# Comparing CERES-wheat and SUCROS2 in the Argentinean Cereal Region

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## INTRODUCTION

Wheat is the main cereal produced in Argentina; the cropping area of about 5 Mha is placed in the Pampas Region that covers a great plain between 31° and 40° latitude S. Environmental variability is very important, yield increments in the north-south sense are the result of more favourable thermal and hydrological conditions for crop development and growth, but all over this region water stress during crop cycle is able to occur.

Because of the great importance of this cereal, both public and private institutions are interested in yield forecasting. For this purpose crop models are very useful tools.

In Argentina, we are using CERES-wheat model (Ritchie and Otter, 1985) since 1990 with a mean absolute error for yield prediction of 9% (Magrin et al., 1991). However, we have still two problems with this model: a) in the southern portion of the Pampas Region (e.g.H.Ascasubi) the model underestimates grain yields and b) the required cultivar-specific inputs are restricting its use when new varieties are introduced. To avoid these problems, more general models such as SUCROS2 (van Keulen et al, 1992) could be applied. The main difference between these approaches is related to cultivar-specific inputs. CERES-wheat needs 6 coefficients related to crop development and growth to describe each cultivar but in SUCROS2 only phasic development needs to be parameterized, suggesting the possibility of grouping cultivars with similar length of cycle.

The aim of this work is to compare the performance of CERES-wheat and SUCROS2 using the same data set, representative of the argentinean wheat production region, which includes different sites, years, hydrological conditions and cultivars where nutrients, pests or diseases are not limiting factors.

## MATERIALS AND METHODS

The models CERES-Wheat (Ritchie and Otter, 1985) and SUCROS2 ( van Keulen et al,1992) can simulate crop development, growth and yield on a day-to-day basis.

Main inputs are related to climate, soil, cultivar and crop management.

Climate: latitude and daily values for global solar radiation, maximum and minimum temperature and precipitation are common to both models but SUCROS2 needs also vapor pressure and wind speed data.

Soil: SUCROS2 needs upper and lower water limits, saturated water content, drainage and initial water content while CERES-wheat also requires evaporation characteristics, organic carbon, pH and initial nitrogen content by layer.

Cultivar-specific information related to phenology is more complex in CERES-wheat as phasic development depends on three coefficients (P) related with thermal and photoperiodic responsiveness of cultivars and five stages are defined between emergence and physiological maturity. In SUCROS2 temperature is the only driven variable and phenology is defined by the rate and order of appearance of vegetative and reproductive organs; development stage is expressed as a dimensionless variable being 0 at emergence, 1 at anthesis and 2 at physiological maturity.

Management : Variety, sowing date, plant density, row spacing and depth; type, quantity and date of application of fertilizers and irrigation are needed to run CERES-wheat, while in SUCROS2 only sowing and emergence dates and plant density are needed.

Both models simulate biomass production as a function of incident solar radiation and it is affected by temperature and water availability. Daily net assimilation is partitioned among roots, stems, leaves and storage organs using partitioning factors which are dependent on phenological development.

In addition, in CERES-wheat there are cultivar-specific coefficients (G1, G2, G3) parameterizing dry matter partition and kernel growth.

CERES-wheat has been calibrated for local conditions (Magrin et al, 1991) and SUCROS2 was calibrated for three cultivars, Oasis, Azul and Federal, with information obtained at Balcarce (37.45° lat S) and Paraná (31.7° lat S) modifying crop development parameters.

The data set used to test the models (Table 1) includes different sites, varieties , years, and water supply but in all the situations nitrogen was supplied to be not limiting.

Statistical procedures suggested by Willmott (1982) were used to evaluate models performance: mean, mean absolute error (MAE), root mean square error (RMSE) and the determination coefficient ($R^2$).

Table 1. Main features of the data set used to test the models

| Sites | Latitude (°) | Cultivars | Years | Treatments |
|---|---|---|---|---|
| Rafaela | -31.2 | Azul, Oasis | 1991-92-93 | irrigated-rainfed |
| Parana | -31.7 | Federal | 1992-93 | rainfed |
| Marcos Juarez | -32.7 | Azul, Oasis | 1990-91 | irrigated-rainfed |
| Balcarce | -37.5 | Oasis | 1990-91-92-93 | rainfed |
| Hilario Ascasubi | -39.3 | Azul,Oasis | 1990-91-92 | irrigated |

**RESULTS AND DISCUSSION**

Photoperiod responsiveness of our cultivars leads to greater errors in anthesis date prediction when using SUCROS2. As this sensibility is not accounted for in the model, in lower latitude sites anthesis was hastened up to 20 days (Figure 1). Several works demonstrated that temperature is not sufficient to explain the wheat development(Baker et al, 1980; Baker and Gallagher, 1983; Ritchie and NeSmith, 1993). In consequence, we have better predictions with CERES-wheat with a mean absolute error of 3 days compared to 6 days using SUCROS2 (Table 2).

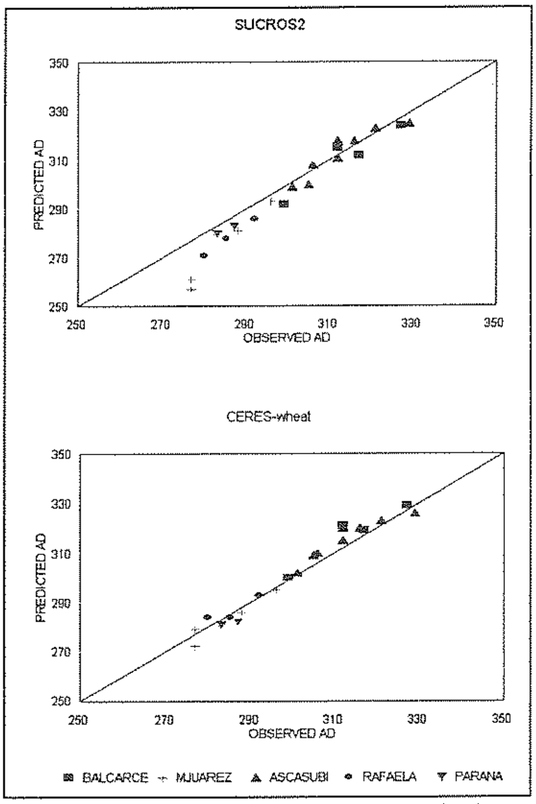


Fig.1. Observed and predicted anthesis date using SUCROS2 and CERES-wheat in Balcarce, M.Juarez, H.Ascasubi, Rafaela and Parana.

Table 2. Mean observed and predicted anthesis date (AD) using CERES-wheat and SUCROS2 and main statistics for all sites tested.

| | AD | MAE | RMSE | $R^2$ |
|---|---|---|---|---|
| CERES-wheat | 302.4 | 3.1 | 3.8 | .966 |
| SUCROS2 | 296.9 | 5.6 | 7.2 | .954 |
| OBSERVED | 301.05 | | | |

The SUCROS2 model produced better grain yield estimates than the CERES-Wheat did, the MAE accounted for 13.8% and 19.9 % of observed yield (5275 kg/ha-1), and RMSE 16% and 26% respectively (Table 3a). However lack of fit in phenology overcame yield estimation errors mainly in Rafaela and Marcos Juarez. In the other sites SUCROS2 shows good agreement between predicted and observed values. Using CERES-wheat, predictions were acceptable for all sites except H.Ascasubi where a systematic yield underestimation conduced to the worse overall result (Figure 2).

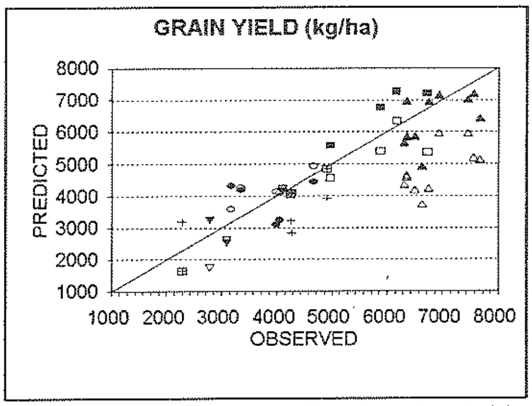


Fig.2. Observed and predicted grain yield using SUCROS2 (closed symbols) and CERES-wheat (open symbols) for different sites. Symbols as in Fig.1.

Excluding H.Ascasubi, mean absolute error of yield prediction was reduced to 9.9% using CERES-wheat and increased to 18% with SUCROS2 (Table 3b).

Table 3. Main statistics obtained when comparing observed and simulated grain yield values for the complete data set (a) and excluding H.Ascasubi (b).

| a] (n=26) | MEAN | MAE | RMSE | $R^2$ |
|---|---|---|---|---|
| CERES | 4383 | 1050 | 1388 | .56 |
| SUCROS | 5122 | 729 | 827 | .76 |
| OBSERVED | 5275 | | | |
| **b] (n=16)** | | | | |
| CERES | 4122 | 425 | 565 | .81 |
| SUCROS | 4325 | 773 | 845 | .69 |
| OBSERVED | 4291 | | | |

Looking for the origin of differences between the two models, overall dry matter production was analysed. Final biomass values were greatly underestimated using SUCROS2 while CERES-wheat produced better results except in H.Ascasubi (Figure 3).

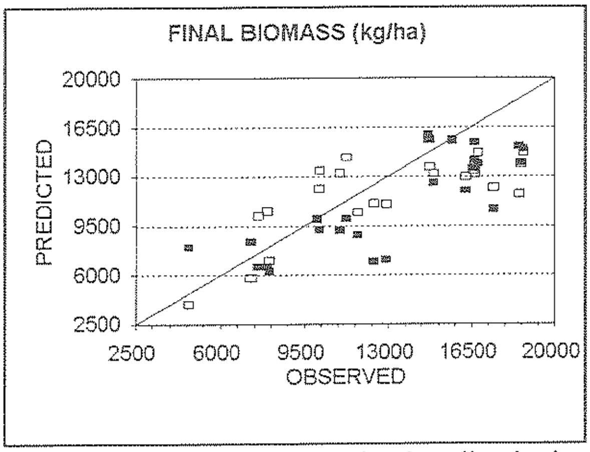


Figure 3. Final biomass observed and predicted using SUCROS2 (closed symbols) and CERES-wheat.(open symbols)

Shifts in biomass estimation could be explained by differences in photosynthesis parameterization. The extinction coefficient is assumed to be 0.6 in SUCROS2 and 0.85 in CERES-wheat but, this value has been criticized as too high, values cited in literature for wheat crops being between 0.4 and 0.6 (Thorne et al., 1988; Porter et al, 1993). The effect of temperature on $CO_2$ assimilation is accounted for in both models by means of reduction factors concerning daytime temperatures where the optimum is considered to be 18°C in CERES-wheat and between 10 and 25°C in SUCROS2. In sites like H.Ascasubi daytime temperatures greater than 20 °C are frequent during maximum crop growth and this could explain the behaviour of CERES-wheat, as water stress did not occur. Better yield predictions obtained with SUCROS2 in this site suggest that the origin of differences between the models is explained by the way in which dry matter is partitioned to harvestable organs.

Greater harvest index (HI) values were obtained with SUCROS2, mean HI for all sites was 0.46 compared to 0.37 obtained with CERES-wheat, while observed HI was 0.41. In CERES-wheat dry matter is partitioned to different plant organs according to the phenological stage but final yield is derived as the product of its components, kernel number and mean grain weight, affected by assimilates supply and by the respective genetic coefficients. In SUCROS2 there is no component discrimination, after anthesis 100 p.cent of current assimilats plus the eventual retranslocation supply, parameterized to be not greater than 20 p.cent, are sent to harvestable organs. The greater partition accounted for in SUCROS2 allowed good yield estimates even with lesser biomass values.

The strong relationship between dry matter production and genetic coefficients which affect its partition improve yield estimation in CERES-wheat but, when dry matter is not well simulated as in H.Ascasubi errors are greatly increased. Nevertheless, the contribution of this site to global production is not very important.

## CONCLUSIONS

Regarding phenological events the use of SUCROS2 would be restricted to higher latitude sites where photoperiod requirements are satisfied. If the main interest is to get grain yield, compensation between biomass production and its partition allows acceptable estimates even with dry matter underestimation. Notwithstanding, results obtained suggest that CERES-wheat has a better performance compared to SUCROS2: phenology, dry matter production and grain yield estimation errors were lower for most of the sites representative of the main wheat production region.

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