Evaluation of GOSSYM – a Cotton Crop Simulation Model – Under the Soil, Climatic and Cultural Conditions in Greece

A.C. Gertsis[1], S. Galanopoulou-Sendouca[2], F.D. Whisler[3], G. Papathanasiou[1], A. Symeonakis[1] and K. Patsialis[4]

[1]TEI, Thessaloniki, Greece
[2]University of Thessaly, Volos, Greece
[3]Mississippi State University, Miss. State, USA
[4] Hellenic Cotton Board, Karditsa, Greece

ABSTRACT

In a research study in Greece, funded by EU, a dynamic cotton growth simulation model, GOSSYM, was evaluated under local soil, climatic and cultural conditions. Field experiments were conducted for three years in three locations, representative of major cotton growing areas of Greece, using four cotton cultivars under two irrigation levels, two fertilization treatments and two plant populations. The variables ranged from conventional to low input values. Weather conditions varied among the three years of experimentation. Soil analyses and weather data were collected according to GOSSYM input requirements and plant growth and yield was monitored through the growing season. The last year of the study the design included comparison of two management schemes, a conventional farmer approach and a low input strategy as suggested by the previous two years results and GOSSYM simulations. The comparison between field measured and simulated values showed a satisfactory simulation of yield and some plant characteristics and a very close simulation of total water used as ET. The results indicated that GOSSYM could be used as a cotton management tool to optimize cotton production in Greece after some variety calibration and soil and climatic site specific sites.

Introduction

Crop simulation models are a useful tool to increase efficiency in management of crop production systems. Their development was based on mathematical expressions of important physical and physiological processes affecting plant growth and development in the continuum "soil-plant-atmosphere". GOSSYM, is a physiologically based cotton crop simulation model (Baker *et al.*, 1983; Whisler *et al.*, 1986; Hodges *et al.*, 1998). It simulates various processes in the soil, plant and atmosphere affecting the growth and development of a cotton plant. It requires certain input information to run a simulation and provides various output results.

The input information required to run a complete simulation is divided in three categories:

1. Crop information: Latitude of location, distance between rows, plant population per unit of planted row, date of emergence and cotton cultivar used (from the existing variety files), time and amount of irrigation and nitrogen fertilizer in various forms.
2. Soil information: Initial (annual) soil files: Initial soil water and fertility levels (NO3-N, NH4-N, organic matter) at 15 cm depth increments, taken at the beginning of each growing season and before any pre-plant fertilization applied. For the permanent soil hydrology files and for each soil horizon, the following parameters must be measured: the soil moisture characteristic curve, the saturated hydraulic conductivity, the textural class and the soil's bulk density.
3. Weather information: Daily air temperature (max. and min.), rainfall, incident solar radiation and wind run.

The model outputs (in screen, printer or file) the information in three formats: (1) Analytical tables (2) Maps and (3) Graphs. The output includes all aspects of soil, plant and weather variables measured in the field.

Also, COMAX (CrOp MAnagement eXpert) system (Lemmon, 1986) is an expert system environment which was developed later than the GOSSYM and coupled to explicitly work with it. The GOSSYM/COMAX systems is more properly called a model -based-reasoning system than an expert system (McKinion *et al.*, 1989).

The system GOSSYM/COMAX was developed in the USA where it is used not only for research purposes (McKinion *et al.*,1989; Gertsis *et al.*, 1988; Staggenborg *et al.*, 1996) but also commercially by farmers. The development phases of GOSYM included validation and calibration under a wide range of soil, plant and weather conditions in the USA (Landivar *et al.*, 1983a,b; Kharche, 1984; Fye *et al.*, 1984; Reddy *et al.*, 1985).

A research project was undertaken in Europe (1994 to 1997) to evaluate this model for optimizing cotton

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production under the soil, climatic and cultural conditions of Greece and Spain, the two cotton producing countries of the European Union (Gertsis *et al.*, 1996, 1997, 1998)

This paper presents preliminary results from experimental locations in Greece. The objective was to evaluate the simulation provided by GOSSYM for some major plant characteristics and cotton yield and to examine the validity of GOSSYM as a tool to increase efficiency in cotton production.

Materials and methods

The cotton crop simulation model GOSSYM was used to provide the seasonal growth and differentiation for the various developmental stages during the growing season of 1996, in field experiments at three locations with different soil and climatic conditions in Greece: (1) Sindos, (TEI of Thessaloniki), (2) Velestino-Volos and (3) Palamas- Karditsa. The experimental treatments were in a split- plot design with eight replications of two main treatments, “FARMER” and “GOSSYM”, and three cotton varieties (Zeta 2, Korina and Sindos 80) as sub-plots, randomized within each main treatment.

The “GOSSYM” plots received about 35 % less irrigation water (mainly during the boll filling period) and 50% less nitrogen fertilization as compared to “FARMER” plots. Plant population varied from 12 plants/m for cv. Zeta 2 and 20 plants/m for cv. Korina and Sindos 80. Total nitrogen applied was 140 kg/ha of N for “FARMER” and 70 kg/ha N for “GOSSYM” plots at Sindos and 100 kg/ha and 200 kg/ha at the other two locations. From the total N, 50% was applied by hand and incorporated by rotary tiller a few days before planting, 25 % was applied by hand in the surface in the at the flowering stage and the remainder 25% applied at boll filling stage, in the same dates for both treatments. P and K application was equally supplied to the entire experimental field. Herbicides were used as preplant/preemergence only but no insecticides, plant growth regulators (PGR) or defoliants were used.

Growth analysis was conducted at various developmental stages during the growing season and included measurement of plant height, mainstem nodes, leaf area index (LAI), number of flowers, squares, green and open bolls and first flower appearance. Irrigation was provided with a drip lines installed in the middle between planting rows.

Soil analysis for the initial fertility and moisture files was done before fertilization applied and at the 50% emergence stage. Weather data (air temperature, wind speed, relative humidity, solar radiation and rainfall) were daily monitored with an automated weather station (Campbell Scientific Inc., model CR10) located nearby to each experimental field. The permanent soil hydrology files were constructed with the methodology of Whisler (1982) and verified from the GOSSYM team at USA.

Results and discussion

The field results for cotton seed yield are shown in Table 1 for the first pick and the total yield. The simulated yield in Sindos for the first pick was 1275 and 1207 kg/ha for Zeta 2 and 1082 and 1050 kg/ha for cv. Korina and “GOSSYM” and “FARMER” treatments, correspondingly. The first pick was selected because it represents the most significant part of the yield in terms of quality and also quantity; the total yield as shown here is not representative of the commercial total yield. The most close general cultivar files for these varieties were used for the above simulation, and the results indicated a close simulation of the actual field trends. The field results verified that the low input system approach is a valid strategy for optimizing cotton yield in Greece. The preliminary simulation by GOSSYM also verified the above trend. In all three locations, the “GOSSYM” practice yielded higher than the conventional “FARMER” practices in the first pick and in most cases in the total yield.

The results from the simulated and field measured plant height and mainstem nodes in the location of Sindos are shown in Table 2. The simulated plant height and number of mainstem nodes did not differ between the two main treatments, a trend also shown in the field. Results from the simulation of LAI and flowering dates also indicated the same trend.

The field and simulation results supported the validity of low input systems as a sustainable management practice for optimizing cotton production under the cultural conditions of Greece (Table 1). Lower inputs of nitrogen and water can support a yield similar to the obtained by conventional practices using higher inputs. This trend was also shown by GOSSYM using general cultivar files.

Conclusions

GOSSYM provided a satisfactory simulation of main plant characteristics and cotton yield. Although the existing general variety files were used, the simulated trend was similar to the observed in the field. These results further support the validity of low input systems as a sustainable management strategy for cotton production under the cultural conditions in Greece. When the specific files for the varieties used in this study are constructed, it is expected that simulation will further be improved. The use of GOSSYM as a management tool seems to be a valuable help to the cotton farmers in Greece.

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Table 1. Cotton seed yield (kg/ha) for the first pick and for total yield in all locations.

Treatment	Variety	Velestino		Palamas[1]		Sindos[2]	
		1st	Total	1st	Total	1st	Total
FARMER	Zeta 2	980	1720	1330	2610	869	1546
FARMER	Korina	2000	2720	1120	2360	1365	2112
FARMER	Acala SJ2	1350	2100	2410	3570	1747	2273
GOSSYM	Zeta 2	1290	1830	1610	2850	1576	2251
GOSSYM	Korina	2140	2500	1680	2950	1723	2146
GOSSYM	Acala SJ2	1680	2200	2440	3030	2167	2922

[1] The first pick in Palamas was about 2 weeks earlier than in Velestino and 4 weeks earlier than in Sindos.
[2] The cotton cv. Sindos 80 was used in Sindos instead of Acala SJ2.
The actual and simulated (in parenthesis) total water used as ET were very close in the Sindos location and for cv. Zeta 2: 479 mm (468) for "GOSSYM" and 576 mm (537) for "FARMER".

Table 2. Simulated and actual plant height (cm) and number of mainstem nodes for cotton cv. Korina in Sindos.

DAE	Height				Mainstem nodes			
	FARMER		GOSSYM		FARMER		GOSSYM	
	Actual	Sim.	Actual	Sim.	Actual	Sim.	Actual	Sim
56	39	69	39	69	9	11	9	11
68	65	83	64	83	13	13	12	13
75	66	96	69	101	13	14	14	14
86	93	100	99	105	15	15	15	15
99	120	133	115	128	19	17	18	17
111	133	138	126	132	21	17	21	17
124	135	139	135	144	22	18	22	18
130	148	140	138	144	22	19	23	18
161	154	144	138	148	25	19	23	19