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# Estimation of potential yield of rice using DSSAT-CERES rice model

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**Abstract**
The main aim of this study is to quantify the potential yields of rice in the Mahabubnagar district of Telangana state. For this DSSAT-CERES Rice model is used. The weather, soil and crop management data are collected from NASA Power and some published sources of PJTSAU and ICAR-IIRR. To run any model in DSSAT firstly it should be calibrated and evaluated. Thus DSSAT-CERES Rice model is evaluated and calibrated with the data collected from the farmers of the Mahabubnagar district. The seasonal analysis was carried out and potential yields of 30 years (1993-2022) were calculated.

**Keywords:** Rice, potential yield, DSSAT, CERES-rice and Mahabubnagar

## Introduction

Rice is one of the most consumed foods on earth, a staple food for more than 3.5 billion people worldwide and about half of the world's population. In India, 50% of its population depends on this grain for sustenance. India is the world's second-largest producer and the largest exporter of rice in the world.

Rice production in the world in the year 2022 is 515.3 million metric tons (USDA, 2022). The food grain production in India during 2021-2022 is 314.51 million tons and the production of paddy during the year is 129.66 million tons (India stat 2021-2022). The production of paddy in Telangana state of India in 2022 is 9.63 million tons.

Potential Yield is the yield of a current cultivar "when grown in environments to which it is adapted; with nutrients and water non-limiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled" (Islam *et al.*, 2021) [11] and measured in a variety of ways such as using crop growth models, maximum yield trials, and other research experiments or best yields from farmers' fields.

An experimental technique for identifying and quantifying yield constraints in farmers' fields was developed and validated by Gomez. It measures the potential yield, the actual yield, and the yields corresponding to the addition or removal of test factors over and above the farmer's levels.

Many crop models can incorporate location-specific physical conditions to estimate crop growth and potential yields for particular crop types, as well as for combinations of many crops. Crop simulation models deal with interactions of crop growth with climatic conditions, soil conditions, and agronomic management practices; therefore, crop simulation can be used to estimate the limitations on crop growth and yield (Ittersum *et al.*, 2013; Liu *et al.*, 2012) [3, 5]. These crop models are often developed using field and experimental data, thus providing reliable estimates of plant growth and potential yields and are very useful tools when designing agricultural systems for the maximization of production outputs.

DSSAT is a popular crop model that is used worldwide for modelling the growth and yield of 30 different crops including rice under given soil and daily weather conditions. For future yield prediction, it is required to calibrate and validate the DSSAT model by adjusting the cultivar genetic coefficients (Kumar *et al.*, 2019) [12]. For rice, there were 8 genetic coefficients and they describe the genotype and environmental interactions.

A validated DSSAT model can be used to predict future rice yields with future weather conditions and find suitable adaptation measures to increase the yield. These tools can reduce the need for expensive and time-consuming field trials and could be used to analyze yield gaps in various crops including rice.

DSSAT modelling system which is an advanced physiological-based rice crop growth simulation model was used to predict rice growth, development, and response to various climatic conditions. This was through the determination of the duration of growth stages, dry matter production and partitioning, root system dynamics, the effect of soil water and soil nitrogen contents on photosynthesis, carbon balance and water balance (Ritchie *et al*., 1998 and Singh *et al*., 2021) [8, 9] followed by sensitivity analysis to assess the effects of change in weather conditions on the yield.

## Materials and Methods

### Study area

This study is conducted in Mahabubnagar district of Telangana state. The latitude and longitude of Mahabubnagar district are 16.7375°N and 78.008188°E. This district was selected as the productivity (<3 tonnes/hectare) of rice was less in this district when compared to all other districts in Telangana.

### Data and Source of the study

For the Mahabubnagar district in Telangana state, the observed daily meteorological data from 1993 to 2022 (Solar radiation, maximum temperature, minimum temperature, and rainfall) were obtained from the NASA Power official website https://power.larc.nasa.gov.For this study, soil data i.e., physical, chemical and biological properties are needed for running the DSSAT model. This data was collected from the GIS.

This study is carried out on rice crops. Some crop parameters data like Crop data (Crop coefficient values, phenological stages, rooting depth, yield and yield attributes etc.) and crop management data (Such as amount of irrigation, irrigation method, amount of fertilizer, fertilizer application method, harvesting and planting information) were required for running the model. This data is collected by conducting a survey in the Mahabubnagar district of Telangana state and some secondary data was collected from the published literature.

### Methodology

### Potential yield ($Y_P$)

Potential Yield is the yield of a current cultivar "when grown in environments to which it is adapted; with nutrients and water nonlimiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled" (Islam *et al*., 2021) [11]. Potential yield depends on location as it relates to weather but is independent of soil, which is assumed to be physically and chemically favourable for crop growth. In this study, potential yield is simulated using the DSSAT v4.7.5 CERES-Rice model.

### DSSAT v4.7.5 CERES-Rice

DSSAT v4.7.5 CERES-Rice modelling system is an advanced physiologically based rice growth simulation model used to predict rice growth, development, and response to various climatic conditions. This was through the determination of the duration of growth stages, dry matter production and partitioning, root system dynamics, and the effect of soil water and soil nitrogen contents on photosynthesis, carbon balance, and water balance (Ritchie *et al*., 1998) [8], followed by sensitivity analysis to assess the effects of change in weather conditions on the yield.

Potential growth is mainly dependent upon photosynthetically active radiation (PAR), light interception, and light conversion efficiency, while actual growth is a constraint of crop management, and soil and weather interactions (Hoogenboom *et al*., 2019) [15]. Thus, the potential yield of Mahabubnagar district of Telangana is simulated by giving the minimum data requirement needed by the model.

### Inputs data required for the CERES-Rice model

Minimum data sets (MDS) on crop management, and macro and micro environmental parameters associated with weather, soil and crop are needed to run the CERES-Rice model (Hoogenboom *et al*., 2003) [2]. Thus, a weather file, a soil data file, a crop management file, an experimental details file and genotype data are required.

### Weather data file (WTH)

The weather data file includes daily weather information for the whole crop period, including the maximum temperature (°C), minimum temperature (°C), rainfall (mm), and total solar radiation (MJ m-2 day-1). The model-specific format for organizing weather data was used to save the file with the extension WTH. Thus, the weather file for the Mahabubnagar district has been created with all 30 years of daily weather data as MABN9032.WTH.

### Soil data file

The soil file for the study region is created using the soil information of the selected district. It involves soil texture, soil classification, the soil family CSC scheme, soil depth (In centimetres), albedo (Fraction), evaporation limit (In centimetres), flow rate (In fractions per day), run-off curve number, mineralization factor (on a scale of 0 to 1), photosynthesis factor (On a scale of 0 to 1), buffer determination process pH, nitrogen, phosphorus and potassium determination process. The model also requires horizon-specific data, including the amount of horizon, its thickness (in cm), its field potential, its crop point, its air-dry level, its reduced drained limit (in cm3 cm-3), its organic carbon content (in per cent), its water and buffer pH, its root development factor (in kg-1) and its cation exchange capacity (0.0 to 1.0) (Mishra *et al*., 2020) [13]. The information from the published literature has been gathered and the soil file for the Mahabubnagar district has been created is saved under ISRIC soil grids + HC27 soil as INMA800376.

### Crop management data (RIX) file

The crop management data file contains details about the crop, the variety, the dates of planting, the planting density, the row spacing, etc. Every experiment that needs to be simulated using this model has input data listed in this file. Information on the experiment conditions, including the name of the weather station and the soil analysis data set of soil parameters utilized for the nutrient simulation. Considerations include planting details, dates of planting, population emergence date, seedling depth row spacing, direction, etc. Initial soil water and inorganic conditions for water and nitrogen in the profile as well as used for root residue carried over from previous crops and N symbiosis initial condition. Dates of irrigation, thresholds, and water depths for rice flooding, fertilizer management (Date, type, and amount of fertilizer application), organic residue application, tillage application, environmental modification, adjustment factor for weather parameters as used in climate change and constant environmental studies, harvest management, and simulation controls are options for model component and output option are considered. A crop management file with the name PJTE2101.RIX was created with all the required data for the DSSAT CERES-Rice model.

### Experimental data (RIA)

The experimental data file contains the data collected from the farmers. The data includes the anthesis dates, maturity dates, transplanting, flowering and harvesting dates and yield data given by the farmers of the Mahabubnagar district of Telangana state. This is used for the validation and calibration of the model by comparing simulated values with observed values. An experimental data file called PJTE2101.RIA is created.

### Cultivars data file

The cultivars data file contains the cultivar-specific co-efficient, a specific number that recognizes the cultivars. Eight genetic coefficients are needed for describing the performance of a particular genotype under various aspects: P1, P2R, P5, P2O, G1, G2, G3 and G4 and these coefficients are described in table 2. These eight genetic coefficients for seven major rice-growing cultivars were developed in all three districts (Karimnagar, Medak and Mahabubnagar). Those seven cultivars are RNR 15048, MTU 1010, JGL 18047, KNM 118, and MTU 1075. These seven cultivars are represented as Cultivar 1, Cultivar 2, Cultivar 3, Cultivar 4 and Cultivar 5 in table 1.

**Table 1:** Different cultivars used in the study

| Cultivar name | Denoted as |
|---|---|
| RNR 15048 | Cultivar 1 |
| MTU 1010 | Cultivar 2 |
| JGL 18047 | Cultivar 3 |
| KNM 118 | Cultivar 4 |
| MTU 1075 | Cultivar 5 |

**Table 2:** The detailed description of 8 genetic coefficients of rice crop.

| Name | Description |
|---|---|
| Juvenile phase coefficient (P1) | The period is expressed as growing degree Days (GDD) °C over a base temperature of 9 °C from seedling emergence, during which rice plant is not responsive to changes in photoperiod. This phase is also known as the basic vegetative phase of the plant. |
| Critical photoperiod (P2O) | The longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P2O, the development is slow. Therefore, there is a delay owing to longer day lengths. |
| Photoperiodism coefficient (P2R) | The extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in °C) for each hour's increase in photoperiod above $P_2O$. |
| Grain filling duration coefficient (P5) | The period in GDD (°C) from the start of grain filling to physiological maturity with a base temperature of 9 °C. |
| Spikelet number coefficient (G1) | Knowable from the number of spikelets per gram of main culm dry weight (less leaf blades and sheaths plus spikes) at anthesis. |
| Single grain weight (G2) | The single grain weight (g) under idyllic growing conditions. |
| Tillering coefficient (G3) | Tillering coefficient relative to IR 64. |
| Temperature tolerance coefficient (G4) | Usually one for the varieties grown in a normal environment. |

### Evaluation

To get the model behaviour to match a certain collection of real-world data, calibration is the act of adjusting particular parameters or coefficients in functional relationships. A fundamental part of verification is calibration (Anurag and Singh, 2019) [1]. It is necessary to calibrate or parameterize a model so that simulated and observed values may be closely compared.

After creating the weather, soil, genotype and crop management input files the CERES-Rice model was run and output files were generated. These simulated results were compared with the observed data for evaluation.

The relevant coefficients were adjusted to produce the greatest possible match between the simulated and observed number of days to the phenological events, and this allowed the genetic coefficients that affect the [occurrence of developmental stages] in the CERES model to be derived. This entails first figuring out the phenology coefficient values, followed by the growth and grain development coefficient values. For calibrating the genetic coefficient, a minimum crop performance data collection, including dates for emergence, anthesis, the start of grain filling, the length of maturity, grain yield, above-ground biomass, grain density, and grain weight, is necessary.

The simplest kind of model validation is comparing observed and simulated data. When a model is validated, it is checked to see if it consistently predicts growth, yield and process for completely unrelated data sets. The model can be regarded as valid if the simulated data falls within the anticipated confidence level band. This can be determined using test criteria from statistical analysis.

Test criteria have been separated into two groups, called summary measures and difference measures. Summary measures include the mean of observed ($\bar{O}$) and predicted values ($\bar{P}$), the standard deviation of observations ($S_o$) and the predictions ($S_p$). The summary measures describe the quality of the simulation while, the difference measures try to locate and quantify the errors. The latter include the Mean Absolute Error (MAE), Mean Bias Error (MBE) and Root Mean Square Error (RMSE). They were calculated according to (Loague and Green, 1991) [6] and were based on the terms ($P_i$ -$O_i$).

$$\text{I } RMSE = \left[\sum_{i=1}^{n} \frac{(P_i - O_i)}{n}\right]^{0.5} \qquad \ldots (3.1)$$

MAE and RMSE indicate the magnitude of the average error, but provide no information on the relative size of the average difference between (P) and (O). The statistic MBE describes the direction of error bias. The value of MBE is related to the magnitude of the values under investigation. A negative MBE indicates that the predictions are smaller in values than those of the corresponding observations. Test criteria have been separated into two groups, called summary measures and difference measures. Summary measures include the mean of observed values (O) and predicted values (P), the standard deviation of observations (So) and the predictions (Sp), the slope (b) and intercept (a) of the least square regression ($P_i$ = a + b + $O_i$). Willmott *et al.* (1984) [10] calculated an index of agreement (D) as follows.

$$D = 1 - \left[\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(|P_i| + |O_i|)^2}\right]; 0 \le D \le 1 \quad \dots (3.2)$$

**Simulation run**

Simulation has been done for assessing the production potential of the rice crop in the Mahabubnagar district of Telangana under the normal conditions in CERES-RICE model incorporated in DSSAT v4.7.5.

**Seasonal analysis of CERES-Rice model**

Once a model is evaluated for use in a particular location or situation, it can be used to evaluate management strategies, such as cultivar selection, cultural and nutrient management practices under various weather patterns and field conditions (Yadav *et al.*, 2021) [14]. In this study, CERES-Rice model was used for long term simulation of potential yields of rice crop for over 30 years (1993 to 2022) for the Mahabubnagar district of Telangana state.

## Results and Discussion

**Caliberation and evaluation of model**

To calculate potential yields through the DSSAT v4.7.5CERES-Rice model, first the model is caliberated. For this, observed data is compared with the model simulated data. The model evaluation is a long term process in which the confidence in the model will be enhanced.

**Genetic coefficients**

CERES-Rice model requires a set of eight eco-physiological coefficients for simulation of phenology, growth and grain yield of rice cultivars. As these values are not available, genetic coefficents were estimated through repeated iterations as suggested by (Jones *et al.*, 2003) [4] until a close match between simulated and observed phenology, growth and yield was obtained. Genetic coefficients for each rice cultivar i.e., cultivar 1, cultivar 2, cultivar 3, cultivar 4 and cultivar 5 were given in the table 1.

The genetic coefficents were estimated with data collected from the 30 farmers of the three selected districts (Karimanagar, Medak and Mahabubnagar) of Telangana. These genetic coefficients include phasic coefficients (P coefficients) and growth coefficients (G coefficients). The P1, P5, P2R, P2O, G1,G2 and G3 coefficients are defined as the duration of the vegetative, grain filling stages, duration of panicle initiation, critical photoperiod or the longest day length at which the development occurs at a maximum rate, potential spiklet number, single grain weight and tillering coefficient respectively. These coefficients are described briefly in the table 2.

In Table 3, it is observed that the duration of vegetative stage(P1), duration of panicle initiation (P2R), duration of grain filling stage (P5), single grain weight (G2) differes from one cultivar to other, whereas the critical photoperiod (P2O) is almost similar (12.6) for all the cultivars expect Cultivar 1 (11.8) and Cultivar 5 (13.0). The lowest duration of vegetative stage is recorded for Cultivar 1 (480.0 GDD) and highest is recorded for Cultivar 2 (670.0 GDD). The lowest and highest duration of panicle initiation are recorded for Cultivar 3 (100.0 GDD) and Cultivar 1 (260.0 GDD) respectively. The duration of grain filling stage is recorded least for Cultivar 1 (370.0 GDD) and highest is recorded for Cultivar 2 (550.0 GDD).The tillering coefficient (G3) for all the rice cultivars is same i.e., 1.

**Phenology**

The accuracy of simulation of phenology of a crop is crucial for accurate simulation of crop growth, development and yield. Two major crop phenological stages *viz.*, days to 50% flowering (anthesis) and physiological maturity were compared with the model data.

**Table 3:** Genetic coefficients of rice cultivars used in this study

| Cultivar name | P1 (GDD) | P2R (GDD) | P5 (GDD) | P2O (hrs.) | G1 (No.) | G2(g) | G3 |
|---|---|---|---|---|---|---|---|
| Cultivar 1 | 480.0 | 260.0 | 370.0 | 11.8 | 72.0 | 0.0120 | 1.0 |
| Cultivar 2 | 670.0 | 130.0 | 550.0 | 12.6 | 70.0 | 0.0240 | 1.0 |
| Cultivar 3 | 570.0 | 100.0 | 515.0 | 12.6 | 78.0 | 0.0260 | 1.0 |
| Cultivar 4 | 520.0 | 190.0 | 540.0 | 12.5 | 80.0 | 0.0250 | 1.0 |
| Cultivar 5 | 550.0 | 130.0 | 515.0 | 13.0 | 75.0 | 0.0200 | 1.0 |

GDD – Growing degree days, hrs.- Hours, No. – Number, g – Grams per unit

**Days to 50% flowering**

The days to 50 per cent flowering depends upon the number of days for panicle initiation. Thus, the accuracy with which the model simulates the crop growth is based upon its accuracy to simulate the days to 50% flowering.

Statistical analysis of the model simulated data with the observed data for all the cultivars was done and presented in the table 4. It was observed that there was no difference in the simulated and observed date for 50% flowering (Anthesis date). The RMSE, n-RMSE and d-stat values for days to 50% flowering were 6.322, 7.3 and 0.838 respectively. According to Loague and Green (1991), if RMSE value lies between 1-10%, simulations are good. As our RMSE value is 6.3, it can be concluded that our simulation was good. In case of n-RMSE, a simulation can be considered excellent if N-RMSE value is smaller than 10%, good between 10% and 20%, fair between 20% and 30% and poor if larger than 30% (Raes *et al*., 2012) [7]. n-RMSE value for days to 50% flowering was found to be 7.3, thus our simulation is excellent. The values of d-stat ranges between 0 and 1, where 0 indicate no agreement and 1 indicate a perfect agreement between predicted and observed data (Willmott 1984) [10]. Our simulated d-stat value was 0.838 which is close to one, hence our simulation is acceptable.

The Fig.1 and table 5 gives the graphical and tabular representation of days to 50% flowering (Anthesis date) for all the rice cultivars respectively.

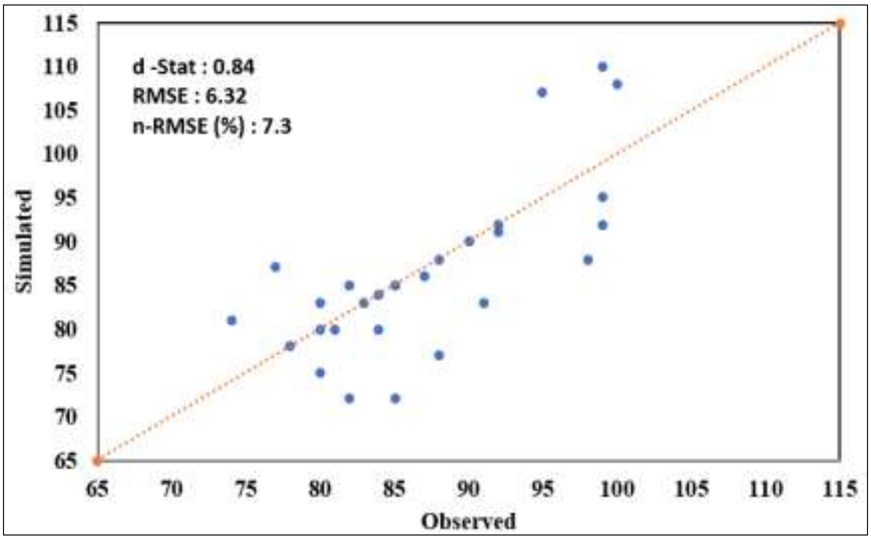


**Fig 1:** Observed vs. simulated days to 50% flowering of rice cultivars after calibration of CERES -Rice model

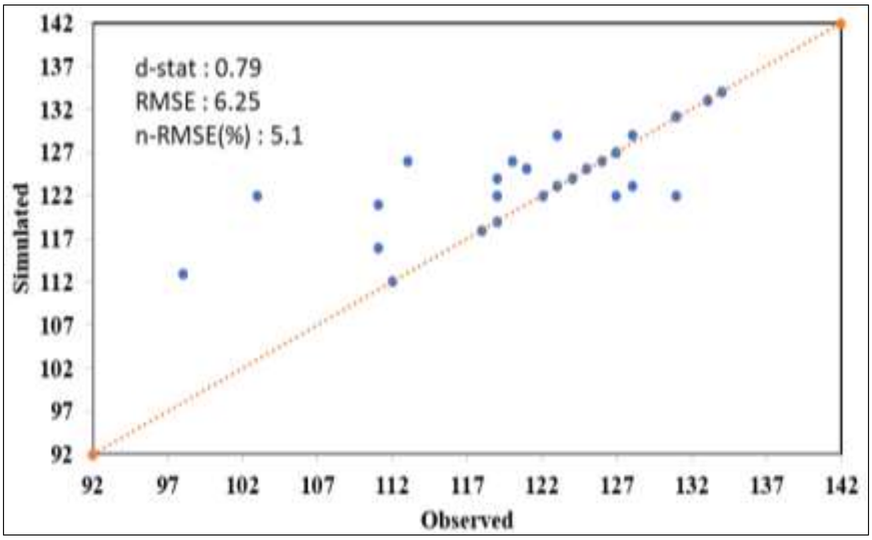


**Fig 2:** Observed vs. simulated days to maturity of rice cultivars after calibration of CERES -Rice model

**Phenological maturity**

The results obtained from the statistical analysis of days to maturity for all the rice cultivars is presented in the table 4. There is mean difference of two days for observed (122) and simulated (124) days to maturity. The RMSE, n-RMSE and d-stat values obtained are 6.253, 5.0 and 0.796 respectively. The RMSE values for each cultivar are in the range of 1-10%. According to Loague and Green (1991) [6], if RMSE value between 1-10%, simulations were good. Thus it is interpreted that days to maturity simulations are good for all the rice varieties. Similarly as n-RMSE value is less than 10 then simulations can be considerd as excellent (Raes *et al*., 2012) [7]. The values of d-stat ranges between 0 and 1, where 0 indicates no agreement and 1 indicates a perfect agreement between predicted and observed data (Willmott 1984) [10]. From the findings, it can be concluded that simulations of all the rice cultivars for days to maturity are good.

All the simulated and observed values of days to maturity for all the cultivars was represented in the graph in Fig. 2 and those values are given in table 5.

**Yield**

The observed and simulated yield data was analysed and shown in the table 4. The observed mean yield for all the cultivars was 5003 kg/ha and the simulated mean yield was 4993 kg/ha. The difference between observed and simulated mean yields is only 10 kg/ha for overall rice cultivars. The RMSE, n-RMSE and d-stat values were 431.1, 8.6 and 0.77 respectively.

According to Loague and Green (1991) [6], as the RMSE values are in the range of 1-10%, hence yield results obtained from the CERES-Rice model were good. Simualtions done can be considerd good and accepatable as they full fill the creteria of N-RMSE and d-stat values given by Raes *et al*., (2012) [7] and Willmott (1984) [10]. These overall observed and simulated mean yields are represented in the table 6 and graph in Fig. 3.

**Single grain weight**

The statistical analysis for single grain weight for rice is done and given in the Table 4. There is no mean difference between the observed and simulated single-grain weight. The observed and simulated mean of single grain weight is 0.018 grams. The RMSE value is 0.001, n-RMSE value is 5.7, and d-stat calculated value is 0.99. As the RMSE value is between 1-10%, then the simulated single-grain weight results are considered good (Loague and Green 1991) [6]. Simulated results are in accordance with the Raes *et al*., (2012) [7] and Willmott (1984) [10] in terms of n-RMSE and d-stat values. The observed and simulated values of single grain weight for all rice cultivars were given in the table 6 and these values are graphically represented in the Fig. 4.

**Table 4:** Statistical analysis of all rice cultivars of DSSAT model

| Variable Name | Mean | | S. D | | $R^2$ | RMSE | N -RMSE | d-Stat. |
|---|---|---|---|---|---|---|---|---|
| | Observed | Simulated | Observed | Simulated | | | | |
| Days to 50% flowering | 87 | 87 | 9.41 | 7.23 | 0.55 | 6.32 | 7.3 | 0.84 |
| Yield kg/ha | 5003 | 4993 | 387.73 | 581.80 | 0.55 | 431.12 | 8.6 | 0.77 |
| Unit Weight g/unit | 0.02 | 0.02 | 0.006 | 0.006 | 0.98 | 0.001 | 5.6 | 0.99 |
| Days to maturity | 122 | 124 | 8.74 | 5.45 | 0.58 | 6.25 | 5.0 | 0.80 |

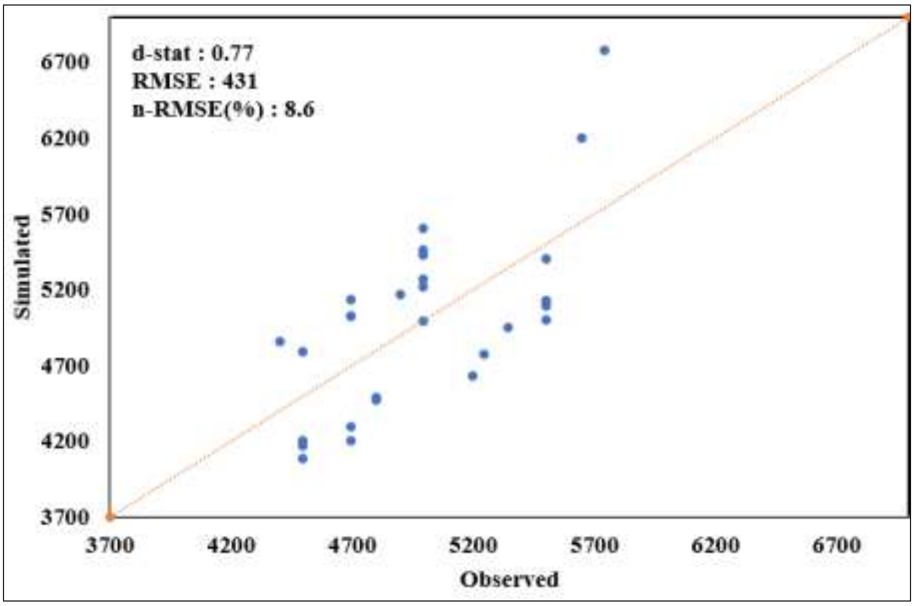


**Fig 3:** Observed vs. simulated yields of rice cultivars after calibration of CERES-Rice model

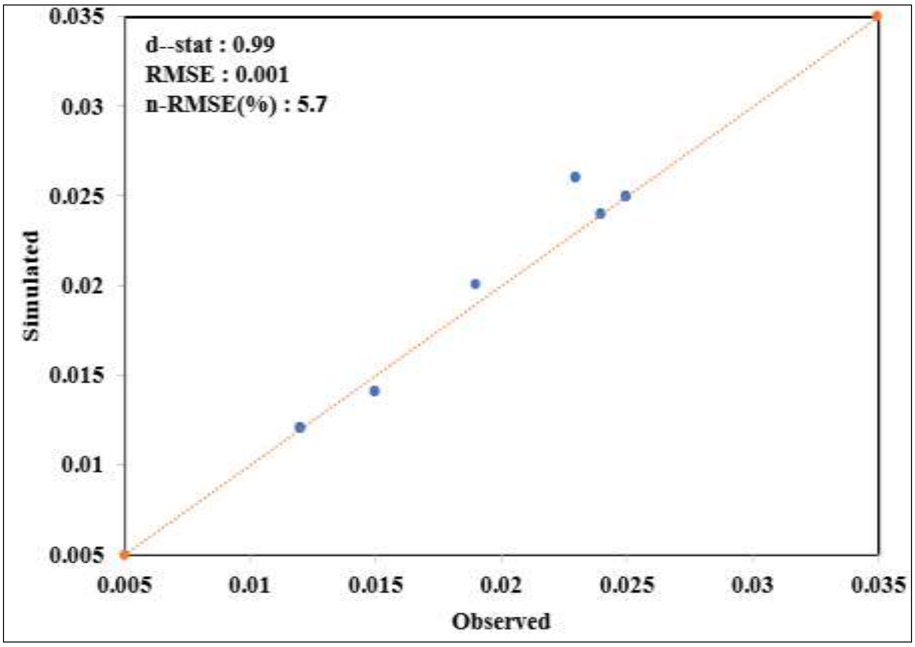


**Fig 4:** Observed vs. simulated single grain weight of rice cultivars after calibration of CERES-Rice model

**Estimation of potential yields through DSSAT model**

The CERES-Rice model is evaluated in DSSATv4.7.5 using the data collected from the selected district. Then the results from CERES-Rice model are good and are in the acceptable range. After evaluation, potential yields of rice crop were calculated for 30 years (1993 to 2022). For calculating potential yields for 30 years the seasonal analysis is carried out in CERES-Rice model. The crop management file is made with all the recommended package of practices in seasonal analysis format.

**Potential yields of Mahabubnagar district**

Potential yields of Mahabubnagar district are given in the table 7 for 30 years (1993 to 2022). In this district, there are five major growing rice cultivars. The potential yields are calculated for each cultivar for every year. The highest and lowest yields obtained are 8695 kg/ha and 6988 kg/ha. The overall mean potential yield for all five cultivars for 30 years is 7881 kg/ha.

**Table 5:** Simulated and Observed values of Days to 50% flowering days to maturity of all rice cultivars after calibration

| Days to 50% flowering (Simulated) | Days to 50% flowering (Observed) | Days to maturity (Simulated) | Days to maturity (Observed) |
|---|---|---|---|
| 87 | 86 | 125 | 121 |
| 82 | 72 | 123 | 128 |
| 88 | 88 | 121 | 111 |
| 74 | 81 | 116 | 111 |
| 78 | 78 | 119 | 119 |
| 77 | 87 | 118 | 118 |
| 80 | 80 | 122 | 119 |
| 88 | 77 | 126 | 113 |
| 83 | 83 | 125 | 125 |
| 85 | 72 | 127 | 127 |
| 91 | 83 | 122 | 103 |
| 99 | 95 | 133 | 133 |
| 80 | 75 | 122 | 122 |
| 100 | 108 | 129 | 123 |
| 82 | 85 | 123 | 123 |
| 92 | 92 | 134 | 134 |
| 84 | 84 | 127 | 127 |
| 84 | 80 | 126 | 120 |
| 85 | 85 | 129 | 128 |
| 98 | 88 | 133 | 133 |
| 92 | 92 | 124 | 119 |
| 80 | 83 | 112 | 112 |
| 95 | 107 | 126 | 126 |
| 81 | 80 | 113 | 98 |
| 99 | 110 | 131 | 131 |
| 90 | 90 | 122 | 131 |
| 99 | 92 | 131 | 131 |
| 90 | 90 | 122 | 127 |
| 92 | 91 | 124 | 124 |

**Table 6:** Simulated and Observed values of Yield and Single grain weight of all rice cultivars after calibration

| Yield kg/ha (Simulated) | Yield kg/ha (Observed) | Single grain Weight g/unit (Simulated) | Single grain Weight g/unit (Observed) |
|---|---|---|---|
| 5161 | 4900 | 0.014 | 0.015 |
| 5084 | 5500 | 0.025 | 0.025 |
| 4198 | 4500 | 0.014 | 0.015 |
| 5132 | 4700 | 0.025 | 0.025 |
| 5017 | 4700 | 0.024 | 0.024 |
| 5399 | 5500 | 0.024 | 0.024 |
| 5016 | 4700 | 0.024 | 0.024 |
| 4163 | 4500 | 0.014 | 0.015 |
| 5262 | 5000 | 0.025 | 0.025 |
| 4772 | 5250 | 0.025 | 0.025 |
| 6193 | 5650 | 0.012 | 0.012 |
| 4788 | 4500 | 0.012 | 0.012 |
| 4469 | 4800 | 0.020 | 0.019 |
| 4987 | 5000 | 0.012 | 0.012 |
| 4287 | 4700 | 0.026 | 0.023 |
| 4198 | 4700 | 0.024 | 0.024 |
| 4629 | 5200 | 0.026 | 0.023 |
| 4481 | 4800 | 0.026 | 0.023 |
| 4071 | 4500 | 0.025 | 0.025 |
| 4851 | 4400 | 0.012 | 0.012 |
| 5123 | 5500 | 0.012 | 0.012 |
| 6768 | 5750 | 0.012 | 0.012 |
| 5423 | 5000 | 0.012 | 0.012 |
| 5598 | 5000 | 0.012 | 0.012 |
| 5455 | 5000 | 0.012 | 0.012 |
| 4946 | 5350 | 0.012 | 0.012 |
| 4999 | 5500 | 0.012 | 0.012 |
| 5215 | 5000 | 0.012 | 0.012 |
| 5123 | 5500 | 0.012 | 0.012 |

**Table 7:** Potential yields of Mahabubnagar district from DSSAT model

| Mahabubnagar | | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **Cultivar 1** | **Cultivar 7** | **Cultivar 4** | **Cultivar 2** | **Cultivar 6** | **Mean** |
| 1993 | 8020 | 7837 | 8214 | 6205 | 5683 | 7192 |
| 1994 | 9299 | 8655 | 8620 | 6797 | 6294 | 7933 |
| 1995 | 7898 | 7972 | 8399 | 6415 | 5548 | 7246 |
| 1996 | 8398 | 9188 | 8938 | 6686 | 6521 | 7946 |
| 1997 | 7214 | 7546 | 8400 | 6111 | 5669 | 6988 |
| 1998 | 8885 | 8034 | 8957 | 6712 | 6344 | 7786 |
| 1999 | 9011 | 8671 | 9369 | 6645 | 5906 | 7920 |
| 2000 | 11233 | 7539 | 8476 | 6668 | 5559 | 7895 |
| 2001 | 8446 | 7676 | 10418 | 7138 | 5985 | 7933 |
| 2002 | 10764 | 9188 | 9707 | 7363 | 6451 | 8695 |
| 2003 | 7982 | 9478 | 9086 | 6440 | 5894 | 7776 |
| 2004 | 8616 | 8449 | 9673 | 6739 | 5637 | 7823 |
| 2005 | 9835 | 9437 | 9036 | 6090 | 6258 | 8131 |
| 2006 | 9131 | 9043 | 8222 | 6834 | 5531 | 7752 |
| 2007 | 8754 | 8659 | 9449 | 6691 | 6224 | 7955 |
| 2008 | 7566 | 9351 | 7579 | 7285 | 6328 | 7622 |
| 2009 | 10419 | 10664 | 9422 | 5430 | 6285 | 8444 |
| 2010 | 8210 | 7772 | 9359 | 6632 | 5707 | 7536 |
| 2011 | 9851 | 8865 | 8383 | 5996 | 6184 | 7856 |
| 2012 | 8226 | 8385 | 9542 | 5828 | 5437 | 7484 |
| 2013 | 10802 | 8866 | 9940 | 5804 | 5747 | 8232 |
| 2014 | 10044 | 9387 | 8912 | 6358 | 6330 | 8206 |
| 2015 | 7793 | 8757 | 8678 | 7166 | 6271 | 7733 |
| 2016 | 7638 | 10872 | 9714 | 6978 | 6313 | 8303 |
| 2017 | 8581 | 9347 | 9921 | 7288 | 6180 | 8263 |
| 2018 | 10369 | 11005 | 9188 | 6369 | 6311 | 8648 |
| 2019 | 8665 | 8934 | 9909 | 6713 | 5797 | 8004 |
| 2020 | 8559 | 8492 | 9730 | 6334 | 5384 | 7700 |
| 2021 | 7292 | 8783 | 7923 | 6290 | 5953 | 7248 |
| 2022 | 8509 | 9733 | 9709 | 6786 | 6145 | 8176 |
| Average | | | | | | 7881 |

## Conclusion

In this study the potential yields of Mahabubnagar district of Telangana state for 30 years (1993-2022) are quantified. Firstly, to simulate the potential yield from DSSAT model, model is calibrated and evaluated. It was observed that, simulations were in the acceptance range as per the values of RMSE, N-RMSE, d-stat values of observed and simulated data. DSSAT model evaluation is done by using the farmers data. Then by using Seasonal analysis of DSSAT v4.7.5 CERES-Rice model by giving the minimum data requirements potential yields of rice for Mahabubnagar district are simulated. The overall mean potential yield simulated is 7881 kg/ha. From this study it can be inferred that the DSSAT model can be used for the simulations of potential yields of different crops.

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## References

1. Anurag S, Singh SV. Calibration and validation of DSSAT model for rice in prayagraj. Journal of Pharmacognosy and Phytochemistry. 2019;8(4):2916-2919.
2. Hoogenboom G, Porter CH, Boote KJ, *et al*. DSSAT Cropping System Model. European Journal of Agronomy. 2003;18:235-265.
3. Ittersum MK, Cassman KG, Grassini P, *et al*. Yield gap analysis with local to global relevance-A review. Field Crops Research. 2013;143:4-17. DOI: 10.1016/j.fcr.2012.09.009.
4. Jones JW, Hoogenboom G, Porter CH, *et al*. The DSSAT cropping system model. European Journal of Agronomy. 2003;18:235-265. http://www.uwyo.edu/plantsciences/afri-cap-legumeadoption/_files/pdfs/dssat.pdf.
5. Liu Z, Yang X, Hubbard KG, Lin X. Maize potential yields and yield gaps in the changing climate of northeast China. Global Change Biology; c2012. DOI: 10.1111/j.1365-2486.2012.02774.x.
6. Loague K, Green RE. Statistical and graphical methods for evaluating solute transport models: Overview and application. Journal of Contaminant Hydrology. 1991;7:51-73. DOI: 10.1016/0169-7722(91)90038-3.
7. Raes D, Steduto P, Hsiao TC, Fereres E. Reference Manual of Aqua Crop Model. Chapter 2, Users Guide, FAO Land and Water Division. 2012;7:164. https://www.fao.org/3/br267e/br267e.
8. Ritchie JT. Soil Water Balance and Plant Water Stress. Understanding Options for Agricultural Production. 1998:41-54. https://link.springer.com/chapter/10.1007/978-94-017-3624-4_3.
9. Singh H, Mishra SK, Singh K, *et al*. Simulating the impact of climate change on sugarcane production in Punjab. Journal of Agrometerology. 2021;23(3):292-298.
10. Willmott CJ. On the evaluation of model performance in

physical geography. Spatial Statistics and Models. 1984:443-460. DOI: 10.1007/978-94-017-3048-8_23.
11. Islam SS, Hassan AK. Determination of Upland Rice Cultivar Coefficient Specific Parameters for DSSAT-CERES-Rice Crop Simulation Model and Evaluation of the Crop Model under Different Temperature Treatments conditions. American Journal of Plant Sciences. 2021;12:782-795. https://doi.org/10.4236/ajps.2021.125054.
12. Kumar A, Nath S, Balpande R, *et al*. Decision support system for agro technology (DSSAT) modeling for estimation of rice production and validation. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):3883-3886.
13. Mishra A, Mehra B, Rawat S, *et al*. Utility of gridded data for yield prediction of wheat using DSSAT model. Journal of Agrometerology. 2020;22(3):377-380.
14. Yadav MK, Patel C, Singh RS, *et al*. Assessment of climate change impact on different pigeon pea maturity groups in north Indian condition. Journal of Agrometerology. 2021;23(1):82-92.
15. Hoogenboom G, Porter CH, Boote KJ, Shelia V, Wilkens PW, Singh U, *et al*. The DSSAT crop modeling ecosystem. InAdvances in crop modelling for a sustainable agriculture Burleigh Dodds Science Publishing; c2019 Dec 10. p. 173-216.