Evaluation of DSSAT V.3.5 CERES-Maize model for western zone of Tamil Nadu

R. KARTHIKEYAN* and T. N. BALASUBRAMANIAN

Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore - 641003

ABSTRACT

Field experiments were conducted at Tamil nadu Agricultural University, Coimbatore, during rabi 2000, Late rabi 2001 and kharif 2001 seasons to evaluate the DSSAT V.3.5 CERES-Maize model under varied times of sowing of maize at Coimbatore, which is located in the western agro climatic zone of Tamil Nadu. The results revealed that the date of tasseling and grain yield predicted by CERES-Maize model showed good agreement with the observed values. But the model poorly predicted the biomass yield and harvest index of maize.

Key words: DSSAT, CERES-Maize model, Evaluation.

Maize, being reputed as "Poor Man's Nutricereal" possesses multiuse because of its higher nutritive value, of which its consumption as feed in the livestock sector is very large. The productivity of maize in India was increased from 547 kg harduring 1950-51 to a present productivity of 1655 kg ha-1. Tamil Nadu is a minor producer of maize in the country and is being cultivated in about 8500 ha area with an average productivity of 1609 kg hard (Season and crops report of Tamil Nadu, 2000). The average annual requirement of maize grain for poultry sector alone in the state is around 0.96 MT. Due to insufficient production and supply, the poultry sector has to depend either on the neighboring state (Karnataka, being the largest producer of maize in India)

or the foreign countries through import. The lower productivity of maize is the major concern in Tamil Nadu. Under these circumstances, Decision support System for Agrotechnology Transfer (DSSAT) is a valuable tool for making viable decisions on technological options and their transfer to any point in space and time.

The CERES-Maize model of DSSAT was developed by Jones and Kiniry (1986) and allows quantitative determination of growth and yield of maize. However, CERES-Maize model has not been evaluated under diverse agro climatic conditions. Therefore, the present study was undertaken to evaluate CERES-Maize model of DSSAT for western agro climatic zone of Tamil Nadu under varied times of

^{*}Present address: Assistant Professor (Agronomy), Pandit Jawaharlal Nehru College of Agricultrue and Research Institute, Karaikal - 609 603.

sowing.

MATERIALS AND METHODS

Field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore duing rabi 2000. Late rabi 2001 and kharif 2001 seasons. Verification trials were also conducted during rabi 2001 and Late rabi 2002 seasons based on the results obtained from the main trials. For CERES-Maize model evaluation, a separate plot was raised near the experimental site under unlimited water and nutrients supply for calculation of genetic coeficients, to be used in construction of Minimum Data Sets (MDS). The soil of the experimental field was low in available nitrogen (105 kg ha-1), medium in available phosphorus (14.2 kg ha-1) and high in available potassium (452 kg ha-1). The test crop hybrid CO H 3 was used for the experiments during all the seasons of the study. Split plot design was adopted and the treatments were replicated thrice during all the three seasons. The main plot treatments consisted of four dates of sowing each at fortnightly interval. The subplot treatments comprised of four fertilizer management practices (Table 1).

For evaluation of CERES-Maize model, a Minimum Data Set (MDS) on crop growth and development (Table 2), daily weather data on maximum and minimum temperature (°C), solar radiation (MJ m⁻² day⁻¹) and rainfall (mm) for 42 years {1960-2001 and experimental soil data were used as input. For soil information, a profile was

opened up near the experimental site and layerwise soil samples were collected for obtaining layerwise data on soil characteristics. The observations on crop growth and development like dry matter-production and leaf area index and date of onset of phenological stages, yield parameters and yield were taken both from the main experimental plots and from the genetic coefficient plots for constructing the MDS.

By using the acquired MDS in the Genetic Calculator programme of DSSAT V.3.5, the genetic coefficients for the test crop hybrid (CO H 3) were generated. The data obtained from the field experiments conducted during the different seasons were for creating corresponding experimental file (TNCB0001.MZX). average file (TNCB0001.MZA) and time file (TNCB0001.MZT) in order to evaluate the CERES-Maize model. While creating the experimental file, the same soil, weather and management conditions were used as that of the conditions that prevailed in the field during the period of experimentation. Using these input files, the model was run and simulated values on date of tasseling, grain/ biomass yield at harvest and harvest index were obtained. These simulated values were compared with the corresponding observed values obtained from the field experiments during different seasons for evaluation purpose. The Root Mean Square Error (RMSE) was worked out for different times of sowing. The percentage of RMSE with the observed values was also worked out.

Table 1: Treatment details

Main plots: Times of sowing (mid day of each fortnight)

Times of sowing	Rabi 2000	Late rabi 2001	Kharif 2001
S ₁ - 1 st fortnight of *	September	December	July
S ₂ - 2 nd fortnight of	September	January	July
S ₃ - 1 st fortnight of	October	February	August
S ₄ – 2 nd fortnight of	October	February	August

(*During late rabi 2000-01 season, S, sowing was carried out in2nd fortnight of Dec. 2000)

Subplots: Fertilizer management practices

- F1 Application of inorganics alone through blanket recommendation.
- F2 Application of inorganics alone through soil test recommendation.
- F3 Combined application of organics and inorganics (50: 50 each) through blanket recommendation
- F4 Combined application of organics and inorganics (50: 50 each) through soil test recommendation.

Using sensitivity analysis option in DSSAT V.3.5 CERES-Maize model, an attempt was also made to develop alternate management strategies to make tactic or strategic decisions by changing the experimental file (TNCB0001, MZX) with respect to sowing dates with an interval of one week and the maize grain yields were predicted for these seasons of study.

RESULTS AND DISCUSSION

Date of tasseling

The model predicted the date of tasseling closely to that of the observed values (Table 3) during all the three seasons of study. The mean observed dates of tasseling were 55, 54 and 54 DAS and the model prediction was 56, 53 and 54 DAS with the mean RMSE values of 2.12, 2.92 and 1.22 durng *rabi* 2000, Late *rabi* 2001 and *kharif* 2001 seasons, respectively.

Among the seasons, the mean percent RMSE with the observed values was very low (2.2) during kharif 2001 season. As the error was less than 5 per cent or slightly higher during all the three seasons of study, the prediction of date of tasseling of maize by CERES-Maize model was considered to be good under the experimental site condition. Shekh et al. (1999) also reported the close prediction of date of silking in maize by CERES-Maize model in Gujarat.

Table 2: Minimum Data Sets (MDS) for genetic coefficients calculation of maize hybrid CO H 3

Sl.No.	Code	Particulars	MDS		
1	HWAM	Yield at maturity (kg ha ⁻¹)	3813		
2	HWUM	Yield (dm / unit) at maturity (kg / unit)	1.46		
3	H#AM	No. at maturity (per sq. m)	6.6		
4	LAIX	Leaf Area Index (maximum)	3.94		
5	BWAH	Byproduct weight (kg ha ⁻¹) at harvest	10924		
6	CWAM	Tops weight (kg ha ⁻¹)	14565		
7	ADAT	Anthesis date	55		
8	MDAT	Physiological maturity date	93		
9	GN%M	Grain nitrogen (%) at maturity	1.71		
10.	CNAM	CNAM Tops nitrogen (kg ha 1) at maturity			
11	SNAM	Stem nitrogen (kg ha ⁻¹) at maturity	38.16		
12	GNAM	Grain nitrogen (kg ha ⁻¹) at maturity	65.2		

India.

Biomass yield at harvest

In geneal, CERES-Maize model underestimated the total biomass yield at harvest during all the three seasons of study (Table 4). During rabi 2000 season, the mean observed biomass production was 10766 kg ha⁻¹ while the model predicted was 9824 kg ha⁻¹. The RMSE was 1535 with a mean RMSE of 14.1 per cent. During Late rabi 2001 and kharif 2001 seasons also, the model prediction was less as against the observed biomass with mean percentages of RMSE of 35.8 and 19.7 respectively. This indicated that the model needed further

refinement with reference to the prediction of biomass yield.

Grain yield

The data on CERES- Maize model predicted and observed grain yield of maize are furnished in Table 5 and in Fig. 1 Among the three seasons of study, the model prediction for grain yield was very closer during rabi 2000 season followed by kharif 2001; whereas during Late rabi 2001 season, the difference between the predicted and observed values of grain yield was very high. The mean RMSE values computed were also low during rabi 2000 season, followed by kharif 2001; season and were

Table 3: Observed and CERES- Maize model predicted date of tasseling of maize in different seasons.

_	Sowings		Rabi 2000		-1	Late rabi 2001	_		Kharif 2001	
		Predicted tasseling date (DAS)	Observed tasseling date (DAS)	%RMSE with observed values	Predicted tasseling date (DAS)	Observed tasseling date (DAS)	%RMSE with observed values	Predicted tasseling date (DAS)	Observed tasseling date	%RMSE with observed
	S	99	S	3.7		56	5.2	0.3	54 .	2.2
	S2	56	57	3.7	51	54	5.4	54	53	2.3
	S3	55	5.4	3.9	52	52	5.6	53	55	2.2
	Sı	58	54	3.9	57	53	5.5	54	54	2.2
_	Mean	99	55.	3.8	53	54	5.4	. 54	54	2.2
	RMSE	2.12		100	2.92			1.22		

Table 4: Observed and CERES- Maize model predicted biomass yield (kg ha⁻¹) at maturity stage of maize in

No. Predicted biomass biomass Yield Predicted biomass biomass Airly biomass biomass Yield Predicted Observed biomass biomass biomass Airly	SI	Sowings		Rabi 2000		ij	Late rabi 2001	1		Kharif 2001	
S1 9861 11310 13.6 10117 12815 20.4 S2 8719 11382 13.5 9838 10396 36.2 S3 10191 10308 15.3 10205 9926 37.9 S4 10526 10064 14.3 2485 9491 39.6 Mean 9824 10766 14.1 8161 10657 35.8 RMSE 1535 - 3767 - -	0		Predicted biomass Yield (kg ha ⁻¹)	0	%RMSE with observed values	Jan 11	Observed biomass Yield (kg ha ⁻¹)	272911 250	Predicted biomass Yield (kg ha ⁻¹)	Observed biomass Yield (ke ha ⁻¹)	%RMSE with observed
S2 8719 11382 13.5 9838 10396 36.2 1 S3 10191 10308 15.3 10205 9926 37.9 S4 10526 10064 14.3 2485 9491 39.6 Mean 9824 10766 14.1 8161 10657 35.8 RMSE 1535 - 3767 - -	42	S_1	1986	11310	13.6	10117	12815	20.4	10115	10853	20.4
S ₃ 10191 10308 15.3 10205 9926 37.9 S ₄ 10526 10064 14.3 2485 9491 39.6 Mean 9824 10766 14.1 8161 10657 35.8 RMSE 1535 - 3767 -	100	S ₂	8719		13.5	9838	10396	36.2	10192	10748	20.4
Sa 10526 10064 14.3 2485 9491 39.6 Mean 9824 10766 14.1 8161 10657 35.8 RMSE 1535 - 3767 -		S3	10191	10308	15.3	10205	9926	37.9	7779	11354	19.5
9824 10766 14.1 8161 10657 35.8		S4	10526	10064	14.3	2485	9491	39.6	9996	12090	18.3
1535 3767		Mean	9824	99201	14.1	8161	10657	35.8	9438	11261	19.7
		RMSE	1535		120	3767	1	37	2209	•	

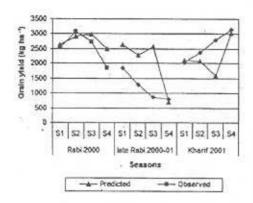
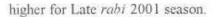


Fig. 1: Observed and model predicted grain yield (kg ha⁻¹) of maize in different seasons



During rabi 2000 season, the mean observed yield was 2547 kg ha-1 while the predicted vield was 2672 kg ha-1 with RMSE of 422 and per cent RMSE with observed values ranged from 13,7 to 22.9 per cent with a mean value of 17.2 per cent. Among the four sowing treatments, the predicted and observed values were very close with lesser percentage of RMSE (13.7 per cent) for S, sowing (sowing in the second fortnight of September)as compared to other sowing treatments. During kharif 2001season, the model underestimated the grain yield for the sowings from S2 to S4 During Late rabi 2001season, the model overestimated the grain yield for all the sowing reatments except in S, sowing,

The results inferred that expect in Late rahi 2001seson, the model prediction of grain yield was satisfactory for both rahi 2000 and kharif 2001seasons of the study.

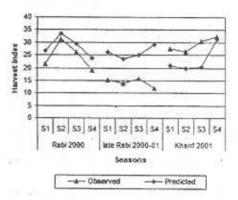


Fig. 2: Observed and model predicted harvest index of maize in different seasons

The performance of the model was very useful for the selection of the best sowing time for raising maize within the season. The performance of CERES-Maize model in maize grain yield prediction was well documented by Singh et al. (1993) in Malawi; Shekh and Rao (1996) in Gujarat, India and Parthipan (2000) in Tamil Nadu, India.

Harvest index

The perusal of the results from Table 6 and Fig. 2 revealed that, among the three seasons of study, the model over estimated the harvest index values for *rabi* 2000 and Late *rabi* 2001 seasons, with an underestimate for *kharif* 2001 season. The mean RMSE value for *rabi* 2000 was 4.01 with a percentage range from 12.70 to 21.10 while for *kharif* 2001 season; it was 6.86 with a mean percentage of 23.70. The RMSE value was high for Late *rabi* 2001 season (12.06). Hence, the model needed

Table 5: Observed and CERES- Maize model predicted grain yield (kg ha") of maize in different seasons.

SI	Sowings		Rabi 2000	2)/=	T	Late rabi 200			Kharif 2001	0
o Z		Predicted grain yield (kg ha ⁻¹)	Observed grain yield (kg ha ⁺)	%RMSE with observed values	Predicted grain yield (kg ha ⁻¹)	Observed grain yield (kg ha ⁻¹)	%RMSE with observed values	Predicted grain yield (kg ha ⁻¹)	Observed grain yield (kg ha ⁻¹)	7 0
22	Š	2642	-	9.91		1850			202	0
ri	S ₂	2924	3073	13.7	2289	1285	82.3	-	2369	0
iń	S3	2493	2739	15.4	2563	875	120.8	1588	2796	Y
4	S	2627	1841	22.9	707	797	132.6	3028	3156	0
	Mean	2672	2547	17.2	2047	1202	98.2	2202	2585	95
	RMSE	422			1057	•		626		1

Table 6: Observed and CERES-Maize model predicted harvest index of maize in different seasons.

No. 1. 2. 2. S ₂			Rabi 2000		1	Late rahi 2001			Kharif 2001	
S 22		Predicted harvest index	Observed harvest index	%RMSE with observed values	Predicted harvest index	Observed harvest index	%RMSE with observed values	Predicted harvest index	Observed harvest index	%RMSE with observed values
S		26.8	21.5	18.6	26.0	15.3	78.8	21.0	27.4	25.0
		33.5	31.4	12.7	23.3	14.0	86.1	20.0	26.4	25.9
S		29.3	26.2	15.3	25.1	15.7	76.8	20.4	30.5	22.5
. S4		23.7	19.0	21.1	29.0	11.9	101.3	30.3	32.4	21.2
Mean	u.	28.3	26.3	16.9	25.9	14.2	85.9	. 23.2	29.2	23.7
RMSE	SE	4.01		100	12.06	23	9	98.9	2	

Table 7: Predicted grain yield (kg ha⁻¹) of maize in different seasons by sensitivity analysis of CERES-Maize model

No.	Rabi	2000	Late ro	abi 2001	Khar	if 2001
	Sowing	Predicted grain yield (kg ha ⁻¹)	Sowing	Predicted grain yield (kg ha ⁻¹)	Sowing	Predicted grain yield (kg ha ⁻¹)
1	8.9.2000	2833 -	6.12.2000	2330	4.7.2001	1950
2	5.9.2000	2642	13.12.2000	2454	11.7.2001	2108
3	2.9.2000	2756	20.12.2000	2389	18.7.2001	1673
4	29.9.2000	2924	27.12.2000	2627	24.7.2001	2082
5	4.10.2000	2800	2.1.2001	2275	1.8.2001	1621
6	11.10.2000	2942	9.1.2001	2360	8.8.2001	1588
7	23.10.2000	2589 -	16.1.2001	2557	15.8.2001	1603
8	30.10.2000	2493	23.1.2001	2289	24.8.2001	3028
9	1.50	Δ.	6.2.2001	2563		
10		2	15.2.2001	2557	-	***

modification for correct prediction of

Sensitivity analysis

Among the three seasons of study, the model predicted higher grain yield (Table 7) for the simulated sowing taken during 4th week of August, 1st and 4th week of September and 2nd week of October, During rabi 2000 season, the highest predicted yield of 2942 kg hard was recorded for the simulated sowing taken during 2nd week of October and it was followed by sowing during 4th week of September (2924 kg hard). Whereas, lesser predicted values were noticed for the simulated sowings taken during the last two weeks of October.

During Late rahi 2001 season, the model predicted lower grain yields for all the simulated sowings.

In respect of kharif 2001 season, higher predicted yield of 3028 kg ha⁻¹ was recorded for the simulated sowing taken during the 4th week of August which was more than the yield obtained during rabi 2000 season. Thus, the sensitivity analysis option made to understand the crop-weather relationship during July. August and September months, irrespective of the seasons in the study area since yield variations are very high.

CONCLUSION

The CERES-Maize model of DSSAT

V. 3.5 gane satisfactory performance to predict the date of tasseling and grain yield of maize hybrid CO H 3 at Coimbatore, India. However, it required further refinement for biomass yield and harvest index prediction.

REFERENCES

- Jones, C.A. and J.R. Kiniry. 1986. CERES-Maize: a simulation model of maize growth and development. Texas A & M University Press, College Station, Texas, USA. P 194.
- Parthipan, T. 2000. Nitrogen management strategies in hybrid maize (CO H 3) using SPAD meter and predictions using CERES- Maize model. M.Sc. (Agri.) Thesis, Tamil Nadu Agricultural University, Coimatore.
- Season and Crop Report. 2000. Department of Statistics, Government of Tamil Nadu, Chennai. P 46.
- Shekh, A.M. and B. B. Rao., 1996. Crop growth modelling: Possibilities and

- limitations an Indian perspective. In: Climate Variability and Agriculture, Y.P. Abrol, Sulochana Gadgil and G. B. Pant (Eds.). Narosa Publishing House, New Delhi. pp. 356 -374.
- Shekh, A.M., H.R. Patel, R.S. Parmar and D. R. Reddy. 1999. Evaluation and comparison of CERES-Maize model with regression model under middle Gujarat agroclimatic region. In: Proc. National workshop on dynamic crop simulation modeling for agrometeorological advisory services, New Delhi. NCMRWF and DST. pp. 55-66.
- Singh, U., P.K. Thornton, A.R. Saka and J.B. Dent. 1993. Maize modelling in Malawi; a tool for soil fertility research and development. In: Systems Approaches for Agricultural Development, F.W.T. Penning de Vries et al. (Eds.) Kluwer Academic Publishers, The Netherlands. pp. 253-273.