A NEW APPROACH FOR PREDICTING KERNEL NUMBER FROM INTERCEPTED RADIATION IN CERES-MAIZE

Jon I. Lizaso, William D. Batchelor and Steve S. Adams

Agricultural and Biosystems Engineering Department, Iowa State University, Ames, IA 50011. USA
Monsanto Company, St. Louis, MO 63167

Introduction

- CERES-Maize is widely used to evaluate and/or forecast effects of environment, management and genotype on maize growth, development and yield.
- The model predicts grain yield as a function of:
  - number of kernels / ear
  - potential kernel growth rate
- Predictions of number of kernels / ear have shown limited accuracy under various environments.
- Higher potential yield of modern hybrids results from increased number of grains per plant (Tollenaar et al., 1992; Otegui, 1995).
- Thus precise forecasting of kernel numbers, under different environments, is a critical component of maize crop modeling.

Objective

- To develop a new approach to improve the prediction of kernel numbers produced per plant within CERES-Maize.

Model Development

- Two approaches were implemented and tested in CERES-Maize: Double-curve (Tollenaar et al, 1992) and line-cutoff (Kiniry and Knievel, 1995).
- The new theory was incorporated into a very similar version of Generic CERES (3.1) distributed with DSSAT 3.1 (Hoogenboom et al., 1994)
- Intercepted photosynthetically active radiation (IPAR, MJ plant^{-1} d^{-1}) is calculated from input solar radiation (SRAD, MJ m^{-2} d^{-1}) and plant population (PLTPOP, plant m^{-2}), and from calculated leaf area index (LAI, m^2 m^{-2}):

$$\mathrm{IPAR} = 0.5 \times \frac{\mathrm{SRAD}}{\mathrm{PLTPOP}} \times (1 - e^{-k \times \mathrm{LAI}})$$

where k is the extinction coefficient calculated by the model. The model assumes that 50% of the solar radiation is within the wavelength of photosynthetically active radiation.

- IPAR is accumulated over a critical thermal time period bracketing silking (230^0 C d before to 100^0 C after silking; Otegui and Bonhomme, 1998):

$$\mathrm{CUMIPAR} = \sum_{t=1}^{\mathrm{IKNDUR}} \mathrm{IPAR}_t$$

where IKNDUR (d) is the number of calendar days of the critical time period.

- Daily average IPAR (KNIPAR, MJ plant^{-1} d^{-1}) is calculated over the critical period IKNDUR (d):

$$\mathrm{KNIPAR} = \frac{\mathrm{CUMIPAR}}{\mathrm{IKNDUR}}$$

- **Double-curve:**
  - Potential number of grains per plant (PGPP) are calculated using two equations, assuming one or two ear bearing kernels are produced:

$$\mathrm{PGPP} = \mathrm{G2} \times (1 - e^{-b_1 \times (\mathrm{KNIPAR} - \mathrm{KNIPAR0}_1)})$$

$$\mathrm{PGPP} = \mathrm{G5} \times (1 - e^{-b_2 \times (\mathrm{KNIPAR} - \mathrm{KNIPAR0}_2)})$$

where b_1 and b_2 are the efficiency of kernel set, $\mathrm{KNIPAR0}_1$ is the IPAR threshold for kernel set in the top ear, and $\mathrm{KNIPAR0}_2$ is the intercept of the 2nd curve; G2 and G5 are the maximum number of kernels in the top one and two ears.

  - The model will select the largest value of PGPP as the potential number of kernels per plant.

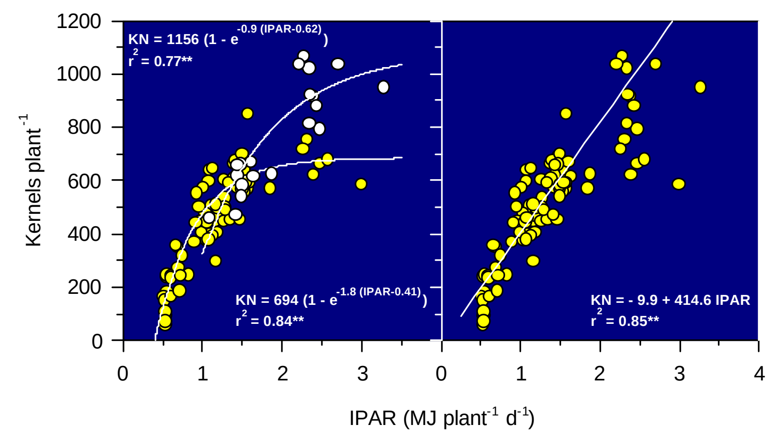
- **Line-cutoff:**

$$\mathrm{PGPP} = A + b \times \mathrm{KNIPAR}$$

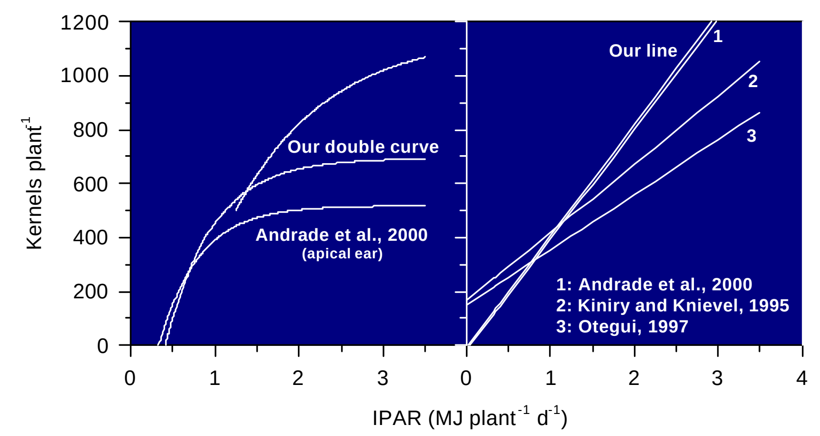
where A and b are the intercept and slope of the relationship. The model constraints PGPP between 0 and G2.

- PGPP is reduced using the average stress factors due to water and nitrogen from tassel initiation to the linear grain filling stage and only nitrogen thereafter.

Model Calibration

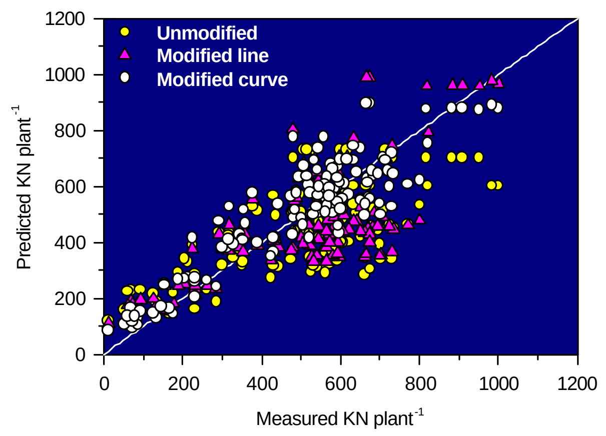


Double-curve and line-cutoff fitted to 105 replicated treatments from Iowa:
○ : only one ear with kernels;
○ : two ears with kernels.

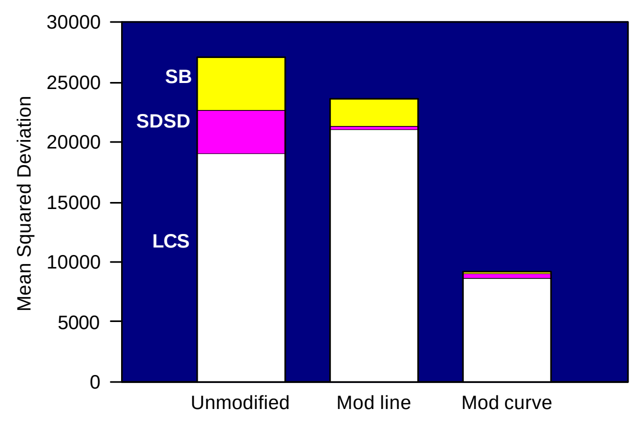


Comparison of our calibrated double-curve and line-cutoff relationships with selected published relationships.

Model Performance



Predicted and field measured kernel number per plant. Independent data set with 134 replicated treatments from Iowa.



Mean Squared Deviation (Kobayashi and Salam, 2000) between predicted and observed kernel number and its components. SB: square bias; SDSD: square difference between standard deviations; LCS: lack of correlation weighted by standard deviation.

References

Andrade et al. 1993. Crop Sci. 33:482-485.

Hoogenboom et al. 1994. Crops models, Vol 2-2. DSSAT Version 3.0. University of Hawaii. Honolulu

Kiniry and Knievel. 1995. Agron. J. 87:228-234.

Kobayashi and Salam 2000. Agron. J. 92:345-352.

Otegui. 1997. Crop Sci. 37:448-455.

Otegui. 1995. Maydica 40:371-376.

Otegui and Bonhomme. 1998. Field Crops Res. 56:247-256.

Tollenaar et al. 1992. Crop Sci. 32:432-438.