

Bulletin 688
June 1994

EVALUATION OF

the GOSSYM-COMAX Cotton Growth Simulation

Model/Expert Management System

IN TENNESSEE

Donald Howard

Philip E. Hoskinson

Marshall Smith

The University of Tennessee
Agricultural Experiment Station
Knoxville, Tennessee
Don O. Richardson, Dean

EVALUATION OF

the GOSSYM-COMAX Cotton Growth Simulation

Model/Expert Management System

IN TENNESSEE

Donald Howard

Philip E. Hoskinson

Marshall Smith

The University of Tennessee
Agricultural Experiment Station
Knoxville, Tennessee
Don O. Richardson, Dean

ABOUT THE AUTHORS

Donald Howard is a Professor in the Plant and Soil Science Department at The University of Tennessee's West Tennessee Experiment Station in Jackson. He has a doctorate in soil science from Auburn University. He has been conducting soil fertility research at Jackson since 1981, and is the author of many publications on the subject.

Philip E. Hoskinson is a Professor Emeritus in the Plant and Soil Science Department at The University of Tennessee's West Tennessee Experiment Station in Jackson. He has bachelor's degrees in Agriculture and Biology from Western Kentucky State University. He earned his master's from The University of Tennessee, where he has been involved in cotton research since 1959.

Marshall Smith is a research associate at Ames Plantation in Grand Junction.

ACKNOWLEDGMENTS

The authors appreciate the cooperation of the Ames Foundation staff under terms of a perpetual trust to The University of Tennessee by Julia C. Ames. We also appreciate the cooperation of the Tennessee Valley Authority for their partial financial support of this research.

Manuscript received August 1993 by the Communications Department, The University of Tennessee Agricultural Experiment Station, Knoxville. Text edited by Heather L. Edwards, student editorial assistant, and Patricia A. Clark. Production by Sandra K. Campbell.

Printed on recycled paper



cover: $\frac{60\% \text{ total recycled fiber}}{30\% \text{ postconsumer fiber}}$

text: $\frac{50\% \text{ total recycled fiber}}{10\% \text{ postconsumer fiber}}$

TABLE OF CONTENTS

Acknowledgments	ii
List of Tables	iv
Abstract	v
Introduction	1
Research Objectives	1
Materials and Methods	1
Model Tracking of the Crop	3
Model Tracking to Squaring	3
Model Tracking to Bloom	5
Model Tracking to Maturity	6
Model Prediction for Extra N Fertilization and Yield	7
Predicted N and Yield for 1988	8
Predicted N and Yield for 1989	10
Predicted N and Yield for 1990	10
Predicted N and Yield for 1991	11
Conclusions	13
Literature Cited	13

LIST OF TABLES

Number	Page
1. Comparison of actual and GOSSYM-COMAX predicted squaring dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage	3
2. Comparison of actual and GOSSYM-COMAX predicted blooming dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage	4
3. Comparison of actual and GOSSYM-COMAX predicted maturation dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage	5
4. Effect of N rate, time of N application, and tillage on yield and predicted yield of cotton at Ames Plantation in 1988	6
5. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1989	7
6. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1989	8
7. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1990	9
8. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1990	10
9. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Milan in 1990	11
10. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1991	12
11. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1991	13
12. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Milan in 1991	14

ABSTRACT

The GOSSYM-COMAX growth simulation model/expert management system for cotton production is a computer model that simulates cotton growth under different conditions. It uses information on soil conditions, weather, fertilizer applications, and early plant growth to estimate needs for extra fertilization and to predict maturity date and yield volume.

The model has been evaluated for accuracy in Mississippi and South Carolina, where it was developed. Because Tennessee is on the edge of the Cotton Belt, and has growing conditions different from the states where the model was originally used, researchers expected the model to perform differently here.

Researchers found that the model's accuracy varied. Each modification improved its predictions for additional fertilization, but yield predictions were erratic. Tillage system had little or no effect on the model's accuracy. Researchers recommend further location-based changes to help the model accurately predict crop maturity in Tennessee.

Researchers returned information to the GOSSYM-COMAX Information Unit, where it was used to make the model easier to use and more accurate.

The large amounts of time and information required to run this model make it more useful to researchers, extension agents, and consultants than to the average producer.

EVALUATION OF THE GOSSYM-COMAX COTTON GROWTH SIMULATION MODEL/EXPERT MANAGEMENT SYSTEM IN TENNESSEE

Introduction

A computer model that simulates cotton growth under different conditions, the GOSSYM-COMAX growth simulation model/expert management system for cotton production was developed during the past decade in Mississippi and South Carolina. The model uses artificial intelligence to analyze information on soil conditions, weather, fertilizer applications, and early plant growth to estimate needs for extra fertilization and to predict maturity date and yield volume. This helps producers make decisions on production management (USDA-GCIU 1990).

Model evaluation was expanded in 1984 to include growing conditions in Mississippi, and was later expanded to include growing conditions throughout the Cotton Belt, incorporating retrieved information into the model. Field evaluation of the model was initiated in Tennessee in 1988.

The version of the model evaluated in 1988 and 1989 was somewhat user unfriendly, especially for entering plant mapping data. Also, this version allowed only one mid-season adjustment using plant growth data. In 1990 the model added a new graphics user interface, along with a revised menu code, which simplified data entry and retrieval of model simulations (USDA-GCIU 1990). Additional changes in the 1990 model version included mouse and keyboard input, pre-emergence simulation, a list for COMAX analysis runs, output to printer or screen, and multiple plant map adjustments per simulation. Other changes are listed in the manual (USDA-GCIU 1990). Model modifications for 1991 included an icon-based main menu, a weather acquisition program in the graphics user-interface, weather editors in the graphics user-interface, and simplified output with warnings and recommendations (USDA-GCIU 1991).

Research Objectives

Research focused on evaluating the GOSSYM-COMAX simulation model/expert management system at the Ames Plantation, West Tennessee

Experiment Station, and Milan Experiment Station. Specifically, research evaluated how accurately the model performed the following tasks:

1. predicting yield using conventional and no-tillage production systems;
2. tracking crop growth and crop maturity;
3. predicting optimum N fertilization rates for cotton production.

Information gathered from these sites was provided to the GOSSYM-COMAX Information Unit for evaluation and incorporation into the model.

Materials and Methods

Field experiments were established in 1988 at Ames Plantation on three types of soil: Memphis silt loam (Typic Hapludalf), Lexington silt loam (Typic Paleudalf), and Vicksburg silt loam (Typic Udifluvent). A site with Grenada silt loam (Glossic Fragiudalf) was added in 1989 to evaluate the model's ability to forecast growth of plants cultivated with trickle irrigation. Conventional-tillage (CT) methods were used on the Memphis, Vicksburg, and Grenada soils, while both CT and no-tillage (NT) methods were used on the Lexington soil. An experiment was established in 1989 on a Lexington silt loam at the West Tennessee Experiment Station at Jackson to evaluate CT and NT production with sprinkler irrigation. Another experiment was established in 1990 on a Loring silt loam (Typic Fragiudalf) at the Milan Experiment Station to evaluate both CT and NT production systems. The experiments were conducted on each site through the 1991 growing season.

The cotton cultivar 'Deltapine 50' was planted during late April to mid-May at all sites. Plots were planted at a rate of 6 to 8 seeds per foot of row, and thinned to 3 to 4 plants per foot after emergence. Gramoxone SuperTM was applied at the rate of 1 qt/A as a burn-down herbicide treatment on the NT plots at Jackson and Milan, while RoundupTM was applied at 2 qt/A on NT plots at Ames Plantation. Cotoran

4L (2.5 pt/A) and Prowl™ (1.75 pt/A) were applied to NT and CT plots for pre-emergence weed control. When needed, recommended insecticides were applied at recommended rates.

Each plot received one of the following treatments:

1. N rate recommended by GOSSYM-COMAX above the base rate;
2. one-half of the N rate recommended by GOSSYM-COMAX above the base rate;
3. base N rates recommended by the University of Tennessee (UT) for upland or bottomland soils, 80 pounds per acres (lb/A) and 60 lb/A, respectively;
4. timing of the N application, with 60% of the base rate applied at planting and 40% applied during late June;
5. 15-15-0 applied 2 × 2 (2 inches below and 2 inches to the side of the seed) at planting;
6. one-half of the base N rate recommended by UT for upland or bottomland soils.

An additional treatment, basing N rates on petiole NO_3^- concentration (Arkansas method) was included at Milan only.

The experiment was designed as a randomized, complete block with treatments replicated four times, except for the Milan site where treatments were replicated five times. Individual plots at Ames Plantation were 13.3 ft (4 rows) wide by 50 ft long, except for the Grenada site, where plots were 13.3 ft wide by 30 ft long. Individual plots at the West Tennessee and Milan Experiment Station sites were 13.3 ft wide by 30 ft long. Ammonium nitrate, concentrated super-phosphate, and muriate of potash were broadcast immediately after planting. Phosphate and potash rates varied with sites and were based on soil test analyses.

In April of each year, soil samples were collected from the GOSSYM-COMAX plots (Treatment 1) to determine soil N levels. These samples were collected in 6-inch increments to a 36-inch depth. Soil nitrate (NO_3^-) levels were determined for the Ames Plantation sites. Both NO_3^- and ammonia (NH_4^+) concentrations were determined for the Jackson and Milan sites. These N concentrations were entered into the model.

Two plants in each treatment replication were marked in the field (mapped) to record plant development at Ames Plantation and Jackson, while only one plant per treatment was mapped at Milan. Dates of 50% of plant emergence, squaring, and flowering were recorded. Plant height and mapping data were collected on a weekly basis, beginning with squaring and ending with maturity. All data were entered into the computer model shortly after collection.

Hydrologic data for the individual soils were not initially available for use in the model. Instead, data determined from a Memphis-type soil in Mississippi were used to model plant growth on the Memphis and Lexington soils. Soil hydrology data for the Lexington soil at Jackson were available by November 1989, and data for all Ames Plantation sites were available for the 1990 growing season. The 1989 data were re-evaluated using the correct hydrologic data.

Twenty cotton petioles (taken from the third mature leaf from the plant terminal) were collected approximately every two weeks after flowering until the first boll opened. Petioles were dried, ground, extracted, and then analyzed to determine NO_3^- concentrations, according to Arkansas procedures.

Yields were determined by harvesting the two middle rows in each plot. Subsamples from each replicated treatment were combined to form one sample. This sample was ginned and evaluated for cotton quality.

The Statistical Analysis System (SAS) was used in the variance analysis to evaluate the effect of rate and timing of N applications on petiole N concentrations and yields. The data presented do not include information obtained from applying 15-15-0 in a 2 × 2 band at planting, because this fertilizer application method could not be entered into the model. The model did not indicate applying nitrogen above the base rate for the Lexington soil at Jackson, the Loring soil at Milan, or the 1991 Ames Plantation sites; so Treatments 1 – 3 were fertilized at the same N rate. Therefore, yield and petiole data for these sites are reported as the mean of three plots for each site-year. Water overflowed the Vicksburg site in 1989, making data from the site unusable. One treatment, the GOSSYM-COMAX, was evaluated for N fertilization and yield predictions at Ames Plantation in 1988, 1989, and 1991.

Model Tracking of the Crop

The GOSSYM-COMAX model predicted a specific date for both squaring and bloom; however, the maturity date predicted by the model had to be interpreted from print-out data.

Model Tracking to Squaring

The ability of the model to track the 1989 crop to squaring varied with site and soil (Table 1). Cool-weather conditions during May and early June

delayed early plant growth and the squaring date. The model predicted squaring 10 days to 2 weeks earlier than the actual, recorded date. To help the model track the crop better, plant emergence dates for the Ames Plantation and Jackson sites were adjusted based upon the squaring date. This adjustment was recommended by the GOSSYM-COMAX Information Unit. Adjusting the emergence date allowed the model to predict squaring to within 2 days. At Ames Plantation, squaring on the Mem-

TABLE 1. Comparison of actual and GOSSYM-COMAX predicted squaring dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage.

Soil	Year	Tillage	Actual date	Predicted	Difference ¹ days
Ames Plantation:					
Memphis	1989 ²	CT	June 29	June 27	2
	1990	CT	26	19	7
	1991	CT	July 8	18	21
Lexington	1989 ²	CT	June 23	24	-1
	1990	CT	21	19	2
	1991	CT	26	14	12
	1989	NT	30	24	6
	1990	NT	20	18	2
	1991	NT	July 1	11	21
Grenada	1989 ²	CT	June 25	25	0
	1990	CT	21	18	3
	1991	CT	July 8	20	19
Vicksburg	1990	CT	June 22	18	4
	1991	CT	July 7	July 18	-11
West Tennessee Experiment Station:					
Lexington	1989 ²	CT	June 30	June 28	2
	1990	CT	20	21	-1
	1991	CT	20	7	13
	1989 ²	NT	30	28	2
	1990	NT	20	21	-1
	1991	NT	19	7	12
Milan Experiment Station:					
Loring	1990	CT	June 20	June 21	-1
	1991	CT	13	15	-2
	1990	NT	20	21	-1
	1991	NT	14	15	-1

¹ Differences in days equals the actual date minus the predicted date; thus, negative values indicate that predicted dates were later than actual dates.

² Plant emergence dates were adjusted in the model based on squaring date.

phis soil was predicted 7 and 21 days earlier than the actual dates for 1990 and 1991, respectively. Predicted 1990 and 1991 squaring dates for the CT Lexington site were 2 and 12 days earlier than the actual dates, while predicted dates for the NT site were 2 and 21 days earlier than the actual dates. Differences between predicted and actual squaring dates for the Grenada soil were within the above ranges. Predicted squaring dates for the Vicksburg soil were 4 days earlier to 11 days later than the

actual dates.

Predicted squaring dates for the CT Lexington soil at Jackson ranged from 1 day after to 13 days before the actual dates, but predicted dates for the NT Lexington site were 12 days earlier to 1 day later than the actual dates (**Table 1**). At Milan, the predicted dates were 1 or 2 days after the actual date for the CT site, and 1 day after the actual date on the NT site.

The 1990 model predicted squaring dates that

TABLE 2. Comparison of actual and GOSSYM-COMAX predicted blooming dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage.

Soil	Year	Tillage	Actual date	Predicted	Difference ¹ days
Ames Plantation:					
Memphis	1989 ²	CT	July 28	July 26	2
	1990	CT	21	16	5
	1991	CT	28	9	-11
Lexington	1989 ²	CT	21	23	-2
	1990	CT	18	16	2
	1991	CT	19	9	10
	1989 ²	NT	28	23	5
	1990	NT	18	12	6
	1991	NT	20	6	14
Grenada	1989 ²	CT	24	24	0
	1990	CT	17	12	5
	1991	CT	28	14	14
Vicksburg	1990	CT	19	12	7
	1991	CT	Aug 3	Aug 9	-6
West Tennessee Experiment Station:					
Lexington	1989 ²	CT	July 28	July 26	2
	1990	CT	12	19	-7
	1991	CT	14	3	11
	1989 ²	NT	28	26	2
	1990	NT	12	19	-7
	1991	NT	12	3	9
Milan Experiment Station:					
Loring	1990	CT	July 12	July 24	-12
	1991	CT	7	11	-4
	1990	NT	12	20	-8
	1991	NT	6	11	-5

¹ Differences in days equals the actual date minus the predicted date; thus, negative values indicate that predicted dates were later than actual dates.

² Plant emergence dates were adjusted in the model based on squaring date.

varied from 7 days before to 2 days after the actual squaring date; whereas, the 1991 version of the model predicted squaring varying from 21 days before to 11 days after the actual date. Burmester et al. (1989) evaluated the model's effectiveness in 1987 and 1988 on planting dates in upland soils in Alabama. They reported that predicted squaring dates varied from 3 days before to 2 days after the actual date. It appears that the 1991 version of the model was less accurate for tracking early season crop growth than the earlier versions. The difference of a week or more between predicted and actual dates indicates the model's inability to accurately track early crop growth.

Model Tracking to Bloom

Differences between predicted and actual bloom dates also varied with experiment site, year, and tillage system (Table 2). Adjusting the emergence date in 1989 allowed the model to predict bloom dates 5 days before to 2 days after the actual dates.

Bloom predictions in 1990 and 1991 for the Ames Plantation sites varied from 14 days before to 11 days after the actual date. For the Memphis soil, predicted dates were 5 days before and 11 days after the actual dates. Predicted bloom dates for the CT Lexington site were 2 and 10 days before the actual bloom dates, while predicted bloom dates for the NT Lexington site were 6 and 14 days before the actual dates. Differences in predicted and actual bloom dates for the Grenada site were 5 and 14 days before the actual dates.

The 1990 and 1991 predicted bloom dates for the CT Lexington site at Jackson were 11 days before and 7 days after the actual dates, while predicted dates for the NT Lexington site were 9 days before and 7 days after the actual date. At Milan, the model predicted bloom dates for the CT Loring were 4 and 12 days after actual bloom dates, while predicted dates for the NT Loring site were 5 and 8 days after bloom.

Bloom dates were predicted more accurately than

TABLE 3. Comparison of actual and GOSSYM-COMAX predicted maturation dates at Ames Plantation, Jackson, and Milan as affected by soil, year, and tillage.

Soil	Year	Tillage	Actual date	Predicted	Difference ¹ days
Ames Plantation:					
Memphis	1989 ²	CT	Oct 7	Oct 31	-14
Lexington	1989 ²	CT	7	31	-14
	1989 ²	NT	7	30	-13
Grenada	1989 ²	CT	8	28	-20
West Tennessee Experiment Station:					
Lexington	1989 ²	CT	Oct 10	Oct 27	-7
	1990	CT	Sept 18	26	-8
	1991	CT	17	31	-14
	1989 ²	NT	Oct 10	27	-17
	1990	NT	Sept 18	30	-12
	1991	NT	17	31	-14
Milan Experiment Station:					
Loring	1990	CT	Sept 27	Oct 17	-20
	1991	CT	20	4	-14
	1990	NT	27	16	-20
	1991	NT	20	2	-12

¹ Differences in days equals the actual date minus the predicted date; thus, negative values indicate that predicted dates were later than actual dates.

² Plant emergence dates were adjusted in the model based on squaring date.

squaring dates. Predicting bloom dates within 7 to 10 days of the actual date indicates that the model is tracking crop growth well. The 1990 model version tracked the crop to bloom better than the 1991 version. Burmester et al. (1989) evaluated the model for upland soil under draught conditions in 1987 and 1988, and reported bloom date predictions within 3 days of the actual date for both early and late planted cotton.

Model Tracking to Maturity

Maturity dates predicted by the model were much later than the actual dates (Table 3). These wide deviations may be the result of the user not properly interpreting the model data. The model determined maturity from diminished yield predictions. Burmester et al. (1988) reported that the model overpredicted the defoliation date by 2 weeks in 1987. They also reported the model predicted

TABLE 4. Effect of N rate, time of N application, and tillage on yield and predicted yield of cotton at Ames Plantation in 1988.

N rate (lb/A)		Yield				
		A ¹	P ²	D ³	P ⁴	D ³
Planting ⁵	Side-dressed ⁶		lb/A	%	lb/A	%
Memphis silt loam - CT						
50	125	880	800	10	710	24
80		870				
48	32	880				
40		780				
L.S.D. (0.05)		NS				
Lexington silt loam - CT						
50	125	1010	780	29	660	53
80		1120				
48	32	1040				
40		1120				
L.S.D. (0.05)		90				
Lexington silt loam - NT						
50	125	990	740	34	510	94
80		970				
48	32	1020				
40		940				
L.S.D. (0.05)		NS				
Vicksburg silt loam - CT						
50	125	590	1150	-49	660	-11
60		570				
36	24	670				
30		770				
L.S.D. (0.05)		140				

¹ A = actual lint yield.

² P = predicted yields from 1988 model version.

³ Percent difference based on predicted yields.

⁴ P = predicted yields from 1991 model version.

⁵ Planted May 11.

⁶ Side-dressed June 10.

defoliation in 1988 within 1 day of the actual date at one location, and 18 days earlier than the actual date at a second location. They further reported that the model predicted defoliation 14 days later than the actual date when Pix™ had not been applied to the crop. However, if dates for Pix™ applications and defoliants are to be evaluated from the model, it must be clear how maturation dates are determined from the model.

Model Prediction for Extra N Fertilization and Yield

Nitrogen fertilization recommendations of 80 lb/A for upland sites and 40 lb/A for bottomland sites made by the University of Tennessee soil testing laboratory for cotton production were applied as the base rate. If the model indicated a need for additional N applications, the rate would be above these base rates. The beneficial effect of additional N was

TABLE 5. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1989.

N rate (lb/A)		Sampling periods			Yield ¹		
		7/20	7/31	8/14	A	P	D ²
Planting ³	Side-dressed	PPM N			lb/A		
Memphis silt loam - CT							
80		13400	9300	8000	790	790	0
48	32 ⁴	13700	9100	7700	830	850	-2
40		8700	9700	8400	640	820	-21
L.S.D. (0.05)		1600	NS	NS	122		
Lexington silt loam - CT							
80	55 ⁵	9200	5700	4200	1220	900	36
80	28 ⁵	11200	5600	3700	1250	970	29
80		10700	5400	3600	1150	890	29
48	32 ⁴	9500	4300	3500	1200	920	33
40		5100	3500	3600	1070	860	24
L.S.D. (0.05)		2500	1300	300	100		
Lexington silt loam - NT							
80	30 ⁵	18100	10900	4600	1070	1070	0
80		15100	7300	3400	1140	930	22
48	32 ⁴	11900	5600	3200	1150	960	19
40		11900	5500	3400	1080	750	45
L.S.D. (0.05)		1900	2000	700	NS		
Grenada silt loam - CT							
80	113 ⁵	8800	3900	3300	810	660	22
80	56 ⁵	10000	3800	3300	800	600	33
80		9400	3700	3300	820	680	20
48	32 ⁴	11300	4600	3300	770	650	19
40		6300	3400	3100	860	470	81
L.S.D. (0.05)		NS	NS	NS	NS		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 1.

⁴ Side-dressed on June 20.

⁵ Side-dressed on August 2.

ascertained by comparing predicted yields with the base N rate yields. Petiole N concentrations also indicated the need for additional N applications. Petiole analyses used on both CT and NT sites at Milan in 1990 and 1991 did not indicate the need for applying N above the base rate.

The model was updated each year, allowing data retrieved from the various locations to be added. Because of this modification, the data will be discussed for each year, rather than as one 4-year period.

Predicted N and Yield for 1988

The 1988 Ames Plantation yield data show variation among soils and N treatments (**Table 4**). The model indicated a need to apply extra N to each of the Ames Plantation sites; however, applying N at rates above the 80 lb/A base rate for three upland sites, or above 60 lb/A for the bottomland soil, did not increase yields. The data indicate that N rates less than those recommended may have been sufficient for the year, since broadcasting 40 or 80 lb/A at planting makes very little difference in yield. At the CT Lexington site, applying N at the rate of 175 lb/A, as the model indicated, produced a lower yield

than applications at 80 lb/A. Splitting the 80 lb/A application produced a lower yield on the CT Lexington site than applying 80 lb/A at planting. Yields were not significantly affected by increasing the N rate applied at planting from 40 to 80 lb/A. On the Vicksburg soil, applying N at the rate of 30 lb/A at planting produced higher yields than applications at rates of 60 lb/A, or higher.

Actual yields were greater for the three upland sites and lower for the Vicksburg site than the model-predicted yields. The model underpredicted yields on the upland soils by 10 to 34%, while it overestimated the yield from the Vicksburg site by 49%. The 1988 Ames Plantation data were re-evaluated using the 1991 model version. Again, actual yields for the three upland sites were higher than predicted yields and the actual yield for the Vicksburg site was lower than predicted. Burmester et al. (1989) reported the 1988 model predicted 1987 yields that were 12 to 50% greater than actual yields in northern Alabama. Using the same version of the model, the 1988 predicted yields ranged from 9 to 14% of the actual yields on five locations. On a sixth, extremely dry location, the model underpredicted yields by 388%.

TABLE 6. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1989.

N rate (lb/A)		Sampling periods			Yield ¹		
		7/20	7/31	8/14	A	P	D ²
Planting ³	Side-dressed ⁴	PPM N			lb/A		
Lexington silt loam - CT							
80		13600	5700	4000	1520	610	150
48	32	13800	5300	3900	1570	620	154
40		9700	3700	3900	1290	610	111
L.S.D. (0.05)		2400	900	NS	110		
Lexington silt loam - NT							
80		16700	5800	4000	1540	560	177
48	32	15500	4600	4000	1570	560	179
40		11700	3800	3100	1340	540	151
L.S.D. (0.05)		1200	800	700	140		

¹ A = actual lint yield; P = predicted yield.

² Percent difference based on predicted yield.

³ Planted May 8.

⁴ Side-dressed on June 20.

TABLE 7. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1990.

N rate (lb/A)		Sampling periods		Yield ¹		
		7/10	8/7	A	P	D ²
Planting ³	Side-dressed	PPM N		lb/A		
Memphis silt loam - CT						
80	55 ⁴	10500	2780	620	740	-16
80	12 ⁴	10000	2930	640		
80		8400	2230	660		
48	32 ⁵	7700	2240	660		
40		6000	820	660		
L.S.D. (0.05)		3000	700	NS		
Lexington silt loam - CT						
80	64 ⁴	5200	2380	1040	910	15
80	32 ⁴	5200	2020	1070		
80		4500	1430	940		
48	32 ⁵	4000	1260	1000		
40		2300	340	880		
L.S.D. (0.05)		2000	750	100		
Lexington silt loam - NT						
80	70 ⁴	3100	640	1180	1180	-1
80	35 ⁴	1600	390	1190		
80		1800	320	1080		
42	32 ⁵	1400	470	1160		
40		300	230	900		
L.S.D. (0.05)		1900	260	80		
Grenada silt loam - CT						
80	53 ⁴	9800	2530	490	830	-41
80	46 ⁴	9200	1700	450		
80		7800	1990	490		
42	32 ⁵	9000	1840	450		
40		9100	1760	450		
L.S.D. (0.05)		NS	NS	NS		
Vicksburg silt loam - CT						
60	71 ⁴	4100	1710	490	760	-36
60	35 ⁴	4800	2250	390		
60		3600	1560	400		
36	24 ⁵	4200	1710	430		
30		2400	590	490		
L.S.D. (0.05)		NS	1040	NS		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 9.

⁴ Model recommended N rates. Side-dressed on August 6 and August 16.

⁵ Side-dressed on June 20.

Predicted N and Yield for 1989

Petiole N concentrations varied with soil and N rate in 1989 at Ames Plantation (**Table 5**). Generally, applying N at rates of 40 lb/A resulted in lower petiole N concentrations than the greater N rates. The model indicated that additional N was needed for the Grenada and Lexington CT and NT sites; however, applying the extra N did not increase yields. It is not clear why the model predicted additional N for the CT and NT Lexington sites but not for the Memphis site. Apparently, the model simulated more water movement through the Lexington profile, causing more NO_3^- to be lost by leaching than was realistic. When differences were observed, applications at 40 lb/A produced lower yields than broadcasting 80 lb/A.

Predicted yields only occasionally and randomly agreed with actual yields. Actual yields were generally greater than predicted yields for three of the four upland soils. Predicted yields ranged from 21% below to 81% above actual yields. Keisling et al. (1990) reported model-predicted yield deviations in Arkansas ranging from 90% below to 150% above actual yields.

Fertilizing above the rate of 80 lb/A was not indicated by the model in 1989 for either the CT or

NT Lexington sites at Jackson. Applying N at the rate of 40 instead of 80 lb/A at planting produced lower petiole N concentrations (**Table 6**). Increasing the N rate from 40 to 80 lb/A on the CT and NT systems increased lint yields, with actual yields ranging from 111 to 179% greater than predicted yields. Plant population recommended for the model was 3 to 4 plants per foot of row; the actual plant population on the Lexington sites was 2.1 plants per foot of row. Lower plant populations allow greater development of vegetative branches, and greater yields. Vegetative branches accounted for 40 to 50% of the total bolls and one third of the open bolls on October 6 (data not shown). The model did not adequately account for vegetative branch production at this lower plant population. Based on these data, the 1990 model was adjusted to account for greater vegetative branch production at lower plant populations.

Predicted N and Yield for 1990

The 1990 Ames Plantation data show that petiole N concentrations and yields varied with soils and N treatments (**Table 7**). The model predicted the need to apply N above the rate of 80 lb/A for the five sites. The rate of extra N ranged from 53 to 71 lb/A,

TABLE 8. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1990.

N rate (lb/A)		Sampling periods			Yield ¹		
		7/10	7/27	8/14	A	P	D ²
Planting ³	Side-dressed ⁴	PPM N			lb/A		
Lexington silt loam - CT							
80		5000	1700	500	1130	850	32
48	32	7400	3700	700	1230	1020	21
40		4200	700	400	1220	780	56
L.S.D. (0.05)		NS	NS	NS	NS		
Lexington silt loam - NT							
80		4700	1500	400	1130	910	24
48	32	7300	2300	700	1170	990	18
40		4004	2100	500	1120	890	26
L.S.D. (0.05)		NS	NS	NS	NS		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 9.

⁴ Side-dressed on June 21.

depending on the soil. Applying N at the rate of 40 lb/A produced lower petiole N concentrations than higher rates. Yields from the Memphis, Grenada, and Vicksburg soil sites were not significantly affected by rate or timing of application. At both the CT and NT Lexington sites, splitting the 80 lb/A application produced greater yields than applying 40 lb/A. Model-recommended N rates, which were applied in August, resulted in greater yields on the CT and NT Lexington soil than applications of 80 lb/A at planting, but yields were not significantly greater than the 80 lb/A side-dress treatment. This observation suggests that rainfall between planting and side-dress time may have reduced soil N concentrations, although soil N was not evaluated during the growing season.

Predicted yields were greater than actual yields on four of the five sites. The model's yield predictions were evaluated on only one treatment on each of the sites at Ames Plantation. Actual yields for the five sites ranged from 41% lower to 15% greater than predicted yields.

The model did not predict the need to apply N above the rate of 80 lb/A for either CT or NT Lexington sites at Jackson. Petiole N concentrations and yields were not significantly affected by N

treatments for either the CT or NT Lexington sites (Table 8). Actual yields ranged from 18 to 56% greater than predicted yields.

The model did not predict the need to apply extra N to either the CT or NT Lexington sites at Milan. Petiole N concentrations were lower when N was applied at the rate of 40 lb/A than when applied at the rate of 80 lb/A (Table 9). Petiole N analysis by the Arkansas method did not indicate a need for extra N. Yields were not significantly affected by N treatments. Actual yields ranged from 37 to 118% greater than predicted yields.

Predicted N and Yield for 1991

Yields from each soil site indicate good to excellent production levels. The model did not predict the need for extra N for any of the 1991 soil sites.

Because of the extremely high rainfall during the first 2 weeks following planting at Ames Plantation, crop germination and the resulting stand varied among and within sites. Petiole N concentrations at Ames Plantation varied by soils and dates of sampling (Table 10). Applying N at the rate of 80 lb/A tended to produce higher N concentrations than applying 40 lb/A. Yields from the CT and NT Lexington sites were significantly affected by N rates and/

TABLE 9. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Milan in 1990.

N rate (lb/A)		Sampling periods			Yield ¹		
		7/11	7/25	8/8	A	P	D ²
Planting ³	Side-dressed ⁴	PPM N			lb/A		
Loring silt loam - CT							
80		9700	7800	3000	1190	870	37
48	32	9400	7700	2000	1170	760	54
40		4400	4200	700	1220	560	118
LSD (0.05)		4300	2100	900	NS		
Loring silt loam - NT							
80		6200	3400	1200	1250	800	56
42	32	7200	2100	1500	1210	690	75
40		3100	1700	700	1180	560	111
LSD (0.05)		2500	1300	400	NS		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 9.

⁴ Side-dressed on June 20.

or times of N application. Broadcasting N at the rate of 80 lb/A at planting resulted in higher yields than broadcasting 40 lb/A. Actual yields for the NT Lexington site, the Memphis site, and the Grenada site ranged from 17 to 40% greater than predicted yields. Actual yields for CT Lexington and Vicksburg sites were less than predicted yields by 16 and 33%, respectively. The CT and NT Lexington yields were significantly increased by increasing the broadcast N

rate applied at planting from 40 and 80 lb/A.

Splitting the N application of 80 lb/A increased NT Lexington yields at Jackson more than broadcasting either 80 or 40 lb/A at planting (**Table 11**). Increased yields from the split N treatment indicate that soil concentrations of N applied at planting were reduced between the application dates by rainfall. Soil N concentrations during the growing season were not measured. Actual yields from the CT and

TABLE 10. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Ames Plantation in 1991.

N rate (lb/A)		Sampling periods			Yield ¹		
		8/8	8/22	9/4	A	P	D ²
Planting	Side-dressed ⁴	PPM N			lb/A		
Memphis silt loam - CT							
80 ³		1200	1100	1200	710	590	20
48	32	1900	1000	1000	720		
40		500	400	400	670		
L.S.D. (0.05)		700	600	700	NS		
Lexington silt loam - CT							
80 ⁵		2000	2000	1400	780	930	-16
48	32	1700	1400	1000	770		
40		1100	700	900	680		
L.S.D. (0.05)		669	893	NS	60		
Lexington silt loam - NT							
80 ⁵		1700	1100	800	820	700	17
48	32	800	900	500	800		
40		1400	1000	500	640		
L.S.D. (0.05)		NS	NS	NS	70		
Grenada silt loam - CT							
80 ³		800	800	400	1270	910	40
48	32	800	600	400	1250		
40		400	600	400	1060		
L.S.D. (0.05)		300	NS	NS	NS		
Vicksburg silt loam - CT							
60 ³		2100	1100	600	580	860	-33
36	24	1900	1400	500	480		
30		1000	1300	500	550		
L.S.D. (0.05)		600	NS	NS	NS		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 20.

⁴ Side-dressed on June 26.

⁵ Planted May 14.

NT sites were 5% less to 34% greater than predicted yields.

Petiole N concentrations were not significantly affected by N treatments (Table 12). Yields were not significantly affected by N treatments for the CT Loring site at Milan. The NT yields were increased by the side-dressed and broadcast 80 lb/A N rates when compared with the 40 lb/A N treatment. Actual yields for the CT and NT sites ranged from 65 to 94% higher than predicted yields. It is interesting that the predicted yield for sites fertilized at 40 lb/A N at planting was higher than sites fertilized at 80 lb/A N at planting.

Conclusions

The GOSSYM-COMAX growth simulation model/expert management system for cotton production was evaluated at three experiment stations on six soils to provide information about Tennessee soils and climatic conditions to the GOSSYM-COMAX Information Unit. Adjustments made to the model over the four-year period included an improved data entry method and the inclusion of plant growth measurements throughout the growing season. The model may need additional modifica-

tions before it can accurately predict crop development to maturity for this area; i.e., modification based on location. The model's ability to predict additional N fertilization improved with each modification; however, the model was erratic in predicting yields based on soils, locations, and N treatments. The model tended to underestimate actual yields in the high-yielding environments at Jackson and Milan, but tended to overestimate yields in the low-yielding Ames Plantation environments. Tillage system did not greatly alter the predictions' accuracy in any location or year.

Literature Cited

- Burmester, C. H., J. F. Adams, and L. J. Chapman. 1988. Effect of nitrogen fertilizer rates and defoliation timing on cotton yield and quality — A GOSSYM-COMAX comparison. In *Proceedings of the 1988 Beltwide Cotton Production Research Conference*, Jan. 3–8, New Orleans, Louisiana. National Cotton Council of America. pp. 509–10.
- . 1989. Field evaluations of GOSSYM-COMAX in Alabama. In *Proceedings of the 1989 Beltwide Cotton Production Research*

TABLE 11. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Jackson in 1991.

N rate (lb/A)		Sampling periods			Yield ¹		
		8/2	8/13	8/27	A	P	D ²
Planting ³	Side-dressed ⁴	PPM N			lb/A		
Lexington silt loam - CT							
80		1000	400	300	1350	1190	13
48	32	1500	600	400	1470	1130	30
40		800	300	200	1250	970	29
L.S.D. (0.05)		540	NS	NS	NS		
Lexington silt loam - NT							
80		1760	890	520	1240	930	33
48	32	1180	650	580	1420	1200	18
40		730	660	630	1230	1300	-5
L.S.D. (0.05)		NS	NS	NS	130		

¹ A = actual lint yields; P = predicted yields.

² Percent difference based on predicted yields.

³ Planted May 3.

⁴ Side-dressed on June 25.

TABLE 12. Effect of N rate, time of N application, and tillage on petiole nitrate concentration, yield, and predicted yield of cotton at Milan in 1991.

N rate (lb/A)		Sampling periods			Yield ¹		
		8/1	8/14	8/29	A	P	D ²
Planting ³	Side-dressed ⁴	PPM N			lb/A		
Loring silt loam - CT							
80		300	300		1220	660	85
48	32	400	400		1280	660	94
40		300	358		1240	670	85
L.S.D. (0.05)		NS	NS		NS		
Loring silt loam - NT							
80		700	700	500	1160	620	87
48	32	700	700	500	1200	620	94
40		500	500	500	1090	660	65
L.S.D. (0.05)		NS	NS	NS	80		

¹ A = actual lint yields; P = predicted yields.² Percent difference based on predicted yields.³ Planted May 2.⁴ Side-dressed on June 25.

Conference, Jan. 2-7, Nashville, Tennessee.

National Cotton Council of America. pp. 493-94.

Keisling, T. C., R. L. Maples, and J. J. Varvil. 1990. A comparison of long-term N rate studies with estimated Gossym-Comax yields. In *Proceedings of the 1990 Beltwide Cotton Production Research Conference*, Jan. 9-14, Las Vegas Nevada. National Cotton Council of America. p. 488.

(USDA-GCIU) U.S. Department of Agriculture GOSSYM-COMAX Information Unit. February 1990. *GOSSYM-COMAX User's Manual*, 102 Mississippi Technology Center, Starkville, Miss. pp. 1-4.

———. January 1991. *GOSSYM-COMAX User's Manual*. 102 Mississippi Technology Center, Starkville, Miss. pp. 3-9.

**THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE, TENNESSEE 37996-4500**

E11-0415-00-008-94

Agricultural Committee, Board of Trustees
Joseph E. Johnson, President of the University;
Amon Carter Evans, Chairman;
L. H. Ivy, Commissioner of Agriculture, Vice Chairman;
Houston Gordon, R. B. Hailey, William Johnson, Nancy Overton;
D. M. Gossett, Vice President for Agriculture

STATION OFFICERS

Administration

Joseph E. Johnson, President
D. M. Gossett, Vice President for Agriculture
D. O. Richardson, Dean
T. H. Klindt, Associate Dean
J. I. Sewell, Associate Dean
William L. Sanders, Statistician

Department Heads

H. Williamson, Jr., Agricultural Economics and Rural Sociology
Fred D. Tompkins, Agricultural Engineering
K. R. Robbins, Animal Science
Bonnie P. Riechert, Communications
Carroll J. Southards, Entomology and Plant Pathology
Marjorie P. Penfield (acting head), Food Science and Technology
John C. Rennie (acting head), Forestry, Wildlife, and Fisheries
James D. Moran III (Associate Dean), Human Ecology
G. D. Crater, Ornamental Horticulture and Landscape Design
John E. Foss, Plant and Soil Science

BRANCH STATIONS

Ames Plantation, Grand Junction, James M. Anderson, Superintendent
Dairy Experiment Station, Lewisburg, H. H. Dowlen, Superintendent
Forestry Experiment Station: Locations at Oak Ridge, Tullahoma,
and Wartburg, Richard M. Evans, Superintendent
Highland Rim Experiment Station, Springfield, D. O. Onks, Superintendent
Knoxville Experiment Station, Knoxville, John Hodges III, Superintendent
Martin Experiment Station, Martin, H. A. Henderson, Superintendent
Middle Tennessee Experiment Station, Spring Hill, J. W. High, Jr., Superintendent
Milan Experiment Station, Milan, John F. Bradley, Superintendent
Plateau Experiment Station, Crossville, R. D. Freeland, Superintendent
Tobacco Experiment Station, Greeneville, Philip P. Hunter, Superintendent
West Tennessee Experiment Station, Jackson, James F. Brown, Superintendent