APSIM Plant Modules

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Crop, pasture and tree modules

- Maize, Sorghum, Sunflower, Millet @, Rice$
- **Wheat**, **Barley**, **Canola**
- **Mungbean, Cowpea, Soybean, Peanut, Pigeonpea@, Navybean, Mucuna**
- **Chickpea, Fieldpea, Faba bean**, **Lentil, Lupin**
- Sugarcane
- **Stylo**, Bambatsi pasture
- **Lucerne**
- Cotton (OzCot)*
- Native pasture (GRASP)
- **Generic weed**
- *Eucalyptus grandis, E. globulus, E. camadulensis*
- Potato, ...

*** by arrangement with CSIRO PI**
@ in association with ICRISAT
 # in association with CSIRO L&W
$ by arrangement with WAU

Inter-species competition

- Can occur between 2 or more crops/pastures in mixture
- Controlled by the “Arbitrator” module
- Competition for **light** based on relative plant heights, leaf areas and extinction coefficients
- Competition for **water** and **N** uptake based on
  - different rooting depths over time,
  - reversing order in which uptake occurs each day in the simulation,
  - different crop LLs for water,
  - different crop rooting depth development over time
- Individual crop/pastures managed separately (eg sowing, cutting/grazing, harvest)

Processes captured

- Phenology and height
- Tillering and leaf area production
- Biomass accumulation and partitioning
- Root growth (depth, density and biomass)
- Crop water relations
- Crop nitrogen relations
- Crop phosphorus relations (not all modules)
- Senescence and plant death

Phenology/Development

Development 'stage'	Determinants
Sowing	User defined
Germination	Thermal time (TT), soil water
Emergence	TT, sowing depth
End of juvenile	TT
Floral initiation	TT, Photoperiod
Flowering	TT
Start of grain fill	TT
End of grain fill	TT
Maturity	TT
Harvest ripe	TT

Leaf area development

- **Net daily change** in leaf area/m^2 (LAI)

  balance between growth and senescence

- **Daily growth** in new leaf area is a function of

  plant density X branching X new leaves produced X

  area per new leaf

- **Daily loss** of leaf area due to senescence a function of

  age, shading, frost, water stress, N stress

Biomass accumulation

- Radiation intercepted by leaf area and extinction coefficient
- Radiation use efficiency converts intercepted radiation to biomass
- Biomass accumulated limited by extremes of
  - temperature
  - N deficit
  - water deficit
  - P deficit
  - oxygen deficit (waterlogging)

Biomass partitioning

Partitioning based on stage-specific ratios/fractions:

- **Root, leaf, stem, reproductive, grain**
- **Roots** grown daily in stage-specific proportion to shoot
- **Emergence to flowering:** biomass partitioned leaf & stem
- **Flowering to start of grainfill:** leaf, stem, pod/flower
- **Start grainfill to maturity:** grain +/- pod/flower
- If demand < supply, residual to leaf, then stem
- If demand > supply, retranslocation from stem & leaf (defined)

Soil water uptake

Minimum of soil water supply and demand

- **Soil water demand (daily):**

  - based on biomass production and transpiration efficiency

- **Soil water supply (daily):**

  - sum of total available water (>lower limit) in all layers with roots

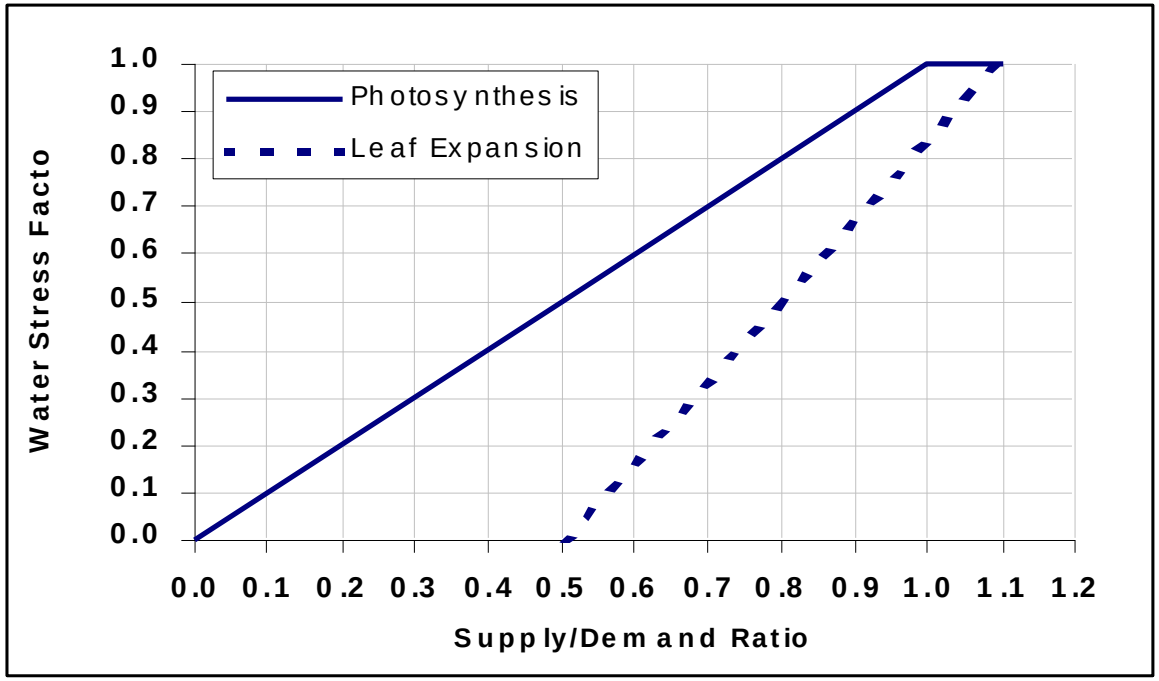
  - ***'kl'*** factor to limit available water for uptake per day

  (varies with layer, empirical based on soil and plant factors limiting uptake)

Water relations - stress factors

Four water deficit factors:

photosynthesis, phenology, leaf-expansion, nitrogen fixation



Nitrogen dynamics

- **Supply** is the sum of N available through active (diffusion), passive (mass flow) uptake and N fixation
- **Demand** is a function of biomass of individual plant parts and their critical N%
- **Uptake** is the minimum of supply and demand
- **Partitioning** to vegetative parts is proportional to the demand of these parts
- **Retranslocation** during grain filling depends on availability in veg organs and grain demand
- **N Stress factors** calculated from N-concentration ratio's

Nitrogen uptake

Minimum of soil N supply and demand

- **Nitrogen demand (daily):**

  - each plant part has **min, max and critical N concentrations**

  - demand attempts to maintain N at critical (non-stressed) level in each plant part

- **Nitrogen supply (daily):**

  - three forms of NO3 and NH4 uptake (mass flow, active, fixation)

  - N distributed to plant parts in proportion to demands

  - grain N is retranslocated from other plant parts (not from soil)

  - N fixation capacity= f(genotype, growth stage, biomass, SW stress)

Depth of the root zone

- Daily potential root depth increase determined by temperature and phenological stage
- Dry soil in a layer (< 25% PAW) limits elongation
- Hospitality factor (***xf***, 0-1) limits elongation through a layer
- Maximum depth limited by depth of profile or season length
- Severe water stress can stop roots

Death and detachment

Plants die/killed:

- No germination within 40 days planting (lack of moisture)
- No emergence within 150 ^{o}C d of sowing (sown too deep)
- Crop past FI and LAI = 0, plants killed due to total senescence
- Fraction of plants killed by high temp. after emergence

Detachment:

- Detachment of dead or senesced plant parts

What can you "do" with a crop in APSIM?

- **Sow it**

  cultivar, sowing depth, plant density,

  row spacing, row configuration

- **Harvest it**

  Height above ground, proportion of crop residues removed

- **Kill it**

  Proportion of plants killed

- **Change class** eg from plant to regrowth

- **Remove** it from the simulation

Some things to keep in mind

- Cultivars basically only differ in phenology
- Some effects not accounted for eg waterlogging,
  other nutrient deficiencies, frost damage at flowering, lodging
- Some variables have different units eg biomass (kg/ha) vs
  biomass_wt (g/m^2)
- Grain yield is at zero moisture content
- Some modules have received more testing than others
  in some environments

Things to watch out for…

- Key variables – *phenology, LAI, root depth, biomass, yield, water and N stress factors (root biomass, residues)*
- Was the crop actually sown, fertilised, irrigated etc on the days you intended?
- Were soil water and N starting conditions what you intended?
- Is the crop making it to maturity?
- Is the downward progress of the root system behaving as it should?
- Does the harvest index seem sensible?

Where can I find out more about the science in a crop module?

- Module documentation
- Key publications
- History of development
- Output variables
- Name of module convener