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Irrigation management of durum wheat in the Mitidja plain (Algeria): Water balance models comparison and validation

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SUMMARY – In Algeria cereal crops are confronted with adverse constraints which include the irregularity of rainfall and the variability of the climate. The water remains the main factor which explains the variations of crop yields because the drought can appear at any time during the cultural cycle. Within the framework of research projects conducted in the Department of Rural Engineering of the National Agronomic Institute, two models concerning the complement irrigation were tested on cereals over the Mitidja plain in the experimental station at the National Institute Agronomy (Algiers). The experimental station is located under a Mediterranean climate. The trials were realized with a durum wheat culture variety Vitron during three campaigns 1999/2000, 2000/2001 and 2001/2002 with devices including differentiated irrigation regimes. The main objective of these experiments was to validate two water budget simulation models, *"Bilhyna"* (INRA, Paris, France) and *"Pilote"* (CEMAGREF, Montpellier, France). The main difference of these two models is that Bilhyna includes the estimation of deep water fluxes by means of finite difference resolution of the Richard's equation while Pilote uses the principle of reservoirs limited by the maximum root depth.

Key words: Drought, Bilhyna, Pilote, irrigation, durum wheat variety Vitron.

RESUME – *"Gestion de l'irrigation du blé dur dans la plaine de la Mitidja (Algérie) : Comparaison et validation de modèles de bilan en eau". En Algérie la céréaliculture est confrontée à diverses contraintes dont notamment l'irrégularité des pluies et la variabilité du climat. L'eau reste tout de même le facteur limitant qui explique pour une bonne partie les variations des rendements. Une des causes des chutes des rendements reste l'effet de la sécheresse qui peut apparaître à tout moment au cours du cycle de la culture. Dans le cadre de projets de recherche menés au département du Génie Rural de l'Institut National Agronomique – laboratoire pour la maîtrise de l'eau en agriculture – nous avons testé deux modèles de gestion de l'irrigation de complément sur céréales au niveau de la Mitidja à la station expérimentale de l'Institut National Agronomique d'El Harrach. La station expérimentale est caractérisée par un climat méditerranéen. Les essais ont été réalisés sur la culture de blé dur variété Vitron durant les campagnes de 2000 à 2002 avec des dispositifs comprenant des régimes d'irrigation différenciés afin de valider les modèles de simulation avec des situations variées. Ainsi, nous avons utilisé les modèles de simulation* "Bilhyna" *et "*Pilote", *respectivement élaborés par l'INRA France et le CEMAGREF de Montpellier (France). Le modèle* "Bilhyna" *permet d'estimer les flux profonds à l'aide de la résolution par différences finies de l'équation de Richards. Le modèle* "Pilote" *est basé sur le principe des modèles de gestion du réservoir sol multicouches.*

Mots-clés : *Sécheresse,* Bilhyna*,* Pilote*, irrigation, blé dur variété Vitron.*

Introduction

The study of water balance on plots depends essentially on both mass and heat transfer and local edaphic characteristics. The new developments on irrigation management modeling allow the description of various scenarios of irrigation under Mediterranean climatic conditions.

The main objective of this study is the calibration and validation of two water budget models called "Bilhyna" and "Pilote" by trials irrigations in the case of durum wheat in Mitidja plain. The two models are based on different approaches for water transfer and crop growth kinetics. The validation consists on the comparison between "simulated" and "measured" following outputs:

(i) Water soil content.

(ii) Leaf area index.

This study joins the term of three (03) experimental campaigns having concerned the growth of durum wheat variety Vitron under two (02) hydrous treatments: rained (PLU) and irrigated (IR). The campaigns of measures during the trials have concerned the hydrous state of the soil (moisture content) and the physiological parameters of the culture (leaf area index, temperature of crop, relative moisture content, leaf potential, root depth…).

Modelling of water balance: The Bilhyna approach

Bilhyna is an agropedoclimatic water balance model working at a daily time step. It assumes physical equations and integrates several modules:

(i) The soil module containing equations of calculations of the water reserve and the deep flows by the numerical resolution of the Richards equation.

(ii) The crop module which simulate the leaf area index (LAI) variations.

The model also runs to estimate the mulch effect, the runoff – infiltration and the captation.

Main inputs are related to the soil (moisture contents in the field capacity, in the wilting point, in the saturation, bulk density of soil…); the crop (maximal leaf area index, sum of temperatures, maximal root depth…) and the climate allowing the calculation of the potential evapotranspiration (ETP) of Penman - Monteith. The major outputs are water consumption by crops (ET_C) and water balance of the soil. It also applies for real time irrigation scheduling and predicts scenario of crop production versus water income (forward-looking scenarios) (Rosnoblet, 2002).

Modelling of water balance: The Pilote approach

Pilote is a water balance model based on reservoirs functioning. It simulates at the daily time step the terms of water balance: leaf area index, sum of temperatures, dry matter and crop yield. As pilot has been proven to be robust and field operational, it can be applied to identify strategies of irrigation (Mailhol *et al.*, 1997). It requires climatic parameters (to calculation of the ETP Penman – Monteith), soil (humidity in the field capacity and wilting point) and crop data (maximal depth root, sum of temperatures at maturity, maximal leaf area index…).

Materials and methods

The trial were conducted for the 2000/2001, 2001/ 2002 and 2002/2003 campains at the experimental station of INA located at 36°43' North of latitude, 3°08' East of longitude and 48 m of latitude. The station is characterized by a Mediterranean climate in sub-humid bioclimatic floor with a rainy winter and a warm and dry summer (Aidaoui and Hartani, 2000). The durum wheat variety *Triticum turgidum* L var. *durum*) was selected for its good adaptation to similar climatic conditions (Chennafi, 2007). The soil is rather silty clayey with a slight alkaline pH trend.

The experimental devices were realized on complete randomized blocks including two (02) levels of treatment: rain (PLU) and irrigated (IR) under sprinkler irrigation. The measures concerned in particular moisture contents in horizons explored by roots (gravimetric method) and leaf area index (LAI). They were nest used to valid the models.

Results and discussions

Soil hydrous kinetics

Through the results for the three (03) campaigns from 2000 to 2002, we can see that the reserves evolutes about the rhythm of rains and irrigations (Figs. 1 and 2). Their evolution show on the whole two phases, one during which reserves remain more or less high and sometimes near to the field capacity, and the second until late growth cycle. For the rain treatments the reserve of water in the soil decrease gradually, it is due to a combination between a depletion of the soil water by roots reaching at this time their maximal growth and an absence of water (rain and irrigation), to note that irrigated treatments when irrigation made in the absence of rains have increased, every time, the reserve. These irrigation doses have allowed keeping the crop in hydrous comfort. Stocks of water of the trial campaigns of 2002 approach the critical threshold due to absence of rains inputs and inadequate irrigations. It may also be noted that the end of the cycle and in all cases, the reserve simulated by Pilote tends to approach more quickly the critical threshold (wilting point) probably because of a difference approach of the functions of hydrous stress.

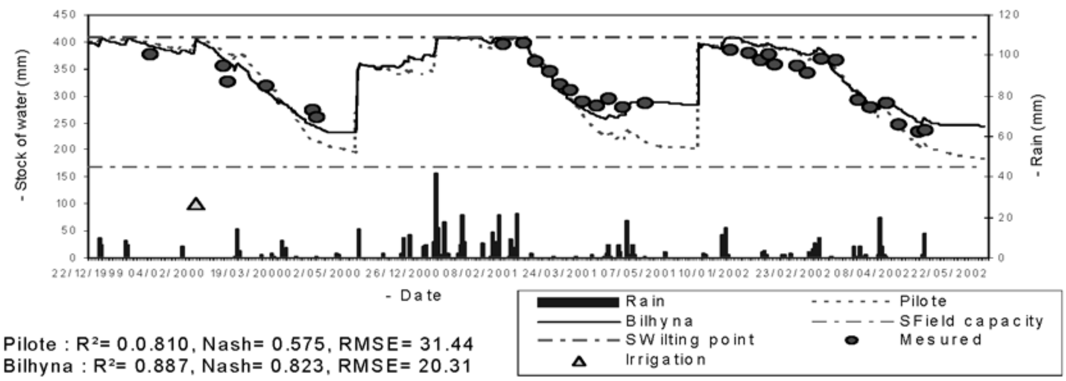

Fig. 1. Evolution of soil water content (rainfeld treatment).

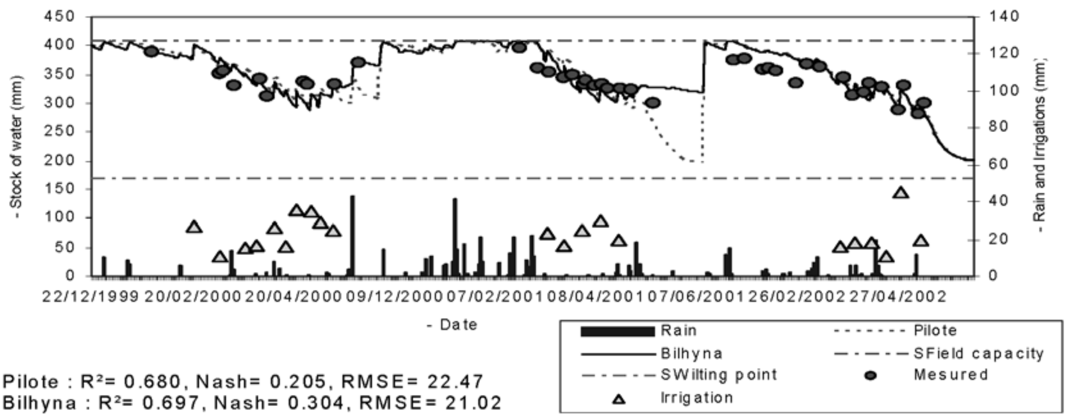

Fig. 2. Evolution of soil water content (irrigated treatment).

The comparisons between the two approaches Bilhyna and Pilote, show a fairly good correlation between the reserves simulated particularly during input water (irrigation and rain). The insertion of the measured values of reserves in the whole show a fairly "good" calibration with reserves simulated by the two approaches, the few difference distorsions) came certainly from the fact that the gravimetric method presents a fairly high variability of the results obtained.

The correlations between the soil water reserves simulated by the two models and measured, and the statistical parameters of equations obtained show that the models simulate significantly the soil moisture.

Leaf area index (LAI) kinetics

The charts of LAI for the two hydrous treatments (rained and irrigated, Figs. 3 and 4), show that there are significant discrepancies between the LAI simulated by Bilhyna and Pilote at least during senescence. However, it should be noted that the LAI_{max} obtained by the two approaches seem to be occur at the same periods, and reflect quite well the value of LAI_{max} of 7.0 taken as input data. Comparisons between LAI simulated and measured seem show fairly concordant on the whole. However, the Bilhyna model seems simulate more significantly the LAI compared with the Pilote model.

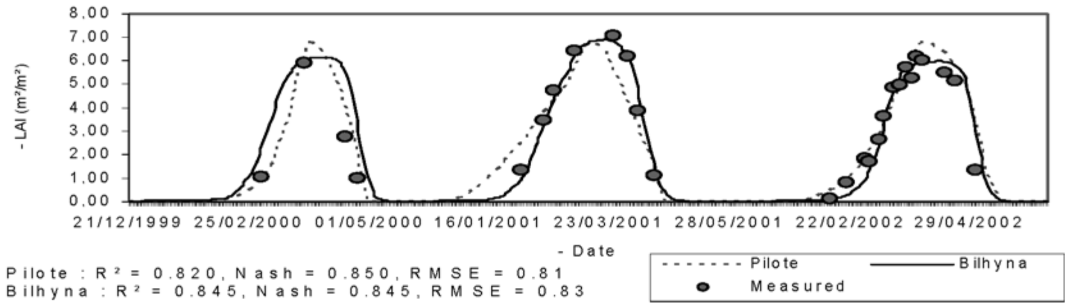

Fig. 3. Evolution of the leaf area index (rainfed treatment).

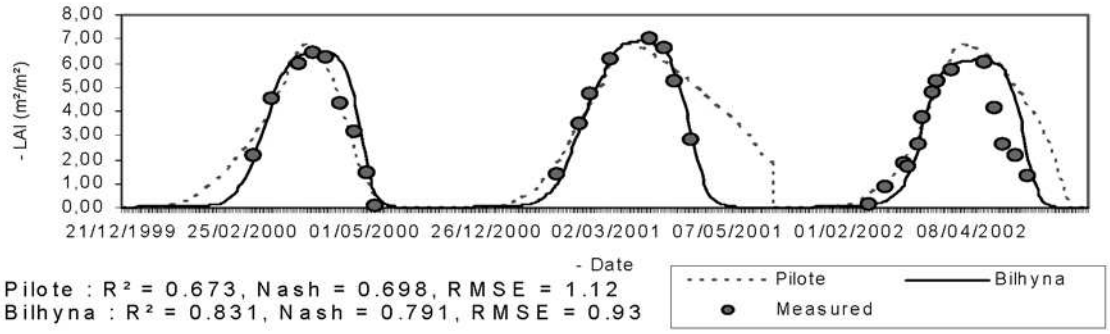

Fig. 4. Evolution of the leaf area index (irrigated treatment).

Statistical analyses between the LAI simulated and measured values have also led to significant results to validate the two models.

General conclusion

The analyses of evolutions of simulated reserves have found that they remain almost identical especially in the midst of vegetative growth then separate at end of cycle (Pilote simulating of reserves approaching much faster to the critical threshold of wilting point). The relationship obtained by the calibration of simulated and measured reserves was satisfactory for both models Bilhyna and Pilote.

The Bilhyna and Pilote models can reach the LAI_{max} occur at the same periods, but present a distortion in growth and senescence phases.

The relationship obtained by the calibration of LAI measured and simulated are acceptable to the particular Bilhyna model. We also found that the best adjustments are obtained for the irrigated treatment.

Finally, we can conclude that the Bilhyna model taking into account many more factors and aspects that Pilote, helps us to better understand the phenomena related to water and kinetics of growth. The Pilote model, which is much more simplified view of the input parameters, can be used in similar situations to our experimental conditions. We suggest lastly, using the Bilhyna and Pilote models in an operational framework of irrigation management in order to conclude a validation and to complete the adjustments we have made.

References

Aidaoui, A. and Hartani, T. (2000). Gestion de l'irrigation du blé dur par des indicateurs de l'état hydrique, INA-Algiers. L'amélioration du blé dur dans la région méditerranéenne. *Options Méditerranéennes*, Series A, 40: 579-582.

Chennafi, H. (2007). Stratégie de gestion des apports d'eau limités sur la culture du blé dur (*Triticum durum* Desf.) en milieu semi-aride. PhD Thesis, Agronomic National Institute, Algiers.

Mailhol J.C., Olufayo, A. and Ruelle, P. (1997). Sorghum and sunflower evapotranspiration and yield from simulated leaf area index. *Agricultural Water Management*, 35: 167-182.

Richards, L.A. (1931). Capillary conduction of liquids in porous mediums. *Physics*, 1: 318-333.

Rosnoblet, J. (2002). *Dynamique du bilan hydrique parcellaire au sein de l'espace rural - Conséquences sur les transferts hydrologiques*. PhD Thesis, Agronomic National Institute, Paris.