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Calibration and validation of the INFOCROP model for moisture stress situation in cotton

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Abstract

INFOCROP model is a generic model that integrates variety, soil, environmental and management practices. In cotton as water deficit stress increases the yield decreases in linear trend. The INFOCROP model overestimates the yield to an extent of 8.79 percent. The INFOCROP model simulated more number of days for phenological observations viz., anthesis (80 days) and maturity (177 days). The simulated boll weight is less than observed. Similarly INFOCROP model showed 16 percent more leaf area index in irrigated and 5.6 percent in rainfed condition. The boll weight deviated to an extent of 40 percent. During 2010-11 in the present study there was 16 percent decrease in yield in rainfed condition as compared to irrigated condition. There was decrease in growth and yield parameters. Thus considering the overall performance of the INFOCROP model, it predicts the yield to 91 percent of accuracy and hence it can be used in the evaluation of inputs and factors controlling growth for yield prediction in cotton.

Keywords: Simulation model, INFOCROP, water deficit, leaf area index

Introduction

Cotton (*Gossypium hirsutum* L.) “The king of fibre” and the leading fibre crop of the world is grown over an area of 34.2 m.ha with a production of 25.3 mt and productivity of 733.0 kg per ha. In India, it is grown on an area of 111.61 ha with a production of 312 million bales and the productivity is 475.0 kg per ha. Whereas in Karnataka, it is grown over an area of 5.34 lakh hectares with a production of 10.0 lakh bales and a productivity of 318.0 kg lint per hectare (Anon., 2010) ^[10].

In recent times several tools or systems research relating to computer and information technology have become available. Crop growth simulation model is one such tool. They are based on quantitative understanding of underlying processes and integrate the effects of soil, weather, crop, pests and management factors on growth and yield. These models need expensive and time-consuming field experimentations as they can be used to extrapolate the results of the research conducted in one season or one location to other seasons, locations or management. They also provide a means to quantify the effect of drought at different growth stages, soil and management on crop growth, yield and sustainability of agricultural production. For conducting such studies, the models are evaluated after calibrating and validating them under local conditions.

There are more than 25 crop simulation models developed around the world in cotton crop. One such model namely INFOCROP has been developed based on parent models viz., SUCROS, ORYZA and MACROS (Aggarwal *et al.*, 2006) ^[2]. A generic model ‘INFOCROP’ has been calibrated and validated using factors like weather, soil, genotypes, date of sowing, nitrogen level as basic inputs (Hebbbar *et al.*, 2007) ^[6]. The model has simulated the phenology more accurately and accuracy of simulated yield was 94% and biomass 89% across the agro-climatic zones. Using the crop model an integrated method was developed along with remote sensed area estimation and GIS techniques incorporating soil and weather parameters to predict the cotton production at regional level.

Materials and Methods

The INFOCROP used is from the Compact Visual Fortran version 6.1. The basic crop model is written in Fortran Simulation Translator (FST/FSE; Graduate school of production ecology Wageningen, The Netherlands) programming language.

INFOCROP considers the following processes of growth and development, soil water, nitrogen and carbon and crop pest interactions:

- **Crop growth:** photosynthesis, respiration, partitioning, leaf area growth, source: sink balance, phenology, transpiration, N uptake, allocation and redistribution, effects of stresses
- Soil water balance
- Soil nitrogen balance
- Soil organic carbon dynamics
- Emissions of green house gases.

INFOCROP includes 8 subroutines out of which the subroutine water stress has the following relations

*** Loss due to water stress

WSTRSX = INSW (ESWI-1.,1., LIMIT (0.,1., ATRANS/NOTNUL (PTRANS)))

WSTRES = INSW (SWXWAT-1.,WSTRSX,1.)

WSTOT = INTGRL (ZERO, WSTRES)

WSMEAN = WSTOT/NOTNUL (DAS)

Format of the data which were incorporated in the INFOCROP model are presented in Appendix I. The output file from each rerun is read in output file (Appendix III) and graph generated is depicted in Appendix IV. The present year values of different parameters averaged from the field and ROS are incorporated in INFOCROP model at peak flowering and boll opening stage are presented in Appendix V.

A) Effect of dates of sowing on growth and yield

Table on effects of dates of sowing on growth and yield is presented in Table 1 (a) and (b). Each year four dates of sowing were under taken at an interval of 20 days and data sets collected in each year was incorporated into the INFOCROP model and output was compared (Actual Vs Simulated).

B) Effects of moisture regimes on growth and yield

In the present study, the impact of moisture stress on growth and yield parameters were computed as the mean values in field and ROS experiment for the four moisture levels (M₁ to M₄). This set of data was used as input data for the simulation. The actual and simulated data is presented in Table 1c.

Results and Discussion

The data sets (observed Vs simulated) generated out of similar study is presented in Table 1a and 1b. In general, there was decrease in parameters associated with growth and phenology as the date of sowing delayed from D₁ to D₄. The model showed more number of days for phenological observation compared to observe. The values of yield and yield components were more in simulated than observed except boll weight. The simulated boll weight is less than observed boll weight. The values for many of these parameters listed decreased with the delay in sowing (D₁ to D₄).

In present study (2010) (Table 1c) indicated decrease in yield and yield components with decrease in soil moisture content. The actual yield decreased from 1603 to 1405 kg/ha from M₁ to M₄. The simulated yield also showed similar trend (3938 to 1969 kg/ha).

In simulation models, phenology is calculated using heat units in cotton (Hebbar *et al.*, 2002)^[4]. In simulation model, it is customary to represent the growth stage from sowing to maturity on same scale. In INFOCROP, this scale is given from 0 to 2. The development stage 0 (zero) represents sowing and 2 represents maturity. The developmental stage for anthesis is given as 1.0. In most cases, cotton at early growth stages suffers from intermittent drought, water logging or insect attack and at later stages due to the occurrence of multiple flushes of bolls. The INFOCROP model, simulated more number of days for anthesis and maturity except in case of Bt cotton hybrids during 2005-2006 (Table 1a). Cotton (Kiran Kadam *et al.*, 2024)^[9] basically is an indeterminate crop where the vegetative and reproductive phases overlap resulting in intra plant competition for photosynthesis between developing bolls and vegetative parts (main stem, lateral branches and leaves). In present day Bt cotton hybrids, there is increase in determinancy. In the beginning of the reproductive phase, almost all the squares formed will set into bolls. As a result, there is more sink activity and comparatively less source. As a result, there is increased determinance. In data sets used for model validation large variation was seen for time to flowering and maturity (Hebbar *et al.*, 2004)^[10]. In crop model's phenology is almost important parameter that decides the growth and yield and it is computed in terms of thermal units.

The mean TDM (from field and ROS experiments) decreased from 2783 kg/ha in irrigated to 2368 kg/ha in rainfed. By incorporation of these values in the INFOCROP model, it simulated TDM 3938 kg/ha in irrigated (M₁) to 1969 kg/ha in rainfed (M₄). Thus, the deviation in actual TDM recorded to simulated is from 29% in irrigated (M₁) to 16% in rainfed (M₄). The LAI in the field experiment decreased from 4.19 in irrigated (M₁) to 3.35 in rainfed condition (M₄). In ROS, it decreased from 3.26 in irrigated to 2.31 in rainfed. By incorporation of these valued in INFOCROP, it simulated LAI of 4.44 in irrigated (M₁) to 3.0 in rainfed (M₄). The intermediate moisture levels (M₂ and M₃) recorded LAI values in between these. Thus, the deviation in actual LAI observed to simulated is from 5% in irrigated (M₁) to 10% in M₄. In ROS, these deviation ranged from 26.5% in irrigated (M₁) to 23% in rainfed (M₄). Similar results were concluded by Hebbar *et al.*, (2004)^[10]. LAI simulated under irrigated condition was more accurate compared to rainfed condition. Model was sensitive to the differences seen in LAI between rainfed condition. During cropping season, the crop experiences heavy rains resulting in more moisture in the field and also at times periods of dry spells occur. Though, model simulates the effects of these stresses correctly, sometimes it become to sensitive which could have possibly under estimated the LAI in rainfed condition (Hebbar *et al.*, 2004)^[10].

The mean yield (from field and ROS experiment) decreased from 2783 kg/ha in irrigated (M₁) to 2368 kg/ha in rainfed condition (M₄). By incorporation of these values in INFOCROP model, it simulated yield 3938 kg/ha in irrigated to 1969 kg/ha in rainfed. Thus, the deviation in

actual yield recorded to simulated is from 32% in irrigated (M1) to 22% in rainfed (M4). INFOCROP model simulates 85% yield to the observed yield under moisture stress condition (Hebbar *et al.*, 2004) ^[10]. Similarly, the model simulates yield, TDM, LAI, boll weight and number of bolls per hectare at different moisture levels. The mean values in the earlier studies (Table 1) (Patil *et al.*, 2004) showed that the output simulated by INFOCROP is in agreement with the actual data recorded in these studies. However, the model deviated more for parameters like boll weight. Model simulated yield and biomass to an accuracy of 85% and 74% respectively (Hebbar *et al.*, 2004) ^[10]. Under rainfed condition, several factors like biotic and abiotic factors attributed in reduction of yield. Thus the final yield is very

complex phenomenon and it depends on the amount of fruit loss and the plants ability to compensate for the loss (Sadras, 1996). This model simulated most of these aspects reasonably. The difficulty in recording of lost leaves, squares and bolls in between the observations is partially responsible for not getting good agreement between simulated and observed biomass at maturity. Thus, INFOCROP model can simulate the growth and yield under different moisture levels. The water stress, in the present model as determined by the ratio of actual water uptake and potential transpiration will influence the rate of germination through thermal time and the leaf temperature during growth (Aggarwal *et al.*, 2000) ^[1].

Table 1a: Effect of dates of sowing on physiological parameters on Non-Bt cotton (Mean of 5 years, 1997-2002)

	DOS	D/	D/Anth		D/Maturity		Total dry matter (kg/ha)		Yield (kg/ha)		Number of bolls/ha		Boll weight (mg/boll)		Max. LAI	
		Emrge	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim
1997-02 (5 years)	D ₁	6.2	74.6	78.0	171.2	196.8	4355.6	4723.8	1263.0	1200.4	588292.0	1117400.0	4234.4	2748.4	2.40	1.55
	D ₂	6.4	75.8	78.4	172.2	196.8	3633.0	5064.4	1003.4	1168.4	561366.0	1180300.0	4315.8	2680.0	2.28	1.83
	D ₃	6.4	76.6	74.2	161.2	187.4	3147.4	5235.0	625.6	1072.0	452046.0	1206200.0	3874.8	2361.6	1.80	2.29
	D ₄	6.8	73.4	70.2	168.4	177.4	3068.2	3775.6	293.4	615.4	390036.0	817700.0	2992.0	2094.6	1.58	1.87
	Mean	6.45	75.10	75.20	168.25	189.60	3551.05	4699.70	796.35	1014.05	497935.00	1080400.00	3854.25	2471.15	2.01	1.89

D₁- First date of sowing, D₂- Second date of sowing, D₃- Third date of sowing, D₄- Fourth date of sowing Obs-Observed Sim-Simulated

Table 1b: Effect of dates of sowing on physiological parameters on Bt cotton (Mean of 2 years, 2005-06)

	DOS	D/	D/Anth		D/Maturity		Total dry matter (kg/ha)		Yield (kg/ha)		Number of bolls/ha		Boll weight (mg/boll)		Max. LAI	
		Emrge	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim
2005-06 (2 years)	D ₁	6.0	88.5	76.5	181.0	193.5	4117.5	5794.0	1536.5	1315.5	755163.5	1030161.0	3665.0	2751.0	1.69	2.12
	D ₂	6.5	88.5	77.5	169.0	191.5	4204.0	5441.5	1573.5	1181.5	449550.0	833413.0	4415.0	2780.0	1.80	2.35
	D ₃	6.5	86.5	80.5	174.5	179.0	3281.5	5319.0	1179.0	1107.5	560748.5	392252.5	3300.0	2601.0	1.41	1.88
	D ₄	6.5	85.5	79.0	161.0	175.5	3092.5	4219.0	944.5	807.5	372497.5	769952.0	4425.0	2299.0	1.50	1.74
	Mean	6.38	87.25	78.38	171.38	184.88	3673.88	5193.38	1491.75	1103.00	534489.9	756445	3951	2608	1.60	2.02

D₁- First date of sowing, D₂- Second date of sowing, D₃- Third date of sowing, D₄- Fourth date of sowing

Table 1c: Effect of moisture levels on growth, phenology and yield on Bt cotton genotypes (Mean of field and ROS, 2010-11)

	DOS	D/	D/Anth		D/Maturity		Total dry matter (kg/ha)		Yield (kg/ha)		Number of bolls/ha		Boll weight (mg/boll)		Max. LAI	
		Emrge	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim	Obs	Sim
2010 (1 year)	M ₁	6.0	76.0	80.0	124.0	187.0	4418.0	5280.0	2783.0	3938.0	131073	515610.0	5688.7	2336.0	3.73	4.44
	M ₂	6.0	75.0	80.0	125.0	187.0	3802.0	4616.0	2592.0	3532.0	116735	513554.0	5045.8	2415.0	3.51	3.25
	M ₃	7.0	74.0	80.0	125.0	187.0	3337.0	4915.0	2478.0	2632.0	109520	513530.0	4404.8	2356.0	3.31	3.25
	M ₄	7.0	73.0	80.0	122.0	187.0	2706.0	4722.0	2368.0	1969.0	99345	419694.0	3493.7	2094.0	2.83	3.00
	Mean	6.50	74.50	80.00	124.00	187.00	3566.0	4883.25	2555.0	3192.7	114168	490597.00	4658.3	2300.2	3.34	3.48

M₁- Irrigated, M₂- two irrigation, M₃- one irrigation, M₄- Rainfed

Conclusion

INFOCROP model developed with the help of several conservative relationships existing between climatic parameters and plant growth will predict the growth and yield of Bt cotton with a fair accuracy under a wide range of moisture regimes apart from empirically quantifying the effect of moisture stress on growth and yield of Bt cotton.

References

- Aggarawal PK, Kalra N, Chander S, Pathak H. INFOCROP: A generic model for simulating the effect of weather, soil, variety, management and pests on growth and yield of annual crops in tropical environments. Users manual. 2000. p.24.
- Aggarawal PK, Kalra N, Chander S, Pathak H. Infocrop: a dynamic simulation model for assessment of crop yields losses due to pests and environmental impact of agro-ecosystems in tropical environments. I. Model description. Agric Syst. 2006;89:1-25.
- Anonymous. All India Co-ordinated Cotton Improvement Project. Annu Rep. 2010;1:2-5.
- Hebbar KB, Venugopalan MV, Rao MRK, Gadade GD, Chatterji S, Mayee CD. Effect of sowing dates and fertilizer levels on phenology, growth and yield of cotton. Indian J Plant Physiol. 2002;7:380-383.
- Hebbar KB, Venugopalan MV, Rao MRK, Seshasai MV, Rao MVR, Patil BC, *et al.* Predicting cotton production using INFOCROP cotton simulation model, remote sensing and spatial agroclimatic data. Current Sci. 2008;95:1570-1579.
- Hebbar KB, Perumal NK, Khadi BM. Photosynthesis and plant growth response to transgenic Bt cotton (*G. hirsutum* L.) hybrid under field condition. Photosynthetica. 2007;45:254-258.

7. Sadras VO. Cotton responses to simulated insect damage: radiation use efficiency, canopy architecture and leaf nitrogen content as affected by loss of reproductive organs. *Field Crop Res.* 1996;48:199-208.
8. Hebbar SS, Ramachandrappa BK, Nanjappa HV, Prabhakar MJ. Studies on NPK drip fertigation in field grown tomato (*Lycopersicon esculentum* Mill.). *European Journal of agronomy.* 2004 Jun 1;21(1):117-27.
9. Kadam K, Chinchane VN, Deshmukh S, Rani R. Correlation and path analysis of yield and fibre quality traits in upland cotton (*Gossypium hirsutum* L.). *Int. J. Adv. Biochem. Res.* 2024;8(3):61-66. DOI: 10.33545/26174693.2024.v8.i3a.675
10. Ladoux B, Anon E, Lambert M, Rabodzey A, Hersen P, Buguin A, Silberzan P, Mege RM. Strength dependence of cadherin-mediated adhesions. *Biophysical journal.* 2010 Feb 17;98(4):534-42.

Appendix I. Format of the present year mean values of different parameters incorporated in INFOCROP

*2010 m1

TIMER STTIME = 177.

WEATHER CNTR='HEBB'; ISTN=1; IYEAR=2010

FUNCTION IRRTSF=0.,0.,44.,0.,45.,15.,46.,0.,59.,0.,60.,0.,61.,0.,89.,0.,90.,15.,91.,0.,119.,0.,120.,15.

FUNCTION LAIO=0.,0.,60.,1.98,90.,2.79,120.,3.73,150.,3.00

FUNCTION TDMO=0.,0.,60.,274.,90.,789.,120.,1882.,150.,2215.

FUNCTION WCL1O=0.,0.42,45.,0.36,75.,0.31,105.,0.27,136.,0.37

FUNCTION WCL2O=0.,0.39,45.,0.32,75.,0.30,105.,0.25,136.,0.36

FUNCTION WCL3O=0.,0.40,45.,0.33,75.,0.28,105.,0.24,136.,0.34

END

*2010 m2

TIMER STTIME = 177.

WEATHER CNTR='HEBB'; ISTN=1; IYEAR=2010

FUNCTION IRRTSF=0.,0.,44.,0.,45.,0.,46.,0.,59.,0.,60.,15.,61.,0.,89.,0.,90.,15.,91.,0.,119.,0.,120.,0.

FUNCTION LAIO=0.,0.,60.,1.24,90.,2.50,120.,3.65,150.,2.90

FUNCTION TDMO=0.,0.,60.,254.,90.,759.,120.,1582.,150.,1215.

FUNCTION WCL1O=0.,0.38,45.,0.30,75.,0.21,105.,0.23,136.,0.37

FUNCTION WCL2O=0.,0.34,45.,0.28,75.,0.20,105.,0.23,136.,0.36

FUNCTION WCL3O=0.,0.40,45.,0.25,75.,0.18,105.,0.22,136.,0.38

END

*2010 m3

TIMER STTIME = 177.

WEATHER CNTR='HEBB'; ISTN=1; IYEAR=2010

FUNCTION IRRTSF=0.,0.,30.,0.60.,0.,90.,0.120.,15,365.,0.

FUNCTION LAIO=0.,0.,60.,1.47,90.,2.33,120.,3.31,150.,2.74

FUNCTION TDMO=0.,0.,60.,214.,90.,503.,120.,1360.,150.,2295.

FUNCTION WCL1O=0.,0.39,45.,0.30,75.,0.21,105.,0.23,136.,0.37

FUNCTION WCL2O=0.,0.38,45.,0.28,75.,0.20,105.,0.23,136.,0.36

FUNCTION WCL3O=0.,0.40,45.,0.29,75.,0.18,105.,0.22,136.,0.34

END

***2010 m4

WEATHER CNTR='HEBB'; ISTN=1; IYEAR=2010

TIMER STTIME = 177.

FUNCTION IRRTSF=0.,0.,30.,0.60.,0.90.,0.365.,0.

FUNCTION UREAP1=0.,80.,1.,0.,29.,0.,30.,40.,31.,0.,59.,0.,60.,40.,61.,0.,365.,0.

FUNCTION LAIO=0.,0.,60.,1.17,90.,2.00,120.,2.83,150.,2.5

FUNCTION TDMO=0.,0.,60.,173.,90.,411.,120.,1118.,150.,3451.

FUNCTION WCL1O=0.,0.38,45.,0.28,75.,0.21,105.,0.23,136.,0.37

FUNCTION WCL2O=0.,0.34,45.,0.26,75.,0.20,105.,0.23,136.,0.36

FUNCTION WCL3O=0.,0.40,45.,0.25,75.,0.18,105.,0.22,136.,0.38

END

Appendix II. Output file from each rerun (Daily output)

LAT	STTIME	DS	ANTHD	DAS	TDM	YIELD	WGRAIN	LAI
14.9	165	2.02	80	180	5280	3938	5688	4.44
14.9	178	2.01	80	180	4616	3532	5045	3.25

14.9	198	1.87	80	180	4915	2632	4404	3.25
14.9	218	1.76	80	180	4722	1969	3493	3.00

Appendix VI. The following values of different parameters averaged from the field and ROS are incorporated in INFOCROP model

Treatments	TDM (Kg/ha)	LAI	YIELD (Kg/ha)	No. of bolls/ha	Boll weight (mg/boll)
M ₁	4417.99	3.73	2783	131072.5	5689
M ₂	3801.57	3.51	2592	116735	5046
M ₃	3337.22	3.31	2478	109520	4405
M ₄	2705.90	2.83	2368	99345	3494

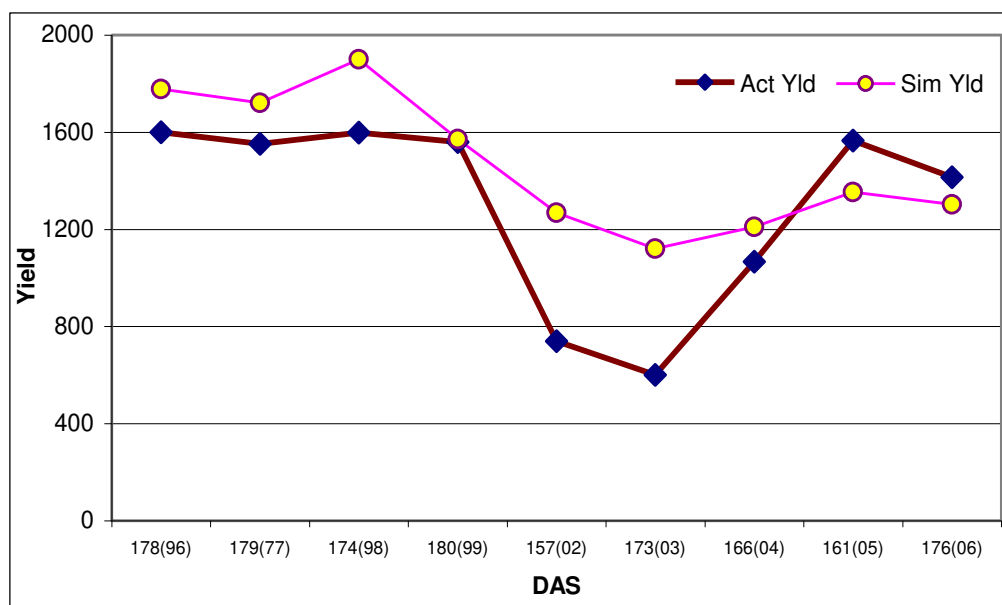


Fig 1: Actual and simulated yield of cotton during first date of sowing (D1)

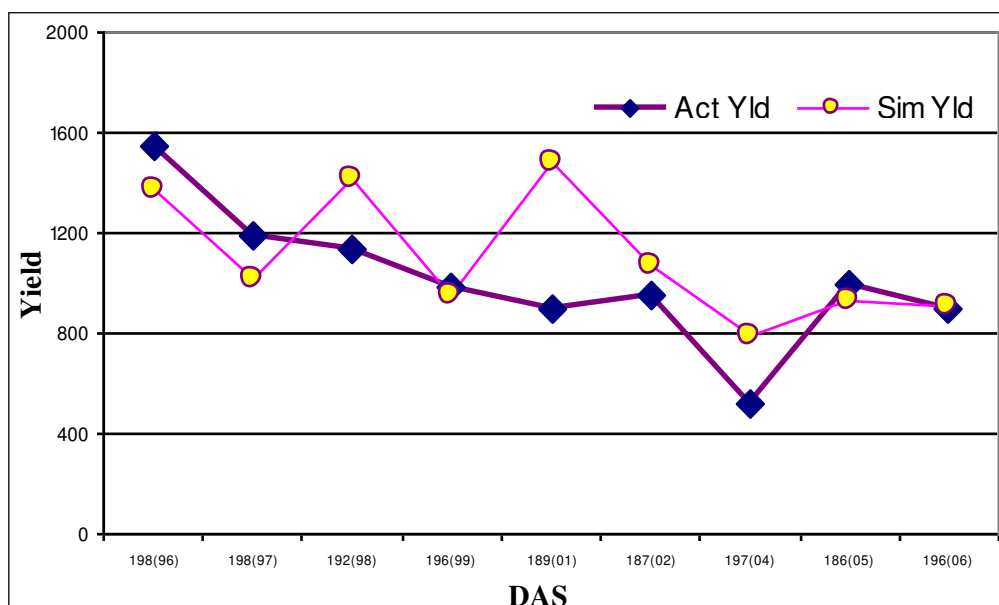


Fig 2: Actual and simulated yield of cotton during second date of sowing (D2)

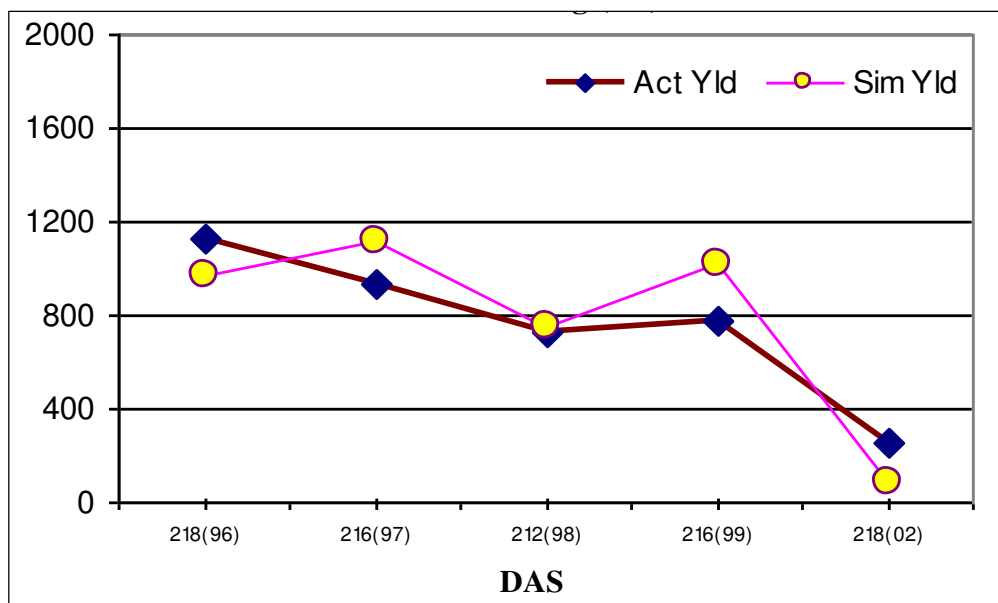


Fig 3: Actual and simulated yield of cotton during third date of sowing (D3)

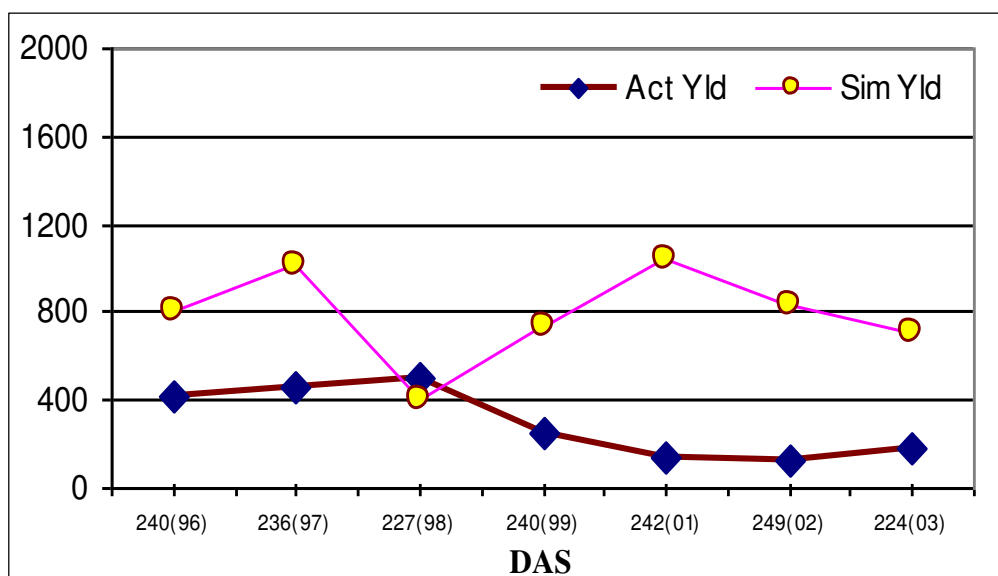


Fig 4: Actual and simulated yield of cotton during fourth date of sowing (D3)