Plant population model versus average plant model in discrete process simulation: The case of cotton fruits abscission by COTONS® model

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ABSTRACT

Sink-source balance for carbohydrate at the cotton plant level involves the fruit shedding process as the main mean for the cotton plant to adjust his demand to the offer. Obviously cotton crop simulation in a material balance approach needs to take in account the fruiting sites abscission process. The COTONS® model simulates cotton plant squares, blooms and bolls shedding as (i) a discrete process in a "plant population" simulation mode, and as (ii) a continuous process in an "average plant" simulation mode. This study compares field observations with the output data respectively in "average plant" and in "plant population" simulation modes. The model "is late" in both simulation modes: later model growth cut-out compared to observed data. This results from an over estimation of square abscission and under estimation of boll abscission by the model. In preferring square abscission the model favors vegetative growth because of higher sink force for boll compared to square. This is mainly the case in plant average simulation mode with the right simulated number of open bolls; even the green bolls simulated number is widely under estimated. At the opposite, the total number of squares and bolls abscissions in plant population simulation mode is well estimated in spite of a widely over estimated number of open bolls. Simulating the abscission process as a discrete process in plant population simulation mode seems to decrease the differences in cut-out delay, in green bolls number and in abscission number estimations. To improve cotton growth and development simulations, especially in fruit abscission process, the COTONS® model needs to be calibrable in plant population simulation mode respecting the discrete character of the simulated process.

Introduction

Sink-source balance for carbohydrate at the cotton plant level involves the fruit abscission process as the main mean for the plant to adjust his instantaneous "demand" to the offer. The "choice of the organs to be dropped" for demand adjustment to the amount of available assimilates, occurs according to a scale of fruit sensitivity for shedding which is variety specific. Obviously cotton crop simulation in a material balance approach needs to take into account fruiting sites abscission process. The COTONS® model (Jallas *et al.*, 1999) simulates cotton plant squares, blooms and bolls shedding as (i) a discrete process in the "plant population" simulation mode, and as (ii) a continuous process in the "average plant" simulation mode. In the second mode of simulation, the sink force assessment for a fruiting site takes into account the cumulative reductions of the potential growth due to carbon stresses affected previously to this fruit. Whereas the seed-cotton weight simulated for a specific site is interpreted as a percentage of plants having still an open boll on this position, by comparison with the potential boll weight. This study compares field observations with the output data respectively in "average plant" and in "plant population" simulation modes for the COTONS® model.

Experimental procedure

Data were collected from an experimental design at Montpellier (42°60' N; 3°90' E; 2000 season). Daily meteorological data include solar radiation, minimum and maximum air temperatures, rainfall and wind speed. Soil analysis data (by layer up to 2 m depth) concern soil texture (for hydraulic properties estimation), mineral nitrogen content (NO_3^-, NH_4^+), carbon content and soil humidity. Plant data were collected from 2 x 32 m² plots sown on 19 May with DES 119 cotton variety. Two times five tagged plants were mapped two times each (15 days interval) from 16 August (85 DAE) to 22nd September (122 DAE). Data collected by plant mapping consist of plant height, number of main stem nodes, number of vegetative branches, number of fruiting branches, position and vein length of each leaf (for plant leaf area estimation based on allometric relationship), status (abscised, square, bloom, green boll and open boll) of each fruiting site. Number, weight and position of bolls harvested 181 DAE complemented the 10 tagged plants dataset, but did not participate in model calibration. Five-point moving averages ("observed data" in all figures) were calculated from time series corresponding to the 20 plant mappings (85 to 122 DAE). An eight variables x by 10 moving averages dataset is used for COTONS® model calibration, i.e. determination of 35 (variety specific) parameters values, by running a genetic algorithm which maximize the fitness between simulated ("average plant" mode) and observed data (moving averages).

Results and Discussion

The model "is late" in both simulation modes: squares and bolls appear later in simulations than in reality (Figures 2 and 3). This delay in simulating corresponds also to later cut-out in growth by the model: late increase of fruiting sites number compared to observed data (Figure 1). This could result from over estimation of square abscission and under estimation of boll abscission by the model. In preferring square abscission the model favors vegetative growth because of higher sink force for boll compared to square.

This is mainly the case in plant average simulation mode with the right simulated number of open bolls in November; even the simulated number of green bolls in September is widely under estimated (Figure 3). At the opposite, the total number of squares and bolls abscissions in plant population simulation mode is well estimated even at the end of the season (Figure 4) in spite of a widely over estimated number of open bolls in November (Figure 3). The main differences between simulated and observed data seem to result from model's over estimation of square abscission. Simulating the abscission process as a discrete process in plant population simulation mode seems to decrease the differences in cut-out delay (Figure 1), in green bolls number (Figure 3) and in abscission number (Figure 4).

Conclusion

To improve cotton growth and development simulations, especially in fruit abscission process, the COTONS® model needs to be calibrable in plant population simulation mode respecting the discrete character of the simulated processes.

References

- Jallas, E., Martin, P., Sequeira, R., Turner, S., Cretenet, M. and Gérardeaux, E. (1999). Virtual COTONS®, the Firstborn of the Next Generation of Simulation Model. *In* Proceedings of 1999 Beltwide cotton Conferences National Cotton Council of America, Memphis. Pp 393:396.

Figure 1. *Plant leaf area dm² (in black) and plant fruiting sites number (in gray), plant population mode (solid line), average plant mode (dotted line) and observed data (symbols).*

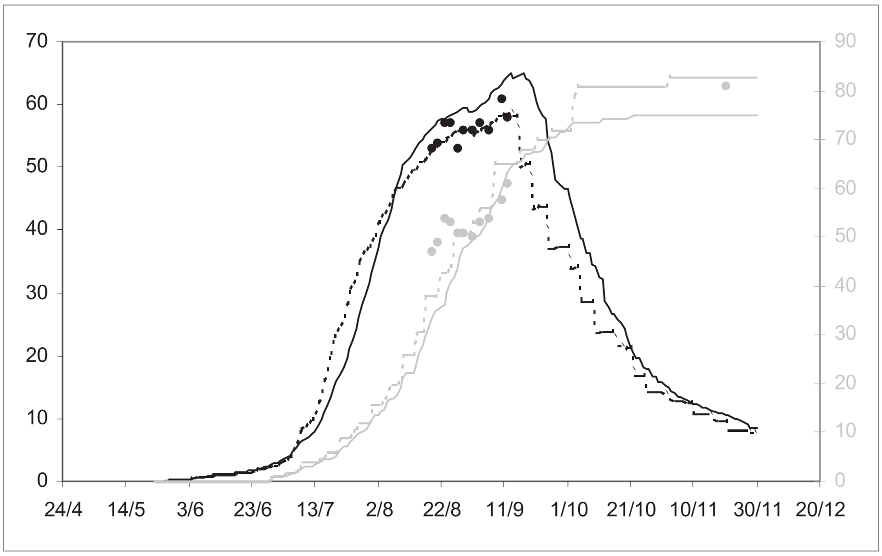

Figure 2. *Plant squares number. Plant population mode (solid line); average plant mode (dotted line) and observed data (symbols).*

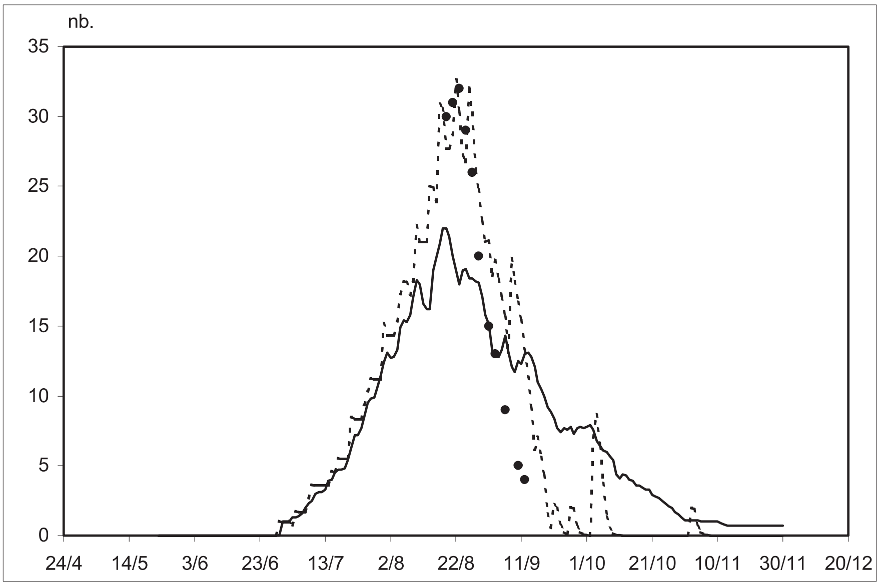

Figure 3.
Plant bolls number. Plant population mode (solid line), average plant mode (dotted line) and observed data (symbols).

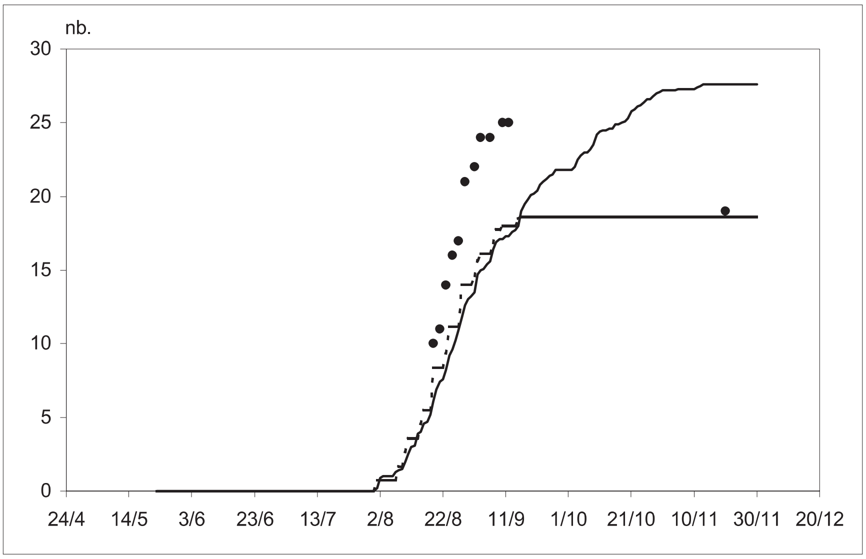

Figure 4.
Plant abscissions number. Plant population mode (solid line), average plant mode (dotted line) and observed data (symbols).