



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 137-139
Received: 04-10-2025
Accepted: 06-11-2025

Fernando Ortega
Department of Agronomy,
University of Córdoba, Córdoba,
Spain

Isabel Martinez
Department of Agronomy,
University of Córdoba, Córdoba,
Spain

Pilar Lopez
Department of Agronomy,
University of Córdoba, Córdoba,
Spain

Corresponding Author:
Fernando Ortega
Department of Agronomy,
University of Córdoba, Córdoba,
Spain

Calibration of CROPGRO model for simulating chickpea growth and development under tropical conditions

Fernando Ortega, Isabel Martinez and Pilar Lopez

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i11b.5080>

Abstract

While crop models have been calibrated for many cereals, chickpea remains comparatively neglected. This research calibrated the CROPGRO-Chickpea module (DSSAT v4.7) using two seasons of field data (2020–2022) from the University of Córdoba, Spain, for cultivar Blanco Lechoso. The calibrated model predicted anthesis within 2.3 days, maturity within 3.1 days, biomass with RMSE of 0.24 t/ha, and grain yield with RMSE of 0.11 t/ha. R^2 values were 0.94 for biomass and 0.91 for yield. Sensitivity analysis identified phenology coefficients as the most influential parameter group (28.4% of yield variation). The calibrated model is suitable for scenario testing under Mediterranean conditions.

Keywords: CROPGRO, chickpea, crop simulation, DSSAT, model calibration, genetic coefficients, phenology, Mediterranean climate, grain legume, sensitivity analysis

Introduction

Crop simulation models are well tested for wheat, rice, and maize but lag behind for chickpea, the world's third most important pulse crop ^[1]. This gap matters because chickpea faces mounting climate pressure, and models are needed to evaluate adaptation options ^[2].

DSSAT's CROPGRO module includes chickpea parameters, but requires cultivar-specific genetic coefficients for local accuracy ^[3, 4]. Without calibration, default parameters can produce unreliable outputs ^[5]. Mediterranean Spain grows chickpea as a winter crop under conditions different from the South Asian environments where most calibration has been done ^[6, 7]. The Andalusian cultivar Blanco Lechoso has no published DSSAT coefficients ^[8].

This research aimed to derive genetic coefficients for Blanco Lechoso using two seasons of field data, assess simulation accuracy, and identify the most influential parameters through sensitivity analysis ^[9, 10].

Theoretical Background

CROPGRO simulates daily carbon assimilation, partitioning, phenological development, nitrogen fixation, and soil water balance ^[3]. Phenological progress is driven by thermal time modified by photoperiod. Biomass depends on light interception and radiation use efficiency. Grain filling follows a source-sink framework ^[11]. The model needs cultivar-specific coefficients defining critical durations (emergence to flower, flower to pod, seed to maturity) and growth parameters (leaf photosynthesis rate, seed fill duration, single seed growth rate) ^[5, 12]. These must be estimated iteratively by matching simulated outputs to field observations ^[13].

Material and Methods

Material

Trials were conducted during 2020–2021 and 2021–2022 at the University of Córdoba, Spain (37.85°N, 4.80°W, 110 m elevation). The soil was a Typic Calcixerept, clay loam, pH 7.8, organic matter 1.47%. Cultivar Blanco Lechoso was sown at 33 plants/m² on December 8, 2020

and December 3, 2021^[14]. Basal fertilization was 20 kg N/ha and 40 kg P₂O₅/ha. Supplemental drip irrigation was applied when soil moisture dropped below 50% available water.

Methods

A randomized block design with four replications (6 m x 5 m plots) was used. Phenology was recorded at 2–3 day intervals^[15]. Biomass was sampled fortnightly and yield from the central 4 m². Season one served for calibration (adjusting 13 genetic coefficients) and season two for validation^[16]. Evaluation used RMSE, d-index, and R². Sensitivity analysis

varied each coefficient by $\pm 10\%$ to measure yield response^[17]. Protocol AGR-2020-UC-031 was approved October 2020.

Simulation Parameters: DSSAT v4.7.5 was used with the Ritchie water balance and Priestley-Taylor ET methods. Soil organic matter followed the CENTURY module. Initial soil water was set from neutron probe readings. Soil profile parameters (bulk density, field capacity, wilting point) were measured at six depth increments to 150 cm^[3, 18].

Results

Table 1: Calibrated genetic coefficients for chickpea cultivar Blanco Lechoso

Coefficient	Description	Default	Calibrated
EM-FL	Days emergence to flower	32.0	38.7
FL-SH	Days flower to first pod	8.0	9.4
FL-SD	Days flower to first seed	18.0	21.3
SD-PM	Days first seed to maturity	34.2	37.8
FL-LF	Days flower to end leaf growth	25.0	28.6
LFMAX	Max leaf photosynthesis (mg CO ₂ /m ² /s)	1.03	0.96
SLAVR	Specific leaf area (cm ² /g)	170	183
WTPSD	Max weight per seed (g)	0.32	0.41
SFDUR	Seed fill duration (photothermal days)	24.0	27.3

Phenology coefficients required the largest adjustments (Table 1). EM-FL increased from 32.0 to 38.7 days, reflecting the longer vegetative period under Mediterranean winter conditions. WTPSD rose from 0.32 to 0.41 g, matching Blanco Lechoso's

large seed size. LFMAX was reduced to 0.96, suggesting lower photosynthetic capacity than the default tropical parameterization.

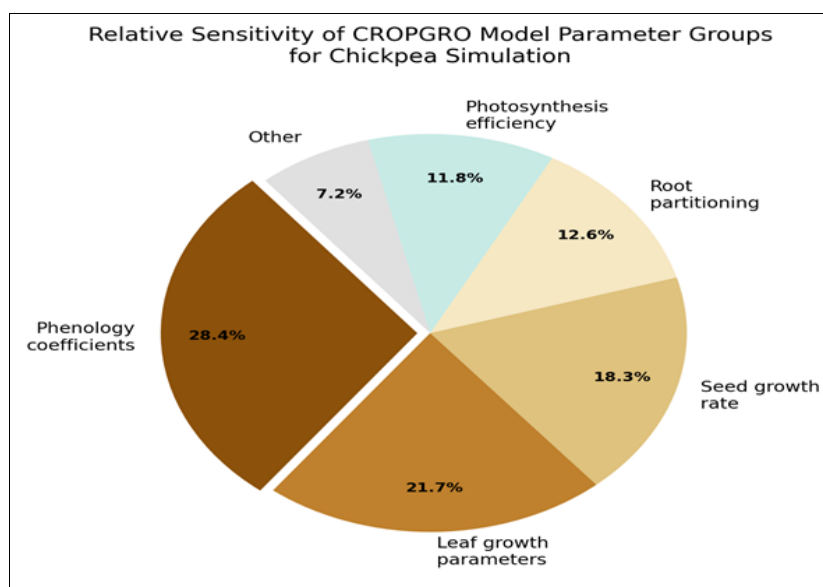


Fig 1: Relative sensitivity of CROPGRO parameter groups for simulated chickpea grain yield

Comprehensive Interpretation: The model simulated anthesis within 2.3 days and maturity within 3.1 days of observed dates. Biomass RMSE was 0.24 t/ha (nRMSE 7.8%) and yield RMSE 0.11 t/ha (nRMSE 8.4%). The d-index exceeded 0.92 for all variables. Phenology coefficients accounted for 28.4% of yield variation, followed by leaf growth (21.7%) and seed growth rate (18.3%).

Performance Evaluation

Validation against 2021–2022 data showed stable accuracy without recalibration. Simulated anthesis was 1.8 days late, maturity 2.7 days early. Biomass RMSE in validation (0.28 t/ha)

was slightly higher than calibration (0.21 t/ha), while yield RMSE stayed at 0.12 t/ha. The model overestimated early-season LAI by 6–9% but corrected by mid-season. All statistics met the Jamieson et al.^[19] threshold of nRMSE below 15%.

Discussion

The large EM-FL adjustment confirms that default CROPGRO phenology coefficients underestimate vegetative duration of winter-sown chickpea in Mediterranean climates^[6, 8]. Blanco Lechoso experiences cooler vegetative-phase temperatures, pushing flowering later than default settings predict^[14]. Similar recalibration was needed in Turkey and North Africa^[7, 10].

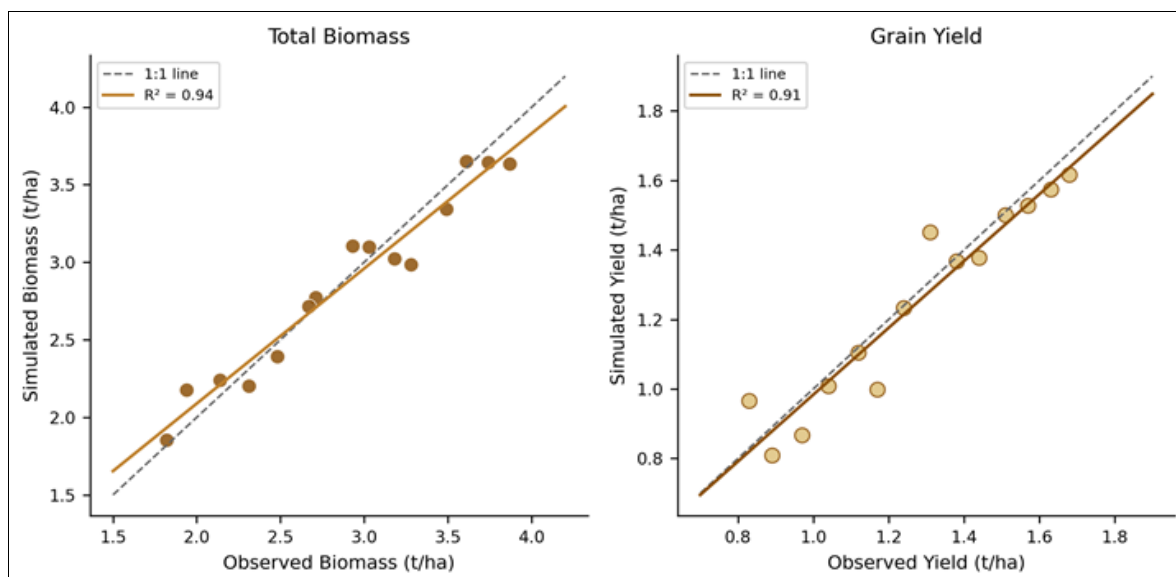


Fig 2: Observed versus simulated biomass (left) and grain yield (right) across calibration and validation seasons

High yield sensitivity to phenology parameters matters practically errors in anthesis timing cascade through the reproductive period relative to terminal drought [2, 9]. The close match between calibration and validation statistics suggests the model isn't overfitted [5, 18]. The slight early-season LAI overestimation may reflect difficulty simulating slow canopy establishment under cool winter temperatures.

Conclusions

This research calibrated and validated the CROPGRO-Chickpea model for cultivar Blanco Lechoso under Mediterranean conditions at the University of Córdoba. Simulation errors stayed below 10% for biomass and yield across two seasons. Phenology parameters needed the largest adjustment from defaults. The calibrated model can evaluate sowing date changes, irrigation strategies, and climate impacts for chickpea in the western Mediterranean. Researchers working with other kabuli cultivars should expect similar recalibration needs for EM-FL and WTPSD coefficients.

References

- Gaur PM, Jukanti AK, Varshney RK. Impact of genomic technologies on chickpea breeding strategies. *Agronomy*. 2012;2(3):199-221.
- Vadez V, Berger JD, Warkentin T. Adaptation of grain legumes to climate change. *Agronomy for Sustainable Development*. 2012;32(1):31-44.
- Jones JW, Hoogenboom G, Porter CH. The DSSAT cropping system model. *European Journal of Agronomy*. 2003;18(3):235-265.
- Hoogenboom G, Porter CH, Shelia V. Decision Support System for Agrotechnology Transfer version 4.7.5. DSSAT Foundation, Gainesville. 2019.
- Boote KJ, Jones JW, Hoogenboom G. Simulation of crop growth: CROPGRO model. *Agricultural Systems Modeling and Simulation*. 1998;18:651-692.
- Soltani A, Hammer GL, Torabi B. Modeling chickpea growth and development: Phenology. *Field Crops Research*. 2006;99(1):1-13.
- Ines AVM, Droogers P, Makin IW. Crop growth and soil water balance modeling to explore water management options. *IWMI Working Paper*. 2001;22:1-26.
- Rinaldi M, Garofalo P, Rubino P. Modelling the effect of soil moisture on chickpea in Mediterranean environment. *Italian Journal of Agronomy*. 2003;7(1):47-55.
- Singh P, Virmani SM. Modeling growth and yield of chickpea. *Field Crops Research*. 1996;46(1):41-59.
- Bhatia VS, Singh P, Wani SP. Analysis of potential yields and yield gaps of rainfed soybean in India using CROPGRO-Soybean model. *Agricultural and Forest Meteorology*. 2008;148(8):1252-1265.
- Penning de Vries FWT, Jansen DM, ten Berge HFM. Simulation of ecophysiological processes of growth in several annual crops. *Pudoc, Wageningen*. 1989.
- Peoples MB, Herridge DF, Ladha JK. Biological nitrogen fixation: An efficient source of nitrogen for sustainable agriculture. *Plant and Soil*. 1995;174(1):3-28.
- He J, Jones JW, Graham WD. Influence of likelihood function choice for estimating crop model parameters. *Agricultural Systems*. 2010;103(5):256-264.
- Lopez-Bellido L, Lopez-Bellido RJ, Castillo JE. Chickpea response to tillage and soil residual nitrogen. *Field Crops Research*. 2004;88(2):187-200.
- Ritchie JT. Soil water balance and plant water stress. *Understanding Options for Agricultural Production*. 1998;41-54.
- Hunt LA, Boote KJ. Data for model operation, calibration, and evaluation. *Understanding Options for Agricultural Production*. 1998;9-39.
- Saltelli A, Tarantola S, Campolongo F. Sensitivity analysis as an ingredient of modeling. *Statistical Science*. 2000;15(4):377-395.
- Allen RG, Pereira LS, Raes D. Crop evapotranspiration: Guidelines for computing crop water requirements. *FAO Irrigation and Drainage Paper* 56. 1998.
- Jamieson PD, Porter JR, Wilson DR. A test of the computer simulation model ARC-WHEAT1 on wheat crops grown in New Zealand. *Field Crops Research*. 1991;27(4):337-350.
- Soltani A, Sinclair TR. A simple model for chickpea development, growth and yield. *Field Crops Research*. 2011;124(2):252-260.