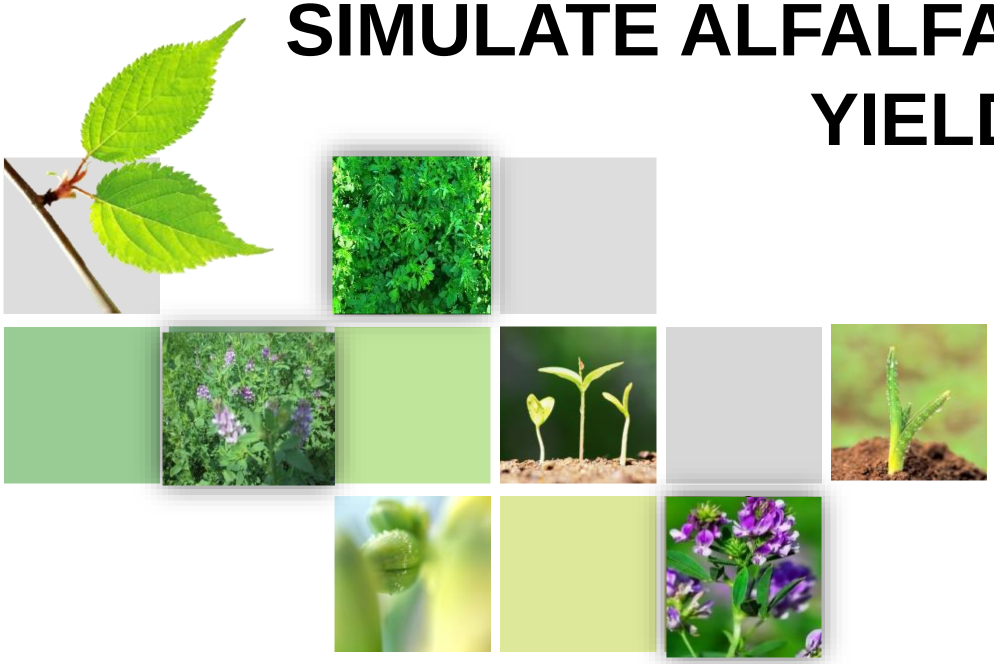
ADAPTING CROPGRO MODEL TO SIMULATE ALFALFA GROWTH AND YIELD



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CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN

UNIVERSITY of FLORIDA

GOBIERNO DE ARAGON
Departamento de Innovación, Investigación y Universidad

May 2018

Outlines

1 Introduction

2 Field data sets

3 Approach for model adaptation

4 Results and discussion

5 Conclusions

Introduction

Thesis title: **Modelling and environmental control of modernized sprinkler irrigated area in the Ebro Valley (Spain)**

Objective: **Develop strategies for the control of diffuse pollution through models simulation in the Ebro Valley (Spain).**

Sub-objectives

- ✓ **Calibrate and validate DSSAT and SWAT models for their application to estimate the quantity and quality of the irrigation returns flows under different scenarios.**
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- ✓ De… ng to dro…

DSSAT calibration and Validation for the main extended crops in La VID.

- ○ **Alfalfa**

- ○ **Maize**
- ○ **Barley**
- ○ **Wheat**
- ○ **Sunflower**

Introduction

Research visit:

Agronomy Department, University of Florida, USA

- Duration:
  - 3 monthes
  - 1st May until 31 th July of 2017
- Supervisor:
  - Kenneth J. Boote: Professor Emeritus,

Hoogenboom, G., J.W. Jones, P.W. Wilkens, C.H. Porter, **K.J. Boote,** L.A. Hunt, U. Singh, J.L. Lizaso, J.W. White, O. Uryasev, R. Ogoshi, J. Koo, V. Shelia, and G.Y. Tsuji.

Field data sets

General Characteristics (study area):

- **Semiarid Mediterranean climate:**
  Monthly average T max =34 °C : T min=0.4°C
  Yearly average rainfall: 325 mm
  Yearly average ET_0: 1227 mm.
- **Sprinkler irrigation system:** (18x18m)
- **Soil characteristics:** clay-loam, 120 cm depth

Field experiments:

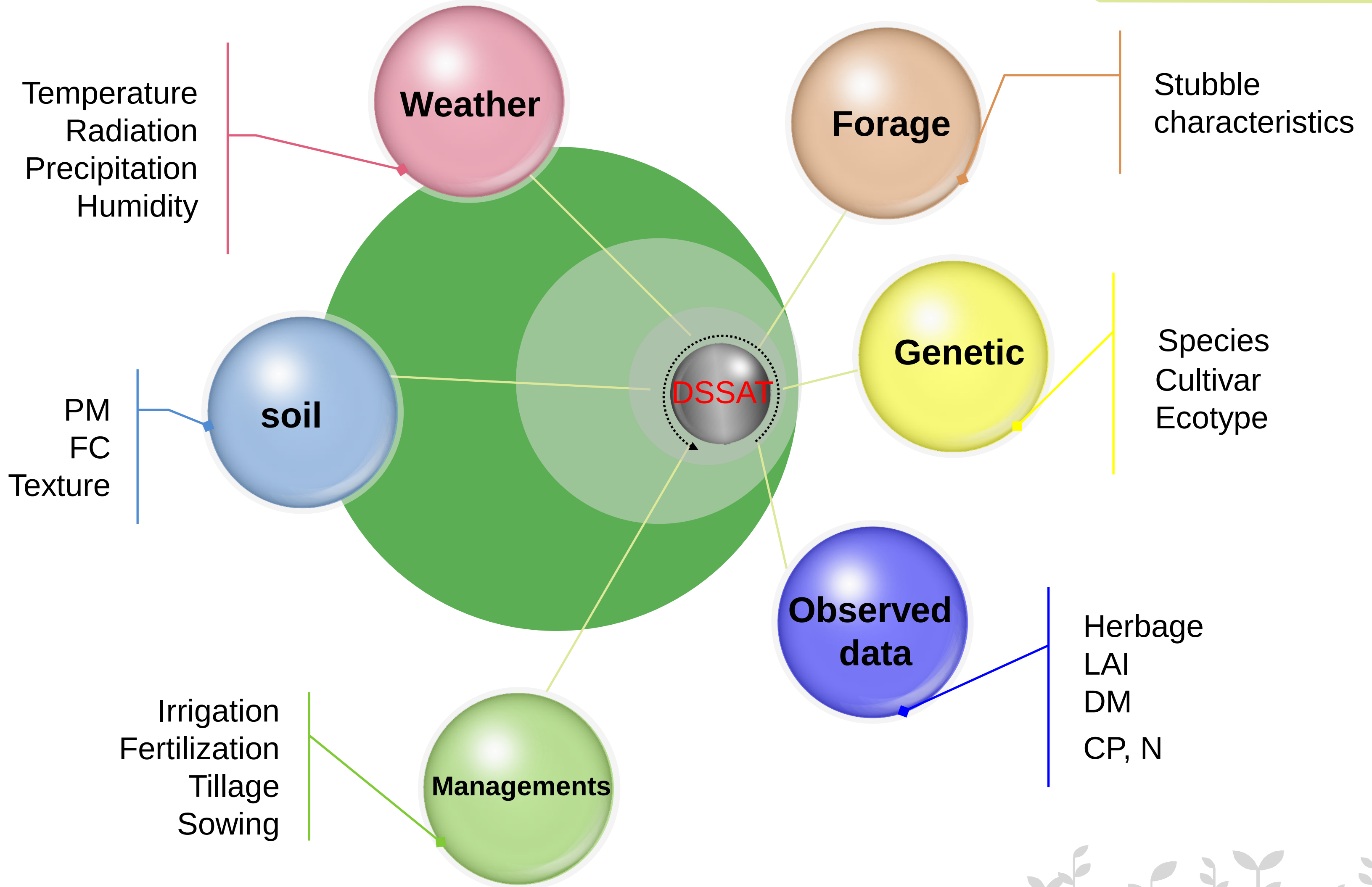
- Experiment 1, 2, 3 and 4: La VID
- Experiment 5: CITA-finca (Ramón).
- Experiment 6: CITA-finca Cavero et al., 2017 (trt 100%)

Collected data:

- Leaf area index (LICOR-LAI-2000) weekly.
- Herbage DM.
- N concentrations (herbage): (TruSpec CN, LECO, St. Joseph, MI, USA).
- Crude protein (herbage): x 6.25 (FAO 2003).
- Crop management (farmer's survey).
- Soil analysis.

Exp.	Duration	Harvest N°	LAI	N	CP	Canopy height
1	2016-2017	7	37	6	6	14
2	2016-2017	7	37	6	6	14
3	2016-2017	2	23	1	1	-
4	2016-2017	2	23	1	1	-
5	2013-2017	19	28	5	5	-
6	2012-2014	18	-	18	18	16

CROPGRO files inputs



Forage characteristics

MOW input file

- ✓ **DATES**: Harvest dates,
- ✓ **MOW** = stubble mass: the amount of live forage mass remaining → 1000 kg/ha, Wiersma and Wiederholt, (2007)
- ✓ **RSPLF**: percentage leaf of the stubble → 20%
- ✓ **MVS**: a "re-staged" leaf number → 2
- ✓ **RSHT**: shoot height 5 cm

SPPI1209.MOW - Bloc-notes

Fichier Edition Format Affichage ?

```
!This file is for parameters controlling si
!for CROPGRO-Forage model.
!Mow height is not used any where, except to
@TRNO   DATE   MOW RSPLF   MVS  RSHT
    1 16116   1000    20     2   5.0
    1 16146   1000    20     2   5.0
    1 16188   1000    20     2   5.0
    1 16215   1000    20     2   5.0
    1 16250   1000    20     2   5.0
    1 16312   1000    20     2   5.0
    1 17102   1000    20     2   5.0
    1 17143   1000    20     2   5.0
```

Ecotype file

Perennial forages remain vegetative during most of the year; therefore, the model was set to remain in the vegetative phase, basically by skipping the juvenile phase and creating a very long vegetative phase (**JU-R0** in the 'Eco file') by setting it to **9999** photothermal days.

Simulation methods used (recommended)

- ✓ The Penman-Monteith FAO 56
- ✓ The CENTURY SOC model
- ✓ Leaf photosynthesis mode

Adaptation approach

DSSAT version 4.6 (Hoogenboom et al., 2015)

1. Comparison to observed experimental data

- ***Plot against available data***
- ***Ratio = observed/simulated***
- ***RMSE: root mean square error:***

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2}$$

- ***Willmott agreement index, d-Statistic:***

$$d = 1 - \left[\frac{\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2}{\sum_{i=1}^{N}\left(\left|\hat{Y}_i - \bar{Y}\right| + \left|Y_i - \bar{Y}\right|\right)^2}\right]$$

2. Values and relationships from the literature

3. Inverse modeling techniques

4. Bayesian optimization approach

Hybrid algorithm program incorporating a Gibbs sampler (Casella and George, 1992) within a version of the Metropolis–Hastings algorithm (Chib and Greenberg, 1995).

Results and discussion

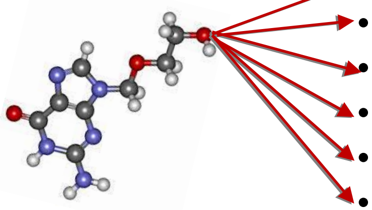
Adaptation process

- **Bracharia brizantha – *Marandu*:** (Diego Pequeno et al., 2014) was used as a starting point.

- **Photosynthesis parameters:** C4→C3 for Ps

1.90	5.50	FNPGN(1-2),TYPPGN-LEAF N EFFECT ON PG
-5.1	10.2	FNPGL(2-3),TYPPGL-TMIN EFFECT-LEAF PG
0.2	35.2	Tb and Topt for leaf Ps (XLMAXT)
0.0	1.0	YLMAXT

- **Plant composition tissues:** Soybean composition and literature
  - Protein concentration (Maximum", "normal growth", and "final")
  - Carbohydrate-cellulose concentration
  - Lignin concentration
  - Mineral concentration



- Leaf
- Stem
- Root
- Shell
- Seed
- Nodule

- **Phenology parameters: cardinal Temperatures (°C)**

TB	TO1	TO2	TM	
3.0	25.0	33.0	45.0	1 VEGETATIVE DEVELOPMENT
4.0	28.0	33.0	45.0	2 EARLY REPRODUCTIVE DEVELOPMENT

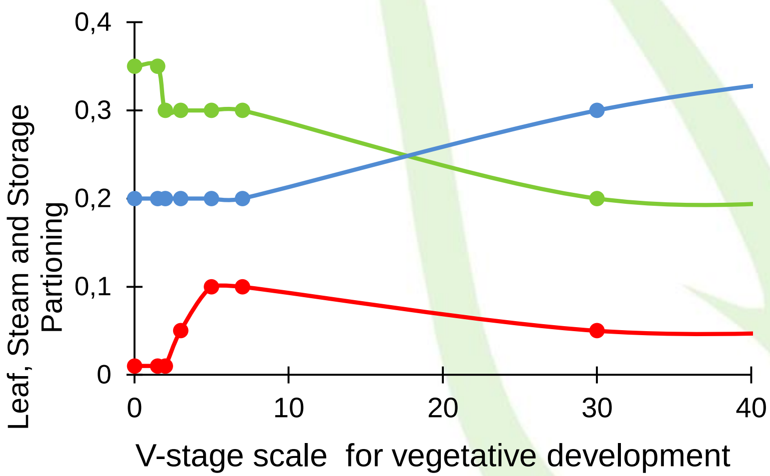
- **Leaf senescence parameters:** dormancy-freezing, 5% foliage loss per C below -2C

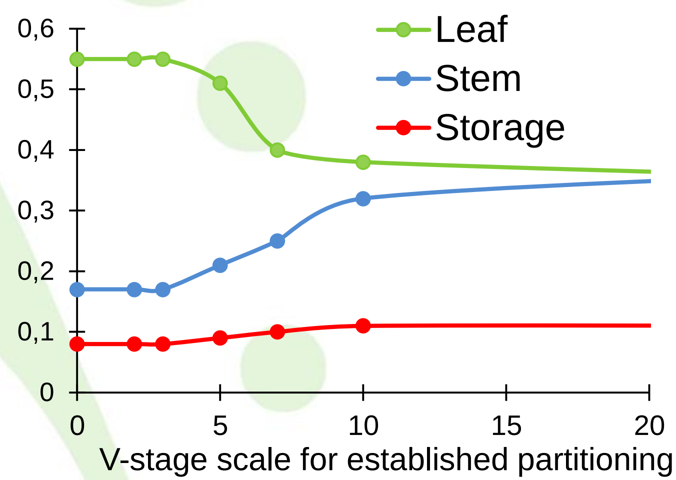
Results and discussion

Adaptation process

➢ **Calibration of vegetative and perennial partitioning**

Dry matter partitioning among leaf, stem, storage and roots (transition from seedling partitioning to perennial partitioning, after SDLEST=60ptd), comparisons of predicted vs. observed data and literature (more leaf allocation)





➢ **Nodule Growth and N2 Fixation** (symbiosis "on") adjustments of temperature sensitivities affecting nodule growth and N2 fixation rate, also initial nodule mass.

-1.00	**19.0**	**30.0**	44.0	LIN	FNNGT(4),TYPNGT-TEMP EFF ON NODULE GROWTH
-2.00	**15.0**	**30.0**	44.0	LIN	FNFXT(4),TYPFXT-TEMP EFF ON N FIXATION

Results and discussion

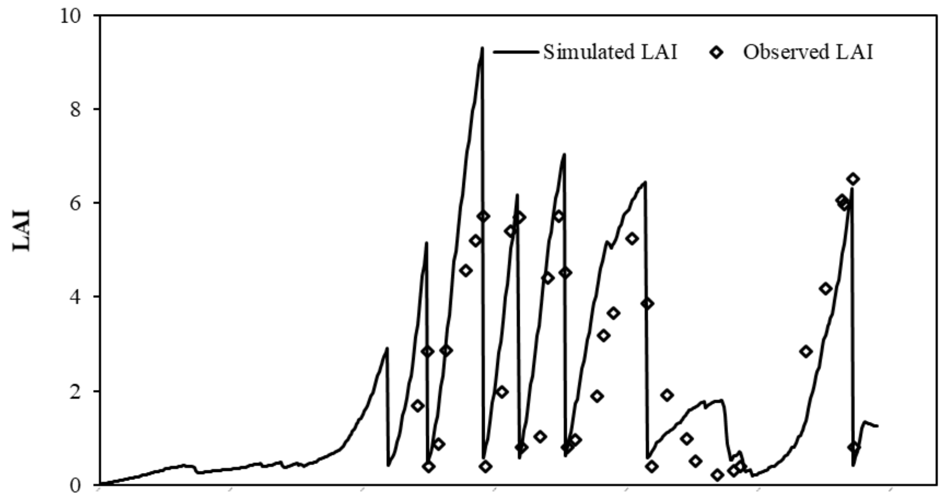
Total biomass, herbage yield, leaf area index (LAI), herbage crude protein (CP), shoot nitrogen concentration (N) and the corresponding statistics averaged over 6 experiments (n=58 herbage harvests).

	Observed data		Simulated data		Ratio (obs./sim.)	RMSE	d-Statistic
	Mean	Range	Mean	Range			
Total biomass (kg DM ha^{-1})	3889	1706-5617	3751	1983-6434	1.04	728	0.76
Herbage yield (kg DM ha^{-1})	2907	990-4617	2810	1278-5475	1.03	760	0.75
LAI (m^{2}m^{-2})	2.5	0.1-6.7	3.0	0.41-9.6	0.81	2.0	0.71
CP (% of DM)	20.3	16-27	19.9	14-26	1.02	5.2	0.39
N (% of DM)	3.7	2.5-5.5	2.8	1.8-3.7	1.3	1.0	0.3

Good results

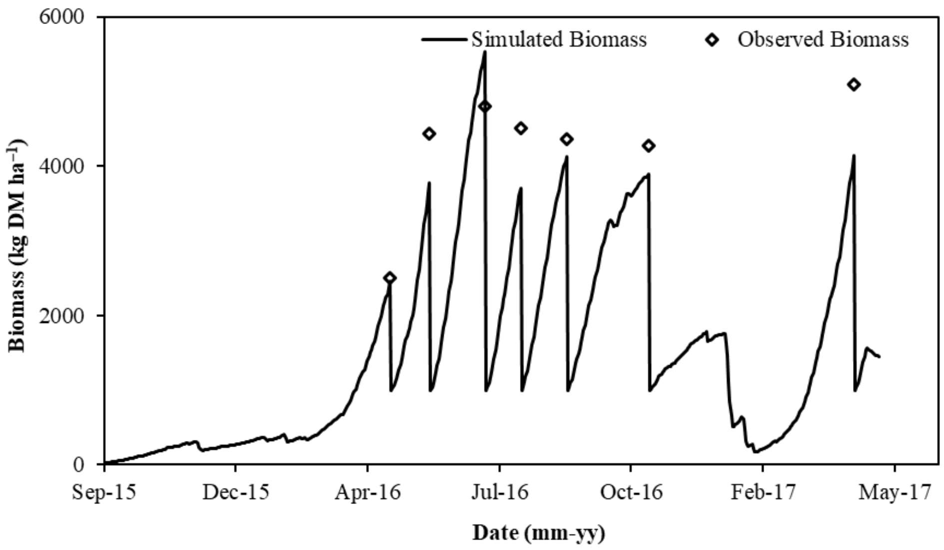
Results and discussion

Exp. 1 (“ H 209-A” case)



(n=37)	LAI ($m^2 m^{-2}$)
Observed	**2.83**
Simulated	**2.65**
RMSE	**2.15**
d-Statistic	**0.73**

(n=7)	Biomass (kg DM ha^{-1})
Observed	**4281**
Simulated	**3947**
RMSE	**625**
d-Statistic	**0.85**



Conclusion (summary)

- Adaptation of the CSM-CROPGRO-PFM model for alfalfa was accomplished by changing parameters and relationships describing species tissue compositions, partitioning, and the species' cardinal temperatures for responses of processes to environmental variables.

- The CROPGRO-PFM is able to simulate alfalfa growth and yield.

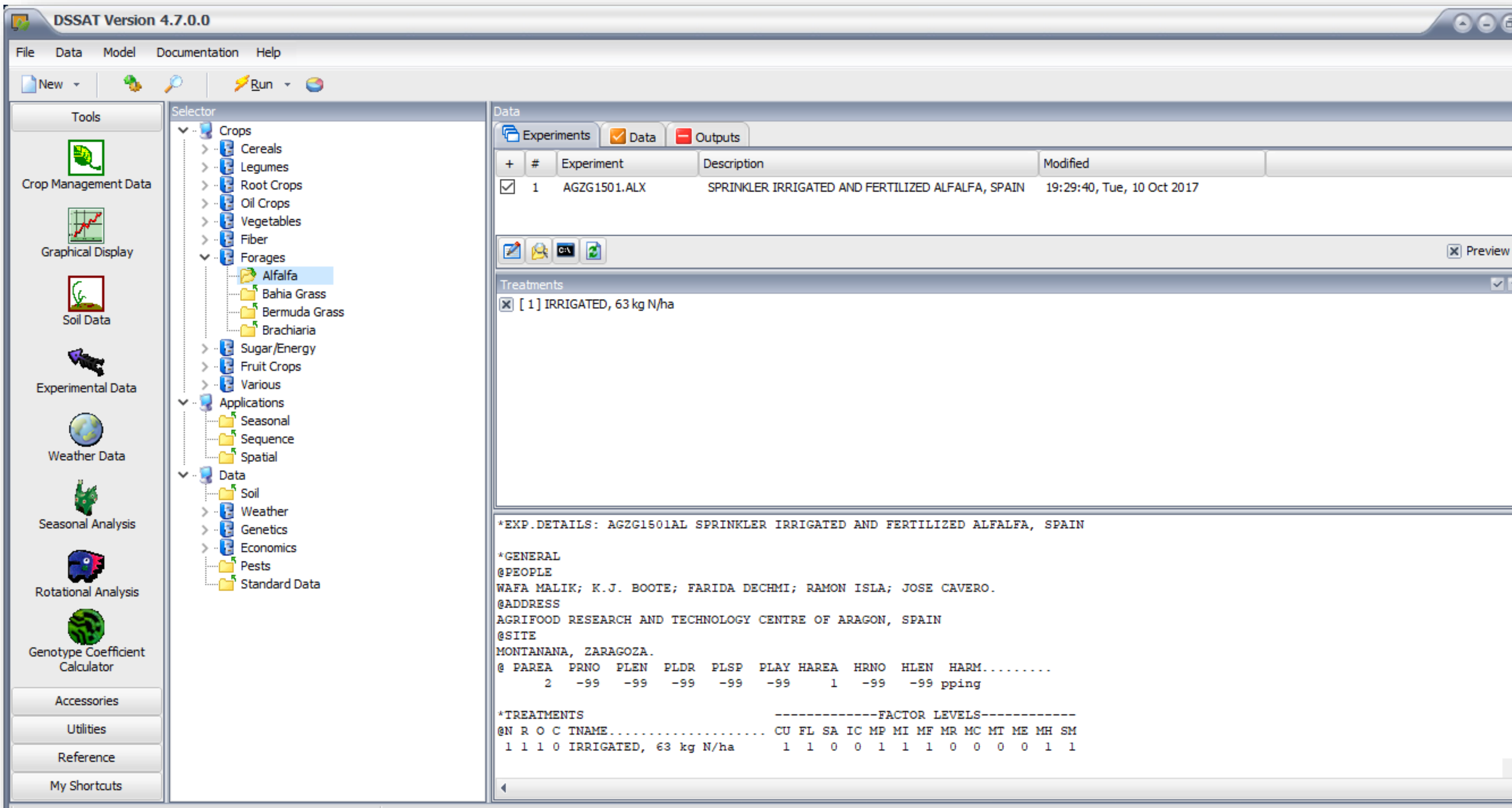
- As a first working version, the modified forage version of CROPGRO model marks a significant step in adapting the model to simulate the growth and yield of alfalfa.

- Further improvement and adaptation for composition tissues and dynamics of carbon and nitrogen remobilization during regrowth. Parameters may be easily adjusted as new knowledge becomes available.

Conclusion (summary)

DSSAT Interfaz Windows

DSSAT version 4.7 (Hoogenboom et al., 2017)



Conclusion (summary)

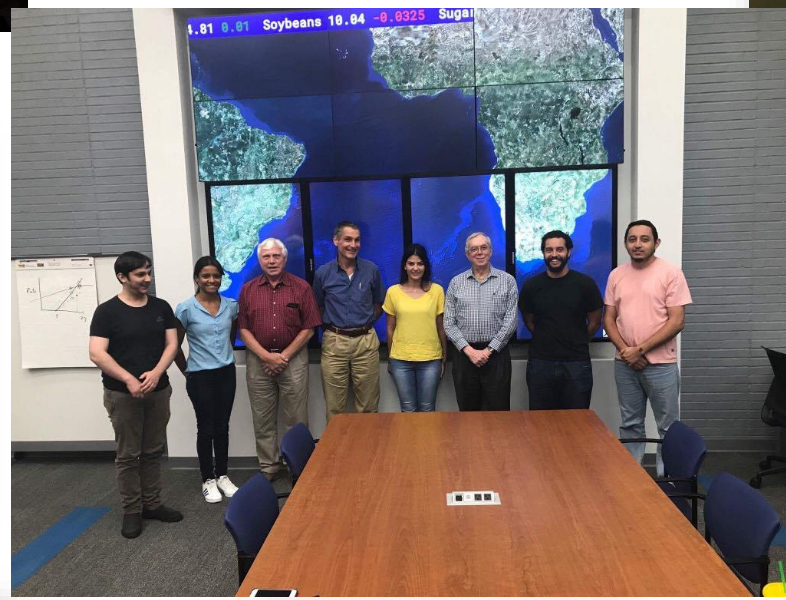
Journal Impact Factor

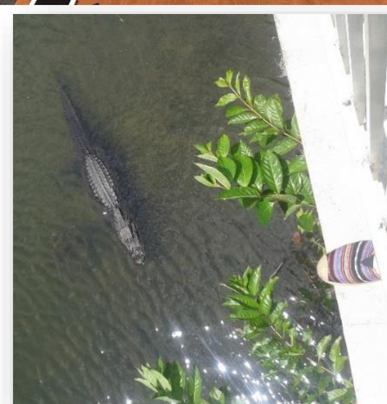
- ***Malik W., Boote K.J.,Hoogemboom G., Cavero J., Dechmi F., 2018.*** Adapting the CROPGRO model to simulate alfalfa growth and yield. “Accepted” (Agronomy Journal).

International Congress

- **K. J. Boote, D. N. L. Pequeno, P. Alderman, S. Rymph, M. Lara, B. Pedreira, W. Malik, and L. Moreno ,** 2018: Introducing the CROPGRO Perennial Forage Model for Tropical and Temperate Grasses and Legumes. AgMIP7 Global Workshop. San Jose, Costa Rica, April 24-26.


Alfred A. McKethan Stadium
University of Florida


Soybeans 10.04 -0.0325



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Thank You!

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