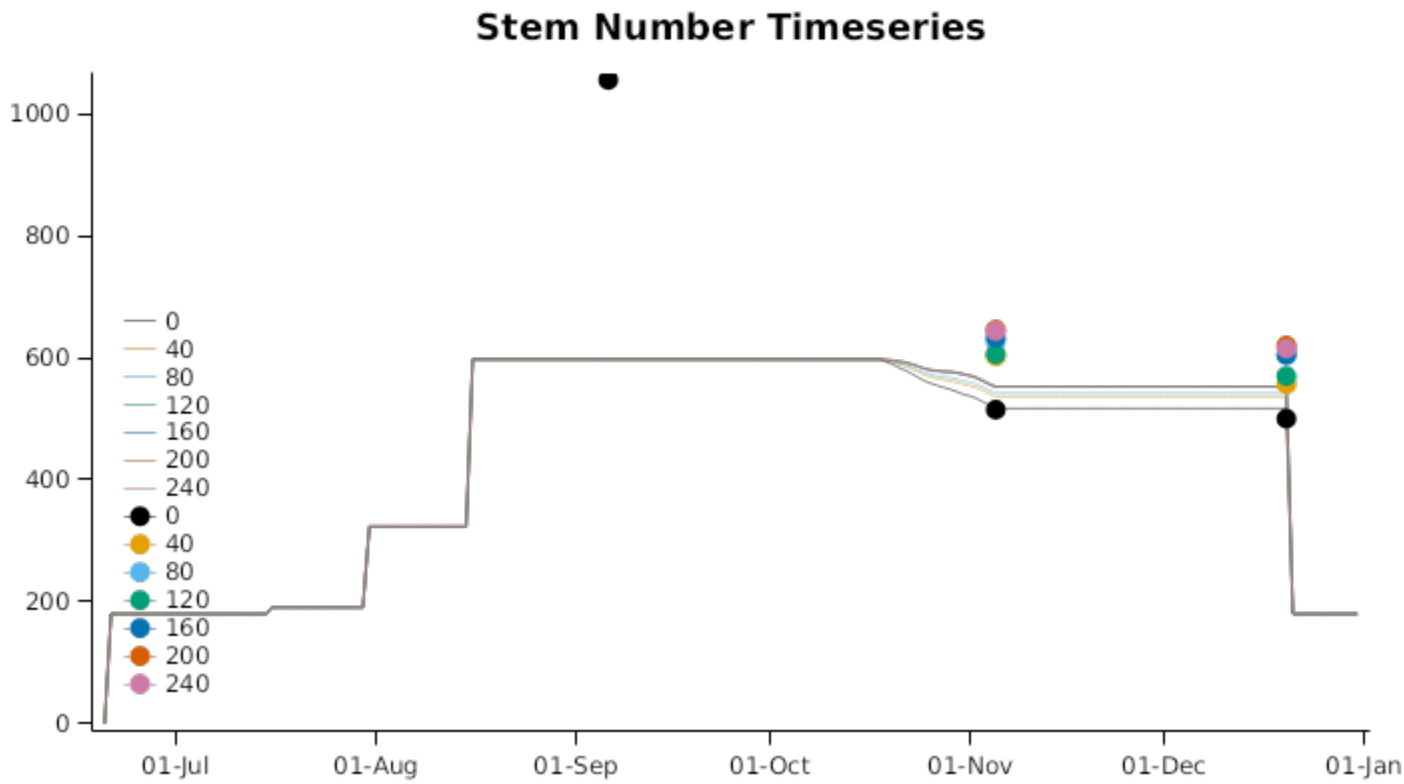
3.6.9.2 Ginninderra1991

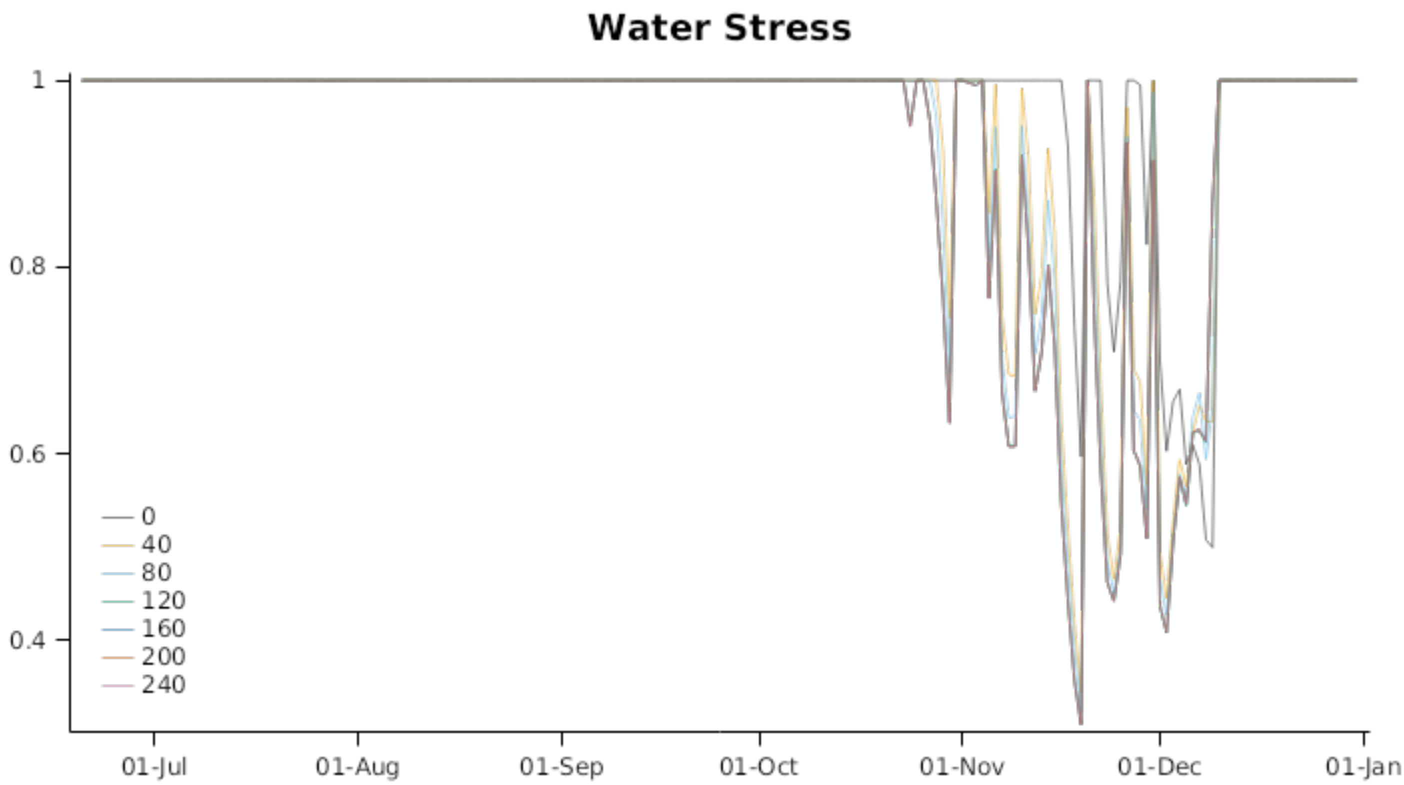

Yield
800
700
600
500
Predicted Yield
0
40
80
120
160
200
240
Regression line
1:1 line
500
550
600
650
700
750
800
Observed Yield

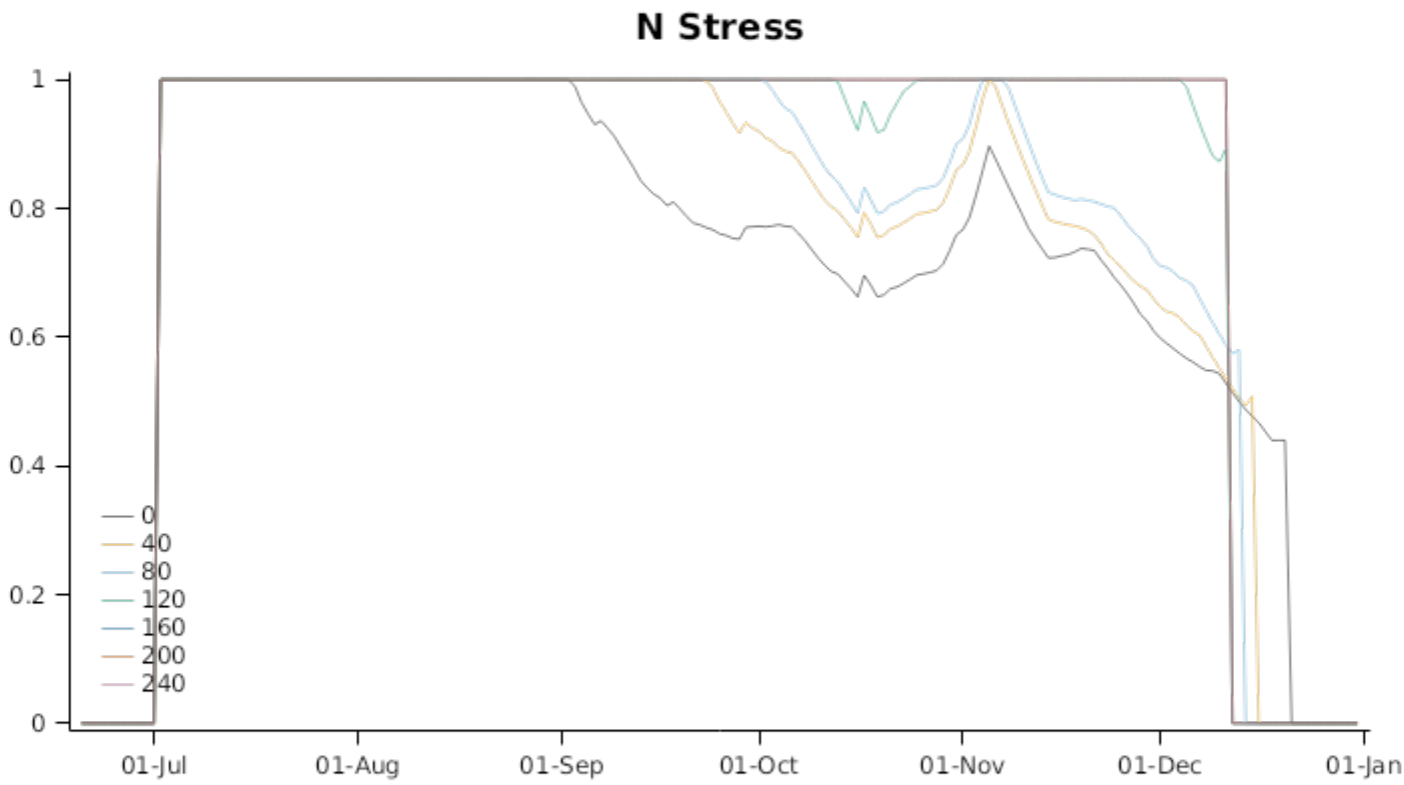

Biomass
1600
1500
1400
1300
0
40
80
120
160
200
240
Regression line
1:1 line
1250
1300
1350
1400
1450
1500
1550
1600
1650

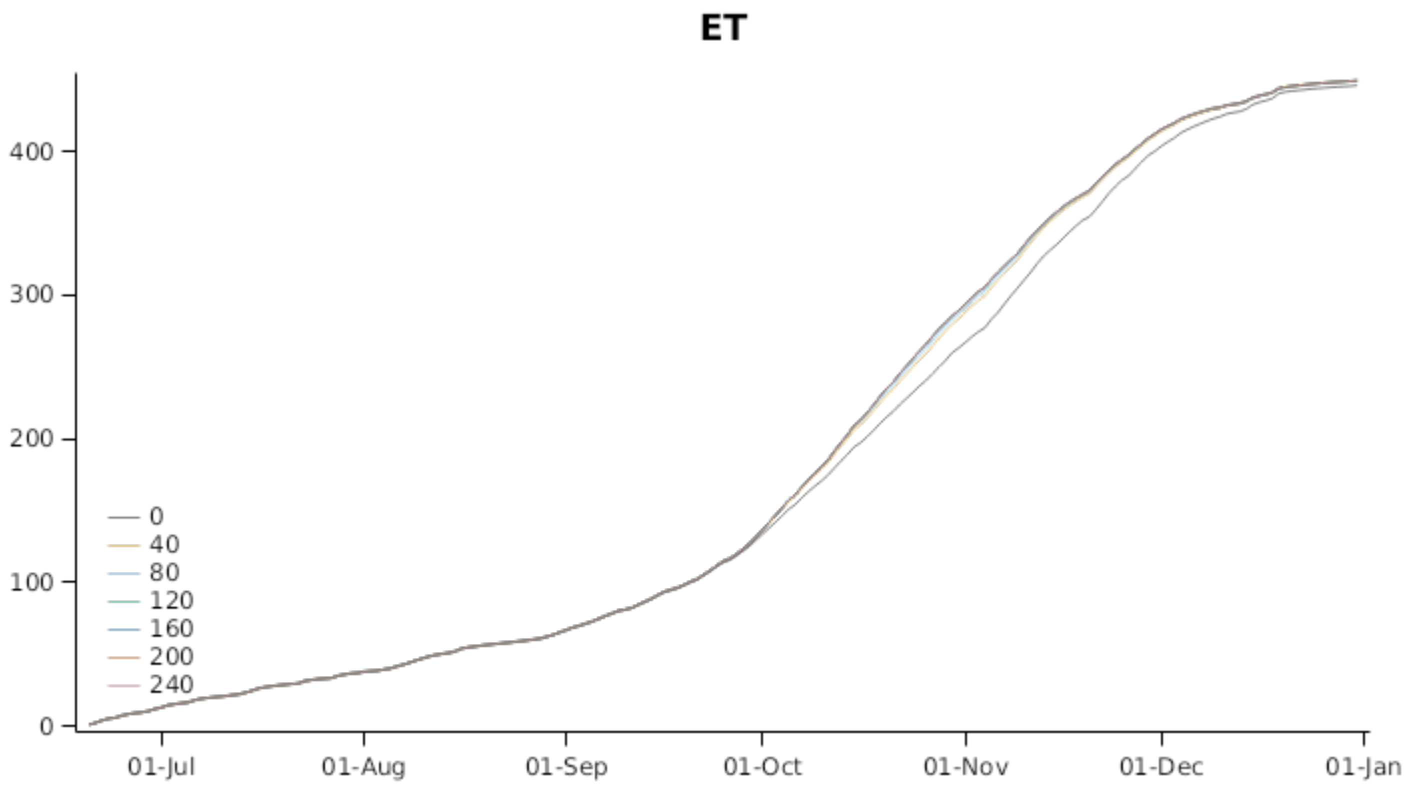

Biomass Timeseries
1500
1000
500
0
0
40
80
120
160
200
240
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

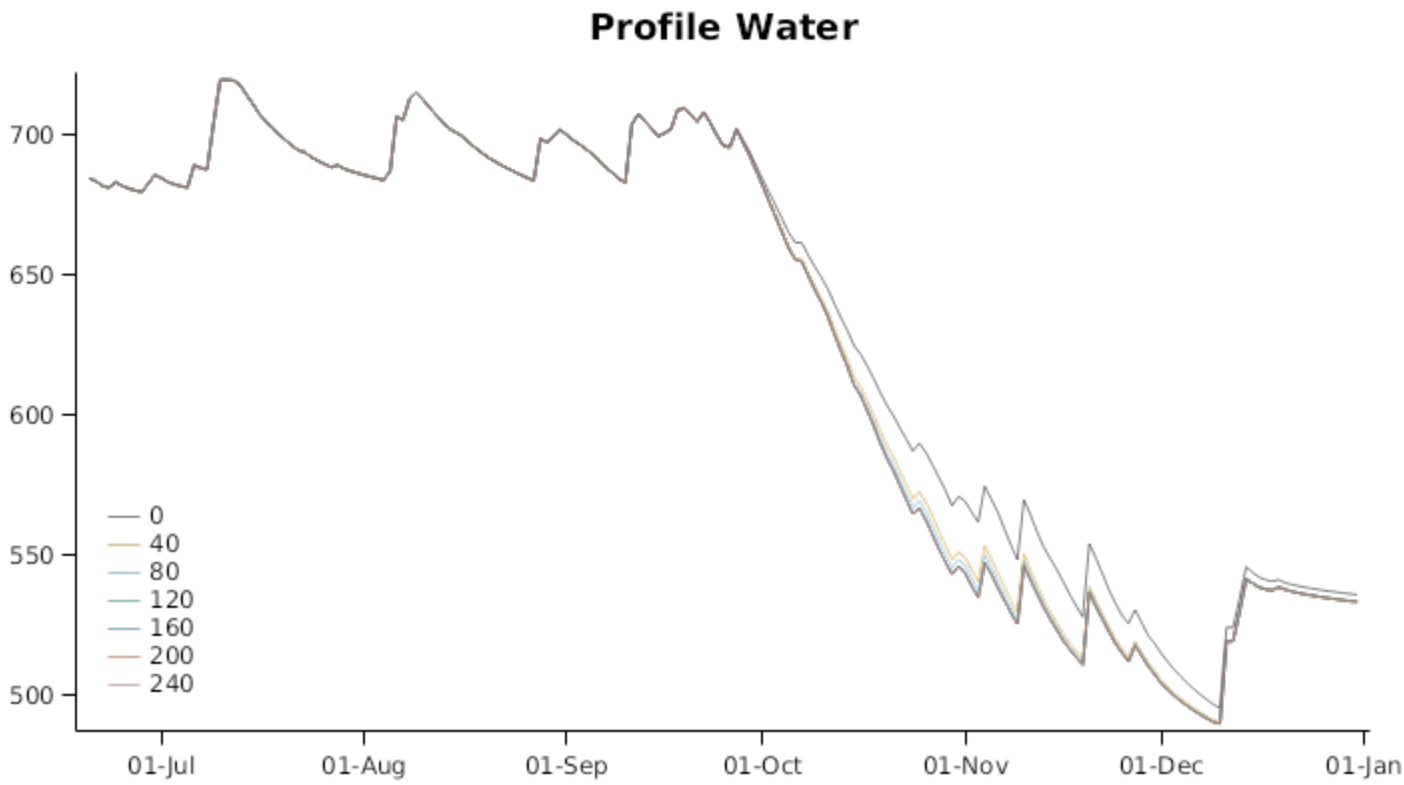

N Uptake Timeseries
20
10
0
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

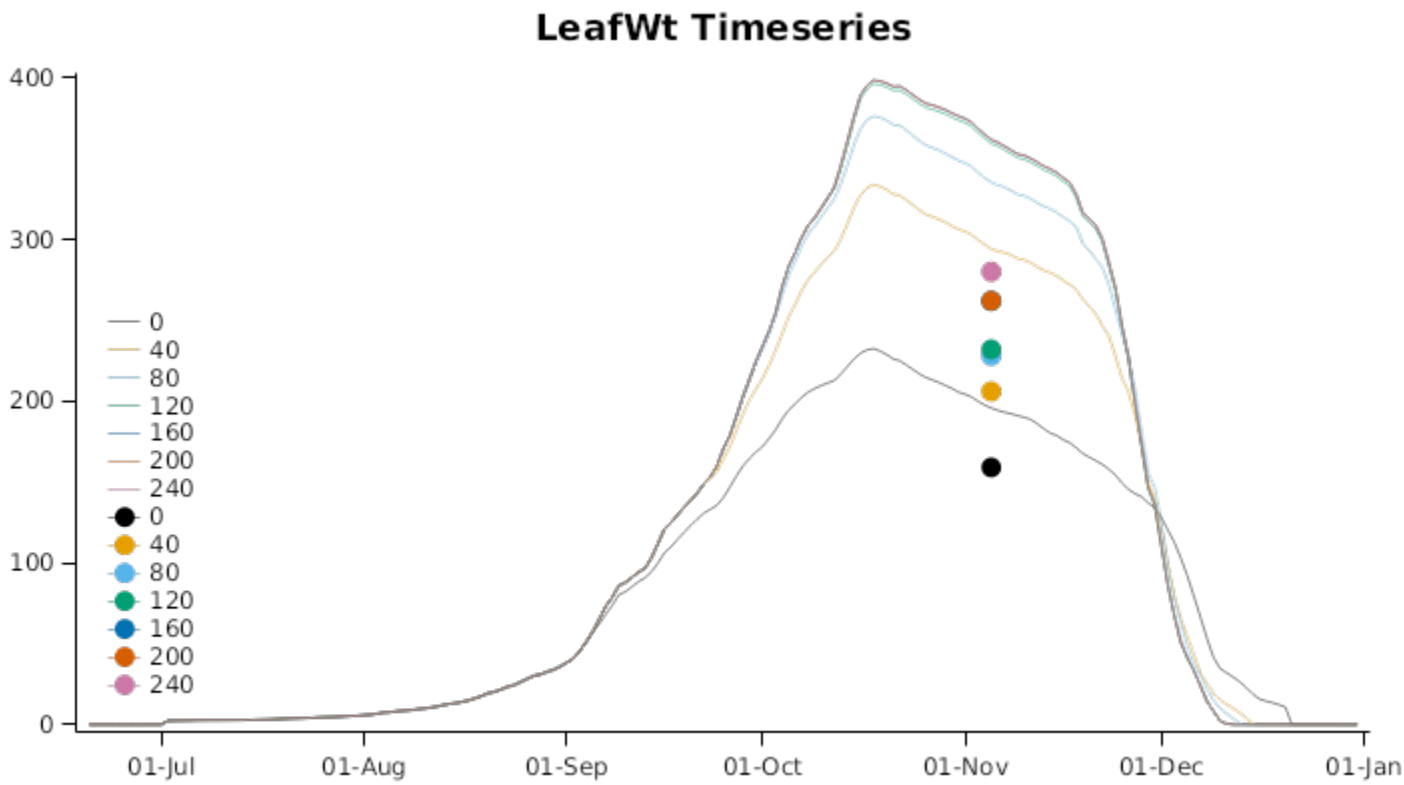

Stem Number Timeseries
1000
800
600
400
200
0
0
40
80
120
160
200
240
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan


Water Stress
1
0.8
0.6
0.4
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

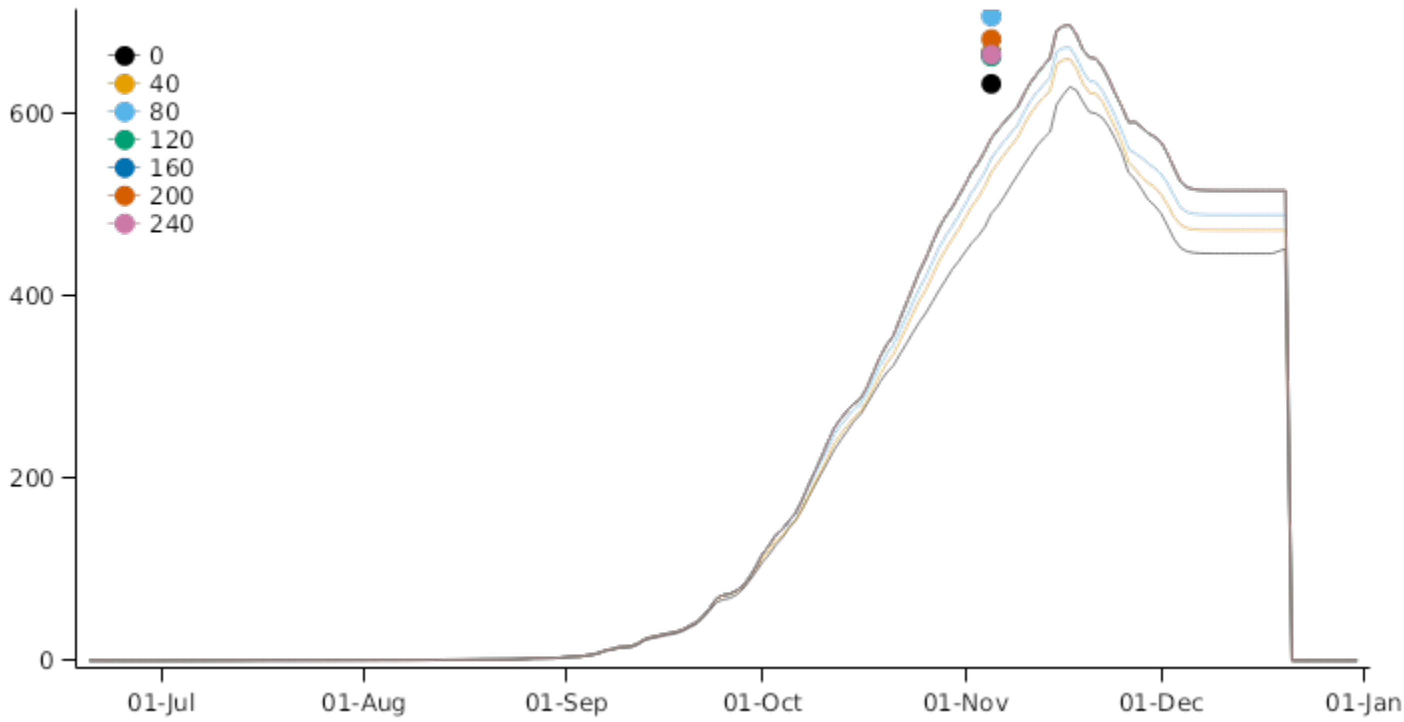

N Stress
1
0.8
0.6
0.4
0.2
0
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
0
40
80
120
160
200
240


ET
400
300
200
100
0
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
0
40
80
120
160
200
240

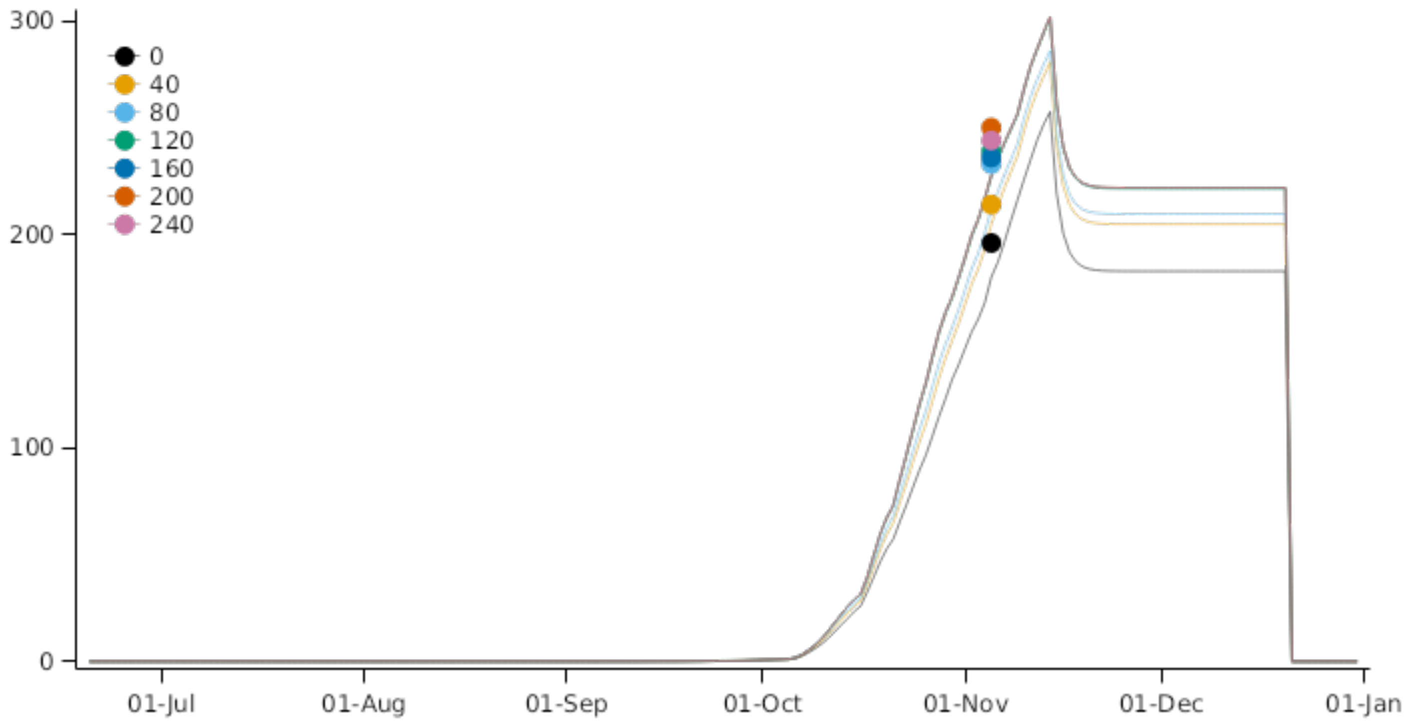

Profile Water
700
650
600
550
500
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

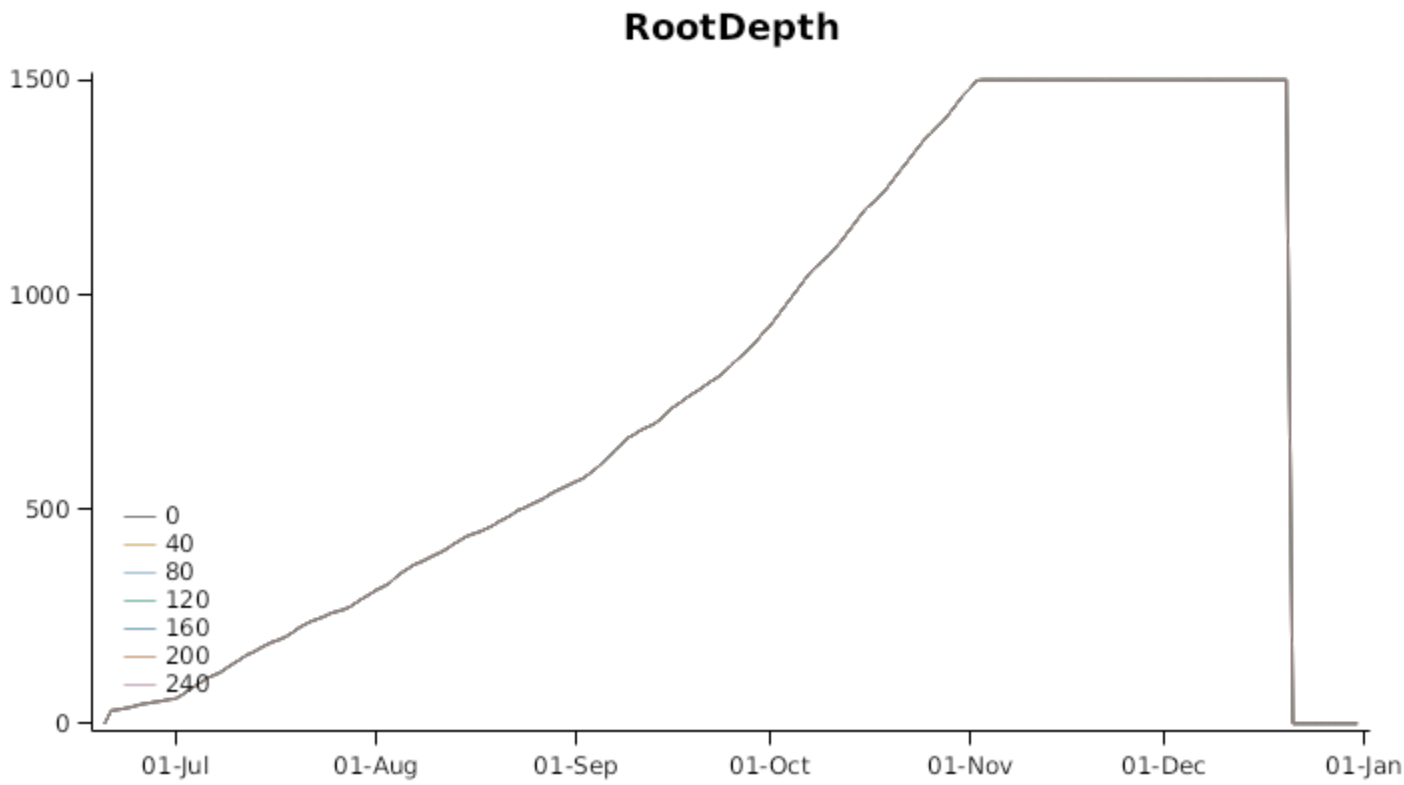

LeafWt Timeseries
400
300
200
100
0
0
40
80
120
160
200
240
0
40
80
120
160
200
240
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

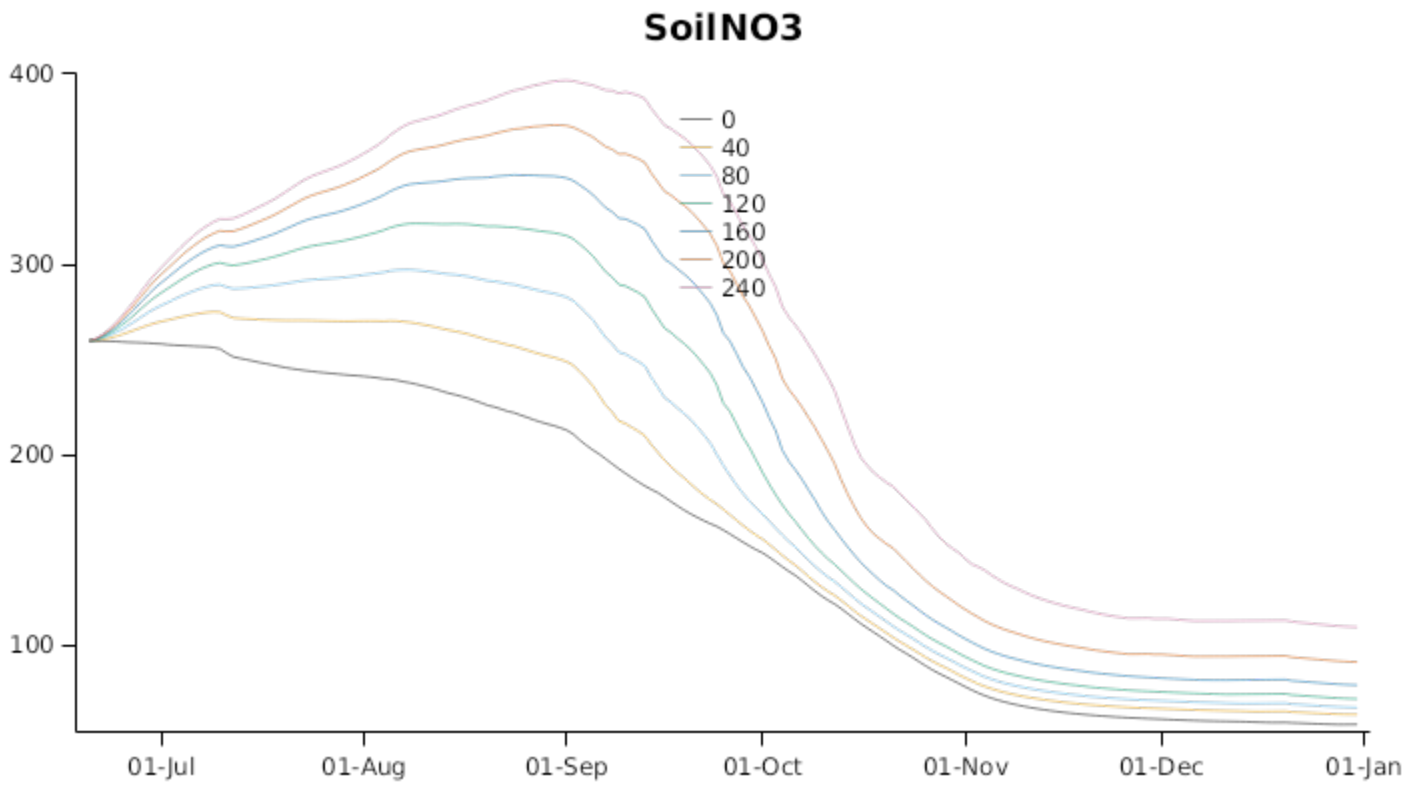
StemWt Timeseries



SpikeWt Timeseries







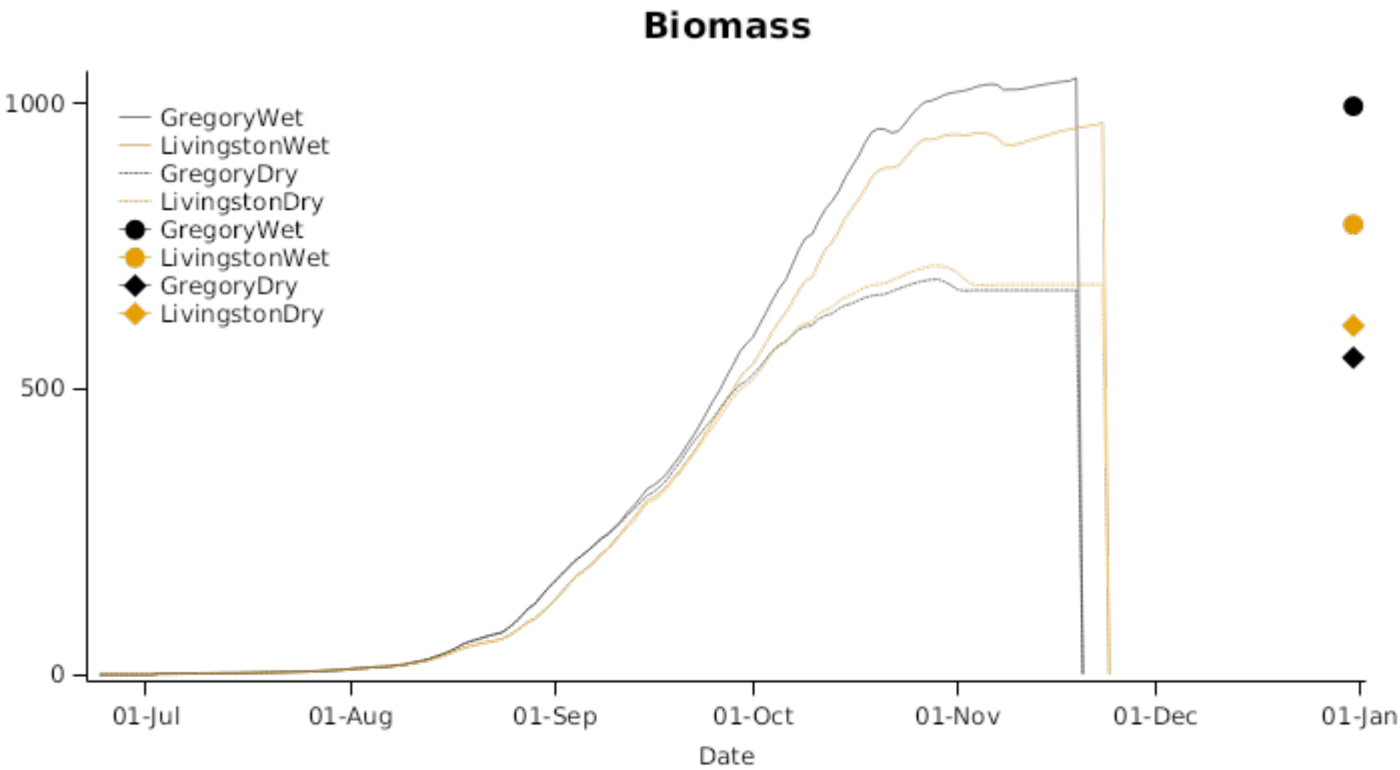
3.6.10 Wagga1314

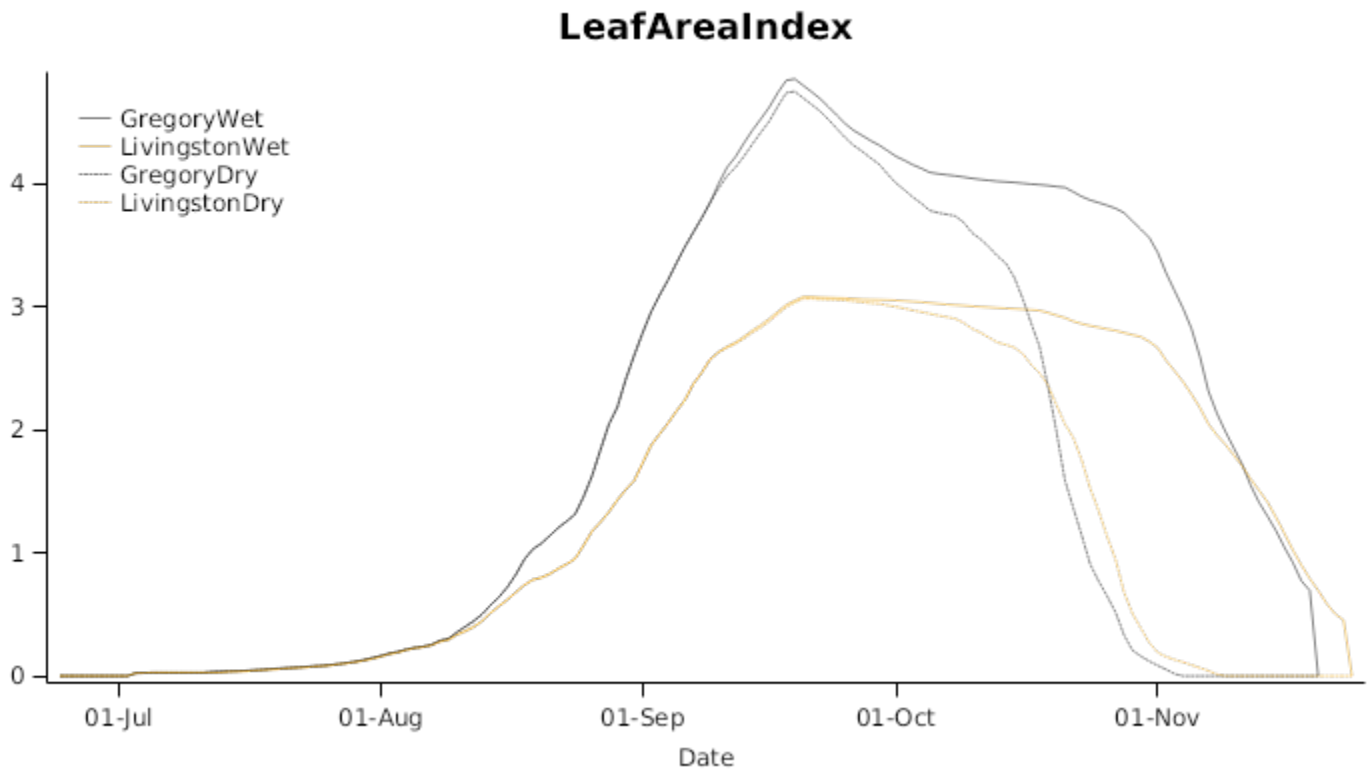
The dataset of K.T. Zeleke et al., 2016 includes plantings of two wheat varieties (Gregory, Livingston) under two water regimes (dry and irrigated) for 2013 and 2014 at the Wagga Wagga Agricultural Research Institute. Yields ranged from 1.63 t/ha to 6.01 t/ha.

List of experiments.

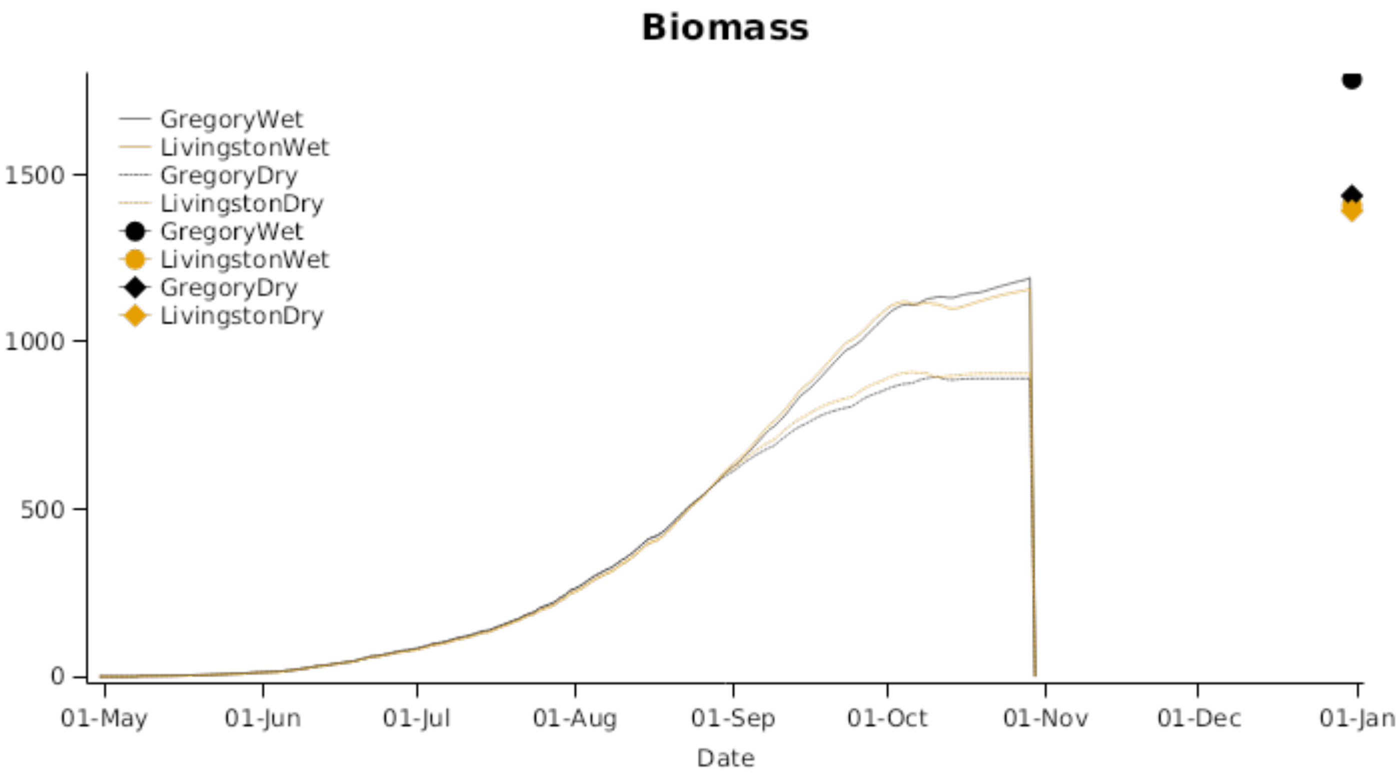
Experiment Name	Design (Number of Treatments)
Wagga2013	Cv x Water (4)
Wagga2014	Cv x Water (4)

3.6.10.1 Wagga2013

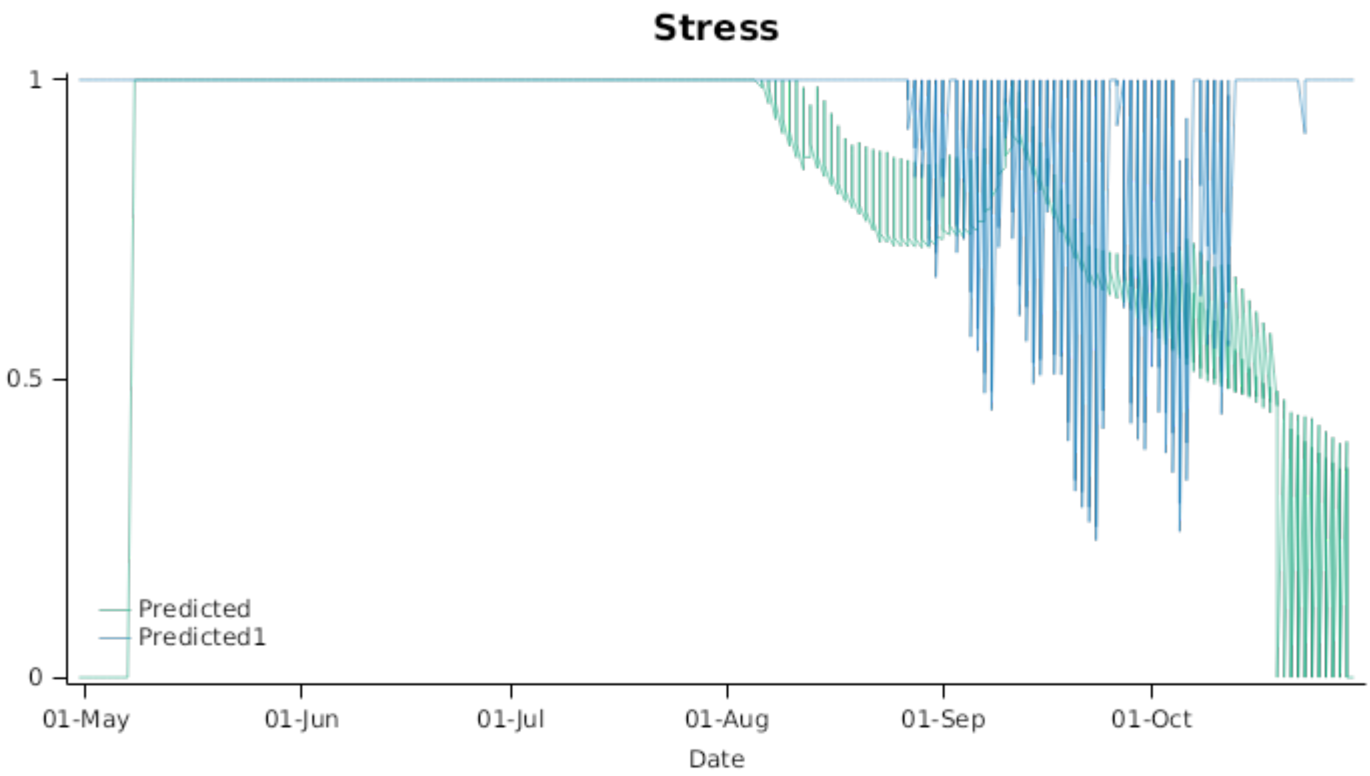




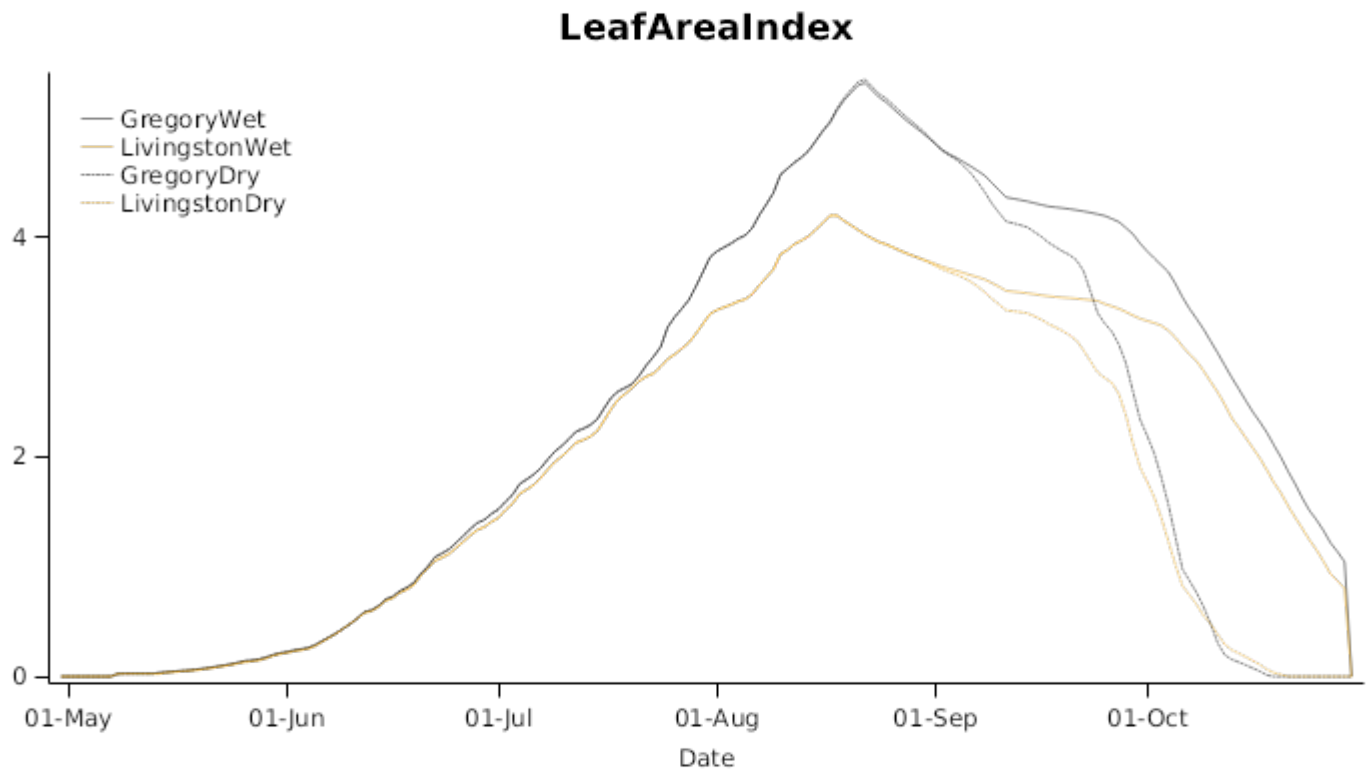
3.6.10.2 Wagga2014



Biomass
GregoryWet
LivingstonWet
GregoryDry
LivingstonDry
GregoryWet
LivingstonWet
GregoryDry
LivingstonDry
1500
1000
500
0
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
Date



Stress
1
0.5
0
Predicted
Predicted1
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
Date



3.6.11 YarrabahCreek

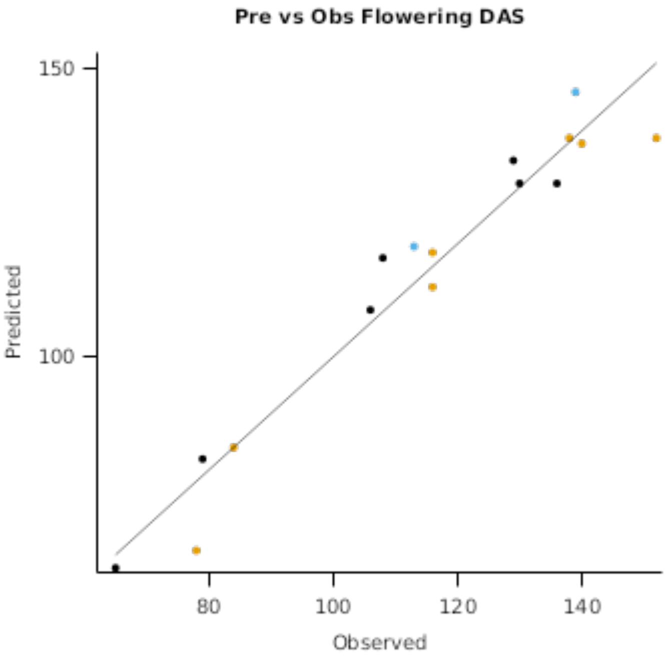
This trial was conducted on a Vertosol soil on the Liverpool Plains, central-eastern Australia in 2001. Hybrid Mercury was sown on 19th of June and biomass, leaf area, phenology, soil water (Neutron Moisture Meter) and water use (Bowen Ratio method) were monitored. More information can be found in Young et al., 2008.

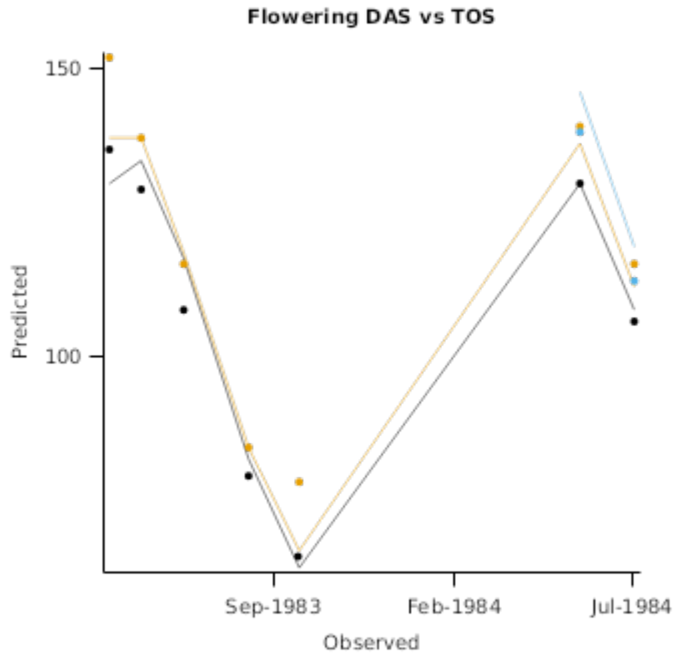
3.6.12 Griffith

This dataset from Stapper et al., 0 includes observed phenological data for range of cultivars, three of which have been used here (Yecora, Egret, Hartog). Planting dates from 1983 and 1984 provide a range of climatic conditions.

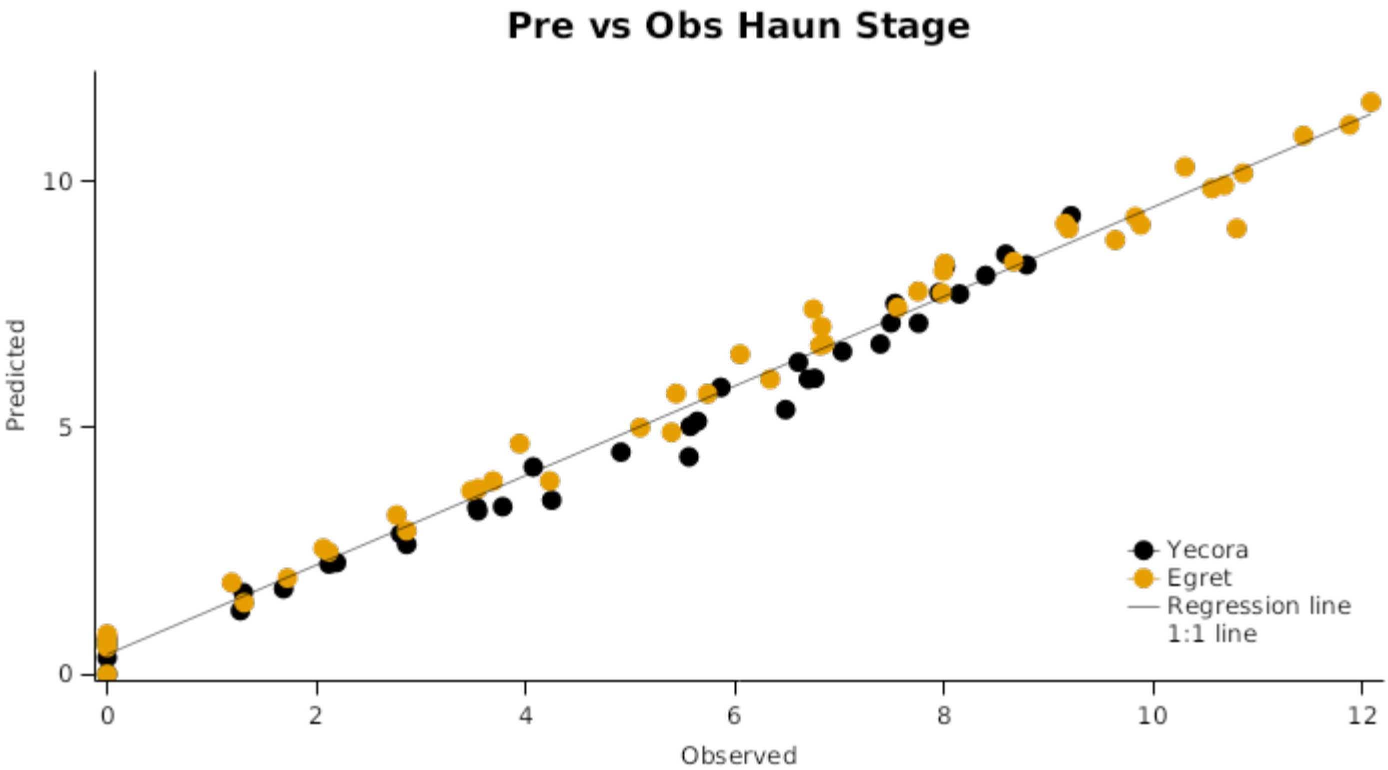
List of experiments.

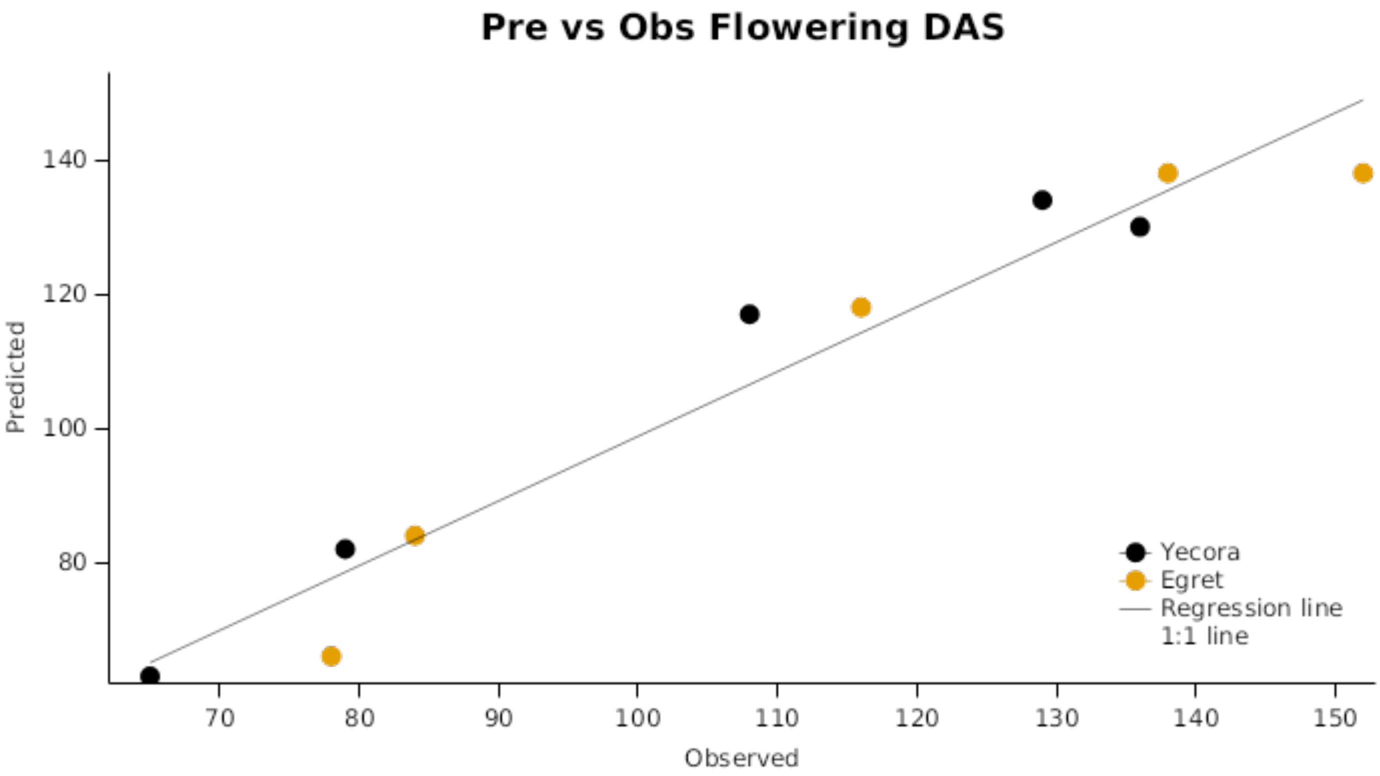
Experiment Name	Design (Number of Treatments)
Griffith1983	Cv x TOS (10)
Griffith1984	Cv x TOS (6)



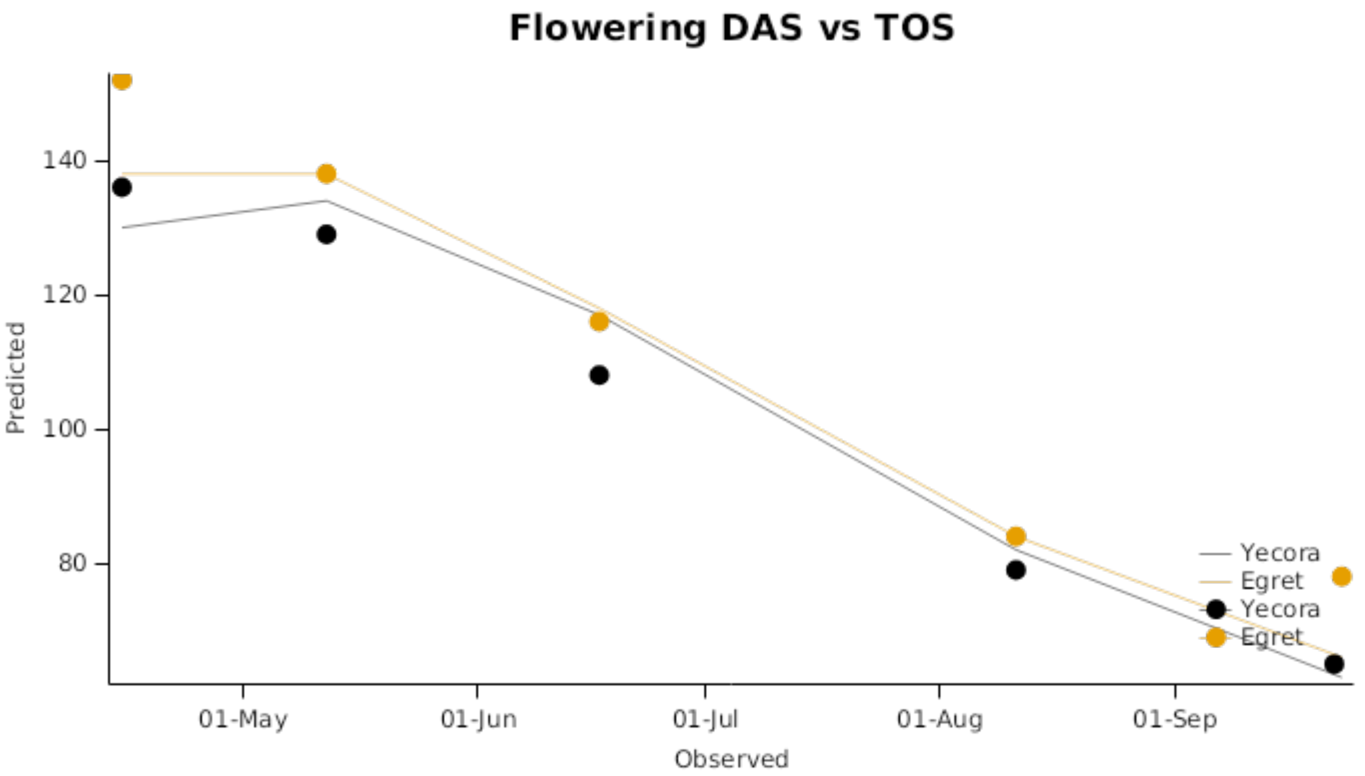


3.6.12.1 Griffith1983

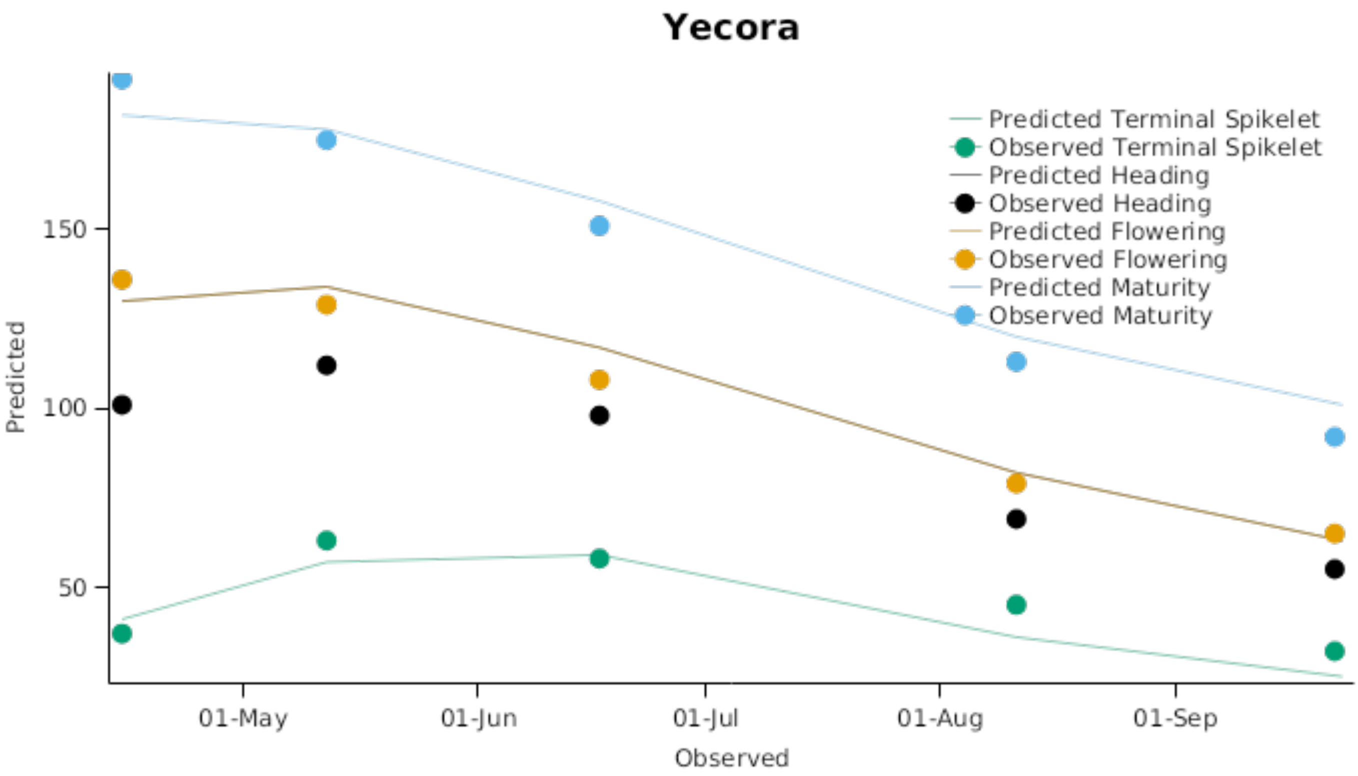




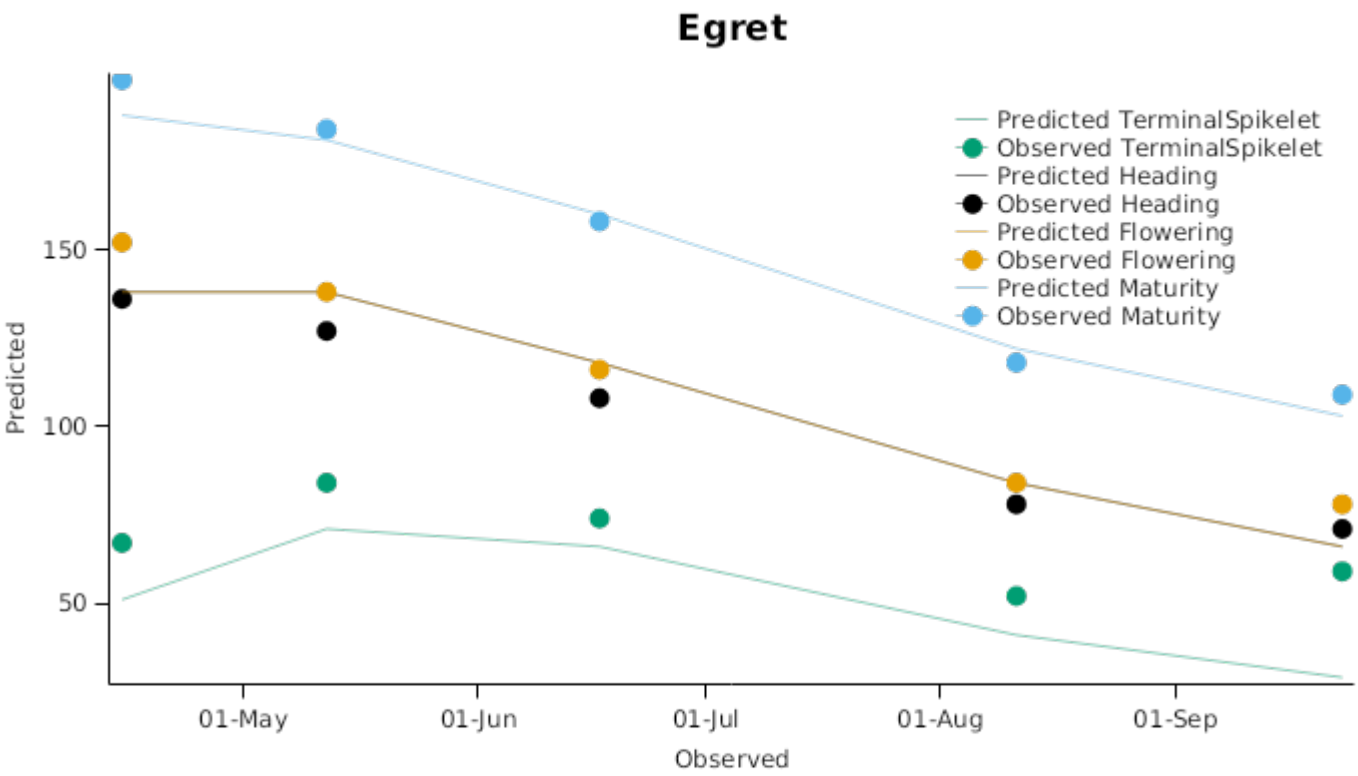
Pre vs Obs Flowering DAS
Predicted
140
120
100
80
70
80
90
100
110
120
130
140
150
Observed
Yecora
Egret
Regression line
1:1 line



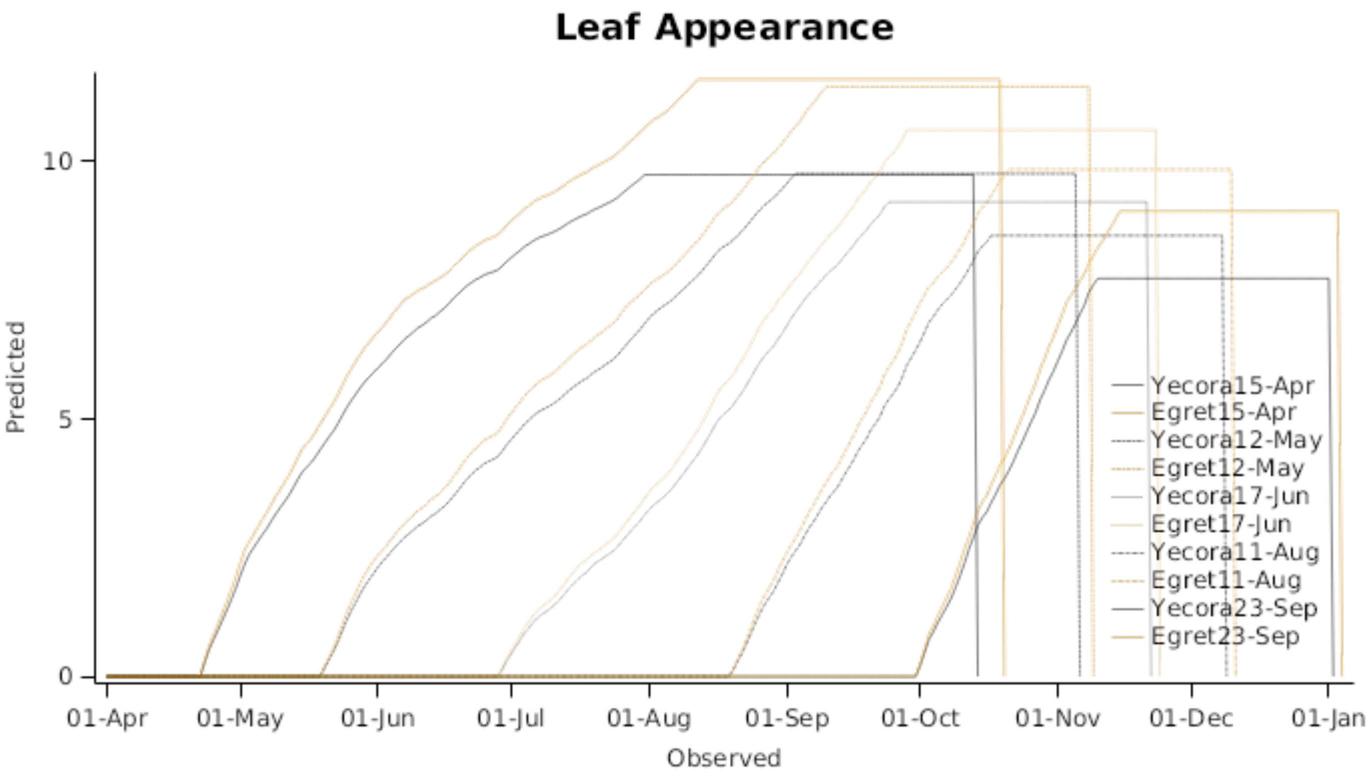
Flowering DAS vs TOS
Predicted
140
120
100
80
01-May
01-Jun
01-Jul
01-Aug
01-Sep
Observed
Yecora
Egret
Yecora
Egret

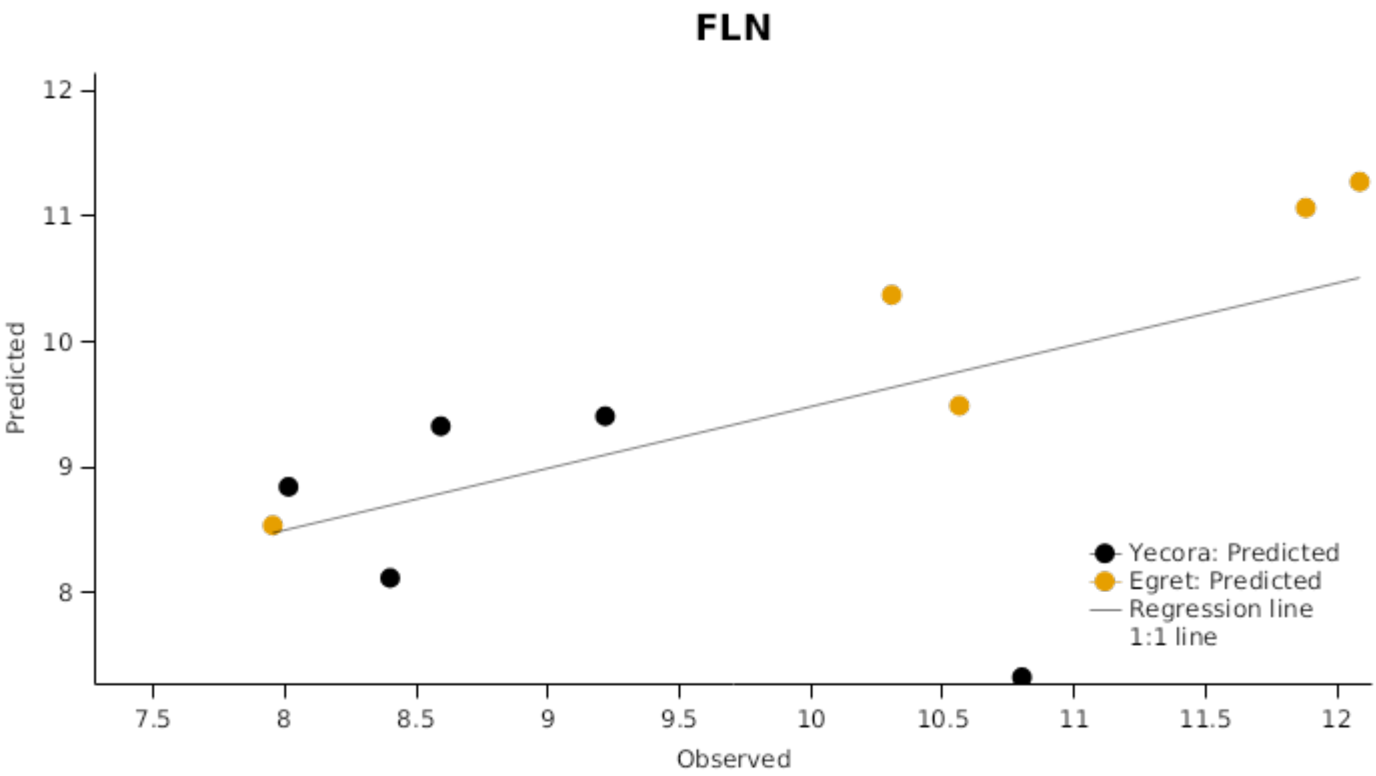


Yecora
Predicted Terminal Spikelet
Observed Terminal Spikelet
Predicted Heading
Observed Heading
Predicted Flowering
Observed Flowering
Predicted Maturity
Observed Maturity
Predicted
150
100
50
01-May
01-Jun
01-Jul
01-Aug
01-Sep
Observed

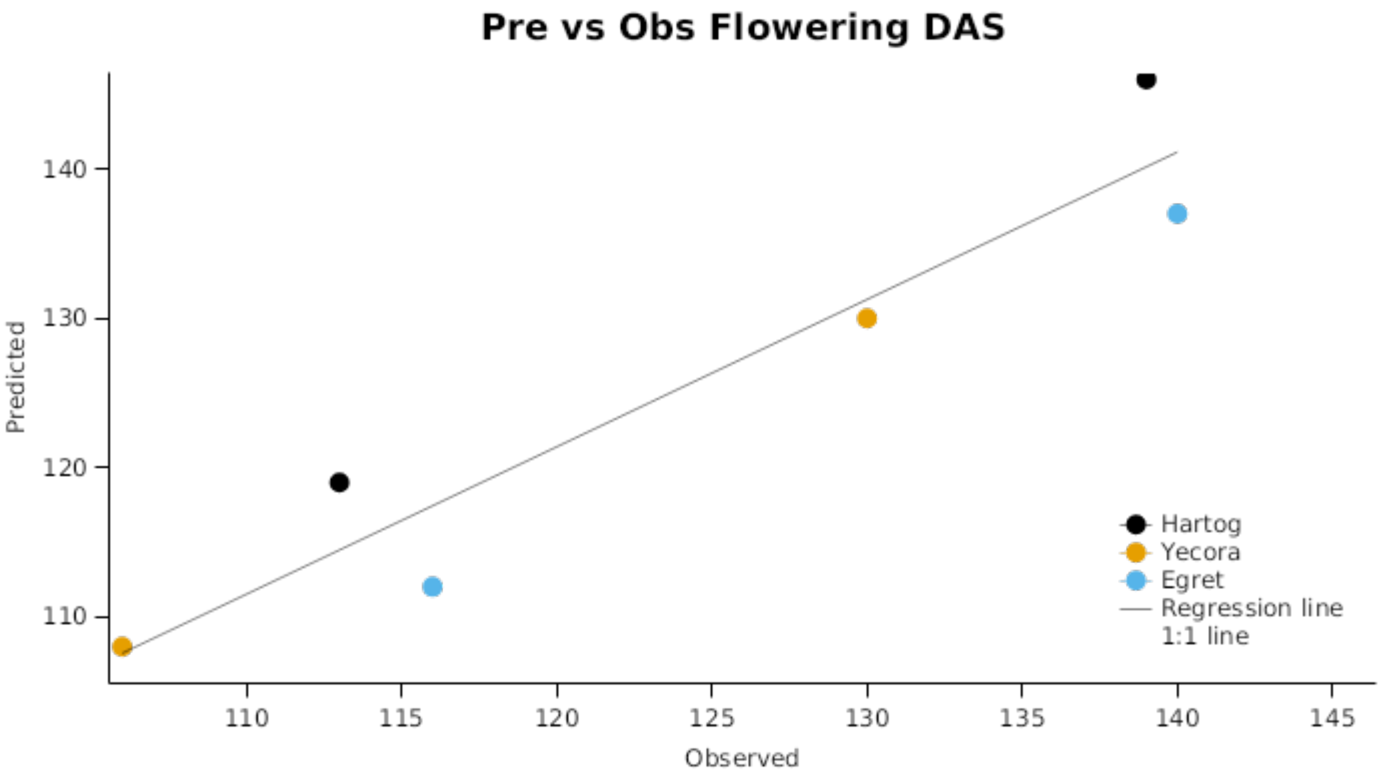


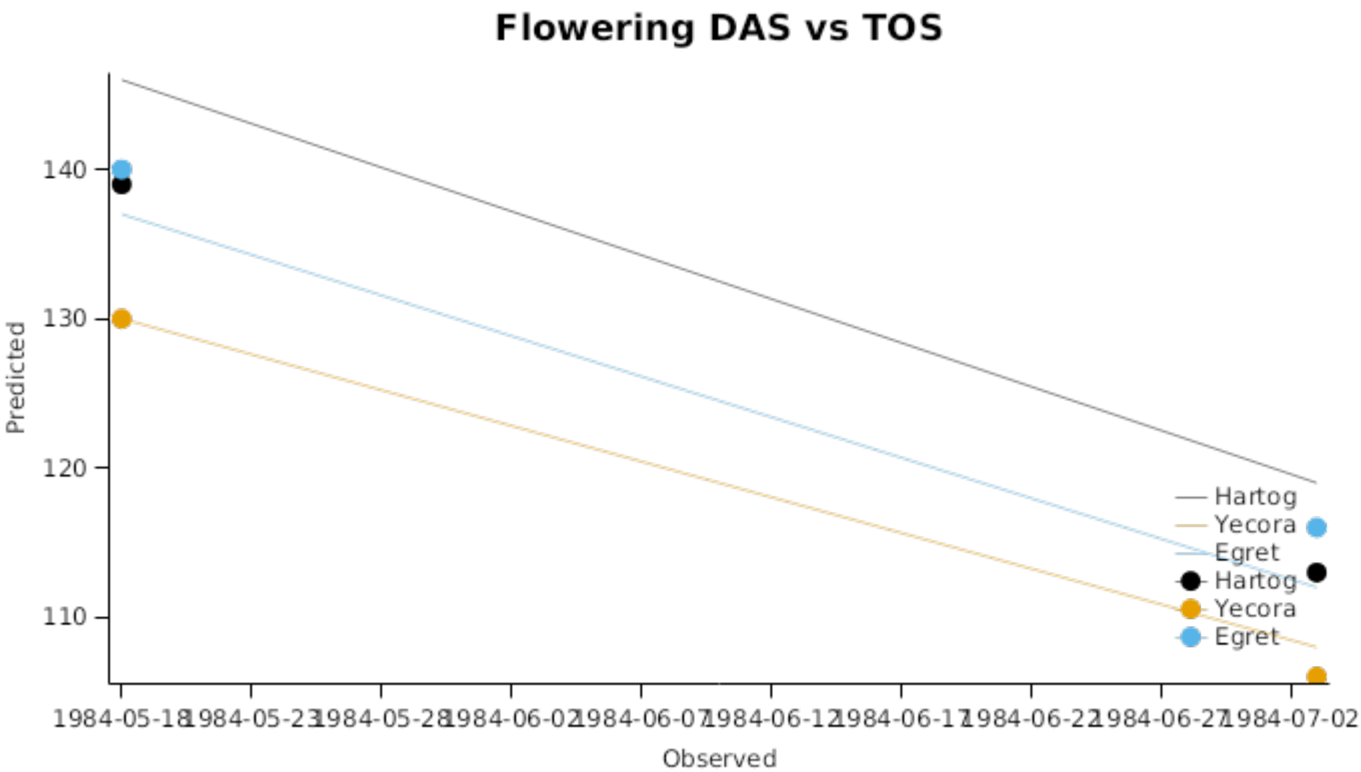
Egret
Predicted TerminalSpikelet
Observed TerminalSpikelet
Predicted Heading
Observed Heading
Predicted Flowering
Observed Flowering
Predicted Maturity
Observed Maturity
Predicted
150
100
50
01-May
01-Jun
01-Jul
01-Aug
01-Sep
Observed





3.6.12.2 Griffith1984





3.7 Europe

3.7.1 Belgium

This trial was conducted at Lonzee near Gembuloux in Belgium and is described in detail by Dufranne et al., 2011 and Moureaux et al., 2008. The trial was run to measure carbon flux from wheat crops using eddy covariance but sufficient crop information was collected to make it suitable as a model validataion dataset also. Crops of wheat (cultivars 'Dekan', 'Rosario', 'Ararat' for the three respective sowing dates) were sown on 14/10/2004, 13/10/2004 and 13/11/2004. Standard management practices for winter wheat in this area were followed. Dates for the timing of key phenological events were used to determine the developmental coefficients for each of the cultivars.

3.8 NorthAmerica

3.8.1 Arizona

These FACE trials were conducted to investigate the effects of atmospheric CO2 concentrations and water stress on wheat growth and development [Hanksar_1996_FACE]. It was conducted at Maricopa, Arazona using Free Air Carbon Enrichment to create elevated CO2 treatments:

1. Normal CO2 (370 ppm) (that is no longer normal)
2. High CO2 (550 ppm)

Irrigation treatmetnts were also applied with:

1. High Irrigation (~600 mm)
2. Low irrigation (~265 mm)

Crop development, Biomass production and soil moisture were monitored throughout the crops duration.

List of experiments.

Experiment Name	Design (Number of Treatments)
ArizonaFACE92	CO2 x Irr (4)
ArizonaFACE93	CO2 x Irr (4)

3.8.1.1 ArizonaFACE92

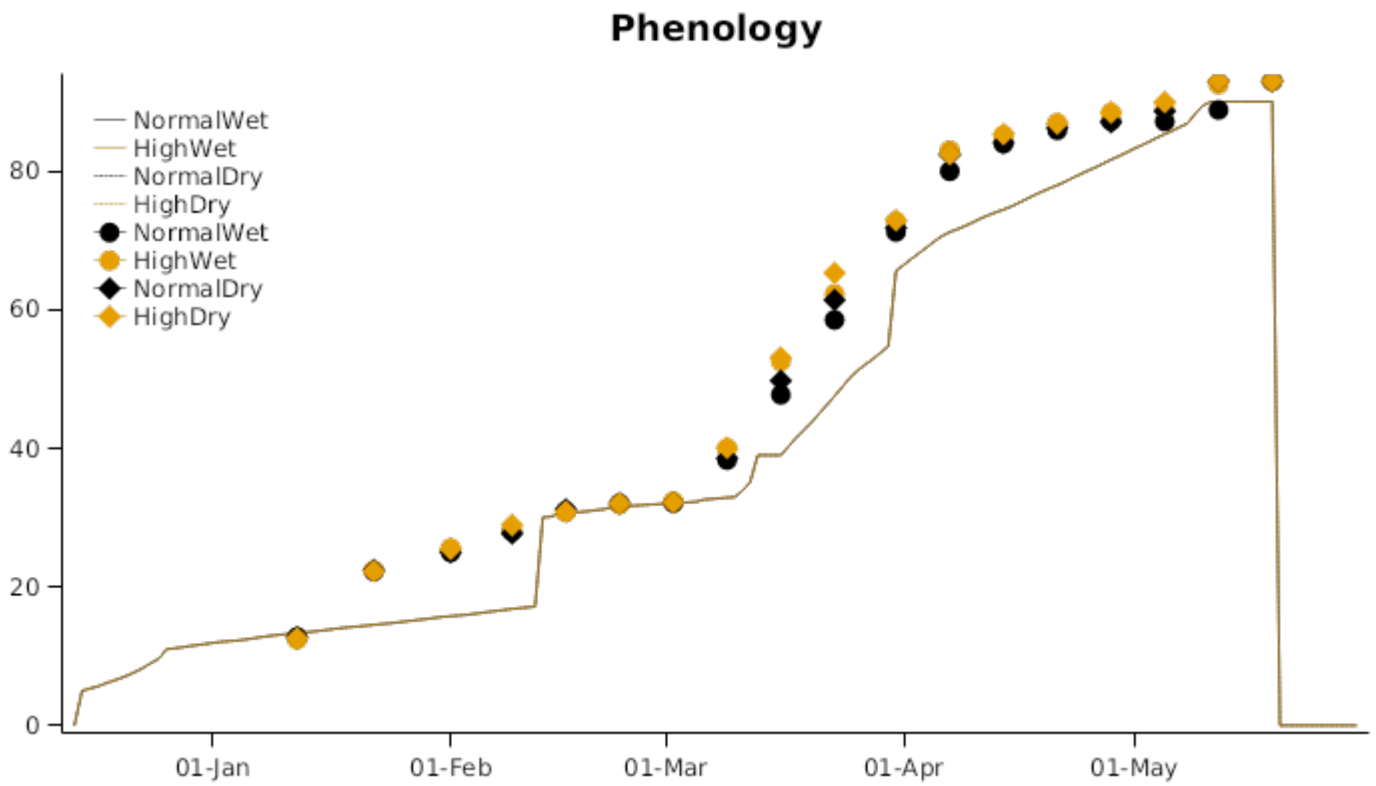
This trial was conducted to investigate the effects of atmospheric CO2 concentrations and water stress on wheat growth and development [Hanksar_1996_FACE]. It was conducted at Maricopa, Arazona using Free Air Carbon Enrichment to create elevated CO2 treatments:

1. Normal CO2 (370 ppm) (that is no longer normal)
2. High CO2 (550 ppm)

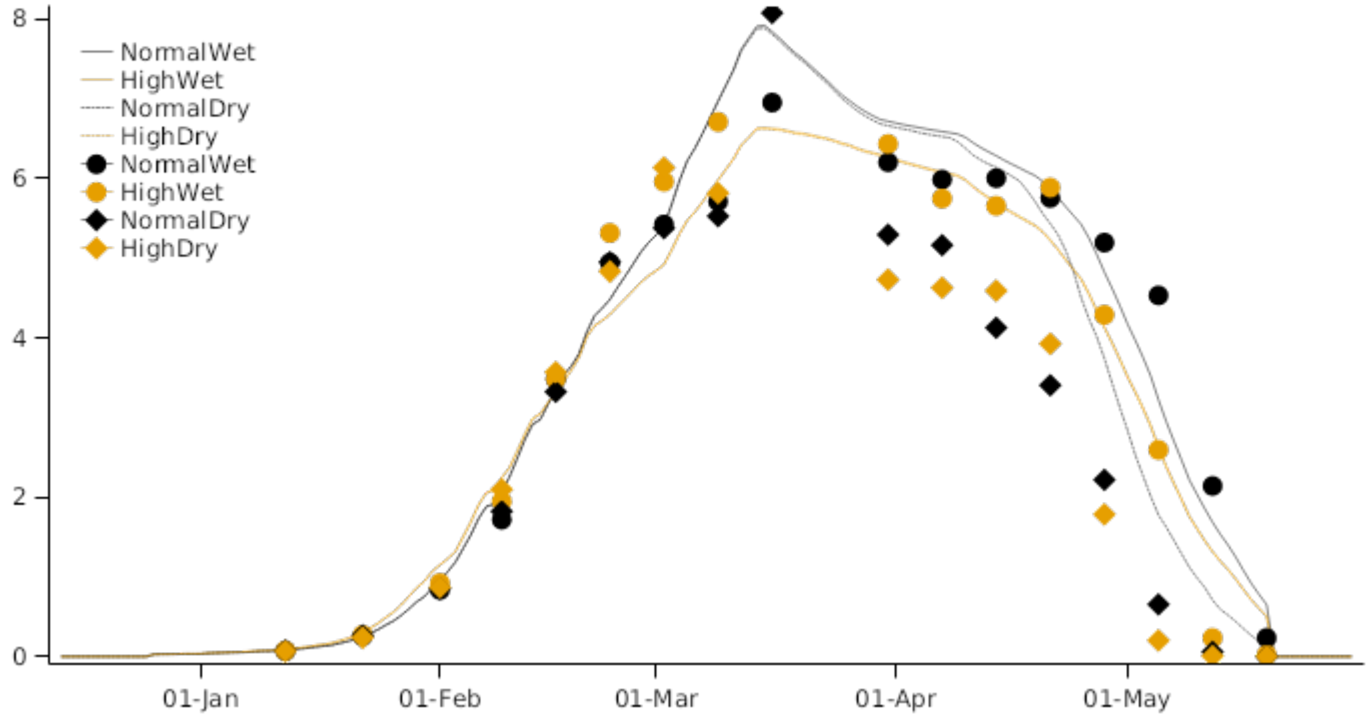
Irrigation treatmetnts were also applied with:

1. High Irrigation (~600 mm)
2. Low irrigation (~265 mm)

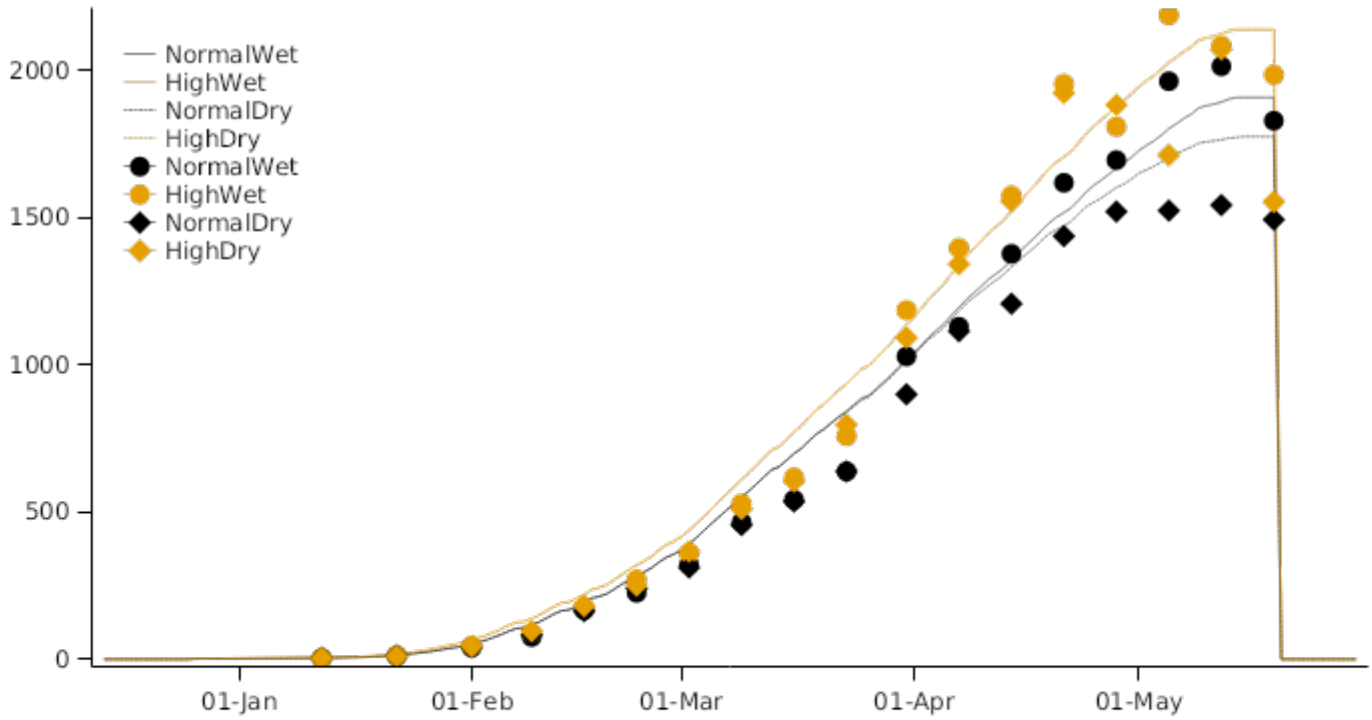
Crop development, Biomass production and soil moisture were monitored throughout the crops duration.

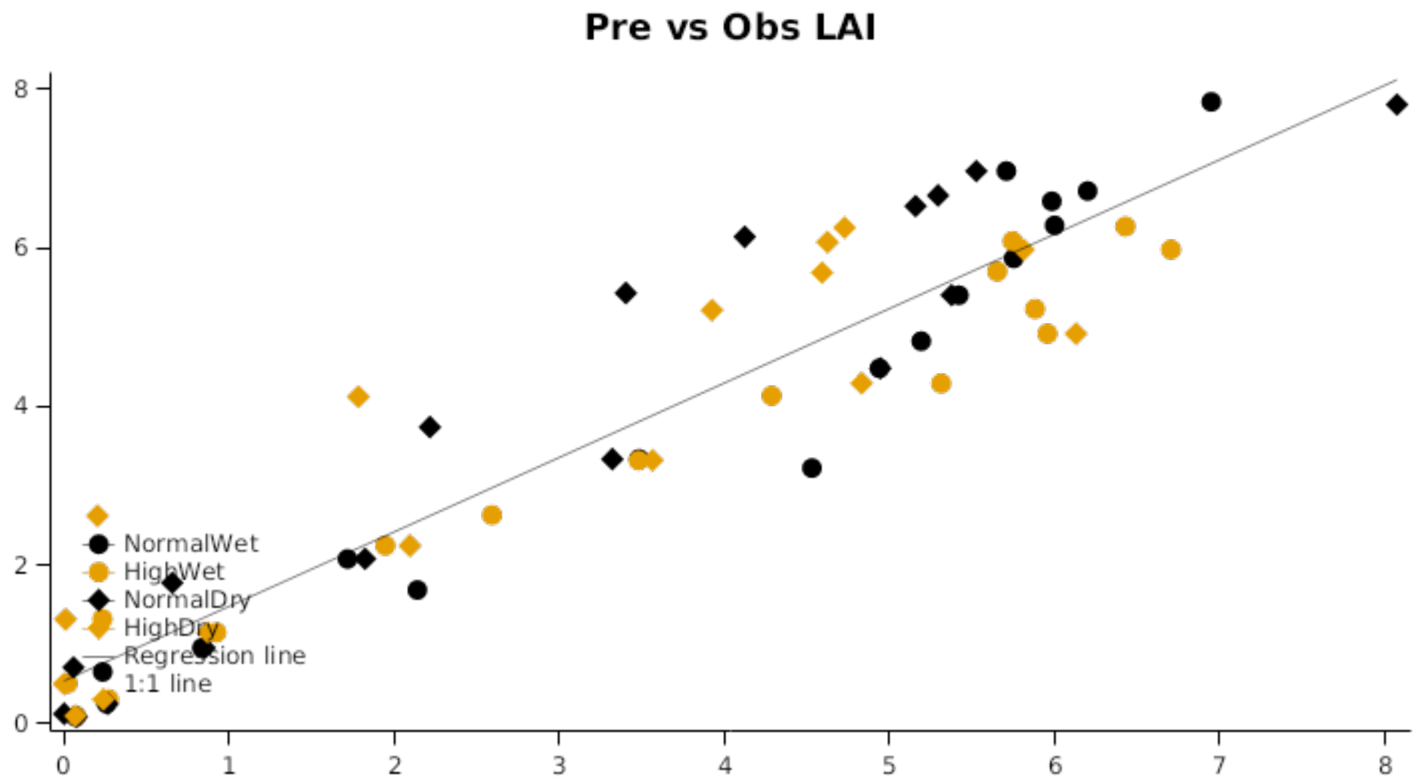


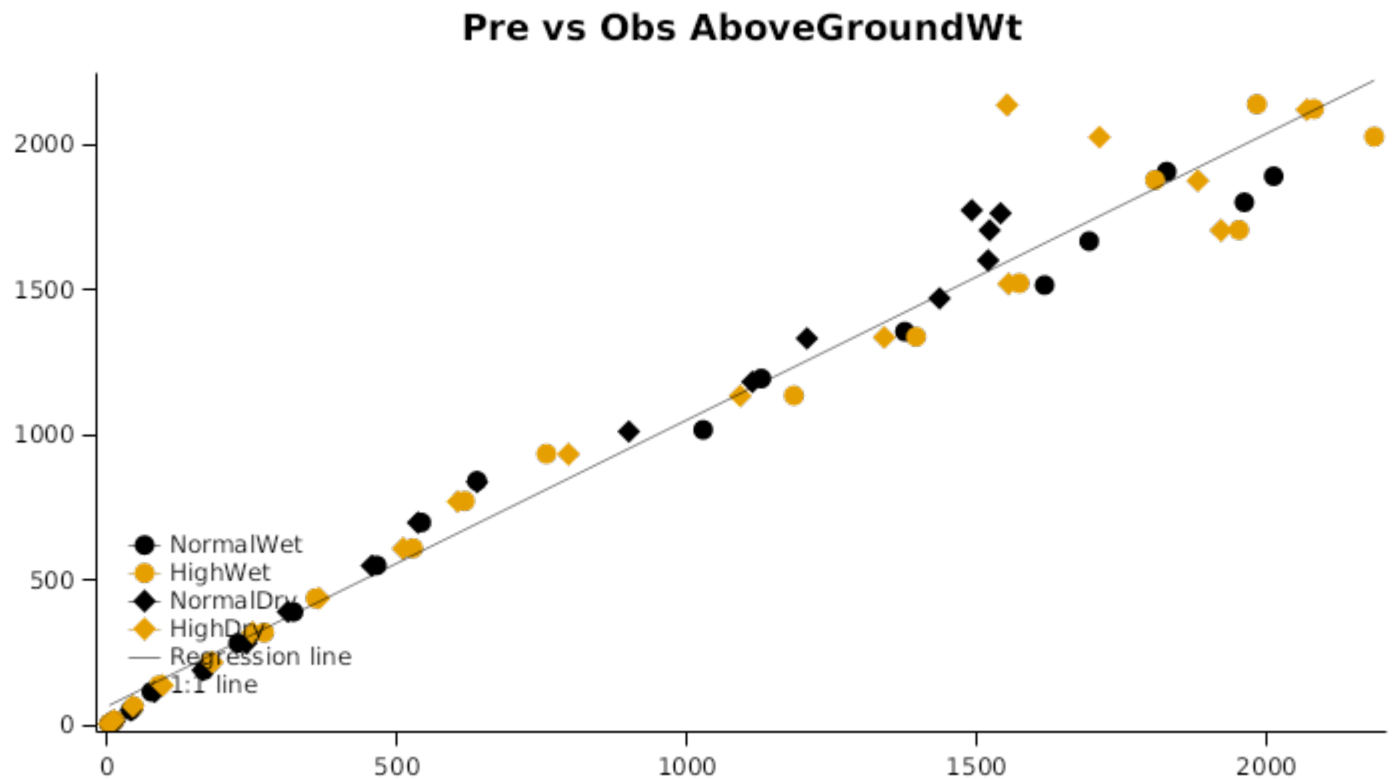
LAI

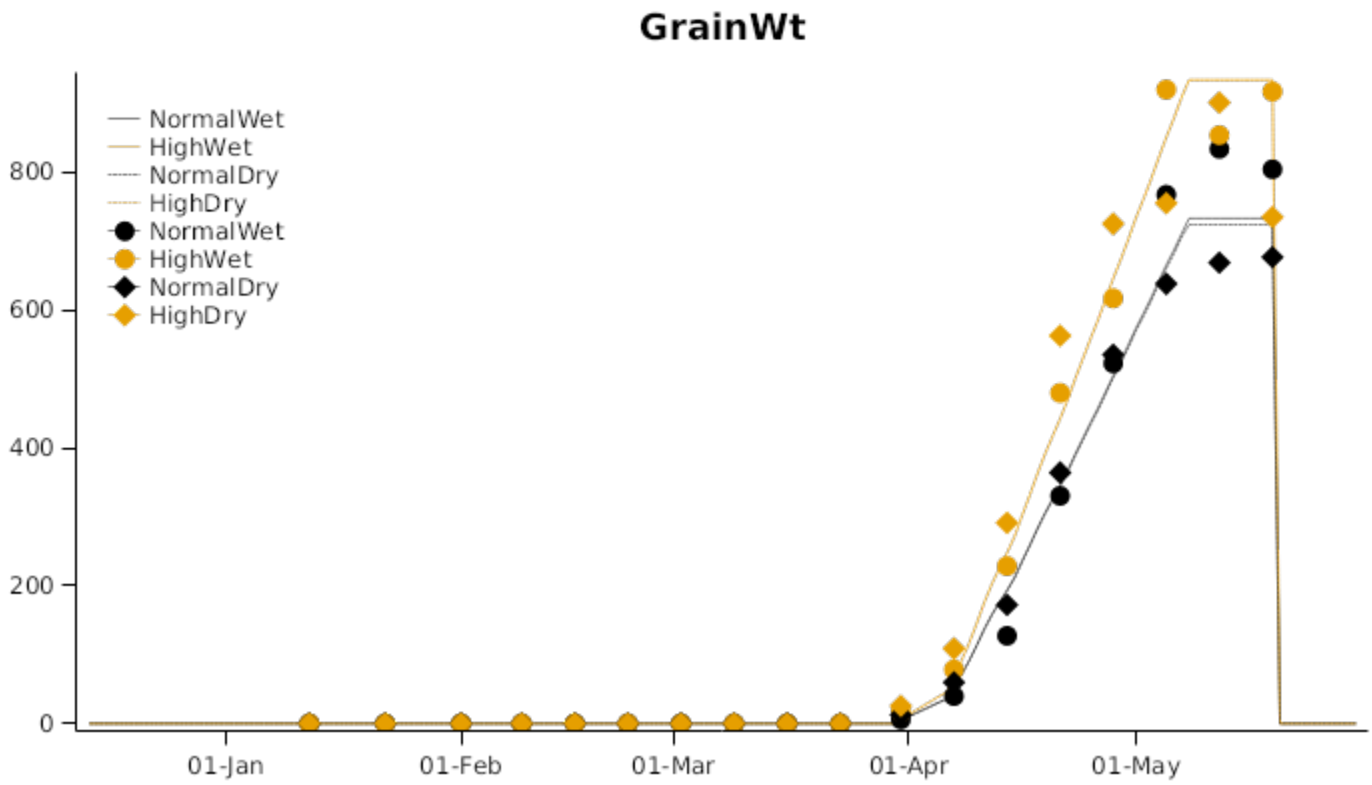


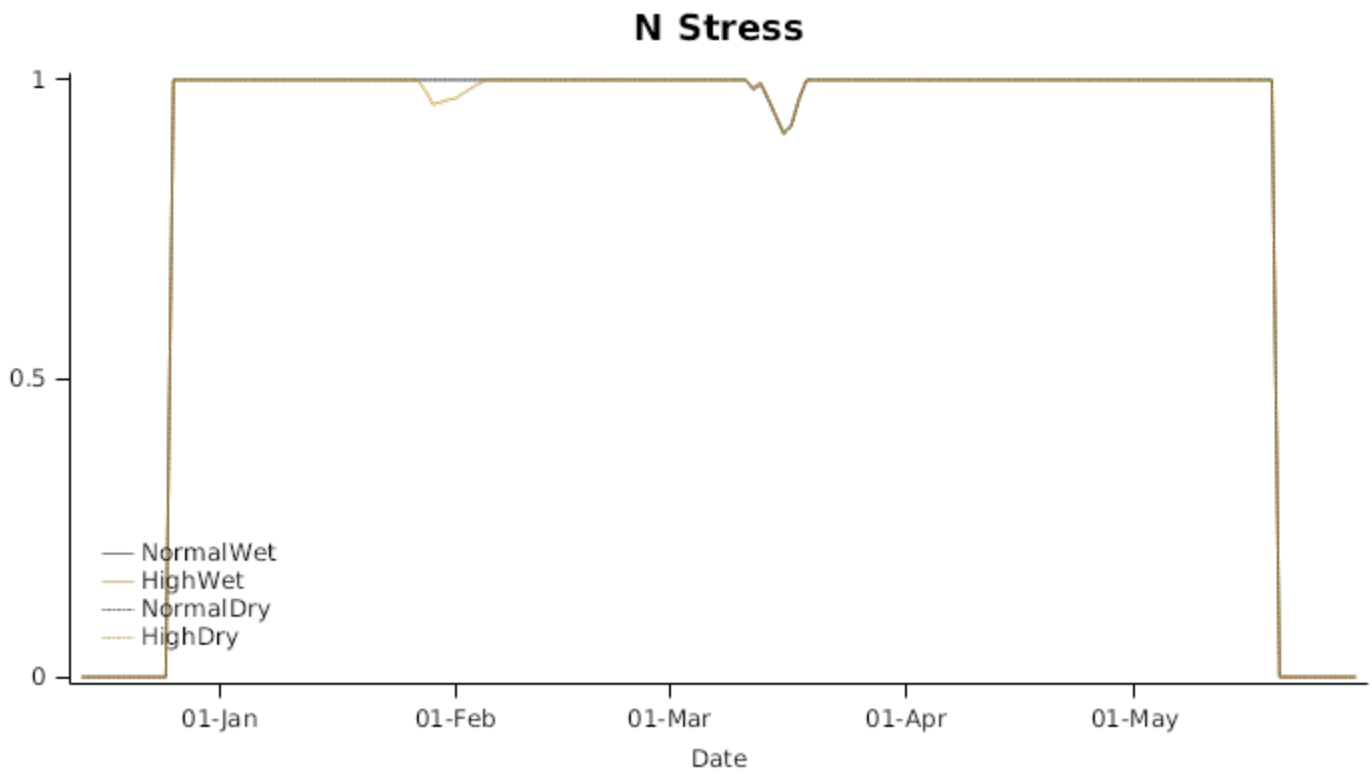
AboveGroundWt

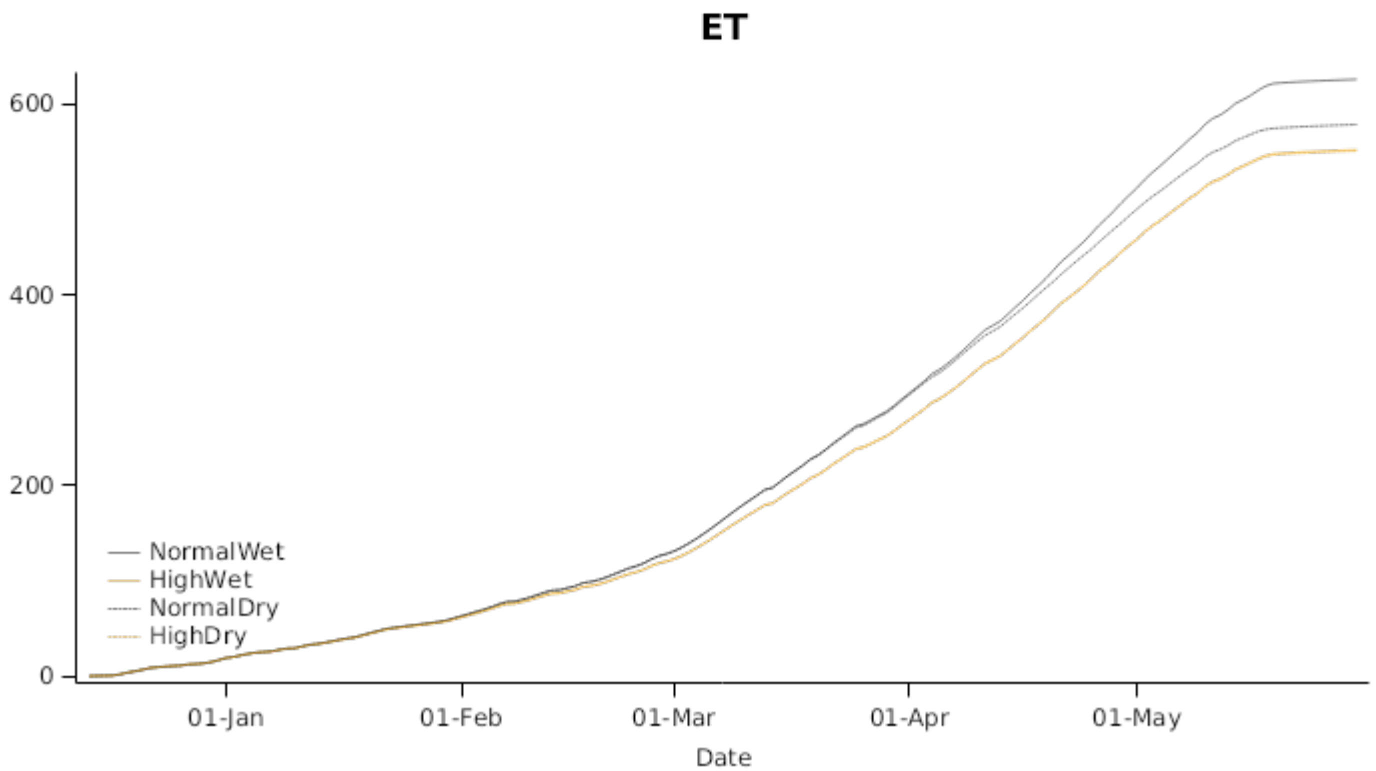


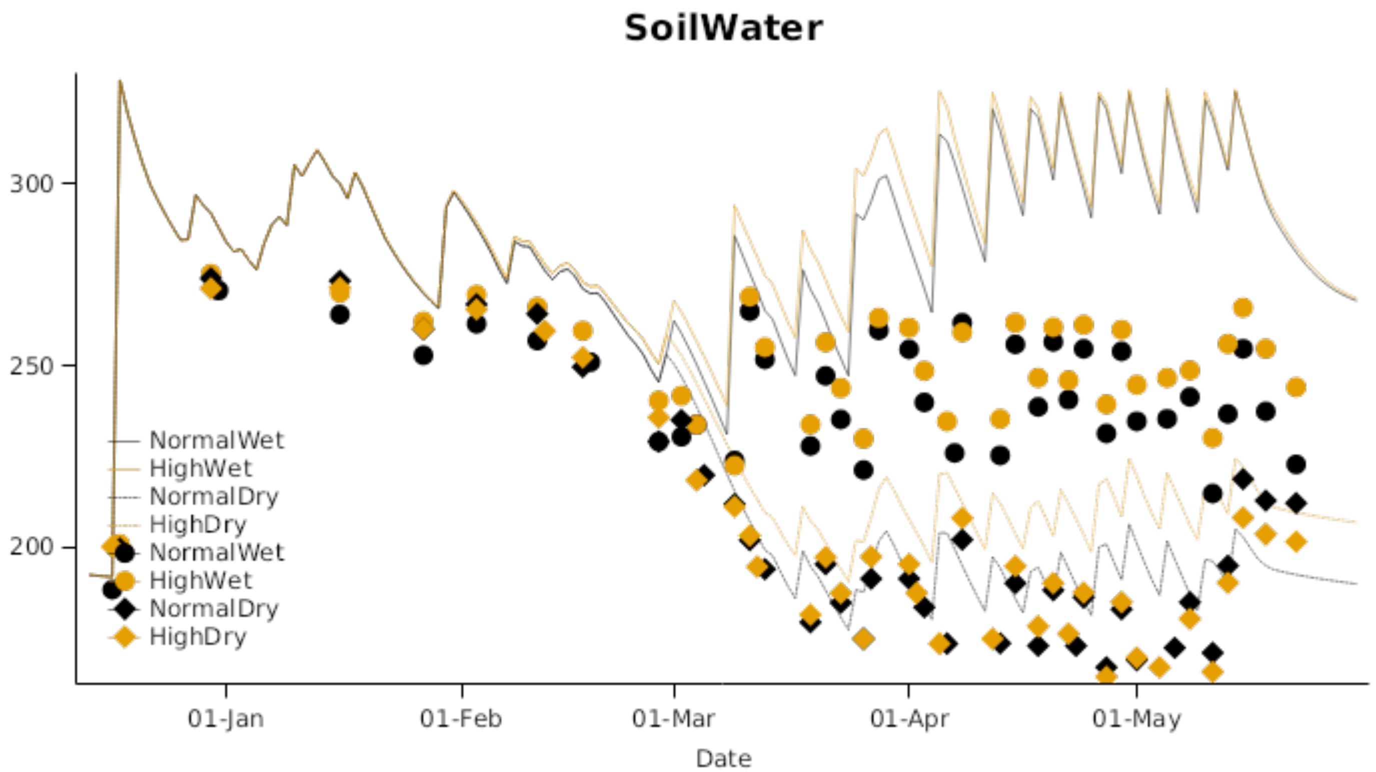

Pre vs Obs LAI
8
6
4
2
0
0
1
2
3
4
5
6
7
8
NormalWet
HighWet
NormalDry
HighDry
Regression line
1:1 line


Pre vs Obs AboveGroundWt
2000
1500
1000
500
0
0
500
1000
1500
2000
NormalWet
HighWet
NormalDry
HighDry
Regression line
1:1 line

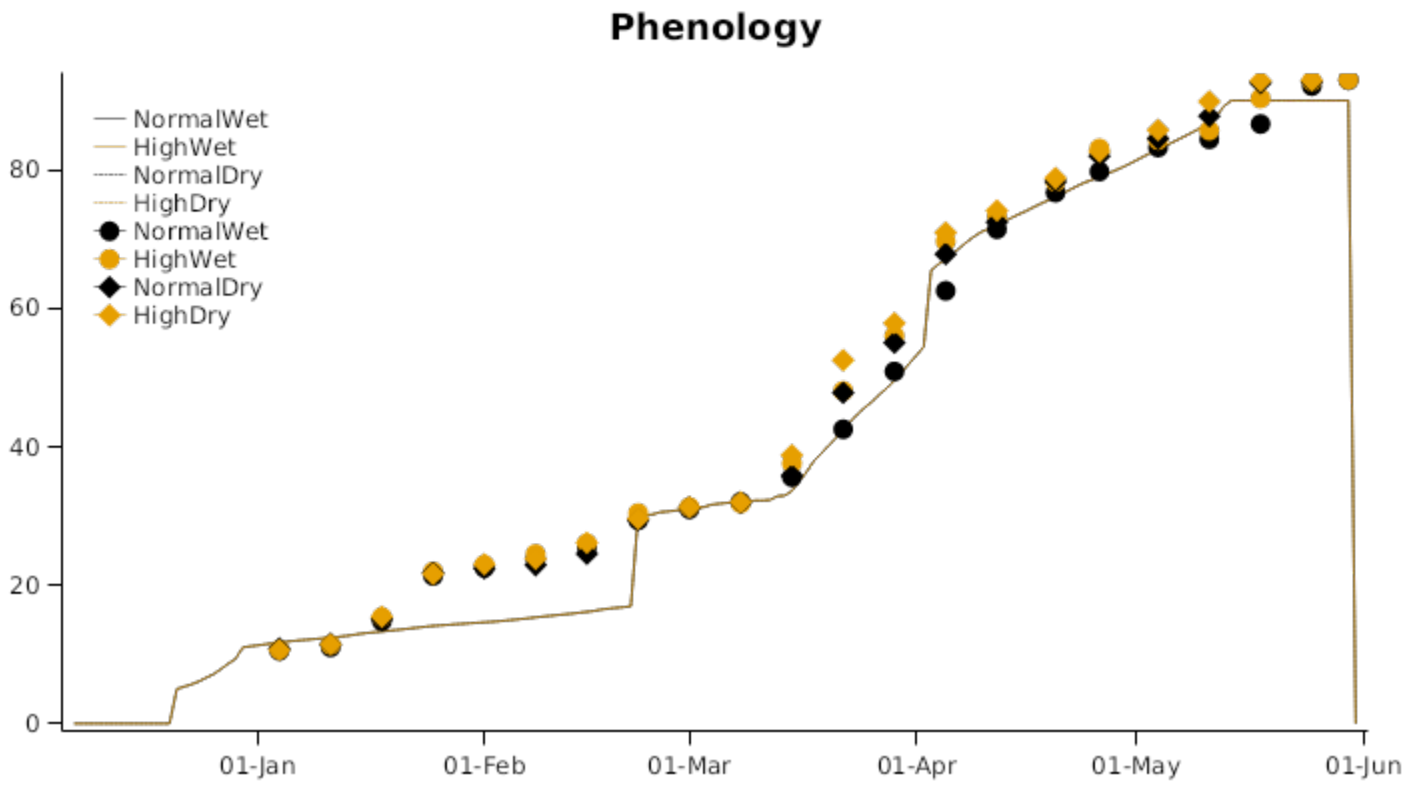

GrainWt
NormalWet
HighWet
NormalDry
HighDry
NormalWet
HighWet
NormalDry
HighDry
800
600
400
200
0
01-Jan
01-Feb
01-Mar
01-Apr
01-May


N Stress
1
0.5
0
NormalWet
HighWet
NormalDry
HighDry
01-Jan
01-Feb
01-Mar
01-Apr
01-May
Date

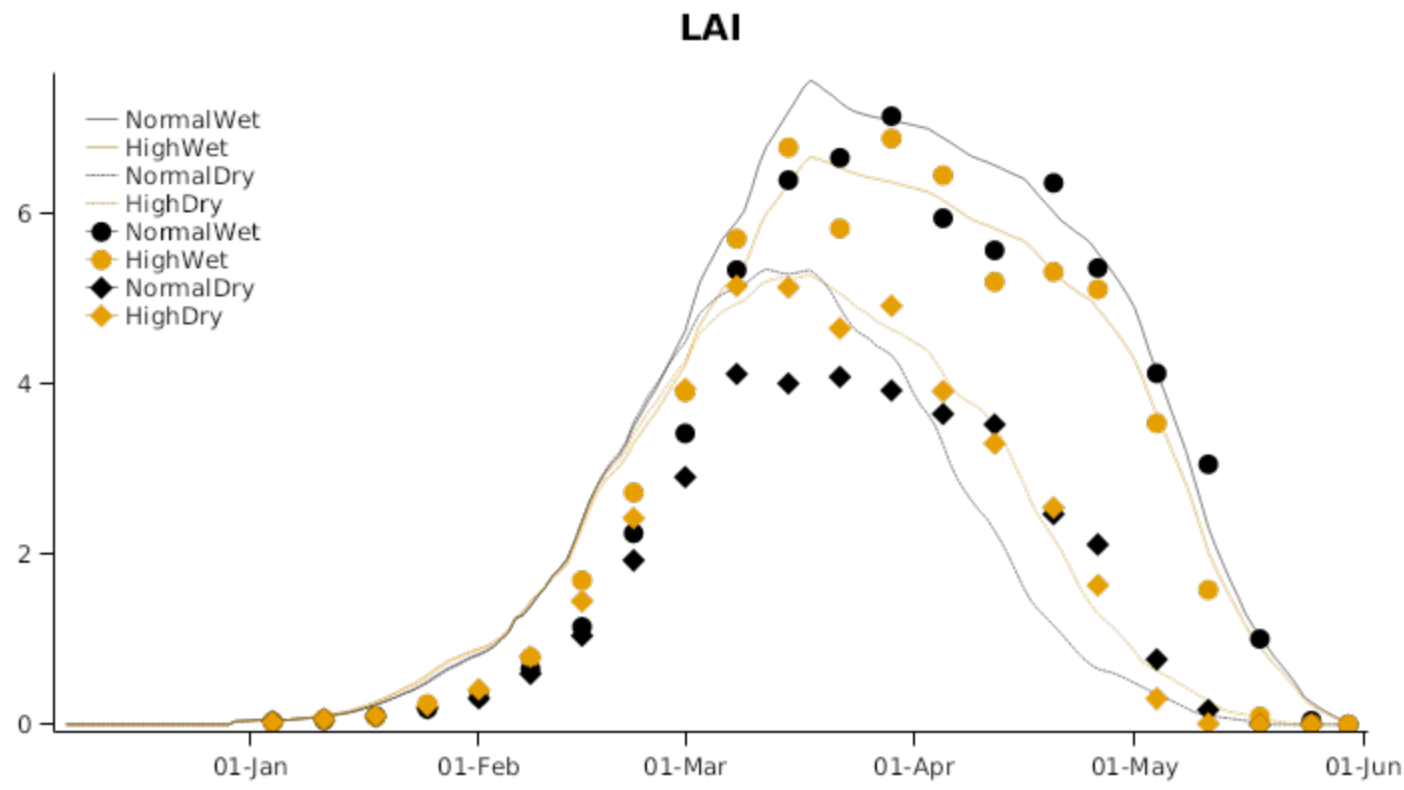




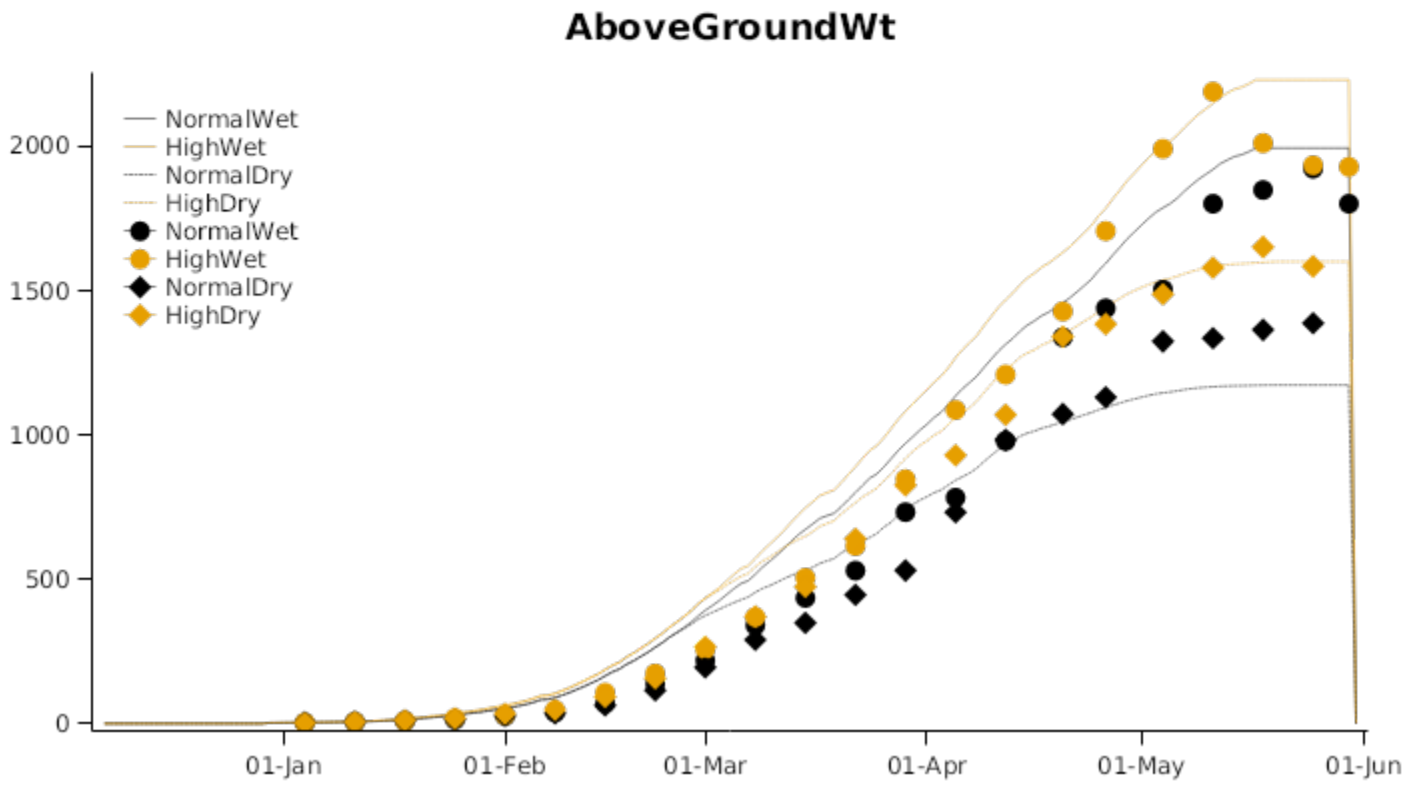
3.8.1.2 ArizonaFACE93

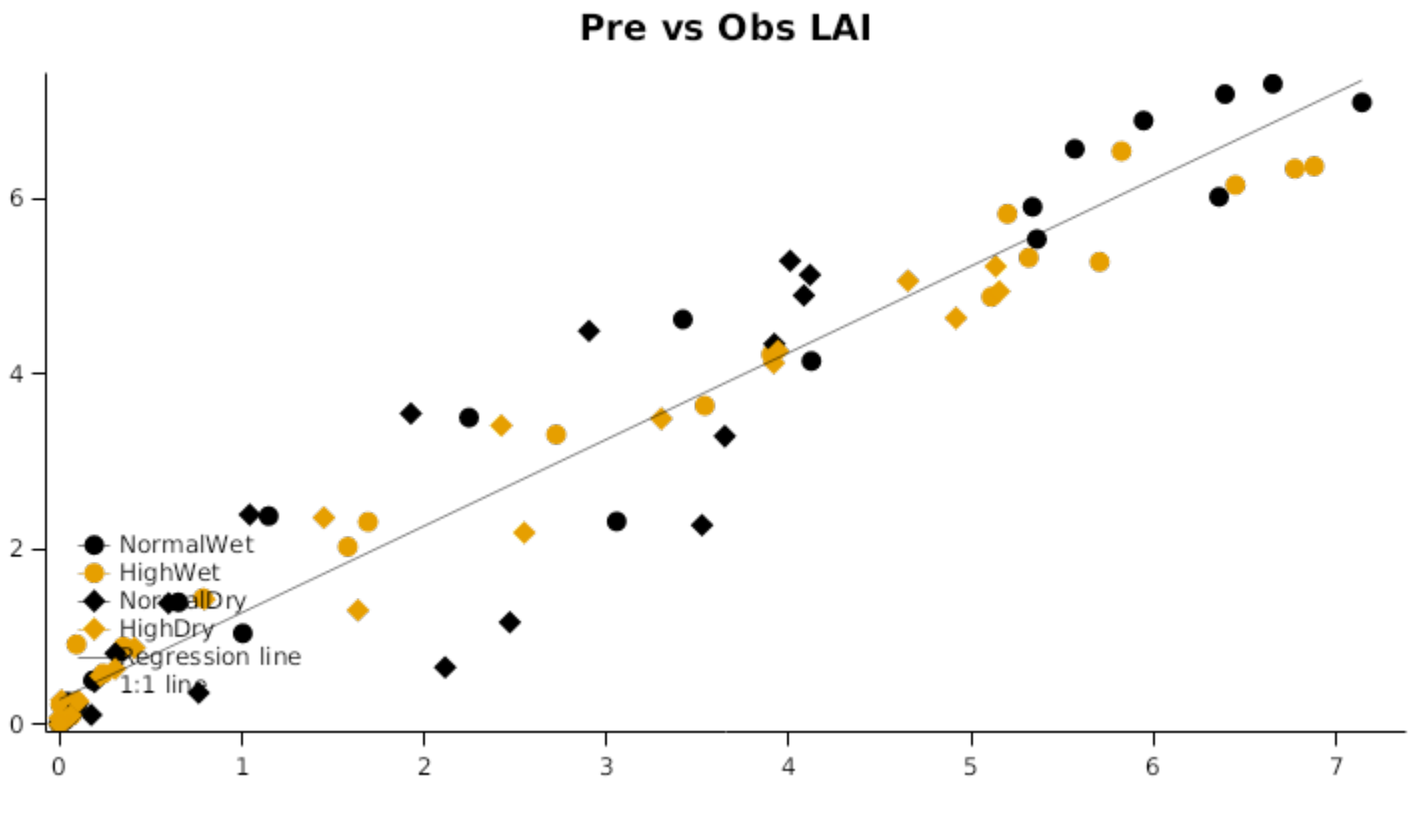


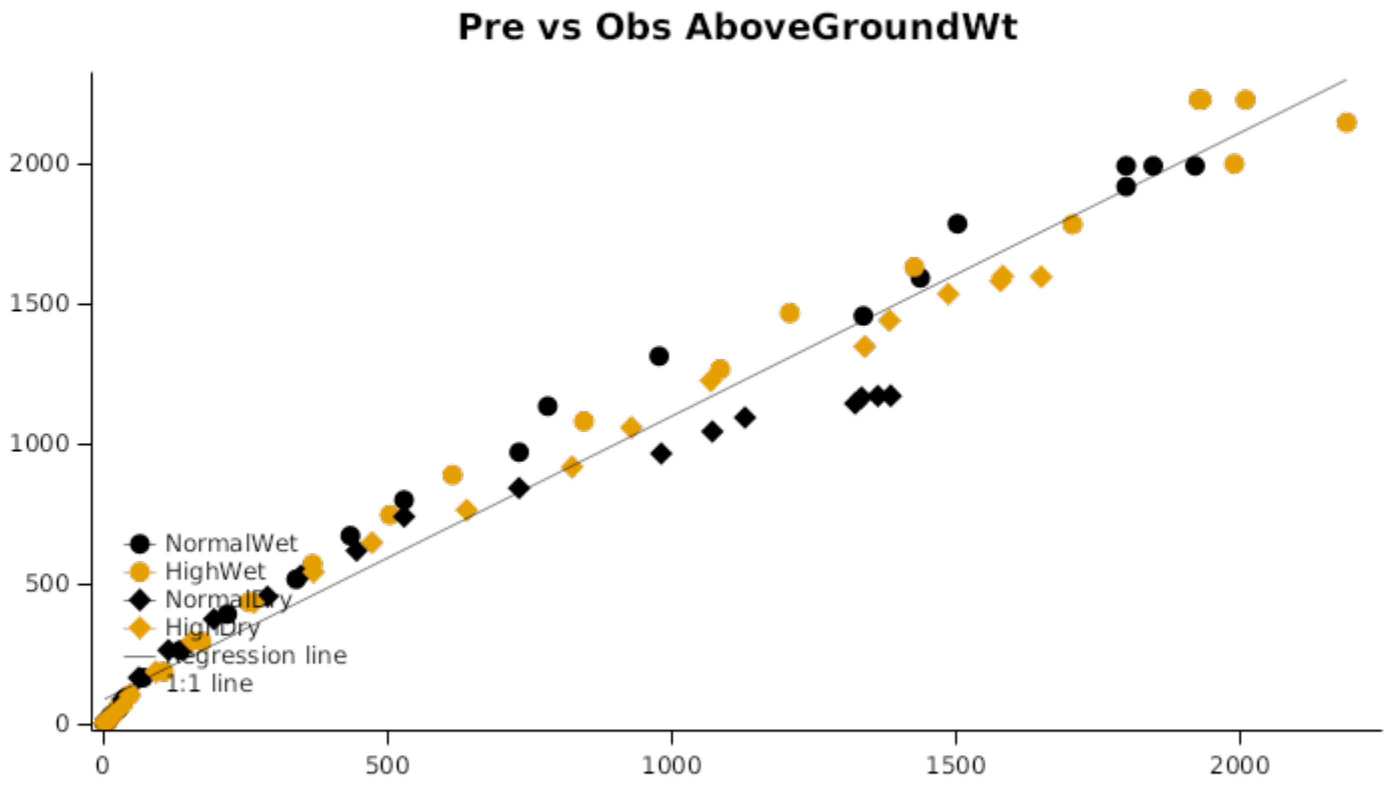
Phenology
NormalWet
HighWet
NormalDry
HighDry
NormalWet
HighWet
NormalDry
HighDry
0
20
40
60
80
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun



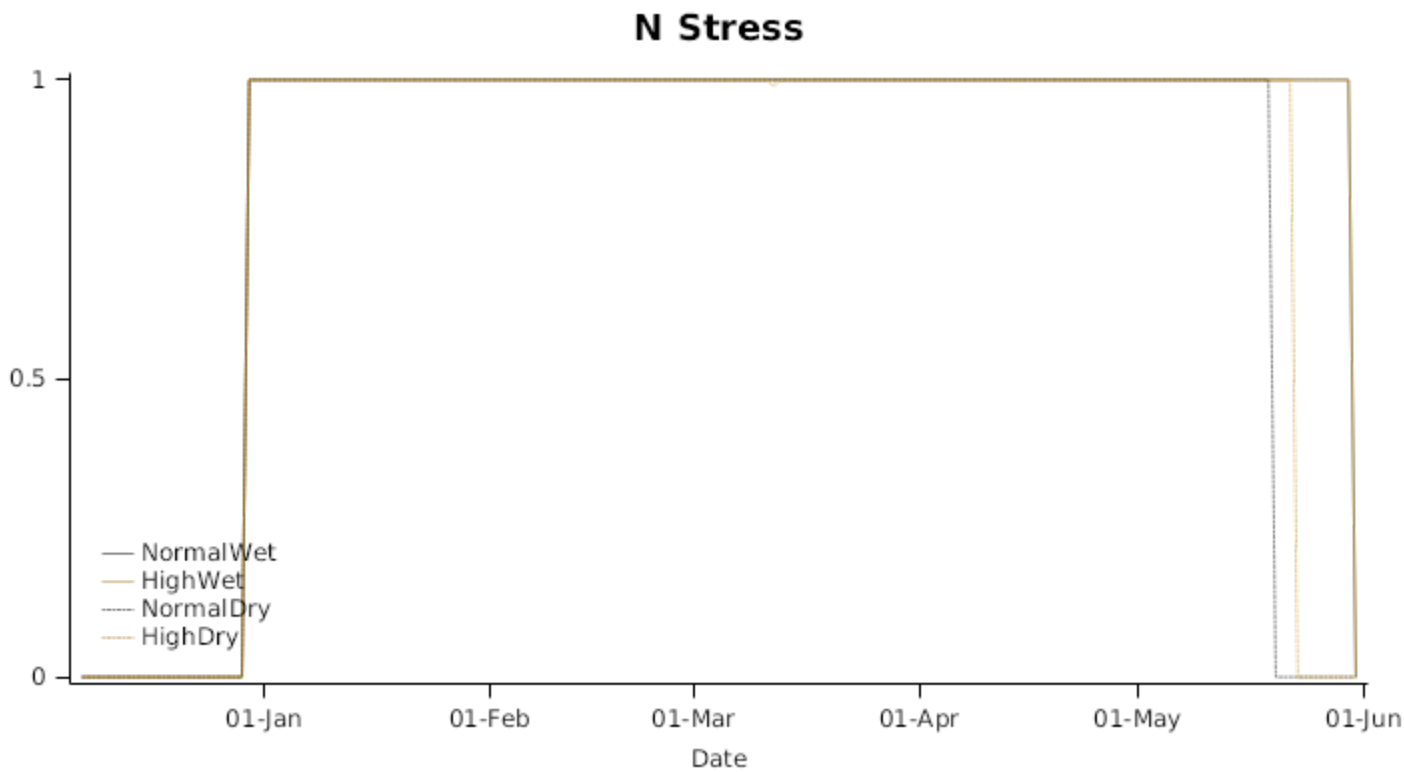
LAI
NormalWet
HighWet
NormalDry
HighDry
NormalWet
HighWet
NormalDry
HighDry
0
2
4
6
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun


AboveGroundWt
NormalWet
HighWet
NormalDry
HighDry
NormalWet
HighWet
NormalDry
HighDry
2000
1500
1000
500
0
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun

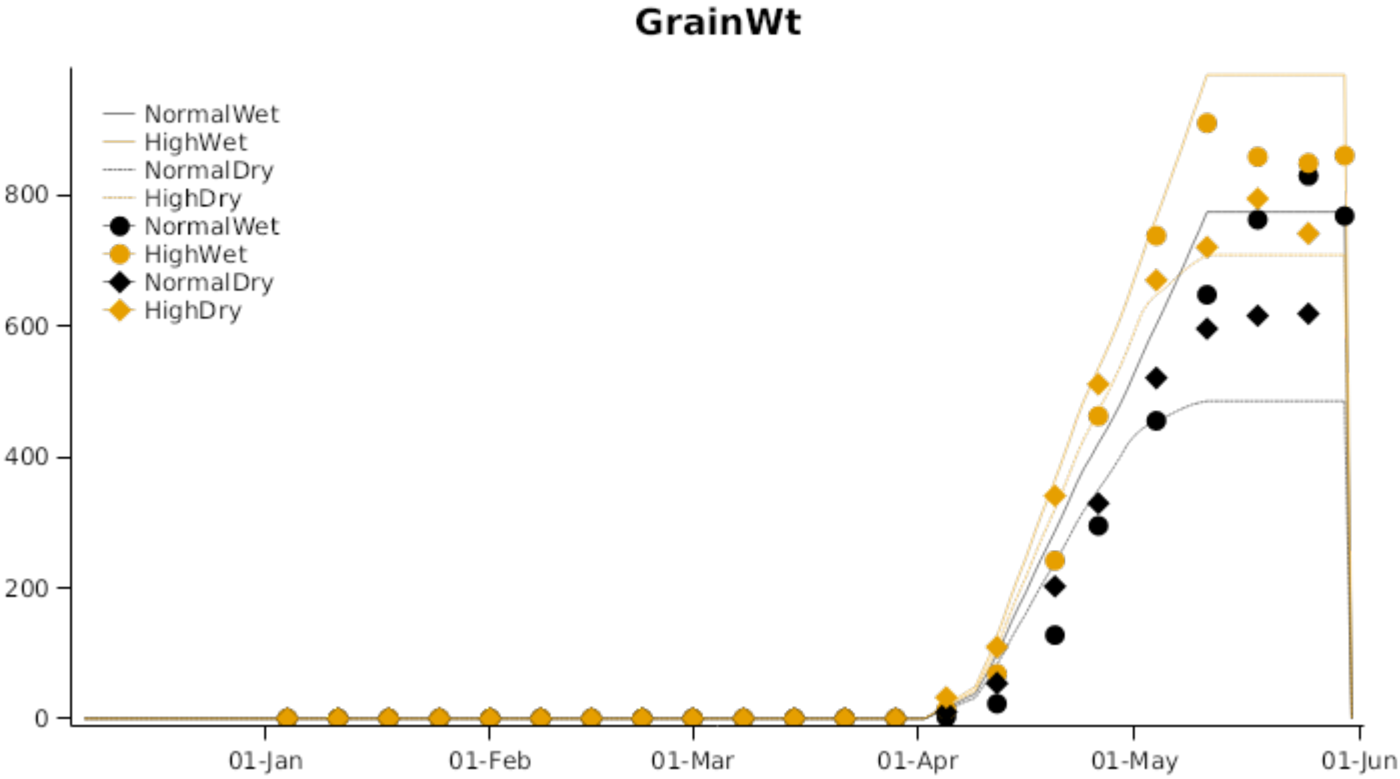

Pre vs Obs LAI
NormalWet
HighWet
NormalDry
HighDry
Regression line
1:1 line
6
4
2
0
0
1
2
3
4
5
6
7

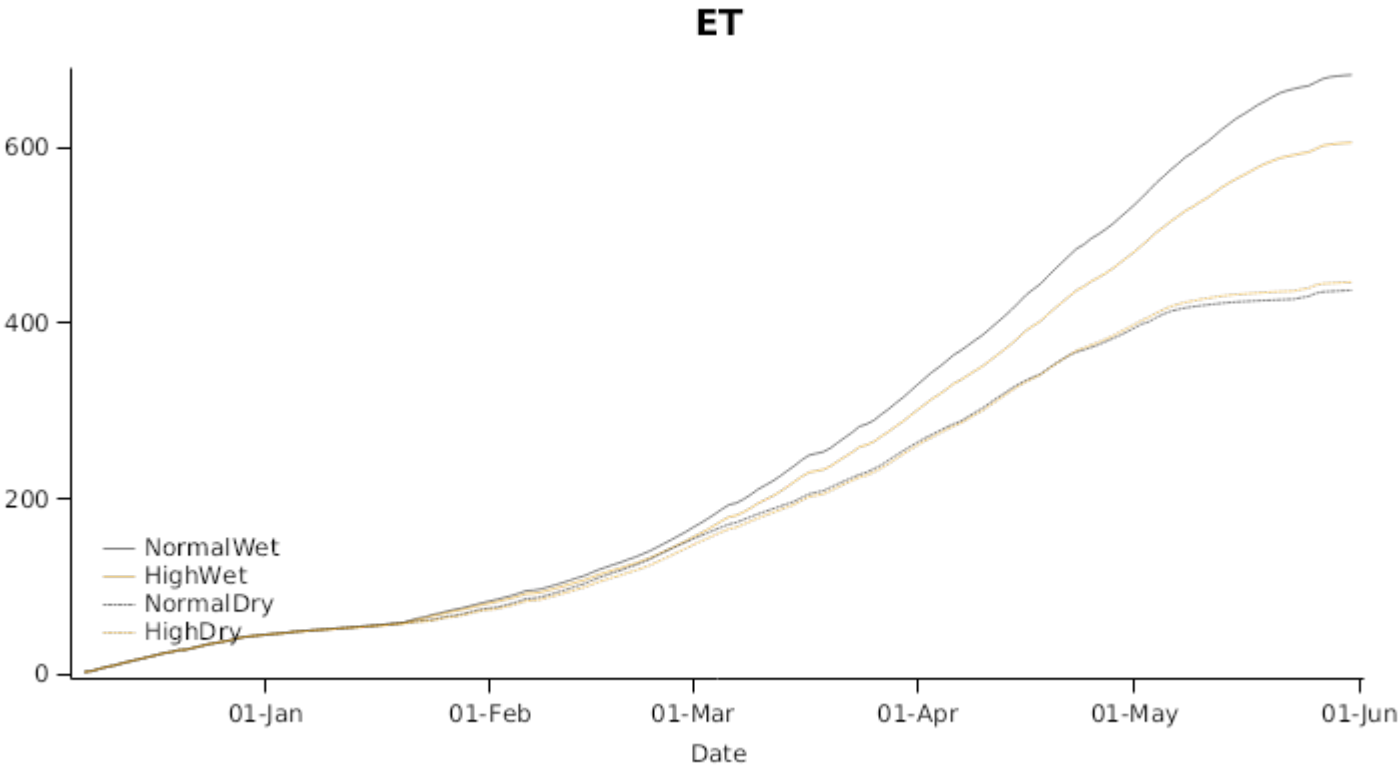


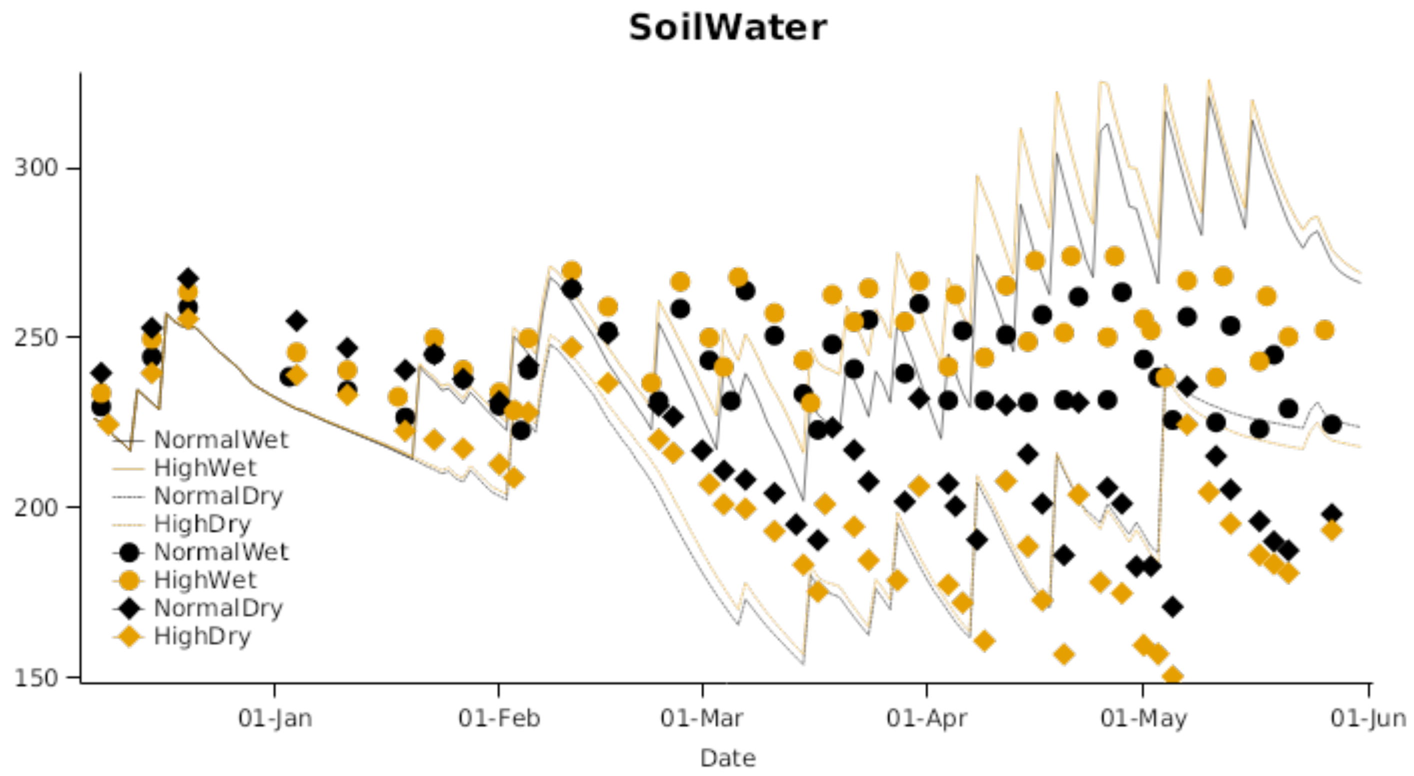
Pre vs Obs AboveGroundWt
2000
1500
1000
500
0
0
500
1000
1500
2000
NormalWet
HighWet
NormalDry
HighDry
Regression line
1:1 line



N Stress
1
0.5
0
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
Date
NormalWet
HighWet
NormalDry
HighDry


GrainWt
NormalWet
HighWet
NormalDry
HighDry
NormalWet
HighWet
NormalDry
HighDry
800
600
400
200
0
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun


ET
NormalWet
HighWet
NormalDry
HighDry
600
400
200
0
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
Date



3.9 Africa

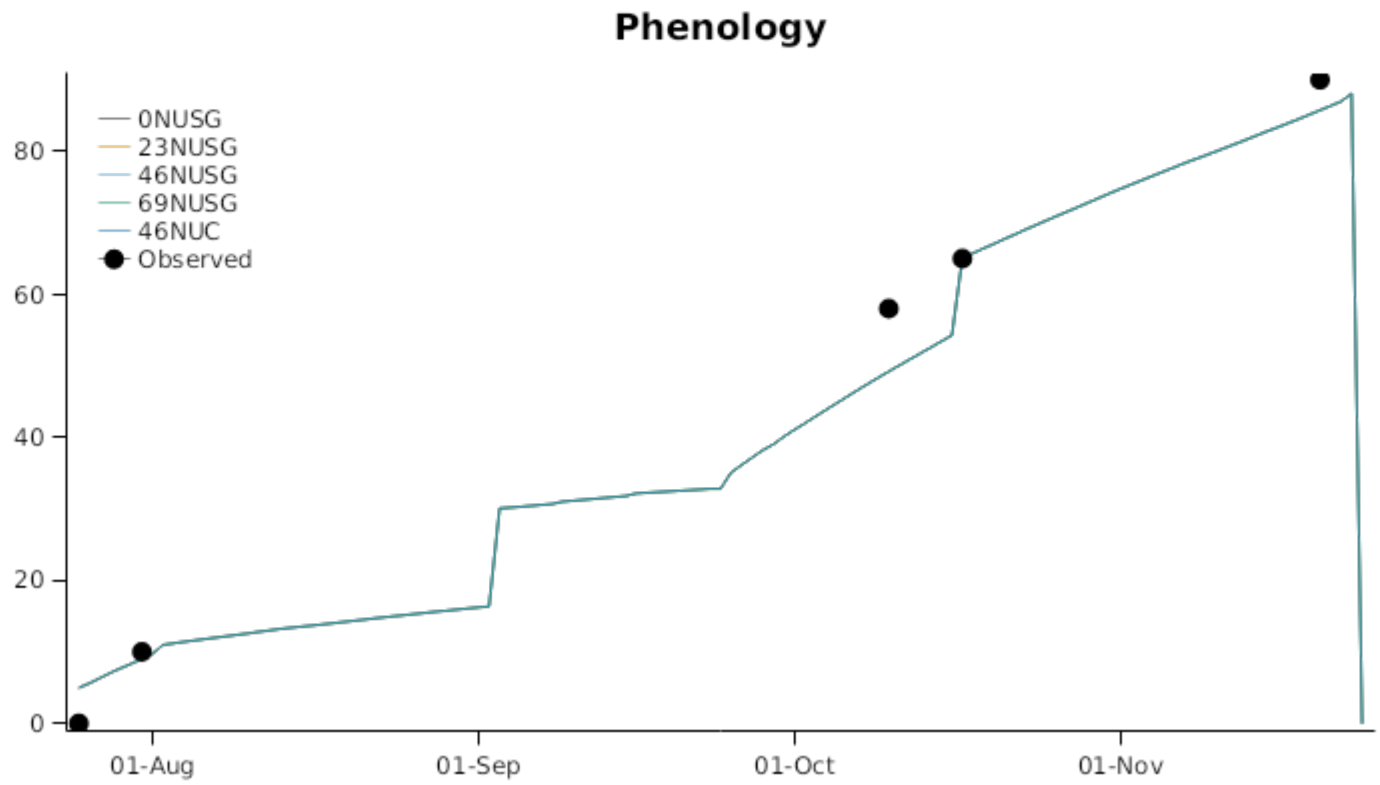
This trial was run in the Jamma district of the Amhara region of the Ethiopia country of the Africa contenentand is described in full by Getu, 2012. 'HAR 1685' Wheat was sown in 20 cm row spacing. Different N fertiliser treatments were applied:

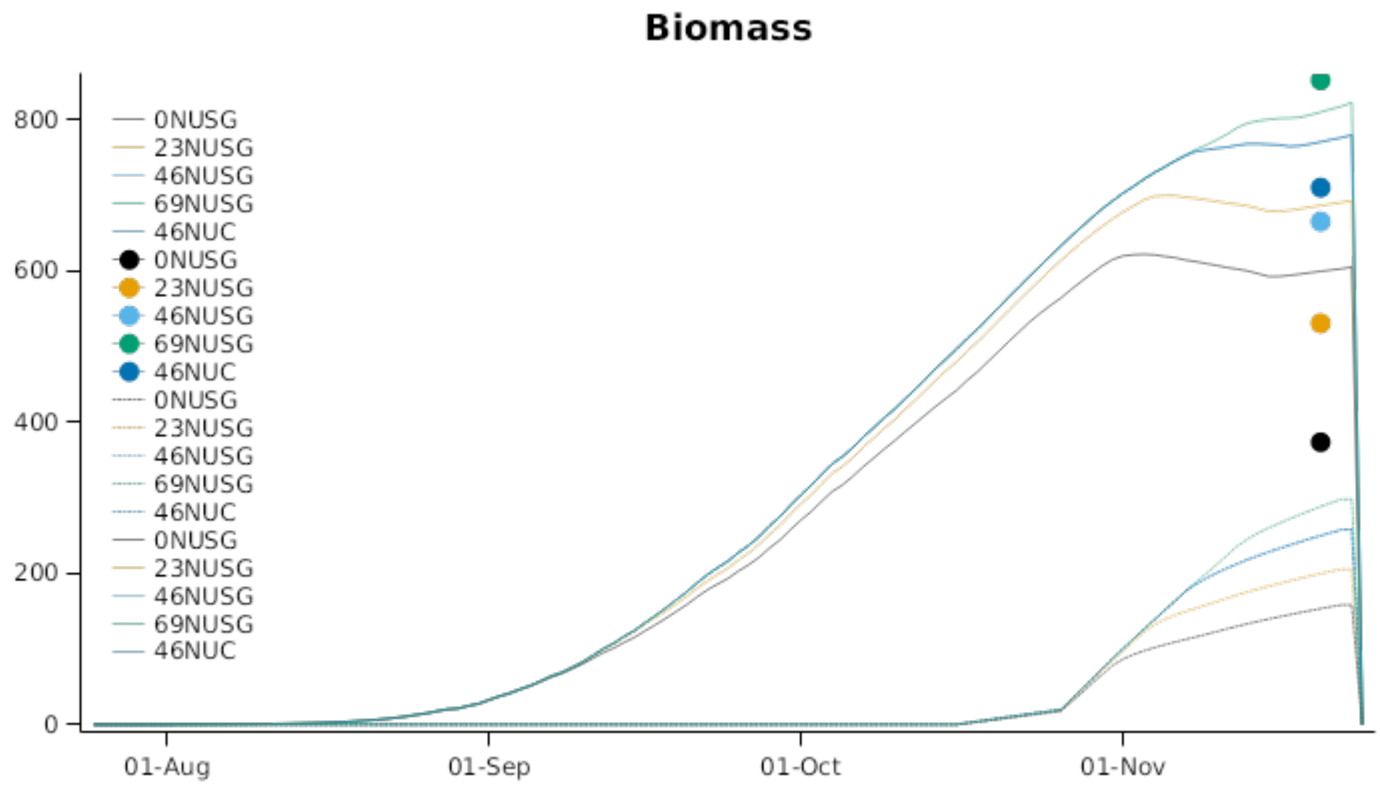
1. 0NUSG = 0kg N/ha
2. 23NUSG = 23 kg N/ha as Urea Super Granules (a slow release urea product)
3. 46NUSG = 46 kg N/ha as Urea Super Granules
4. 69NUSG = 69 kg N/ha as Urea Super Granules
5. 46NUC = 46 kg N/ha as Uncoated Urea

List of experiments.

Experiment Name	Design (Number of Treatments)
Jamma	NRate (5)

3.9.1 Jamma


Phenology
0NUSG
23NUSG
46NUSG
69NUSG
46NUC
Observed
0
20
40
60
80
01-Aug
01-Sep
01-Oct
01-Nov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46NUC
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400
600
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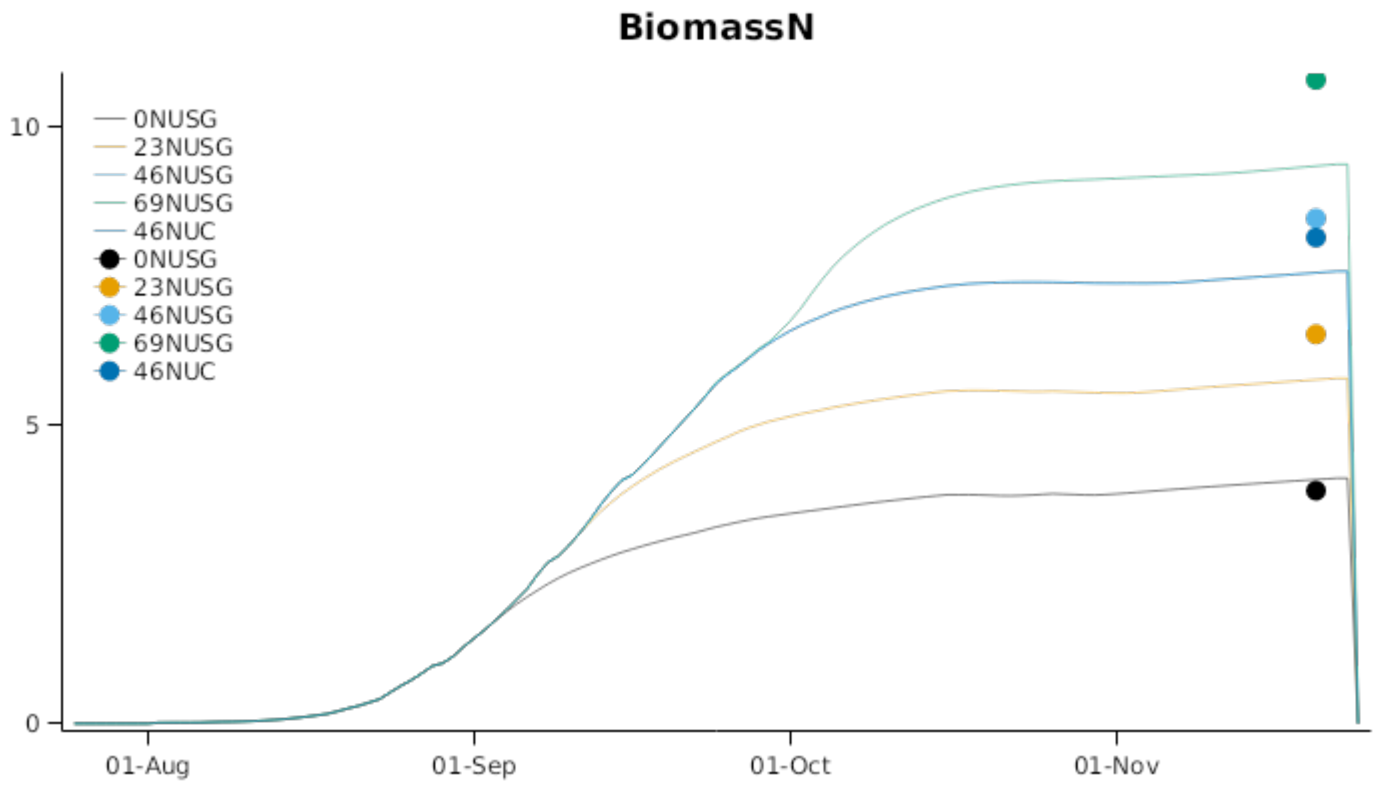
01-Sep
01-Oct
01-Nov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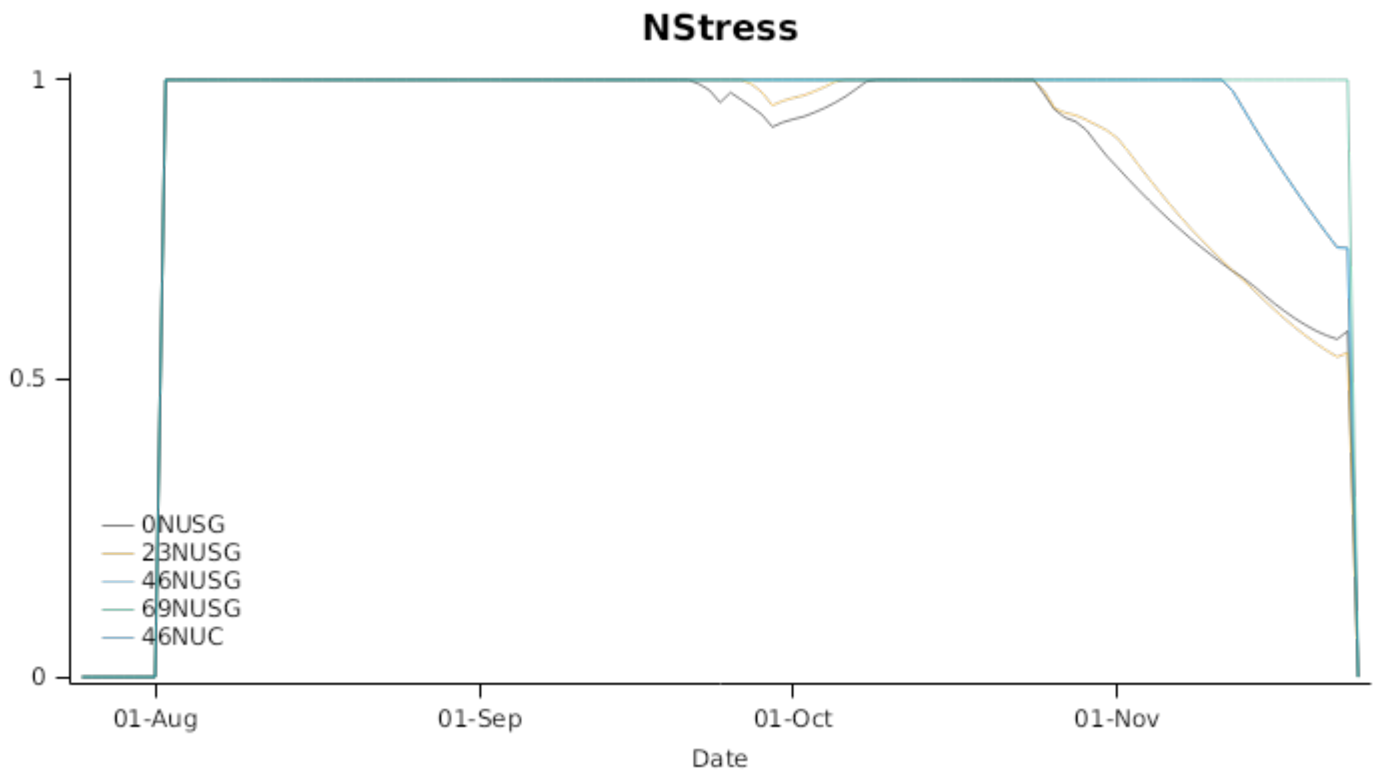
01-Aug
01-Sep
01-Oct
01-Nov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46NUC
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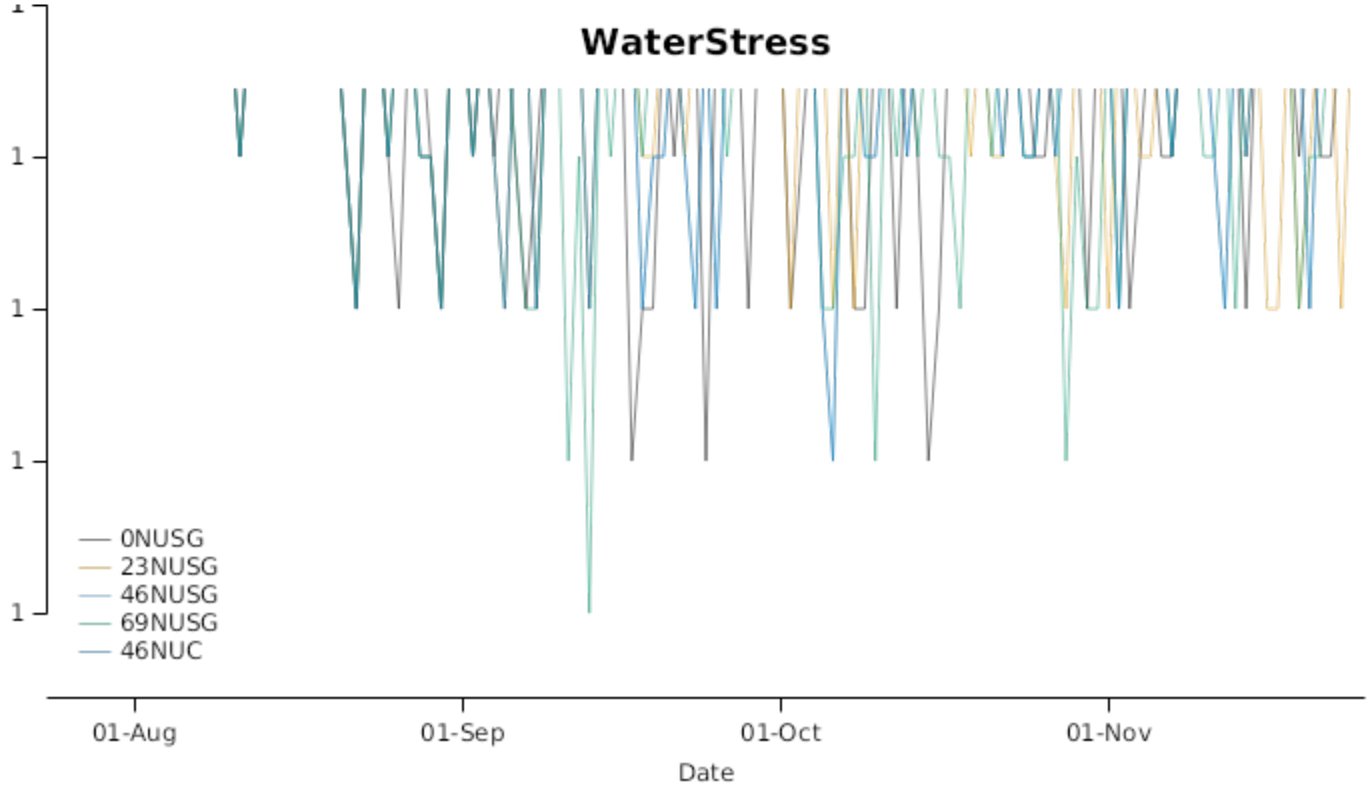
0.5
0
01-Aug
01-Sep
01-Oct
01-Nov
Date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1
1
1
1
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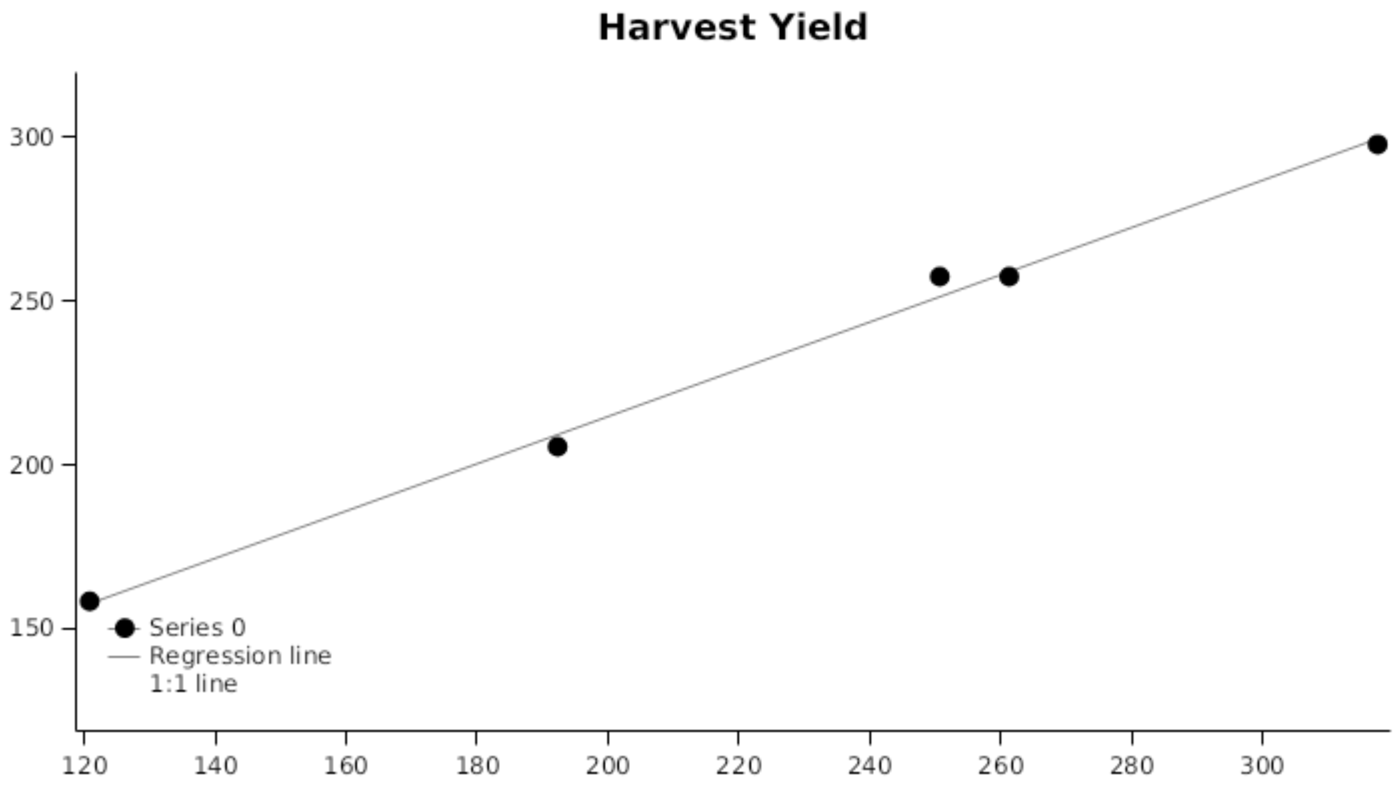
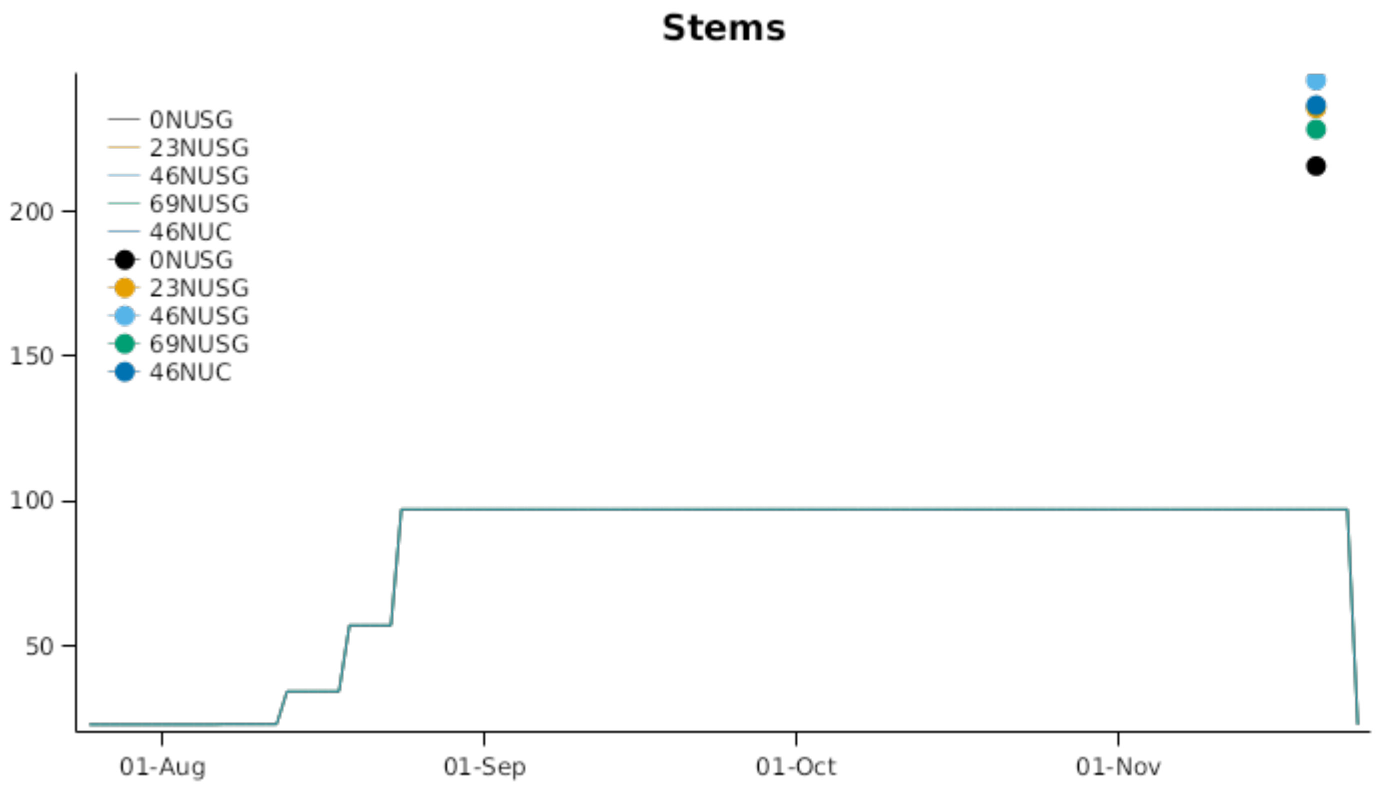
01-Sep
01-Oct
01-Nov
Date

SoilNO3

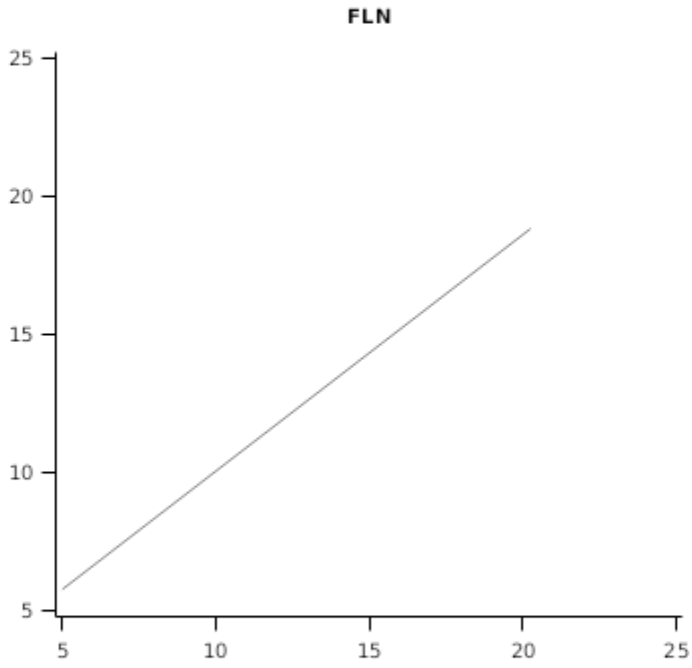




3.10 ControlledEnvironment

List of experiments.

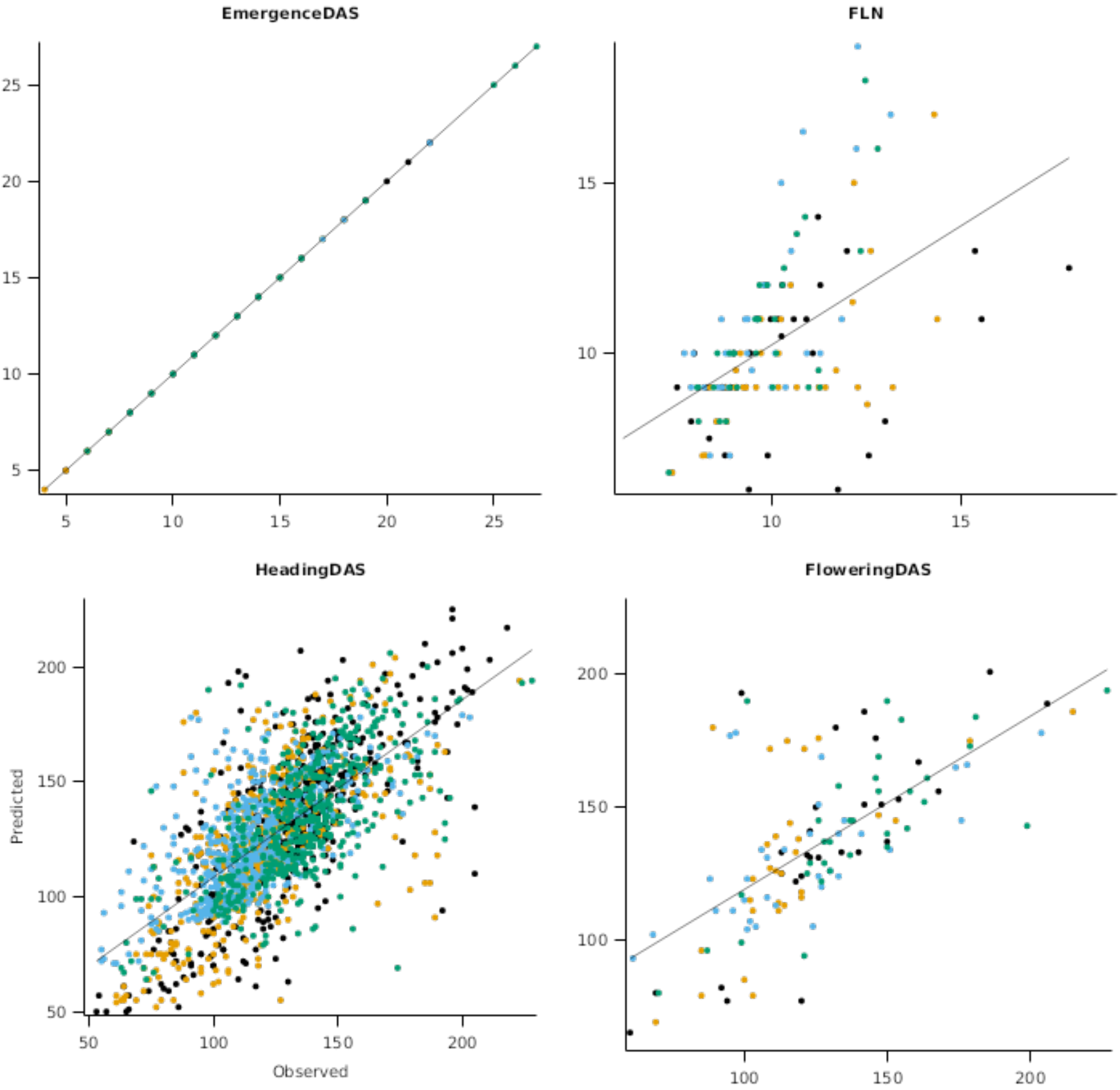
Experiment Name	Design (Number of Treatments)
LaTrobeCE	Treat x Cv x Durat (276)
PalmerstonNorthCE	Treat x Cv x Durat (208)
LincolnCE	Treat x Cv x Durat (24)



3.11 NPIField2019

List of experiments.

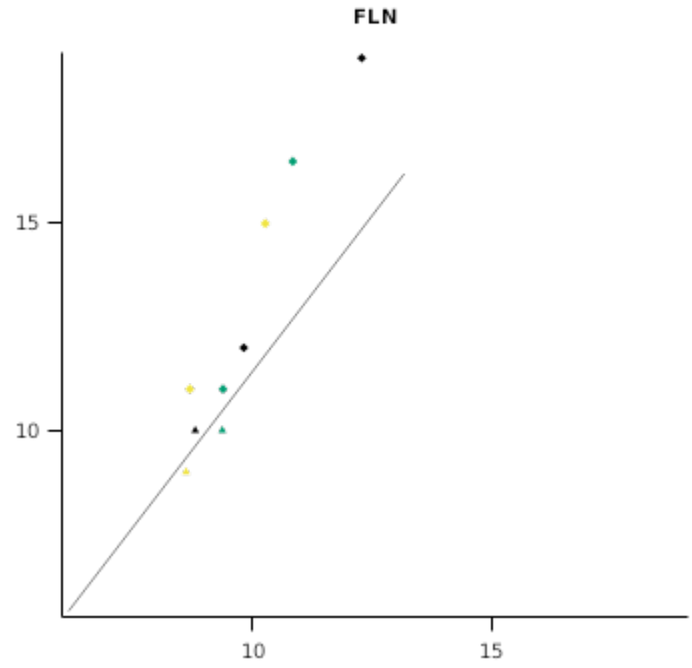
Experiment Name	Design (Number of Treatments)
WaggaWagga	TOS x Cv (512)
Callington	TOS x Cv (512)
Dale	TOS x Cv (512)
YanYean	TOS x Cv (512)

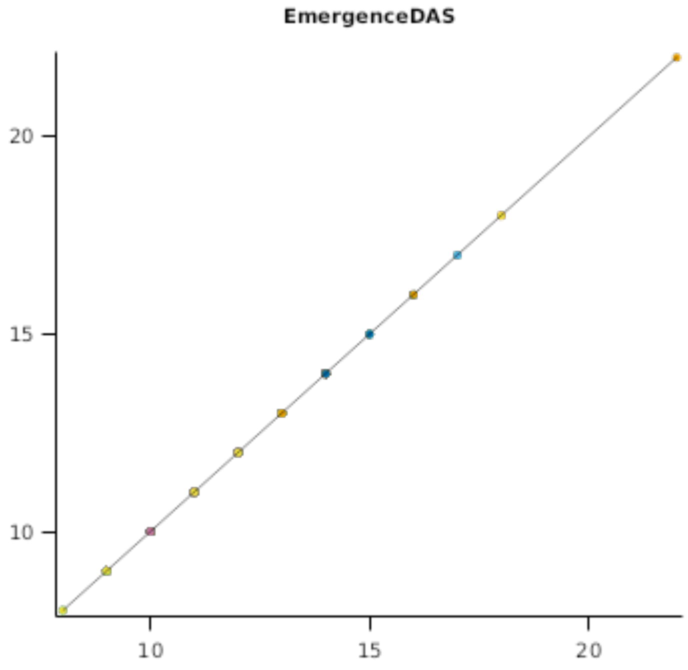


3.11.1 Dale

3.11.1.1 PredObs

HaunStage





3.12 NPIValidation

List of experiments.

Experiment Name	Design (Number of Treatments)
SGEHEAT_13GEHEAT-1	Cultivar (6)
SGEHEAT_13GEHEAT-2	Cultivar (6)
14SSOW-1	Cultivar (34)
14SSOW-2	Cultivar (35)
14SSOW-4	Cultivar (34)
14SSOW-5	Cultivar (31)
12JuneeJames-1-100	Cultivar (2)
12JuneeJames-1-50	Cultivar (1)

Experiment Name	Design (Number of Treatments)
12JuneeJames-2-100	Cultivar (2)
12JuneeJames-2-50	Cultivar (1)
12JuneeJames-3-100	Cultivar (3)
12JuneeJames-4-100	Cultivar (2)
BCVT_Ardingly_1992-06-19	Cultivar (1)
BCVT_Badgingarra_2005-05-26	Cultivar (1)
BCVT_Badgingarra_2005-05-28	Cultivar (1)
BCVT_Badjaling_2003-05-30	Cultivar (1)
BCVT_Chapman_1992-06-23	Cultivar (1)
BCVT_Chapman_1992-06-24	Cultivar (1)
BCVT_Chapman_1994-06-10	Cultivar (1)
BCVT_Gairdner_River_2004-06-09	Cultivar (1)
BCVT_Georgina_1992-06-26	Cultivar (1)
BCVT_Konnongorring_1997-06-13	Cultivar (1)
BCVT_Konnongorring_1997-06-27	Cultivar (1)
BCVT_Kumarl_1999-05-22	Cultivar (1)
BCVT_Kunjin_2005-05-26	Cultivar (1)
BCVT_Meckering_2003-06-04	Cultivar (1)
BCVT_Merredin_1995-05-30	Cultivar (1)
BCVT_Merredin_1996-06-25	Cultivar (1)
BCVT_Merredin_1996-07-02	Cultivar (1)
BCVT_Merredin_1998-06-19	Cultivar (1)
BCVT_Merredin_2000-06-19	Cultivar (1)
BCVT_Merredin_2002-06-10	Cultivar (1)
BCVT_Merredin_2003-06-06	Cultivar (2)
BCVT_Mt_Madden_1994-06-13	Cultivar (1)
BCVT_Mukinbudin_2000-06-13	Cultivar (1)
BCVT_Mullewa_1993-06-04	Cultivar (1)
BCVT_Mullewa_2004-05-28	Cultivar (1)
BCVT_Munglinup_1994-06-08	Cultivar (1)
BCVT_Scaddan_1999-05-25	Cultivar (1)
BCVT_Speddingup_2001-05-30	Cultivar (1)
BCVT_Tammin_1999-06-09	Cultivar (1)
BCVT_Wannamal_1992-06-25	Cultivar (1)

Experiment Name	Design (Number of Treatments)
BCVT_Wongan_Hills_1998-06-09	Cultivar (1)
BCVT_Wongan_Hills_2001-06-11	Cultivar (1)
BCVT_Wongan_Hills_2002-06-09	Cultivar (1)
BTOS_2008GE1	Cultivar (6)
BTOS_2008GE2	Cultivar (7)
BTOS_2008GE3	Cultivar (8)
BTOS_2008GE4	Cultivar (11)
BTOS_2008KA1	Cultivar (2)
BTOS_2008KA2	Cultivar (1)
BTOS_2008KA3	Cultivar (5)
BTOS_2008KA4	Cultivar (12)
BTOS_2008NM2	Cultivar (1)
BTOS_2008NM3	Cultivar (12)
BTOS_2008NM4	Cultivar (12)
BTOS_2009GE1	Cultivar (5)
BTOS_2009GE2	Cultivar (2)
BTOS_2009GE3	Cultivar (10)
BTOS_2009GE4	Cultivar (12)
BTOS_2009KA3	Cultivar (3)
BYIE_08HIR	Cultivar (4)
BYIE_08KA	Cultivar (7)
BYIE_08NB	Cultivar (13)
BYIE_08RS	Cultivar (13)
BYIE_08WH	Cultivar (13)
BYIE_09ER	Cultivar (12)
BYIE_09GN	Cultivar (13)
BYIE_09HIR	Cultivar (1)
BYIE_09KA	Cultivar (7)
BYIE_09MDL	Cultivar (14)
BYIE_09RS	Cultivar (5)
BYIE_09WH	Cultivar (14)
PTOS_10Kairi-1	Cultivar (8)
PTOS_10Kairi-2	Cultivar (8)
PTOS_10Kairi-3	Cultivar (7)

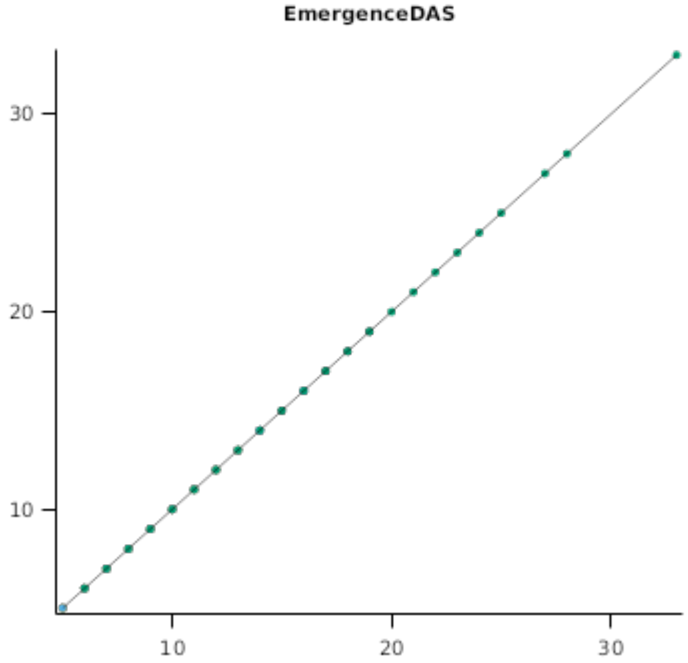
Experiment Name	Design (Number of Treatments)
PTOS_10Kairi-4	Cultivar (7)
PTOS_10Kairi-5	Cultivar (9)
PTOS_10Mackay-1	Cultivar (8)
PTOS_10Mackay-2	Cultivar (8)
PTOS_10Mackay-3	Cultivar (7)
PTOS_10Mackay-4	Cultivar (7)
PTOS_10Mackay-5	Cultivar (9)
HAGT_09Roseworthy-1	Cultivar (2)
HAGT_09Roseworthy-2	Cultivar (2)
HAGT_09Roseworthy-3	Cultivar (2)
HAGT_09Roseworthy-4	Cultivar (3)
HAGT_09Roseworthy-5	Cultivar (3)
17CuryoMESW-TOS1	Cultivar (5)
17CuryoMESW-TOS2	Cultivar (5)
17CuryoMESW-TOS3	Cultivar (5)
17CuryoMESW-TOS4	Cultivar (5)
17HartMESW-TOS1	Cultivar (5)
17HartMESW-TOS2	Cultivar (5)
17HartMESW-TOS3	Cultivar (5)
17HartMESW-TOS4	Cultivar (5)
17LoxtonMESW-TOS1	Cultivar (5)
17LoxtonMESW-TOS2	Cultivar (5)
17LoxtonMESW-TOS3	Cultivar (5)
17LoxtonMESW-TOS4	Cultivar (5)
17MilduraMESW-TOS1	Cultivar (5)
17MilduraMESW-TOS2	Cultivar (5)
17MilduraMESW-TOS3	Cultivar (5)
17MilduraMESW-TOS4	Cultivar (5)
17MinnipaMESW-TOS1	Cultivar (4)
17MinnipaMESW-TOS2	Cultivar (4)
17MinnipaMESW-TOS3	Cultivar (4)
17MinnipaMESW-TOS4	Cultivar (4)
18HartMESW-TOS1	Cultivar (5)
18HartMESW-TOS2	Cultivar (5)

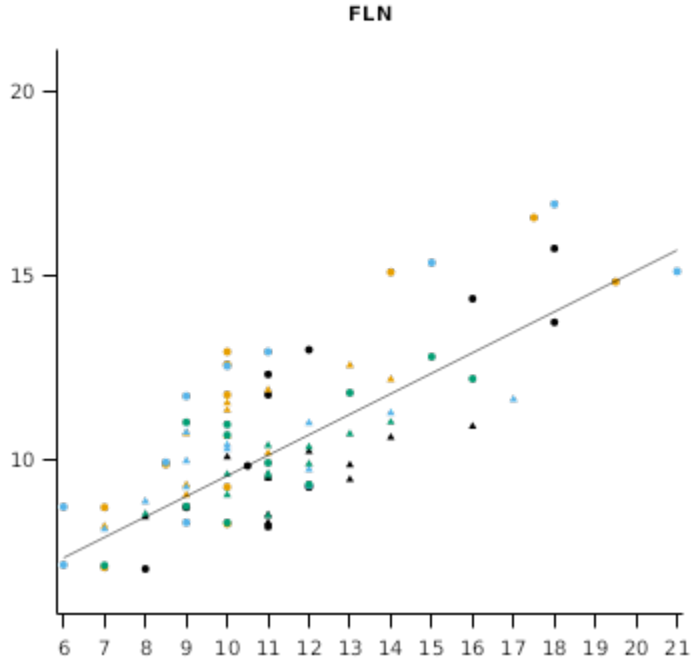
Experiment Name	Design (Number of Treatments)
18HartMESW-TOS3	Cultivar (5)
18HartMESW-TOS4	Cultivar (5)
18LoxtonMESW-TOS1	Cultivar (5)
18LoxtonMESW-TOS2	Cultivar (5)
18LoxtonMESW-TOS3	Cultivar (5)
18LoxtonMESW-TOS4	Cultivar (5)
18MilduraMESW-TOS1	Cultivar (5)
18MilduraMESW-TOS2	Cultivar (5)
18MilduraMESW-TOS3	Cultivar (5)
18MilduraMESW-TOS4	Cultivar (5)
Inverleigh2013-TOS1	Cultivar (1)
Inverleigh2013-TOS2	Cultivar (1)
Temora2015-TOS1	Cultivar (7)
Temora2015-TOS2	Cultivar (7)
Temora2015-TOS3	Cultivar (7)
Temora2015-TOS4	Cultivar (7)
Brookstead2015-TOS1	Cultivar (3)
Brookstead2015-TOS2	Cultivar (3)
Brookstead2015-TOS3	Cultivar (3)
Emerald2015-TOS1	Cultivar (3)
Emerald2015-TOS2	Cultivar (3)
Emerald2015-TOS3	Cultivar (3)
Minnipa2015-TOS1	Cultivar (4)
Minnipa2015-TOS2	Cultivar (4)
Minnipa2015-TOS3	Cultivar (4)
Temora2016-TOS4	Cultivar (2)
Hart2015-TOS1	Cultivar (2)
Hart2015-TOS2	Cultivar (2)
Hart2015-TOS3	Cultivar (2)
Inverleigh2013-TOS3	Cultivar (1)
Inverleigh2013-TOS4	Cultivar (1)

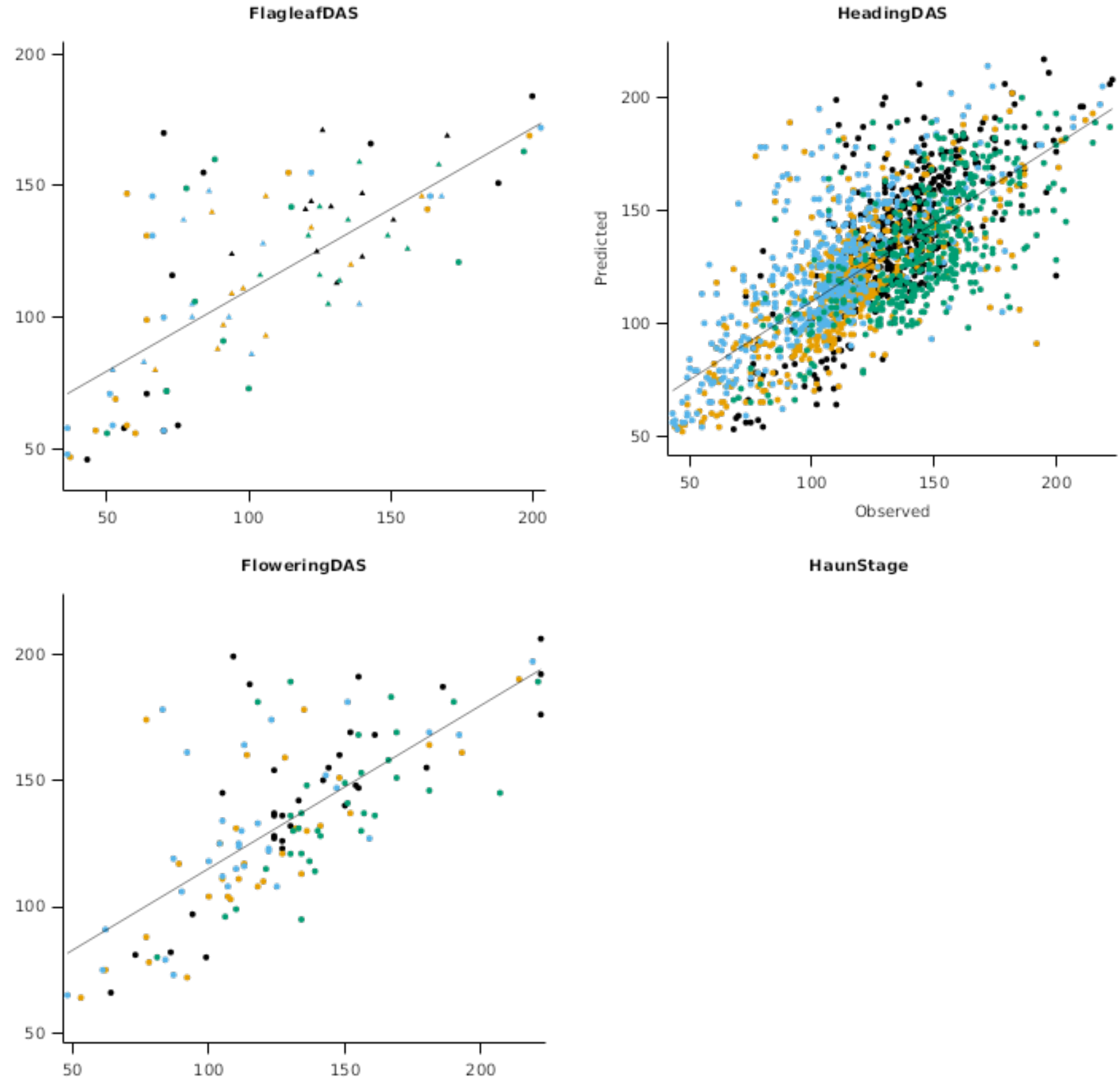
3.13 NPIField2020

List of experiments.

Experiment Name	Design (Number of Treatments)
WaggaWagga2020	TOS x Cv (504)
Urrbrae2020	TOS x Cv (504)
Dale2020	TOS x Cv (504)
YanYean2020	TOS x Cv (441)

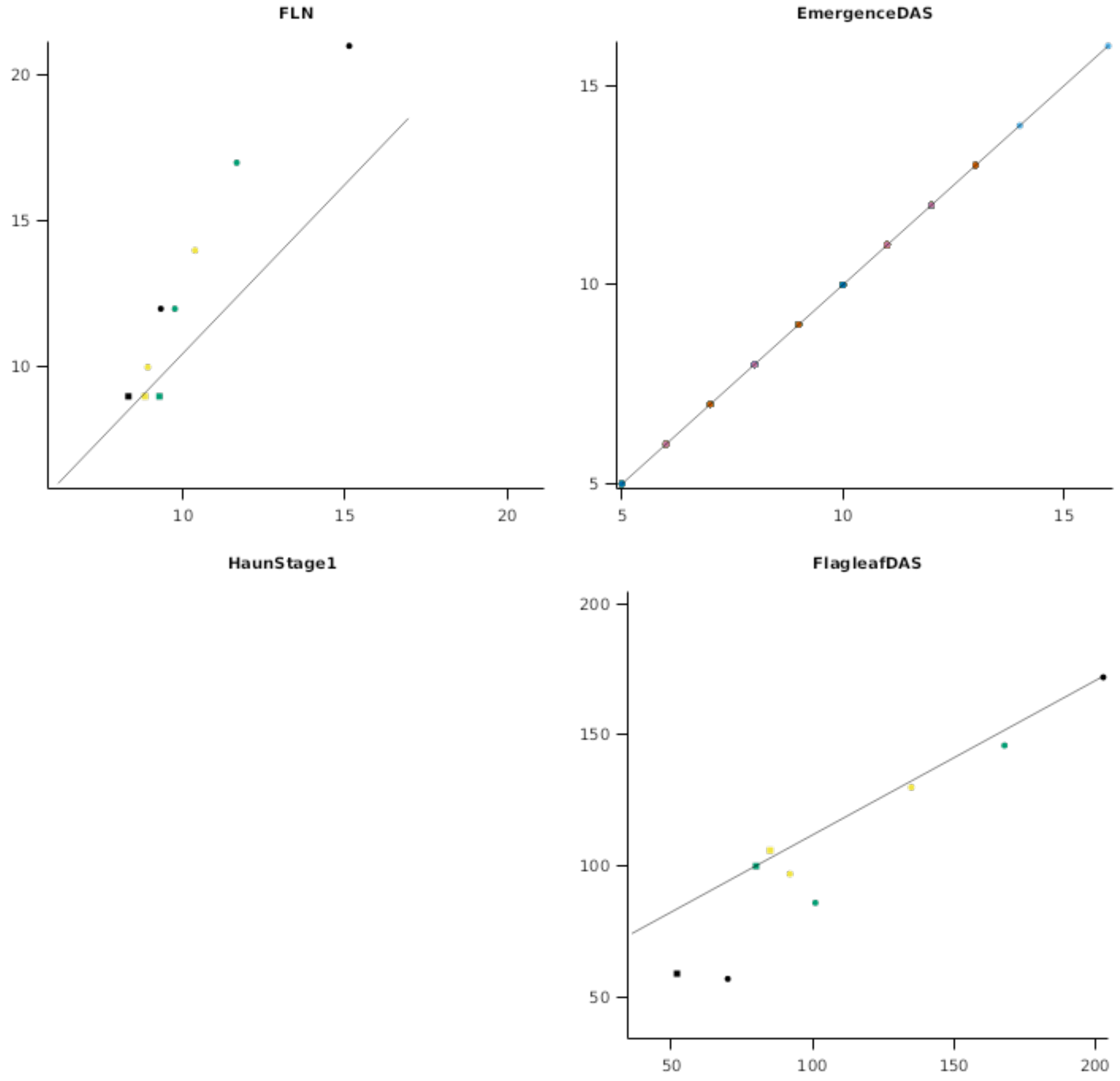






3.13.1 Dale2020

3.13.1.1 PredObs



4 Sensibility

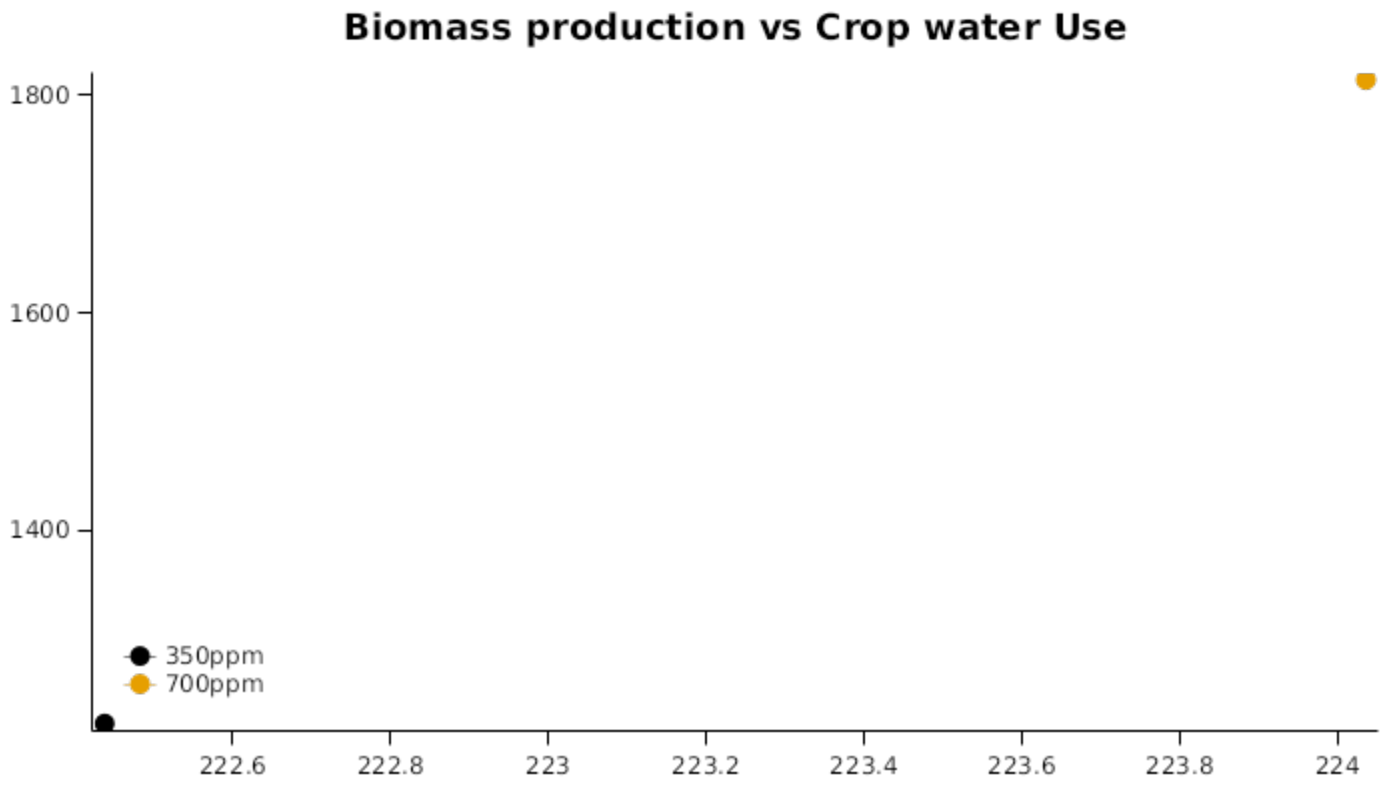
4.1 CO2AndTranspirationEfficiency

List of experiments.

Experiment Name	Design (Number of Treatments)
CO2TE	CO2 (2)

4.1.1 CO2TE

This test examines the impact of a doubling of CO2 from historical (350ppm) on Transpiration Efficiency. Reyenga et al., 1999 suggest an increase of approximately 37% in Transpiration Efficiency over this range in CO2 concentration. In this test, a series of wheat crops are simulated for Dalby, Queensland, Australia. Nitrogen limitation is removed. The slope of plots of biomass production vs crop water use is used to quantify a gross seasonal TE. The change in slope should approximate the response suggested by Reyenga et al., 1999.



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