2011 SWAT International Conference, June 15-17, Toledo

APPLICATION OF SWAT MODEL TO A SPRINKLER IRRIGATED WATERSHED IN THE MIDDLE EBRO RIVER BASIN (SPAIN)

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Introduction

- Agricultural practices, such as irrigation and fertilization, are commonly considered as being sources of water and soil contamination (Sharpley, 1995; Burkholder et al., 1997).

- In agricultural irrigated systems (such as the Ebro River watershed systems, Spain), the irrigation returns flows (IRF) are the major nonpoint source pollution of surface and groundwater bodies (Aragües and Tanji, 2003).

- A widespread control of contaminants and irrigation water inputs is an effective solution to prevent further deterioration and establish the best management practices (BMPs).

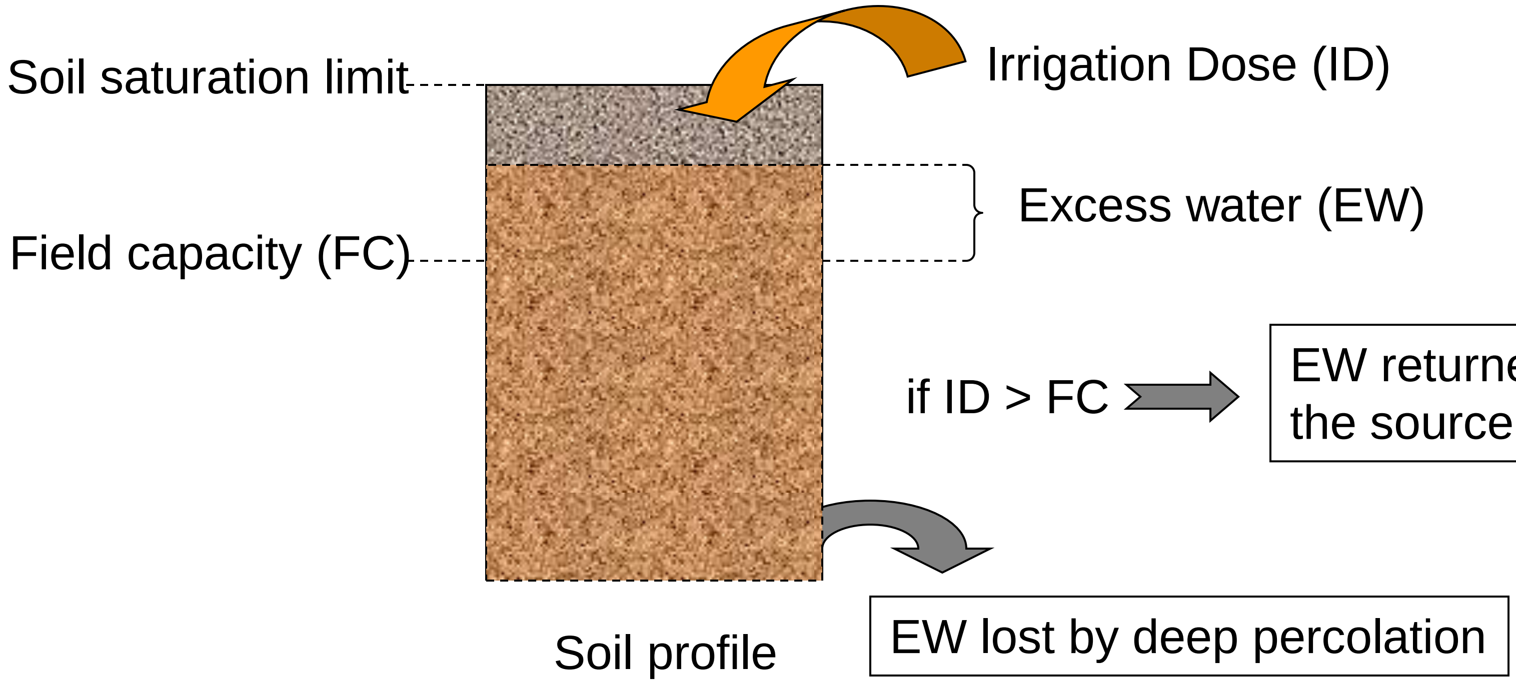
- Conducting fields experiments and collection of long-term data is very expensive (cost of instrumentation and operation) and time consuming (Santhi et al., 2006).

- Application of watershed simulation models is an alternative to evaluate BMPs performance in reducing nutrients contamination from irrigated agricultural watersheds and for making management recommendation.

Introduction

- SWAT model (version 2005), was considered to assess the effectiveness of post-implementation of the BMPs in the middle Ebro River Basin, Spain.

- Application of SWAT2005 original using real farmer irrigation practices was not possible because of it's limitation on the irrigation dose maximum value that could be applied as an irrigation event when the source is outside.

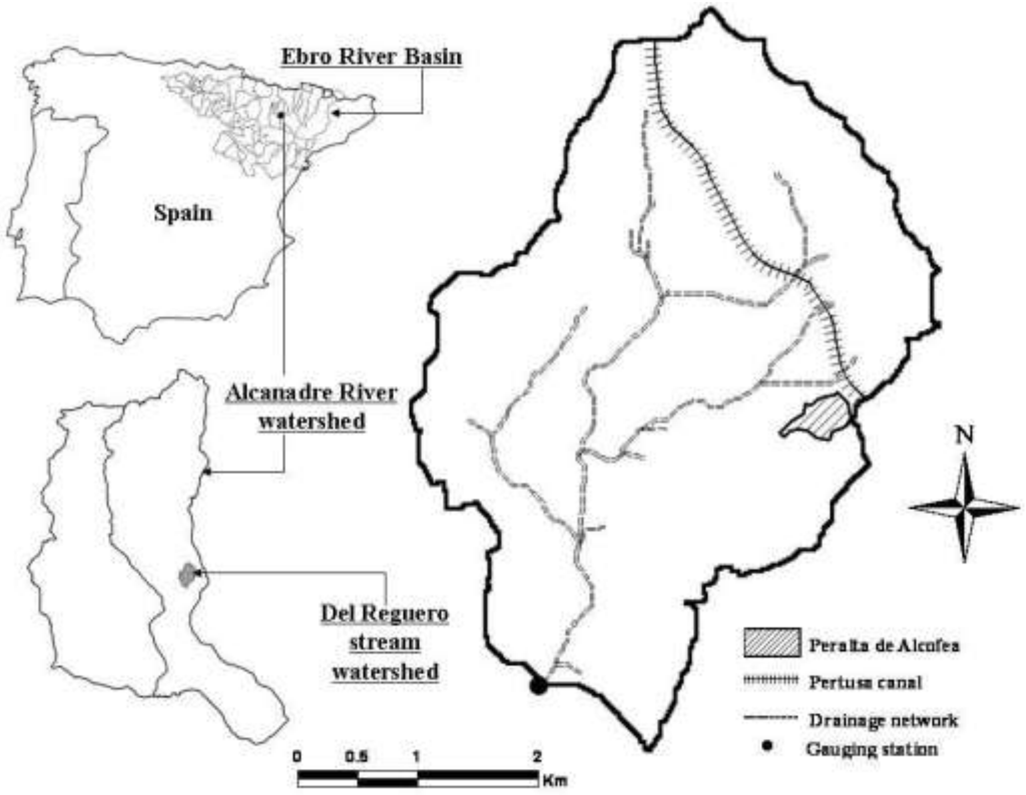


Objectives

1. Modification of SWAT model to improve it performance in the middle Ebro River Basin irrigation systems (Spain).

2. Evaluation of SWAT performance in modeling water flow, sediments and phosphorus by comparison between observed and simulated data.

Study zone



- **Surface**: 1,865.5 ha (**71%** under irrigation)
- **Climate**: semiarid
- **Average Precipitation**: 391 mm
- **Average PET**: 1294 mm
- **Irrigation systems**: solid-set sprinkler
- **crops**: corn, alfalfa, sunflower, barley

Location of the Del Reguero watershed

Methodology

1. Model modification

- Maximum amount of water to be applied;
- Processes used to calculate water percolation;
- Soil water routing order;

SWAT-2005 ⇨ **SWAT-IRRIG**

Methodology

2. Model modification

1- The maximum amount of water to be applied corresponds to depth of irrigation water applied to HRU specified by the user instead of the amount of water held in the soil profile at field capacity.

2- As the model percolation calculation subroutine includes only precipitation excess, a new variable, that correspond to water excess generated from irrigation practices when the amount of irrigation water applied exceed the soil layers field capacity, was added in the soil percolation depth calculation.

3- In SWAT2005 source code, the subroutine “*subbasin*” that controls the simulation of the land phase of the hydrologic cycle, the soil water routing is performed before performing the irrigation operations from sources outside watershed. SWAT-IRRIG perform the irrigation operations before performing the soil water routing.

Methodology

3. Model calibration and validation

Simulation periods:

a) **Warm-up**: January 1st, 2007 to January 14th, 2008

b) **Calibration**: January 15th, 2008 to December 31st, 2008

c) **Validation**: January 1st, 2009 to December 31st, 2009

Observed data:

a) **Streamflow**: using daily observed data

b) **TP, TDP, PP**: using daily observed data

c) **TSS**: using weekly observed data

Methodology

4. Model performance evaluation

a) Nash-Sutcliffe Efficiency (NSE)

b) Root Mean Square Error (RMSE)

c) Percent Bias (PBIAS)

d) RMSE-observation standard deviation ratio (RSR)

e) Coefficient of Determination (R^2)

5. Model performance criteria (satisfactory)

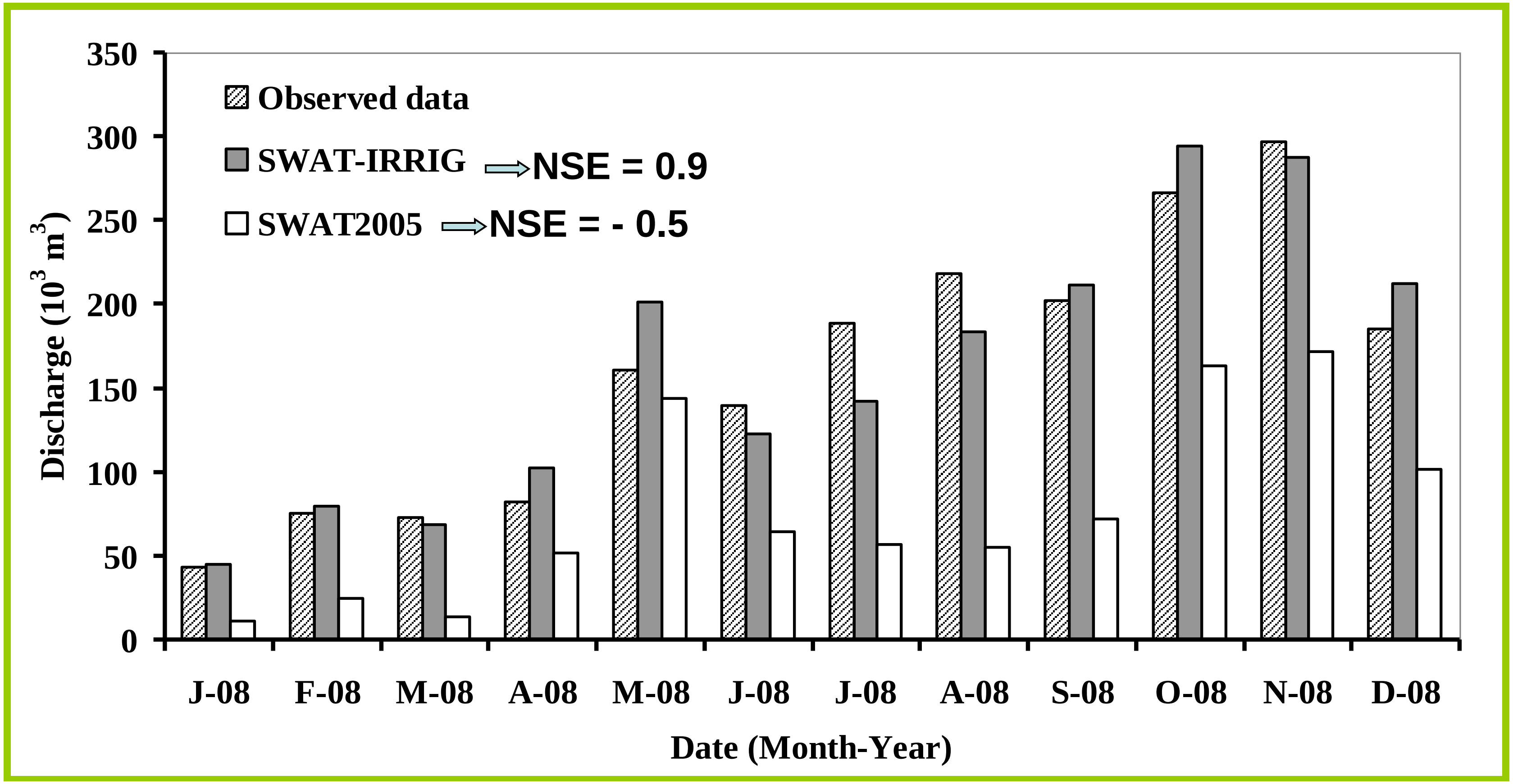
a) **Water flow**: NSE > 0.5; RSR ≤ 0.7; PBIAS ± 25%

b) **TP, TDP, PP**: NSE > 0.5; RSR ≤ 0.7; PBIAS ± 70%

c) **TSS**: NSE > 0.5; RSR ≤ 0.7; PBIAS ± 55%

Results

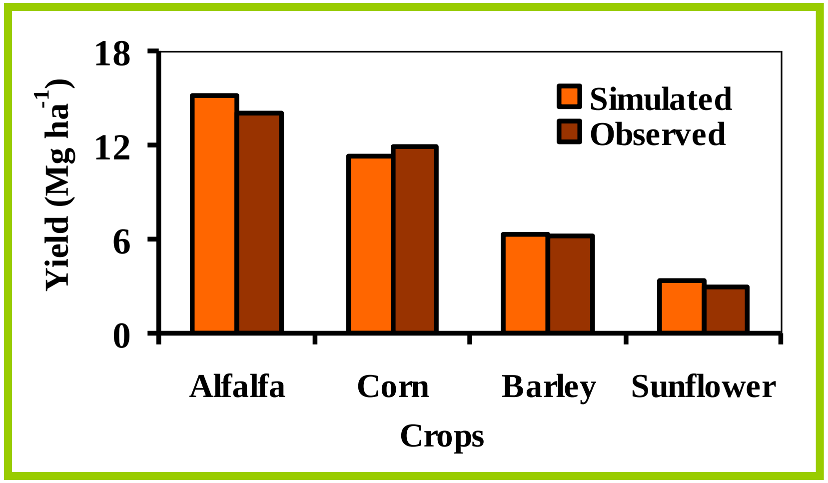
1. SWAT2005 *vs.* SWAT-IRRIG



Comparison of monthly discharge between observed data and, simulated using SWAT2005 and SWAT-IRRIG.

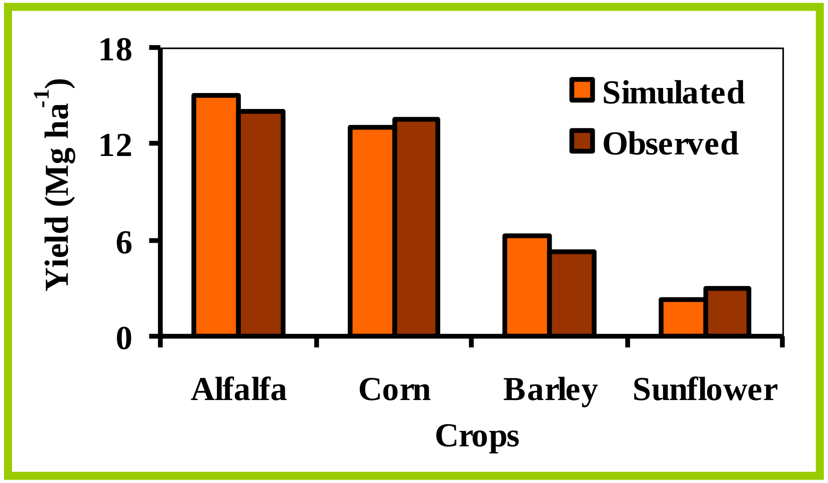
Results

2. Crop model calibration and validation



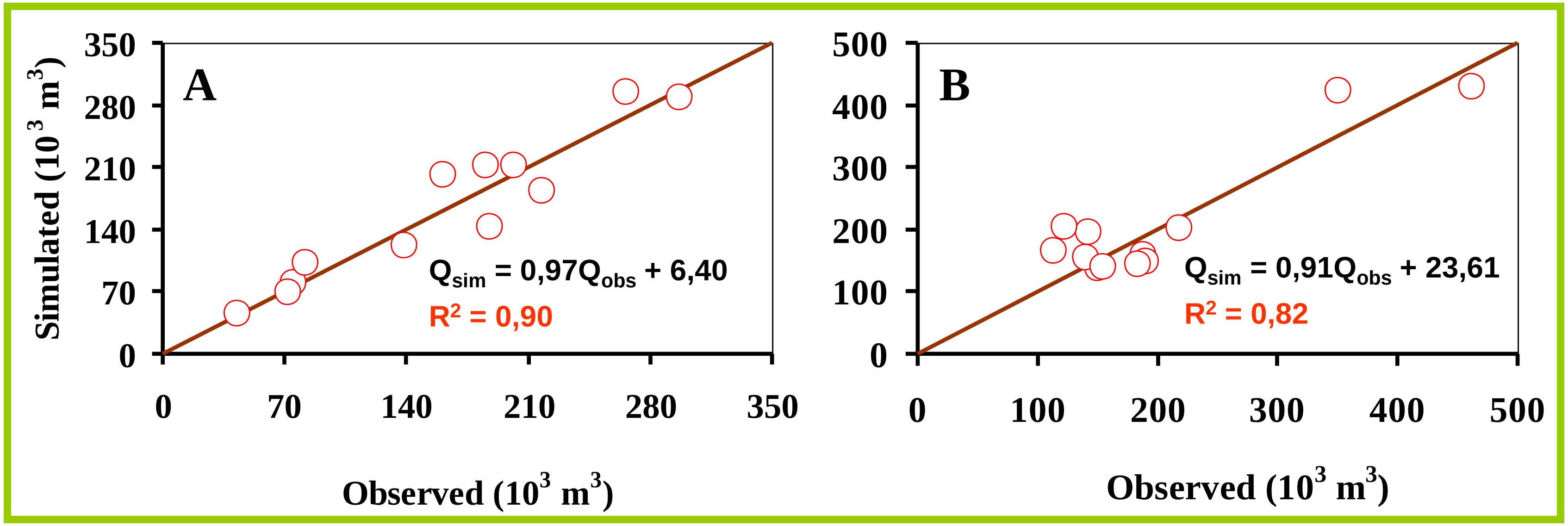
Calibration (2008)

Validation (2009)



Results

3. Streamflow calibration and validation



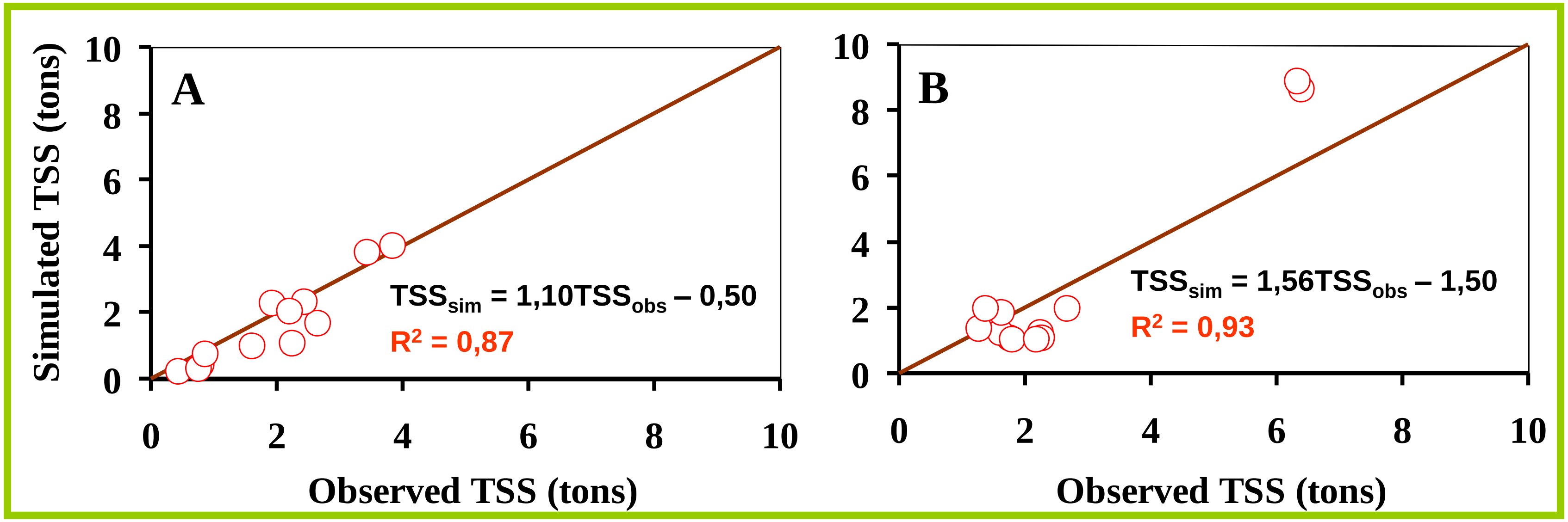
Comparison between monthly stream discharge observed and simulated with SWAT-IRRIG at DRW outlet for the calibration (A) and validation (B) periods. The diagonal line represents the 1:1 relationship.

Statistic parameter	Calibration (A)	Validation (B)
NSE	0.90	0.80
PBIAS (%)	1,1	3,2
RSR	0.33	0.45
Predictive criteria[1]	Very Good	Very Good

[1] Moriasi et al., 2007

Results

4. Sediments calibration and validation



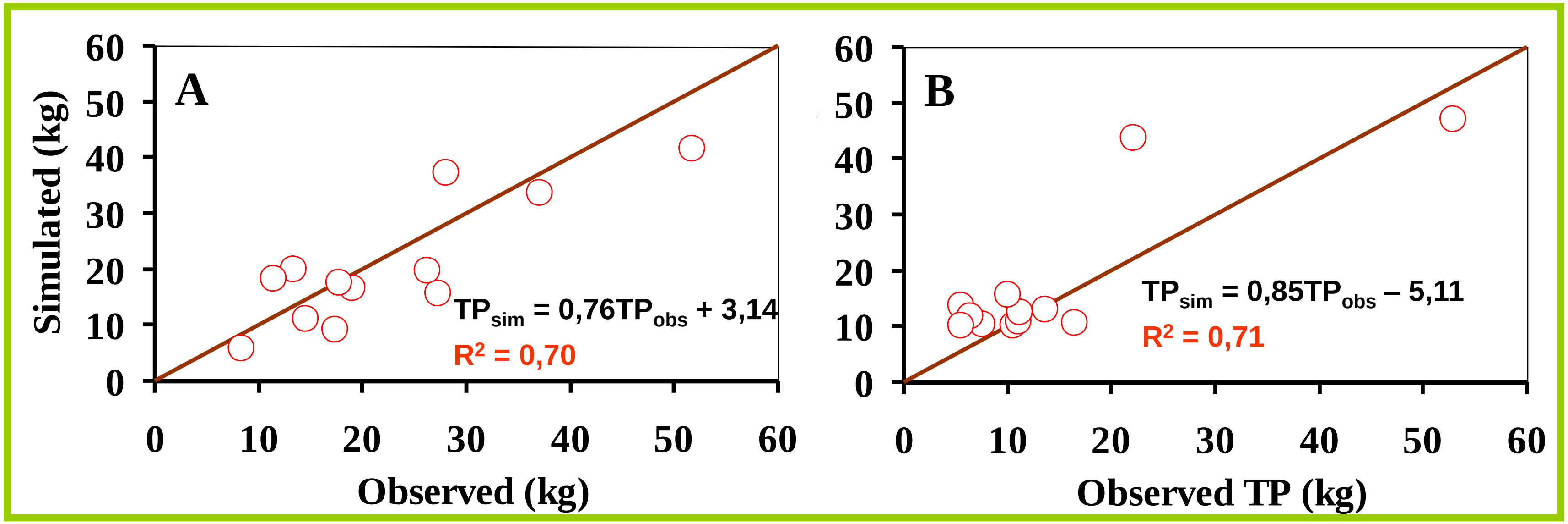
Comparison between monthly TSS loads observed and simulated with SWAT-IRRIG at DRW outlet for the calibration (A) and validation (B) periods.

Statistic parameter	Calibration (A)	Validation (B)
NSE	0.72	0.52
PBIAS (%)	-15.9	-1.4
RSR	0.38	0.27
Predictive criteria[1]	Good	Satisfactory

[1] Moriasi et al., 2007

Results

5. TP calibration and validation



Comparison between monthly TP loads observed and simulated with SWAT-IRRIG at DRW outlet for the calibration (A) and validation (B) periods.

Statistic parameter	Calibration (A)	Validation (B)
NSE	0.66	0.63
PBIAS (%)	-9.8	20.9
RSR	0.57	0.56
Predictive criteria[1]	Good	Good

[1] Moriasi et al., 2007

Conclusions

1. SWAT2005 doesn’t reproduce the irrigation return flow at the outlet of intensive irrigated systems.
2. Alternatively, the modified version (SWAT-IRRIG) showed better model performance under sprinkler irrigated systems.
3. Monthly model calibration and validation indicated a “very good” SWAT-IRRIG performance in describing stream discharge at the outlet of the study area.
4. Monthly calibration and validation results indicated “good” and “satisfactory” SWAT-IRRIG performance in describing TP and sediment yields in Del Reguero watershed, respectively.
5. Finally, the calibrated SWAT-IRRIG for hydrology, sediments and phosphorus can be used to determine the effects of different best management practices scenarios on phosphorus transfer from irrigated agricultural land to the water bodies.


THANK YOU VERY MUCH