Application of the Model SUNFLO For Sunflower Crop (Helianthus Annuus L.) In The Semi Arid Region of Chlef (Algeria)

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Abstract

Variety assessment could be supported by the use of dynamic crop modelling. The SUNFLO model was developed to simulate the achene yield and oil concentration of sunflower crop with a special attention paid to the description of varietal diversity. For that purpose, a variety was characterized in the model by 12 parameters of phenology, leaf area development, allocation and response to water stress. These parameters were measured either in field conditions (dense stands) or in greenhouse pot experiments. The originality of the model is that it SUNFLO [7,11], can account for differences between genotypes on different criteria (penology, their architecture, their behavior in response to water stress and how they fulfill their seeds) and the fact that these features are available because they are measurable only in trials evaluating varieties in the field or greenhouse. SUNFLO model allows predicting the performance of the oil content of sunflower on the scale of a plot and calculates indicators of stress experienced by the culture. The yield of a given variety in a given environment was simulated with a mean error of 5 q.ha-1 (relative error = 16 %). When averaging a variety over all the environments or an environment over all the varieties, the error was of 3.5 q.ha-1 (relative error = 11 %). The model could be used to rank environments (through sunflower crop response) in a variety assessment network and to separate varieties with sufficient phenotypic differences.

Keywords: crop model, sunflower, variety assessment, genotypic parameter

1. Introduction

Sunflower models should adequately quantify the water balance and growth responses to environment to predict yield over the wide range of conditions in which the crop is grown. However, most models for sunflower growth and yield are simple and simulate few processes. Yield has been regressed against weather variables to predict yield in some areas [14].

Culture models consist of a set of mathematical relationships describing the operation of the dynamically agrosystem whose time stepis most often daily [20]. They comprise a set of input variables (daily climate, cultivation techniques, the initial state of the system start of the simulation), parameters (constants mathematical equations) state variables (variables describing the system every day, such as biomass Aerial culture) and output variables (chain-end simulation) such as crop yield, oil content [2];[5]. If the representation of the plant incorporates the differences between genotypes, the model can generate interactions between these genotypes and the Environment (IGE), although they are not explicitly included in the model [16]. One example is the interaction between genotypic sensitivity to stress and the type of water stress which may explain differences in behavior of the same genotype in environments varied [4,7].

Dynamic simulation models were developed in 1980s make account the response to stress of a culture major abiotic (temperature, radiation, water, nitrogen) [12].

For most of the parameters that are cropping knowledgeable in these models, the question of genetic variability is asked [3]. Several recent examples simulation models that can be mobilized effectively to understand and predict the interaction variety × environment × conduct [1, 13].

In sunflower, there are already several Simulation models of culture. Some are specific to sunflower [9, 19, 15], others represent culture generically [6, 17]. However, the parameterization of these models is not backed phenotyping explicit genetic variability. In addition, the number of parameters, often high, making it difficult to update regular parameters compatible with varietal innovation. For these reasons, the simulation model SUNFLO was developed by [7]. This model simulates dynamically performance (yield, oil content [TH]) sunflower varieties based major abiotic stresses and line culture. A number of characters are measured dense stands in the tests so-called VAT (Value for Cultivation and Technology) [18]. This is why method chosen for phenotyping SUNFLO used for VAT and complete this set flow varieties listed each Sunflower year (approx 20-30) [10].
The objective of this paper is to present:

- The phenotyping method developed for SUNFLO;
- Phenotypic variability observed among recent varieties for some characters studied;
- The setting of quality and SUNFLO adjustment;
- Model evaluation SUNFLO network.

1. Materials and Method

The culture model SUNFLO simulates day after day the progression of rooting, the development of leaf area and air biomass sunflower within the constraints of temperature, radiation, water and nitrogen[8]. Biomass production is a function of the energy intercepted by the canopy. The model is based on development and senescence distributed leaf area and not approach 'big leaf'. Environmental constraints involved so multiplicative potential to reduce production permitted by the radiation and temperature.

The model divides the cycle into 6 phases using the thermal time (4.8 ° C basis):
(i) drill (A0)-emergence (A2) (ii) A2-button star (E1) (iii) E1-F1 stage (early flowering), (iv) F1-M0 stage (early filling seeds), (v) M0-M3 stage (physiological maturity), (vi) M3-M4 stage (harvest). Each step change induced differentiated physiological processes.

The absorption of water and nitrogen is measured daily and stress indices are calculated to reflect the multiplicative effect of these two constraints on leaf expansion and biomass accumulation. The yield is estimated by the through a harvest index applying to the total dry matter produced at physiological maturity and not from yield components. The harvest index (IR) and oil content (TH) are estimated by multiple linear regressions including varietal potential parameters (IRpot, THpot) and state variables of the population estimated by the model. Twelve genotypic parameters used to characterize and differentiate varieties operation (Table 1): 4 phenology parameters, leaf architecture 4 parameters, two parameters of response to water stress, 2 allocation parameters of photosynthetic products to the seeds. Most of these parameters are measured directly in the field (plots VAT) or greenhouse. Some are calculated from field measurements: the case of M0 and E1 stages and the extinction coefficient of the light (k). The soil is described by the Reserve height (mm) on the depth of soil available to plant roots and by the rate of mineralization potential of nitrogen (kg N / j normalized).

The climate for daily use simulation includes five variables: maximum and minimum temperatures, precipitation, potential evapotranspiration, global radiation. Driving culture is described by the date of seeding density of lifting, dates and amounts of water supply and nitrogen. Dates of emergence and Harvesting may be enforced in the model [11].

2. Results

Performance of SUNFLO model is estimated through harvest index (IR) applies to the total dry matter produced at physiological maturity and not from yield components. The IR and TH are estimated by multiple linear regressions including varietal potential parameters (IRpot, THpot) and state variables of the population estimated by the model.

All the parameters used to characterize and differentiate the varieties are summarized in the following table:

Tableau 1. *Paramètres variétaux du modèle SUNFLO et méthodes de caractérisation.*

Processus	Signification	Nom	Unités	Mesure champ (peuplement dense)	Mesure serre (pots)	Calcul	Base de données VAT
Phénologie	Durée « levée-stade E1 »	TT_E1	°C.Jours	Possible	Non	Oui	Non
	Durée « levée-stade F1 »	TT_F1	°C.Jours	Oui	Non	Non	Oui
	Durée « levée-stade M0 »	TT_M0	°C.Jours	Difficile	Non	Oui	Non
	Durée « levée-stade M3 »	TT_M3	°C.Jours	Oui	Non	Non	Non
Architecture	Nombre de feuilles (total)	NFT	s.u	Oui	Possible	Non	Non
	Rang de la plus grande feuille	n_SFimax	s.u	Oui	Possible	Non	Non
	Surface de la plus grande feuille	SFimax	cm^2	Oui	Possible	Non	Non
	Coefficient d'extinction du rayonnement	k	s.u	Difficile	Non	Oui	Non
Réponse à la contrainte hydrique	Seuil de réduction de l'expansion foliaire	a_LE	s.u	Non	Oui	Non	Non
	Seuil de réduction de la transpiration	a_TR	s.u	Non	Oui	Non	Non
Allocation	Indice de récolte potentiel	IRpot	s.u	Oui	Non	Non	Non
	Teneur en huile potentielle	THpot	%	Oui	Non	Non	Oui

Discussion

The "model performance" in itself is not an easy term to define, so improving it can be difficult. For statistical models, the error level calculation is a systematic and important part of the analysis. A confidence interval is often estimated and associated with the model but this approach is not easily applied to crop models.
The general method (presented in figure1) is to compare, in different situations (weather patterns, soils), the model predictions and crop observations to estimate a mean error level. But this method is not ideal. First, the model has often been fitted to the data (through parameter estimation); in this case, the measured error level corresponds to the fitting error and underestimates the prediction error [8].

The representativeness or reliability of observed data is rarely discussed, although the error level can vary widely in situations where the model is used. In this section, we will discuss the model's use-cases in relation with its performance.

The SUNFLO crop model can simulate variations in genotypic performance between different environments (GEM interactions). These interactions played a significant part in yield variability in both the actual and simulated network although they were higher in the actual network. Such results raise several methodological points for discussion concerning the relevance of a dynamic crop model for genotype evaluation, the limitations of the modeling approach and finally the prospects for the use of the model.

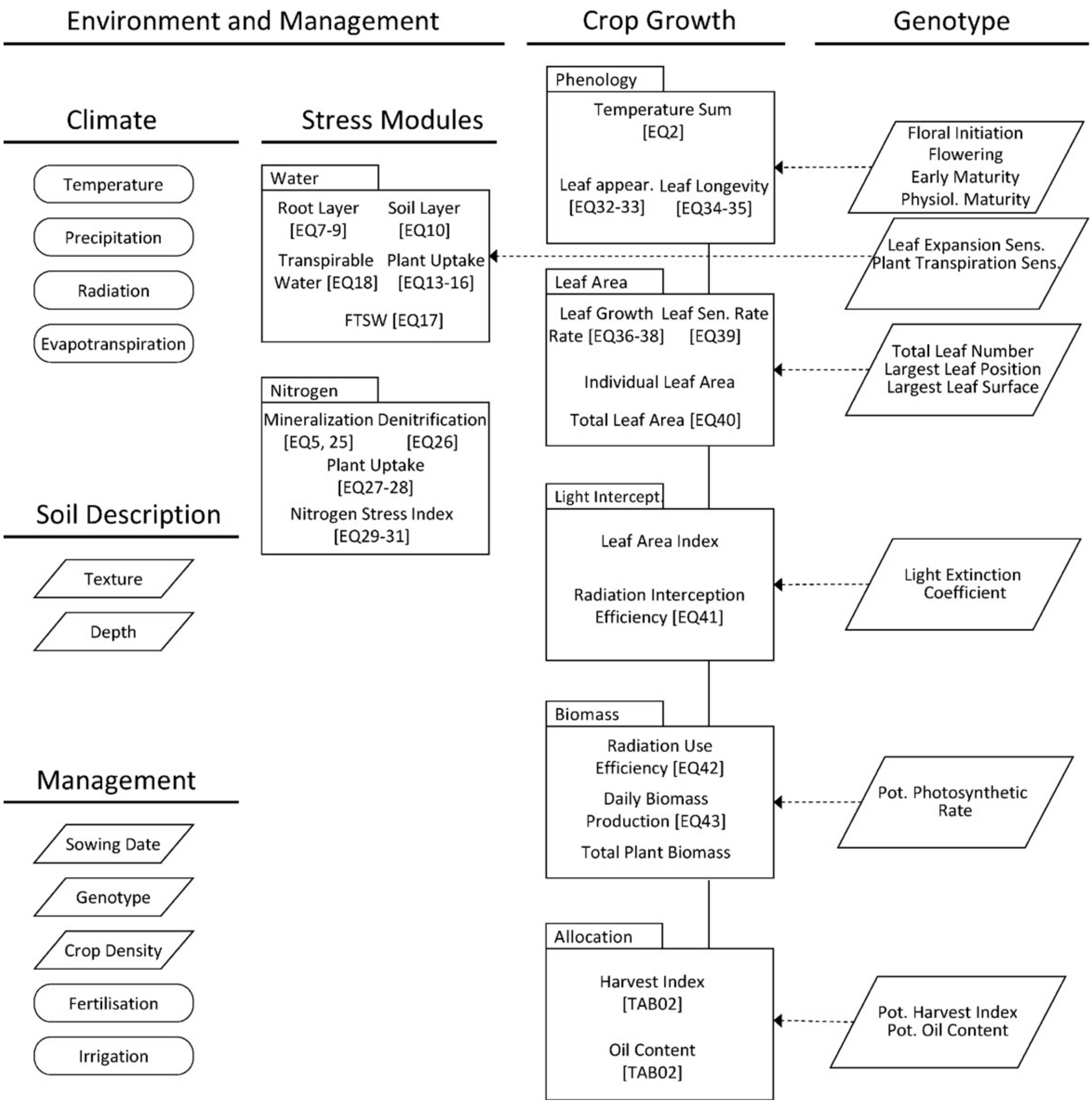

Fig. 1. Chaining for different modules defining yield and oil production. Crop growth, displayed in the centre part, is viewed as the interaction between environmental and management-related limiting factors (left part) and genotypic information (right). Intermediate variables appear in modules (rectangles) with references to equations in the text. The schematic modules reflect the paragraphs' structure in the "model structure" section of the text. Parallelograms (parameters) and ellipses (variables) represent model inputs.

Conclusion

The model SUNFLO could be mobilized to assist the varietal evaluation in several directions:

- The definition yields accessible through trial and determination correlated indicators of stress (leaf area index, nitrogen nutrition index, ETR / ETM) to formulate a diagnosis agronomic genotype x environment;
- Simulation of situations encountered in the non pedoclimatic annual network;
- Assessment by mid-range torque conduct relevant to clarify the mode of use of new varieties;
- Assessment of exploratory varietal characteristics of interest [7].

Experimentation and varietal network could be designed to test the model and take advantage of diagnostic capabilities and exploratory simulation tool.

Abreviations

Ao: Drill stage of sunflower
A2: Emergence stage of sunflower
E1: Button start stage of sunflower
ETR: Real evapotranspiration
ETM: maximum evapotranspiration
F1: Flowering stage
IGE: Interaction between genotypes and the environment
IR: Harvest index
IRpot: Harvest index potential
KgN/j: kilogram of Nitrogen by day
Mo: Earling filling seeds stage of sunflower
M3: Physiological maturity stage of sunflower
M4: Harvest stage of sunflower
q/ha: quintal/hectare
TH: oil content
THpot: oil content potential
TT_E1: thermical time in degree Celsius
VAT: Value of cultivation and technology

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