Integrating pests into crop models

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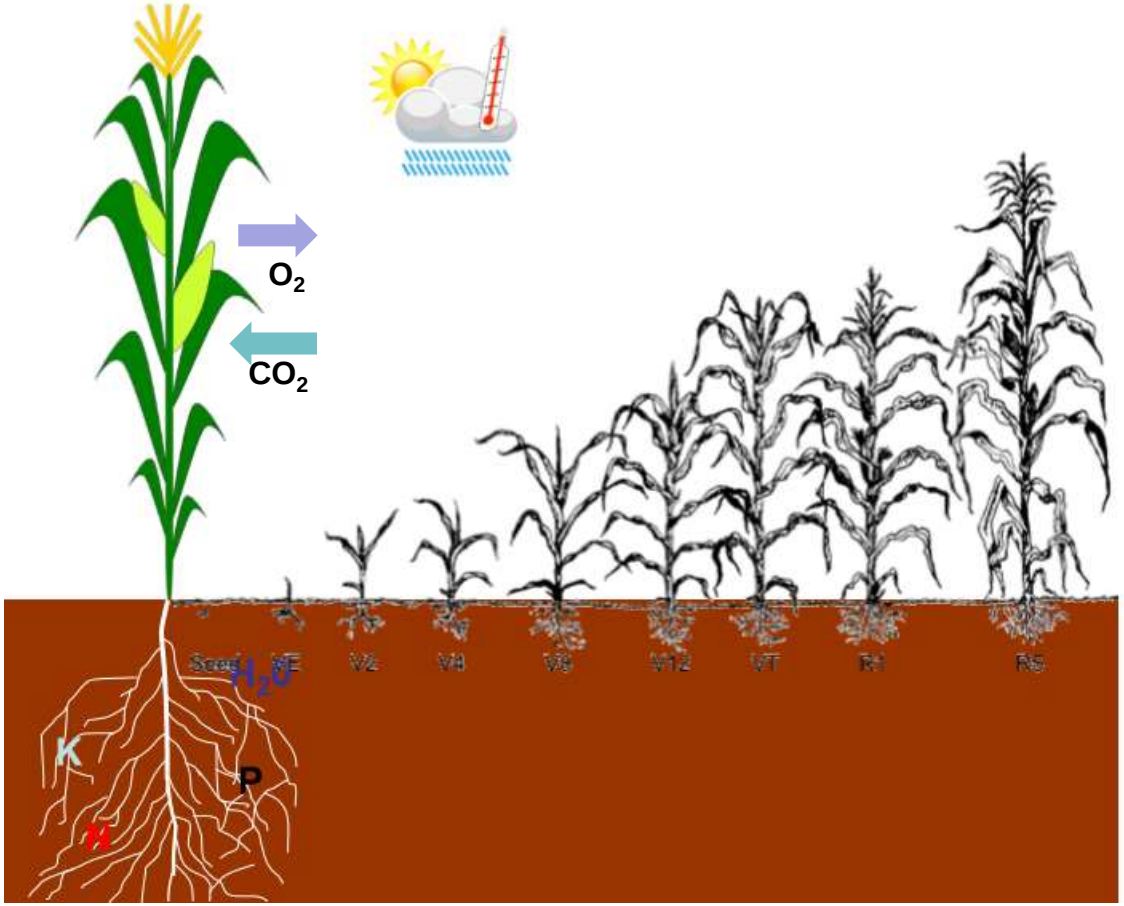
Federal Research Centre for Cultivated Plants
Germany

2016/10/10

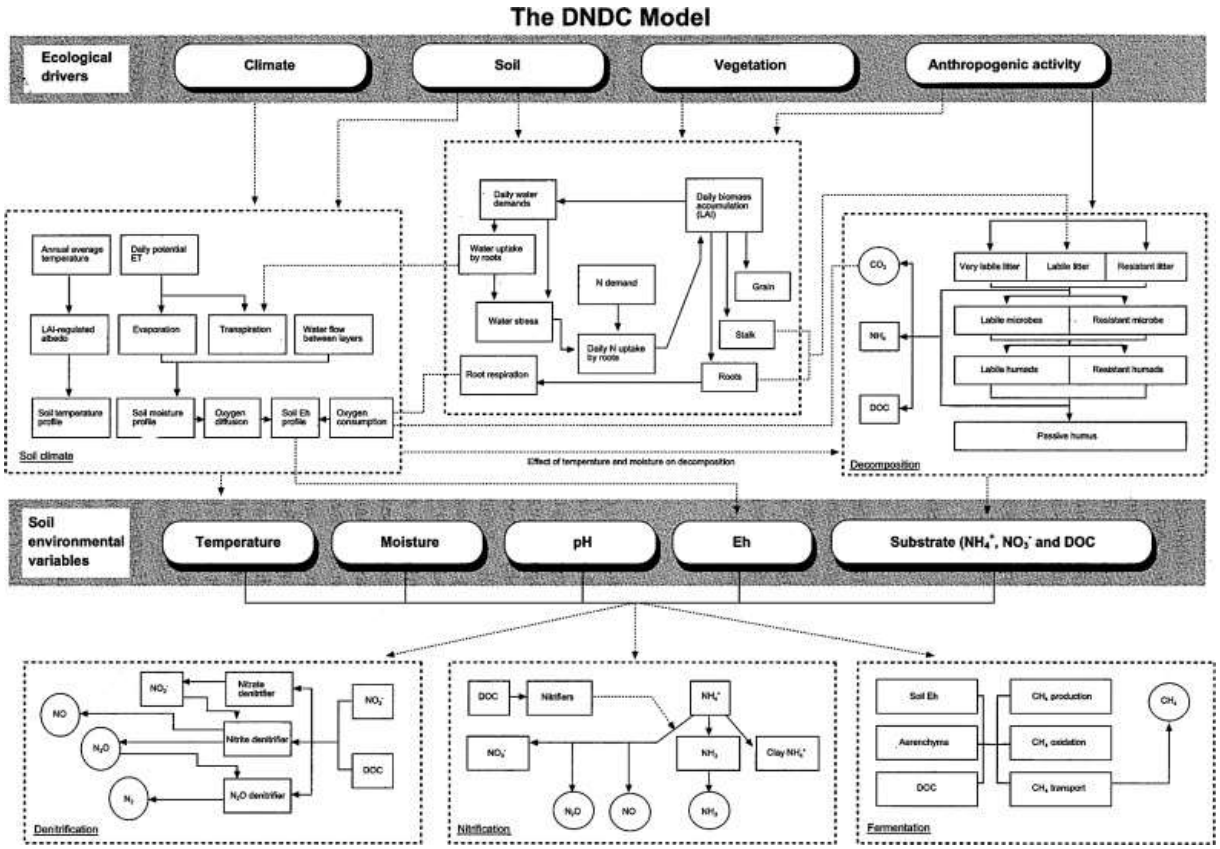
Crop models

- Simulate plant development, dry-matter accumulation and yield based on observed soil and weather data



Crop models

- Simulate plant development, dry-matter accumulation and yield based on observed soil and weather data



Crop model development

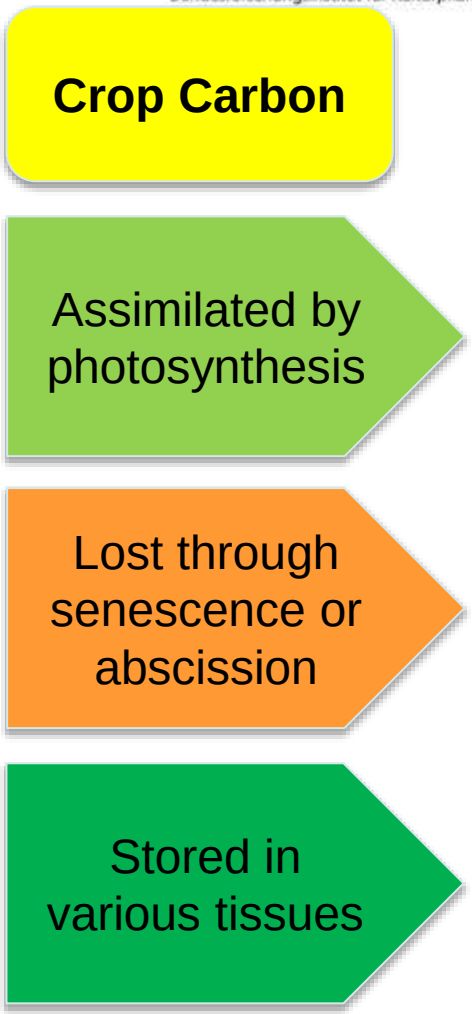
- Developed based on experiments that run under optimal conditions
- Need to know the plant phenologic development and dry matter development under optimal conditions
- No drought stress
- No heat stress
- No N limitation
- No pests

Images: Pioneer.com, theorganicfarmer.com, NASA.gov

Coupling points of pests

At the level of:

- Inputs
  - Water, light, nutrient
- Rate processes
  - Photosynthesis, transpiration water uptake, senescence
- State variables
  - Number of organs, mass of tissues



Categories of pest damages

- Assimilate sappers

Aphids
Aphidoidea

Whitefly
Aleyrodidae

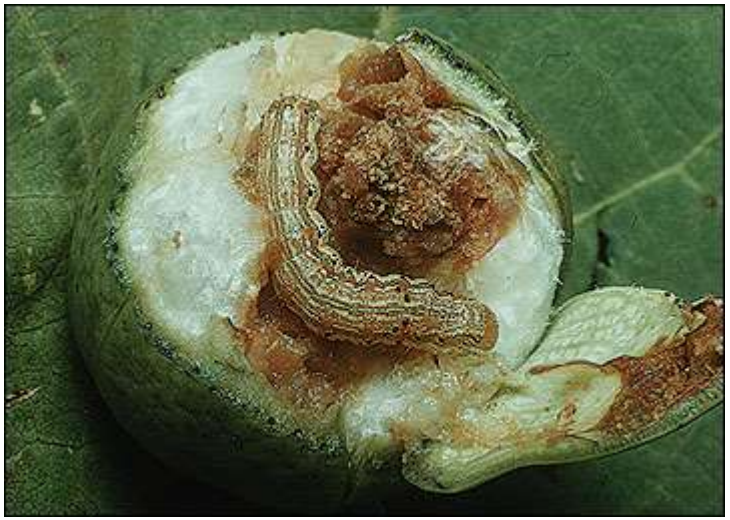
→ Assimilate (C and N) removal as function of pest number or activity

Images: tamu.edu, Wikipedia

Categories of pest damages

- Assimilate sappers
- Tissue consumers

Potato beetle
Leptinotarsa decemlineata



Cotton bollworm
Helicoverpa zea

→ Tissue type, rate and timing of consumption

Images: J. Hahn mnu.edu; extension.missouri.edu

Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers

Black cutworm
Agrostis ipsilon

Stripped stem borer
Chilo suppressalis

→ Number (share) & distribution of lost plants + timing (compensation)

Images: A. Sisson, Iowa State University, Bugwood.org; Sreepatra.com

Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers

Tomato ringspot virus
Secoviridae

→ Level of pest infection on photosynthetic light response curve

Image: msue.anr.msu.edu; M. Grabowski, UMN Extension

Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators

Cercospora
Cercospora beticola

→ Added to other senecence drivers (self-shading, aging, drought, N-limitation)

Images: commons.wikimedia

Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators
- Light stealers

Powdery mildew
Blumeria graminis

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almeri

→ Number, distribution, height and leaf area of weeds (or damaged crop leaves)

Images: www.ag.ndsu.edu

Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators
- Light stealers
- Turgor reducers

Verticillium wilt

→ Rate of feeding and secondary tissue death

Images: wikipedia

Challenges

- Single pest often damages via several categories
- Quantify amount of damage per unit or number of pest
- Crucial for predicting yield effect of different pests

Example ex-post pest integration

- Effect of late leaf spot disease (*Cercosporidium personatum*)
- Necrotic lesions → photosynthesis↓ + leaf senescence↑
- PNUTGRO
- Coupling: diseased leaf area + defoliation damage
- UFGA8701.pnx

DSSAT Version 4.5.0.0

File Data Model Help

New Run

Tools

Crop Management Data

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Weather Data

Seasonal Analysis

Rotational Analysis

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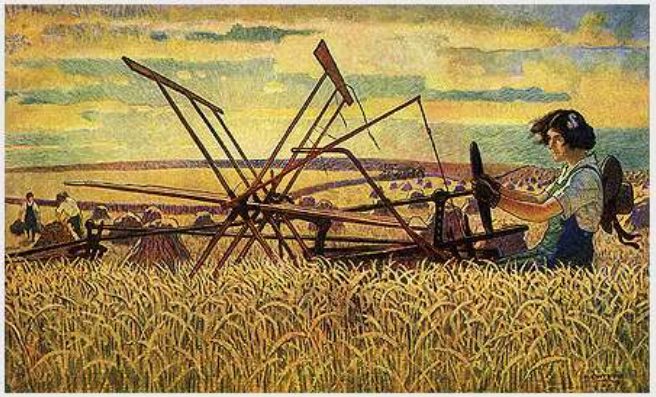
Reference

My Shortcuts

Selector

- Crops
  - Cereals
  - Legumes
  - Root Crops
  - Oil Crops
  - Vegetables
  - Fiber
  - Forages
  - Sugar/Energy
  - Fruit Crops
  - Various
- Applications
  - Seasonal
  - Sequence
  - Spatial
- Data
  - Soil
  - Weather
  - Genetics
  - Economics
  - Pests
  - Standard Data

Data



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    - Chickpea
    - Cowpea
    - Drybean
    - Faba Bean
    - Peanut
    - Soybean
    - Velvet Bean
  - Root Crops
  - Oil Crops
  - Vegetables
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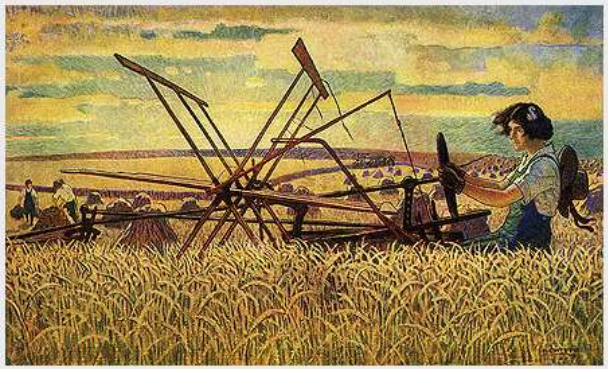
Data



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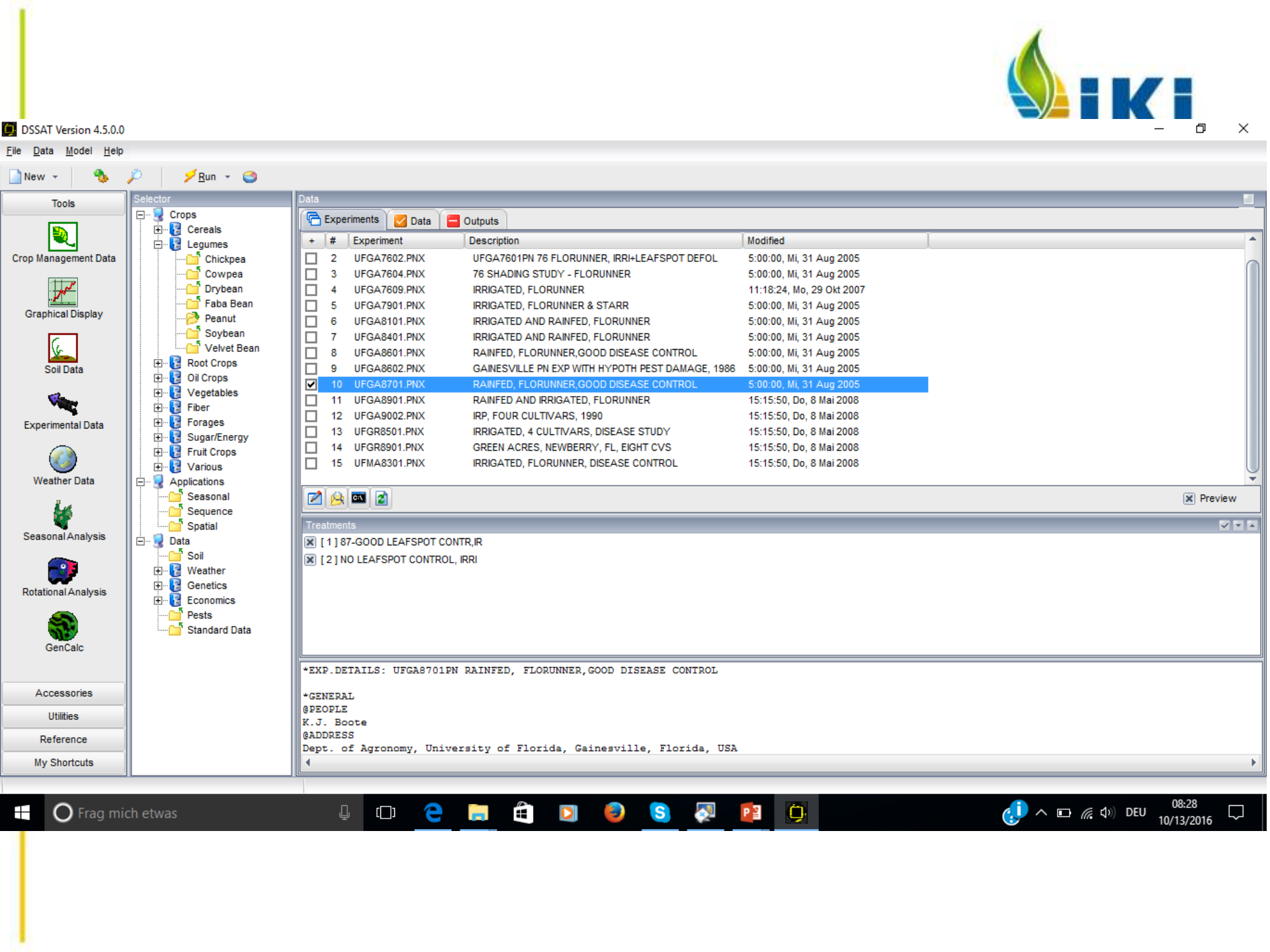
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Fruit Crops
Various
Applications
Seasonal
Sequence
Spatial
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Experiments
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Outputs
+ # Experiment Description Modified
2 UFGA7602.PNX UFGA7601PN 76 FLORUNNER, IRRI+LEAFSPOT DEFOL 5:00:00, Mi, 31 Aug 2005
3 UFGA7604.PNX 76 SHADING STUDY - FLORUNNER 5:00:00, Mi, 31 Aug 2005
4 UFGA7609.PNX IRRIGATED, FLORUNNER 11:18:24, Mo, 29 Okt 2007
5 UFGA7901.PNX IRRIGATED, FLORUNNER & STARR 5:00:00, Mi, 31 Aug 2005
6 UFGA8101.PNX IRRIGATED AND RAINFED, FLORUNNER 5:00:00, Mi, 31 Aug 2005
7 UFGA8401.PNX IRRIGATED AND RAINFED, FLORUNNER 5:00:00, Mi, 31 Aug 2005
8 UFGA8601.PNX RAINFED, FLORUNNER,GOOD DISEASE CONTROL 5:00:00, Mi, 31 Aug 2005
9 UFGA8602.PNX GAINESVILLE PN EXP WITH HYPOTH PEST DAMAGE, 1986 5:00:00, Mi, 31 Aug 2005
10 UFGA8701.PNX RAINFED, FLORUNNER,GOOD DISEASE CONTROL 5:00:00, Mi, 31 Aug 2005
11 UFGA8901.PNX RAINFED AND IRRIGATED, FLORUNNER 15:15:50, Do, 8 Mai 2008
12 UFGA9002.PNX IRP, FOUR CULTIVARS, 1990 15:15:50, Do, 8 Mai 2008
13 UFGR8501.PNX IRRIGATED, 4 CULTIVARS, DISEASE STUDY 15:15:50, Do, 8 Mai 2008
14 UFGR8901.PNX GREEN ACRES, NEWBERRY, FL, EIGHT CVS 15:15:50, Do, 8 Mai 2008
15 UFMA8301.PNX IRRIGATED, FLORUNNER, DISEASE CONTROL 15:15:50, Do, 8 Mai 2008
Preview
Treatments
[1] 87-GOOD LEAFSPOT CONTR,IR
[2] NO LEAFSPOT CONTROL, IRRI
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*GENERAL
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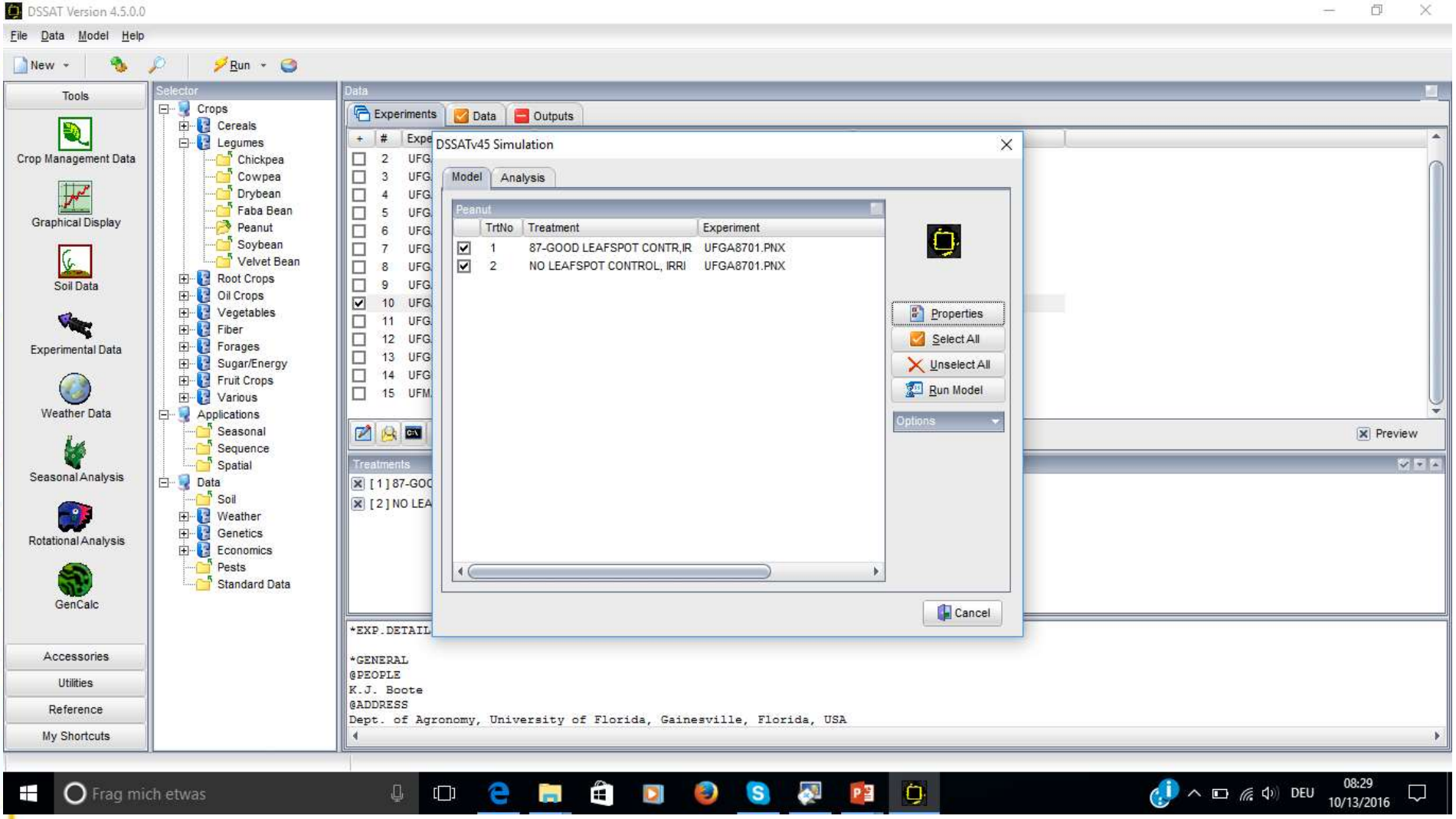
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2 NO LEAFSPOT CONTROL, IRRI UFGA8701.PNX
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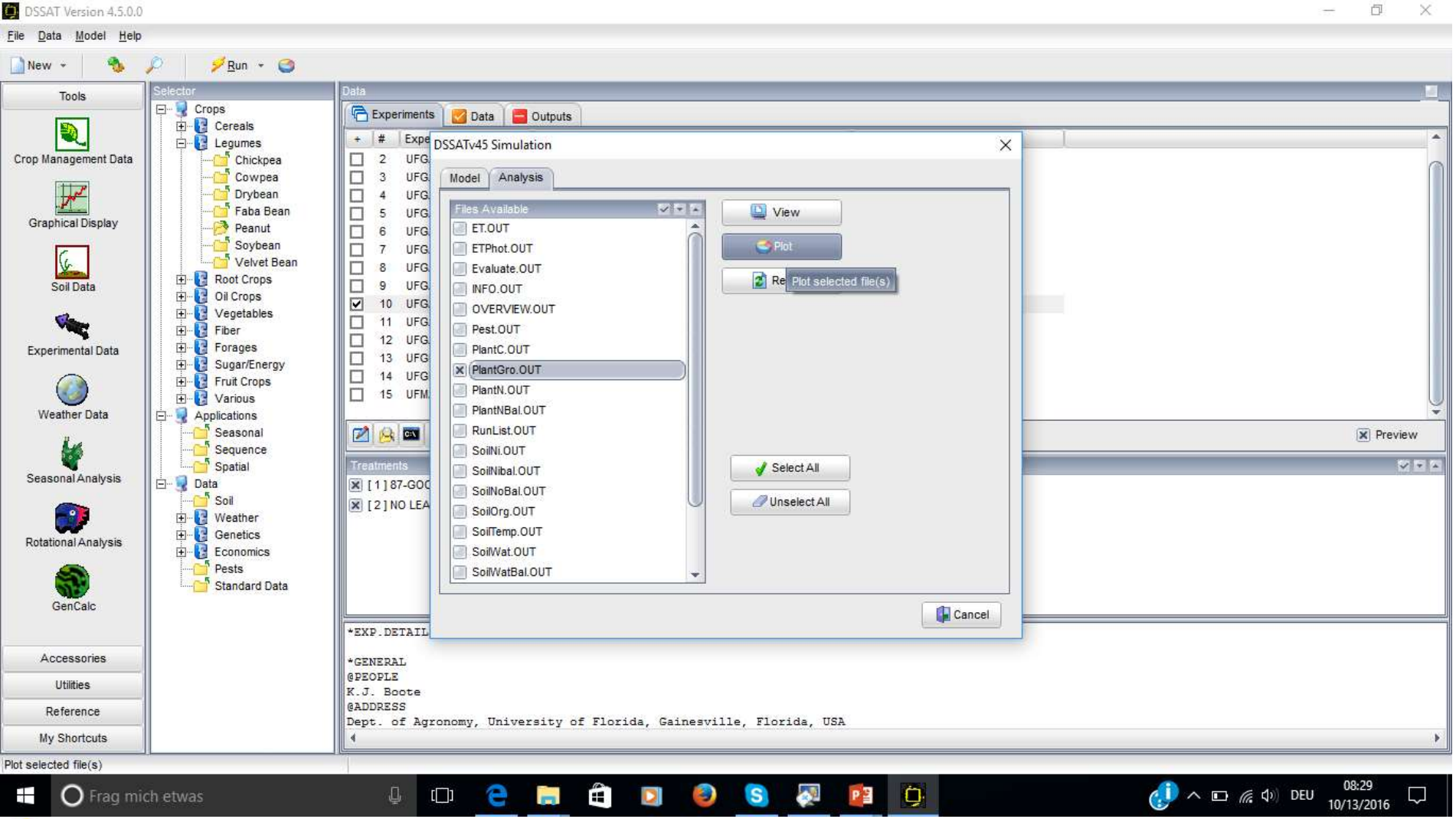
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ETPhot.OUT
Evaluate.OUT
INFO.OUT
OVERVIEW.OUT
Pest.OUT
PlantC.OUT
PlantGro.OUT
PlantN.OUT
PlantNBal.OUT
RunList.OUT
SoilNi.OUT
SoilNibal.OUT
SoilNoBal.OUT
SoilOrg.OUT
SoilTemp.OUT
SoilWat.OUT
SoilWatBal.OUT
View
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Plot selected file(s)
Select All
Unselect All
Cancel
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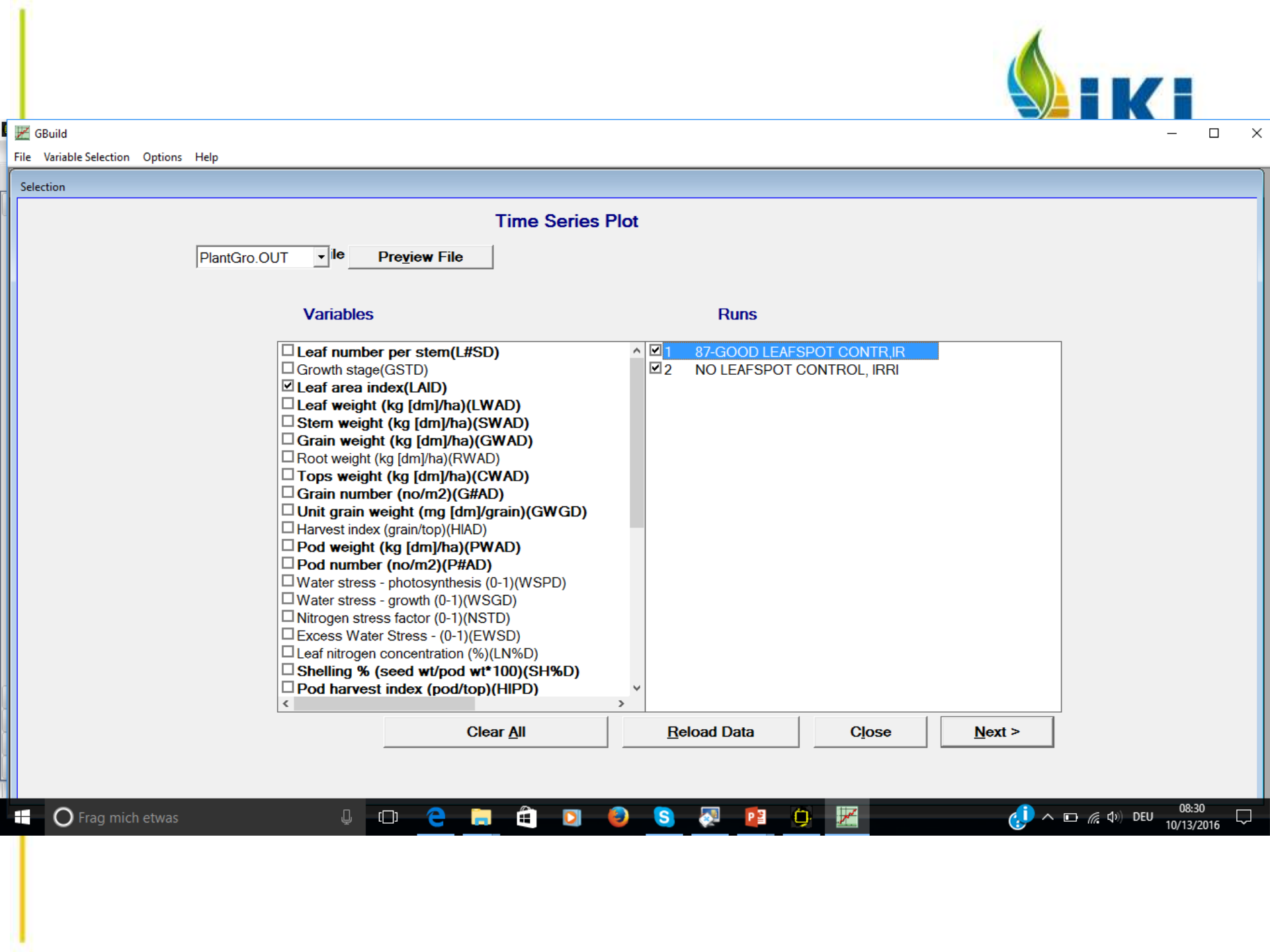
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Help
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Time Series Plot
PlantGro.OUT
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Preview File
Variables
Runs
Leaf number per stem(L#SD)
Growth stage(GSTD)
Leaf area index(LAID)
Leaf weight (kg [dm]/ha)(LWAD)
Stem weight (kg [dm]/ha)(SWAD)
Grain weight (kg [dm]/ha)(GWAD)
Root weight (kg [dm]/ha)(RWAD)
Tops weight (kg [dm]/ha)(CWAD)
Grain number (no/m2)(G#AD)
Unit grain weight (mg [dm]/grain)(GWGD)
Harvest index (grain/top)(HIAD)
Pod weight (kg [dm]/ha)(PWAD)
Pod number (no/m2)(P#AD)
Water stress - photosynthesis (0-1)(WSPD)
Water stress - growth (0-1)(WSGD)
Nitrogen stress factor (0-1)(NSTD)
Excess Water Stress - (0-1)(EWSD)
Leaf nitrogen concentration (%)(LN%D)
Shelling % (seed wt/pod wt*100)(SH%D)
Pod harvest index (pod/top)(HIPD)
1 87-GOOD LEAFSPOT CONTR,IR
2 NO LEAFSPOT CONTROL, IRRI
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Reload Data
Close
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File Variable Selection Options Help

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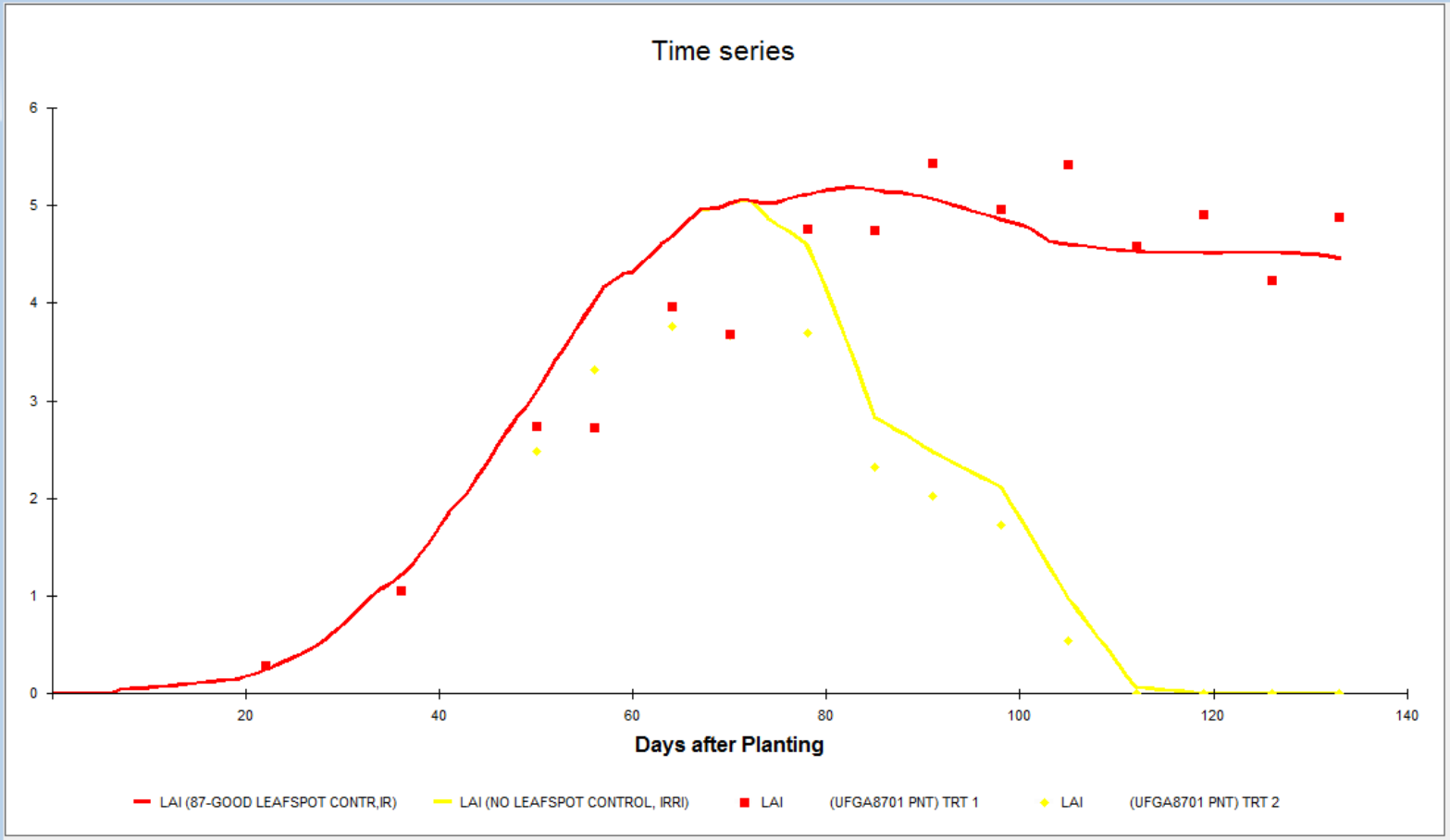

Statistic

Print

Export data to text file

Export to Excel

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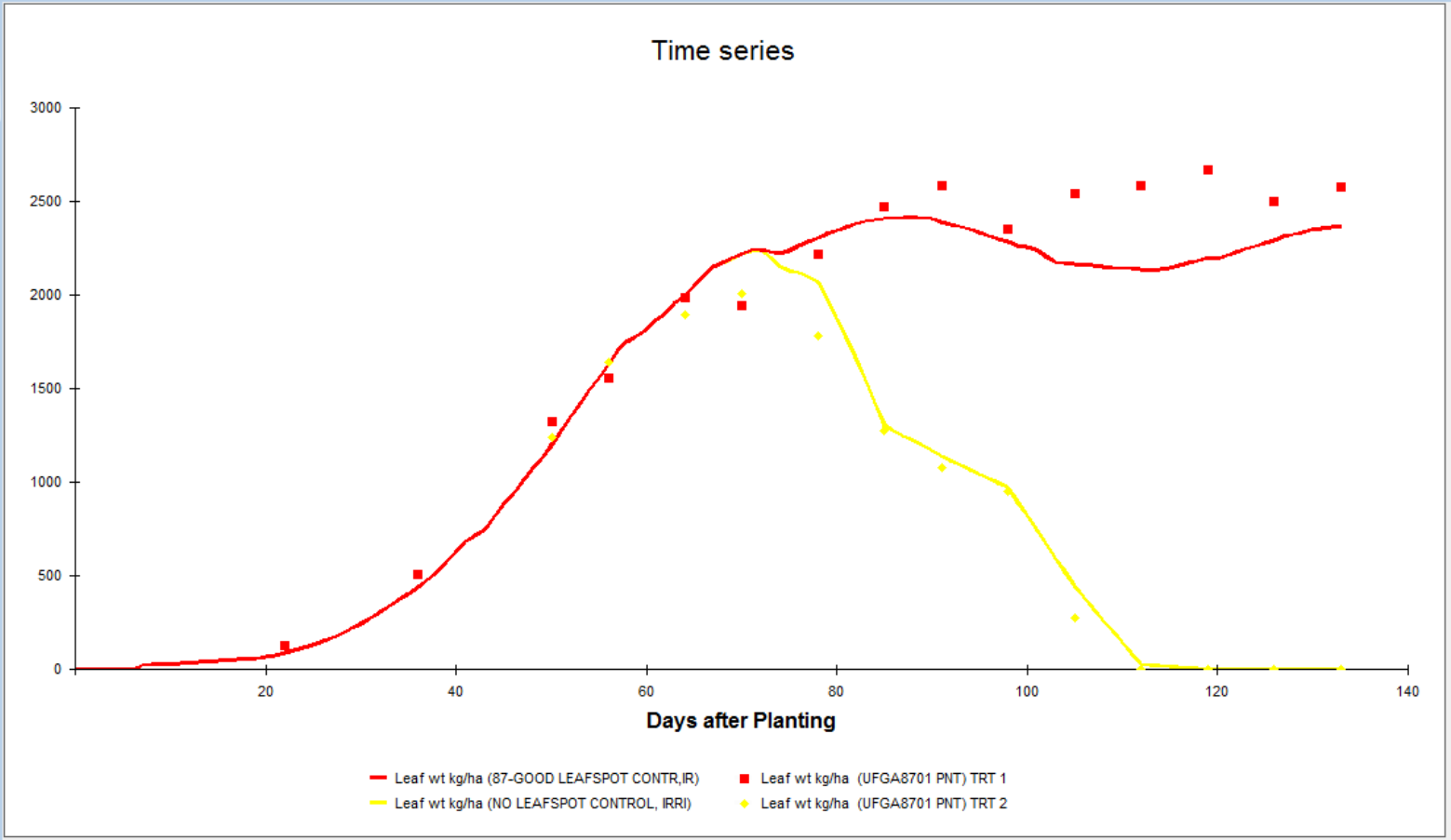

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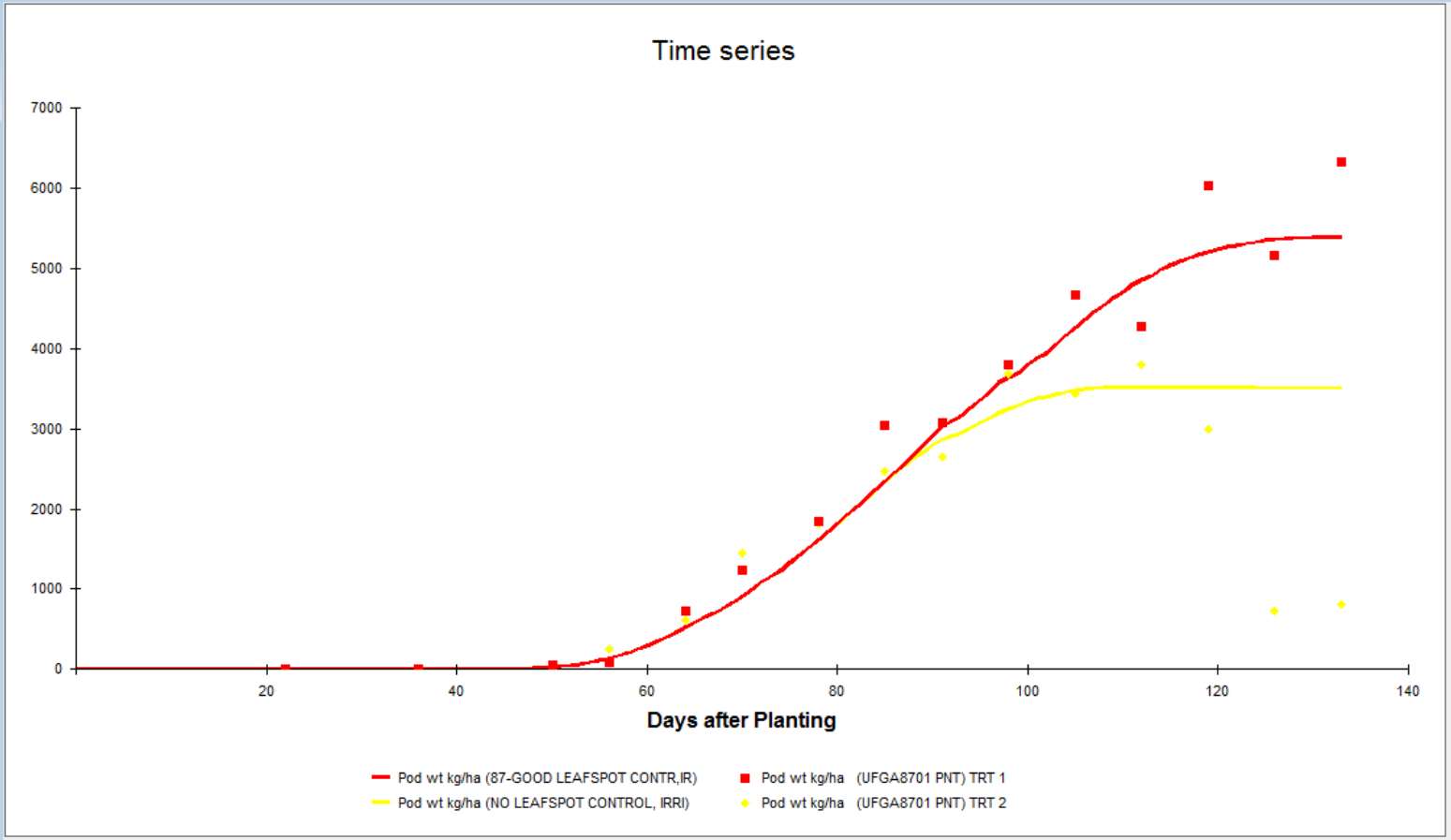

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Summary and outlook

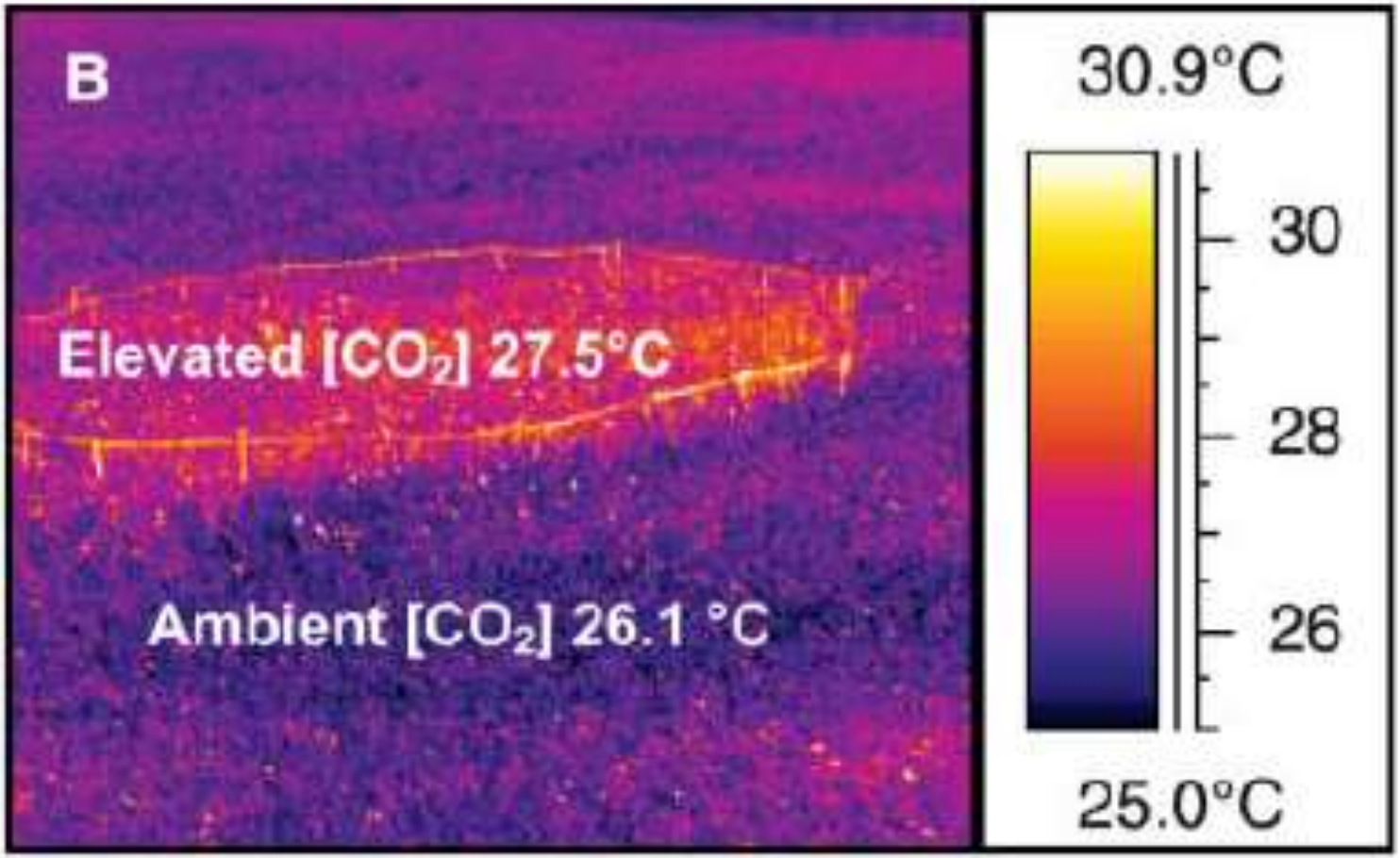

Image: Leakey, 2009

Summary and outlook

- Define how pests damage crops
- Ex-post integration of pest damage possible
- But not sufficient
- Dynamic modelling of crops and pests and their interactions
- Consideration of canopy microclimate

Image: Leakey, 2009