*Journal of Agrometeorology 7 (2) : 190 - 198 (Dec 2005)*

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

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## 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, Evalaution.

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 ha$^{-1}$ during 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 ha$^{-1}$ (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

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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 used 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 |
|---|---|---|---|
| $S_1$ – 1st fortnight of * | September | December | July |
| $S_2$ – 2nd fortnight of | September | January | July |
| $S_3$ – 1st fortnight of | October | February | August |
| $S_4$ – 2nd fortnight of | October | February | August |

(*During late *rabi* 2000-01 season, $S_1$ 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 | Tops nitrogen (kg $ha^{-1}$) at maturity | 112.4 |
| 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 gencal, 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.

| Sl. No. | Sowings | *Rabi* 2000 | | | 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 (DAS) | %RMSE with observed values |
| 1. | $S_1$ | 56 | 56 | 3.7 | 53 | 56 | 5.2 | 53 | 54 | 2.2 |
| 2. | $S_2$ | 56 | 57 | 3.7 | 51 | 54 | 5.4 | 54 | 53 | 2.3 |
| 3. | $S_3$ | 55 | 54 | 3.9 | 52 | 52 | 5.6 | 53 | 55 | 2.2 |
| 4. | $S_4$ | 58 | 54 | 3.9 | 57 | 53 | 5.5 | 54 | 54 | 2.2 |
| | Mean | 56 | 55 | 3.8 | 53 | 54 | 5.4 | 54 | 54 | 2.2 |
| | RMSE | 2.12 | - | - | 2.92 | - | - | 1.22 | - | - |

**Table 4:** Observed and CERES- Maize model predicted biomass yield (kg ha$^{-1}$) at maturity stage of maize in different seasons.

| Sl. No. | Sowings | *Rabi* 2000 | | | Late *rabi* 2001 | | | *Kharif* 2001 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Predicted biomass Yield (kg ha$^{-1}$) | Observed biomass Yield (kg ha$^{-1}$) | %RMSE with observed values | Predicted biomass Yield (kg ha$^{-1}$) | Observed biomass Yield (kg ha$^{-1}$) | %RMSE with observed values | Predicted biomass Yield (kg ha$^{-1}$) | Observed biomass Yield (kg ha$^{-1}$) | %RMSE with observed values |
| 1. | $S_1$ | 9861 | 11310 | 13.6 | 10117 | 12815 | 20.4 | 10115 | 10853 | 20.4 |
| 2. | $S_2$ | 8719 | 11382 | 13.5 | 9838 | 10396 | 36.2 | 10192 | 10748 | 20.4 |
| 3. | $S_3$ | 10191 | 10308 | 15.3 | 10205 | 9926 | 37.9 | 7779 | 11354 | 19.5 |
| 4. | $S_4$ | 10526 | 10064 | 14.3 | 2485 | 9491 | 39.6 | 9666 | 12090 | 18.3 |
| | Mean | 9824 | 10766 | 14.1 | 8161 | 10657 | 35.8 | 9438 | 11261 | 19.7 |
| | RMSE | 1535 | - | - | 3767 | - | - | 2209 | - | - |

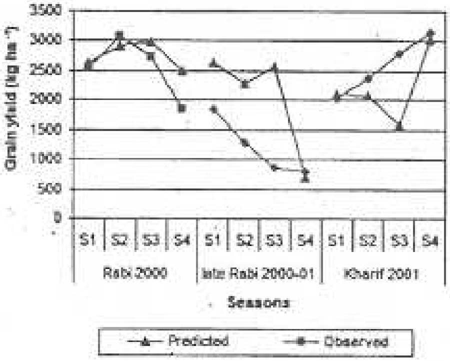


Fig. 1: Observed and model predicted grain yield (kg ha$^{-1}$) of maize in different seasons

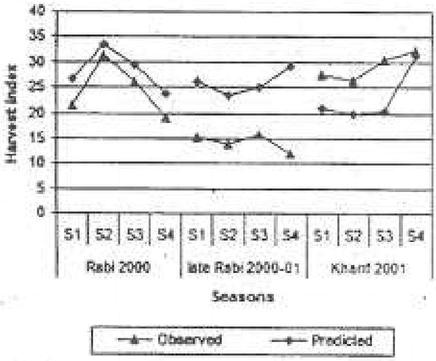


Fig. 2: Observed and model predicted harvest index of maize in different seasons

higher for Late *rabi* 2001 season.

During rabi 2000 season, the mean observed yield was 2547 kg ha$^{-1}$ while the predicted yield 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 $S_2$ 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 $S_2$ to $S_4$. During Late rabi 2001season, the model overestimated the grain yield for all the sowing reatments except in $S_4$ sowing.

The results inferred that expect in Late *rabi* 2001seson, the model prediction of grain yield was satisfactory for both *rabi* 2000 and *kharif* 2001seasons of the study. 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* 2001season. 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 $ha^{-1}$) of maize in different seasons.

| Sl. No. | Sowings | *Rabi* 2000 | | | Late *rabi* 2001 | | | *Kharif* 2001 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 $ha^{-1}$) | %RMSE with observed values | Predicted grain yield (kg $ha^{-1}$) | Observed grain yield (kg $ha^{-1}$) | %RMSE with observed values |
| 1. | $S_1$ | 2642 | 2536 | 16.6 | 2627 | 1850 | 57.1 | 2108 | 2020 | 31.0 |
| 2. | $S_2$ | 2924 | 3073 | 13.7 | 2289 | 1285 | 82.3 | 2082 | 2369 | 26.4 |
| 3. | $S_3$ | 2493 | 2739 | 15.4 | 2563 | 875 | 120.8 | 1588 | 2796 | 22.4 |
| 4. | $S_4$ | 2627 | 1841 | 22.9 | 707 | 797 | 132.6 | 3028 | 3156 | 19.8 |
| | Mean | 2672 | 2547 | 17.2 | 2047 | 1202 | 98.2 | 2202 | 2585 | 24.9 |
| | RMSE | 422 | - | - | 1057 | - | - | 626 | - | - |

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

| Sl. No. | Sowings | *Rabi* 2000 | | | Late *rabi* 2001 | | | *Kharif* 2001 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 |
| 1. | $S_1$ | 26.8 | 21.5 | 18.6 | 26.0 | 15.3 | 78.8 | 21.0 | 27.4 | 25.0 |
| 2. | $S_2$ | 33.5 | 31.4 | 12.7 | 23.3 | 14.0 | 86.1 | 20.0 | 26.4 | 25.9 |
| 3. | $S_3$ | 29.3 | 26.2 | 15.3 | 25.1 | 15.7 | 76.8 | 20.4 | 30.5 | 22.5 |
| 4. | $S_4$ | 23.7 | 19.0 | 21.1 | 29.0 | 11.9 | 101.3 | 30.3 | 32.4 | 21.2 |
| | Mean | 28.3 | 26.3 | 16.9 | 25.9 | 14.2 | 85.9 | 23.2 | 29.2 | 23.7 |
| | RMSE | 4.01 | - | - | 12.06 | - | - | 6.86 | - | - |

**Table 7:** Predicted grain yield (kg $ha^{-1}$) of maize in different seasons by sensitivity analysis of CERES-Maize model

| No. | *Rabi* 2000 | | Late *rabi* 2001 | | *Kharif* 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 | -- | -- | 6.2.2001 | 2563 | -- | -- |
| 10 | -- | -- | 15.2.2001 | 2557 | -- | -- |

modification for correct prediction of harvest index.

### *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 $ha^{-1}$ 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 $ha^{-1}$). Whereas, lesser predicted values were noticed for the simulated sowings taken during the last two weeks of October.

During Late *rabi* 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.

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