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**RESEARCH PAPER**

# DSSAT model based assessment for the suitability of *kharif* sorghum CSH-16 under current climate across north interior Karnataka

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**Abstract:** Sorghum is an important cereal staple food crop of millions of people in semi-arid tropics (SAT). It is considered as the 'King of millets' and extensively grown in Africa, India, China, USA and Mexico. In India sorghum is the fifth major cereal crop grown during both *kharif* and *rabi* seasons. CSH-16 hybrid released for *kharif* land when grown under rainfed situation the yields are greatly influenced by onset, progress and withdrawal of South West monsoon. As South-West monsoon greatly varies over space and time, it is important to study the performance of *kharif* sorghum across different districts of North Interior Karnataka (NIK). Study was carried out using DSSAT-CERES model to run the simulations for 31 years (1988-2018) on two predominant soil types (black clay and red loamy soil) grown across nine dates of sowing (15$^{th}$ May to 15$^{th}$ July) at weekly interval following the standard production practices recommended by the university for rain fed crop across 12 districts of NIK. Model simulated yearly outputs were averaged for 31 years which showed that average grain yield simulated under current climate (1988-2018) in rainfed condition was the highest in Bagalkote (3476 kg/ha) followed by Dharwad (3416 kg/ha) and Gadag (3104 kg/ha) districts, where as the lowest was simulated for Koppal (1817kg ha$^{-1}$) followed by Ballari (2202 kg/ha) and Raichur (2299 kg/ha) districts. Hence this study concludes that under current climate Bagalkote, Dharwad and Gadag districts are the best region to grow *kharif* sorghum hybrid CSH-16.

**Key words:** Calibrate, Climate, Performance, Sorghum

## Introduction

Sorghum is one of the world's most important cereal crops and also the major nutritional and staple food crop of millions of people in semi-arid tropics (SAT). In India among the food crops, sorghum is the fifth major cereal crops grown during both *Kharif* and *Rabi* seasons. Its major area is concentrated in the Deccan Plateau, Central and Western India apart from few patches in Northern India. Sandeep *et al* in 2017 reported that More than 90 % of the total area is rain-fed and about 85 % of total production comes from semi-arid regions of Karnataka, Maharashtra, Telangana and Andhra Pradesh.

The North Interior Karnataka (NIK) is a geographical region of semi-arid climate constitutes the northern part of the Karnataka state in India.Total area of this region is 88,361 km$^2$, which has a population of 24.57 million at a density of 280 persons per square km. This region is largely covered with rich black cotton and red loamy soils, gently sloping lands and plains, summits of plateau, and table lands. Sorghum being grown during *kharif* mostly under rainfed situation, the yields are greatly influenced by onset, progress and withdrawal of South West monsoon. As South-West monsoon greatly varies over space and time it is important to study the performance of *kharif* sorghum across different districts of NIK to identify yielding potential.

However, such studies in the field of agriculture science are generally carried out using conventional 'trial-and-error' and experience-based field and/or laboratory based experimentations. In such studies crop performance and yield functions are derived from statistical analysis without referring to all the under lying bio-physical principles involved. However, use of correlation and regression analysis helps, to some extent, in qualitative understanding of the variables and their interactions, and has enabled the progress of agricultural science (Jones *et al.*, 2003). Field experiments have their own limitations *viz.,* time consuming, labour intensive and resource demanding. Moreover, it is logistically difficult to include all aspect of climate into field studies. With the crop models, it has now become possible to predict a living plant through the mathematical and conceptual relationship which governs its growth in the Soil–Water–Plant-Atmosphere continuum and crop interacts with soil, weather, inputs and management practices bio-physically. Therefore, the crop simulation models explain the interaction between the surrounding environment and crops. The crop growth models are useful to assess the impact of climate change on the stability of crop production under different management options, hence provide an effective and efficient meansto quantify the effect of climate as well as management practices on soil, crop growth, productivity and sustainability of agriculture production (Gebrekiros *et al.,* 2016). Simulation models also reduce the need for expensive and time consuming field experimentation and can be used to analyse yield gaps in various crop production zones or systems (Hoogenboom *et al*., 1994). The objective of the study was to quantify the performance of *kharif* sorghum hybrid CSH-16 across NIK districts using DSSAT-CERES Sorghum model for the current climate with a hypothesis that performance across NIK varies depending on climate and soil of each districts (Sannagoudar *et al.,* 2016).

## Material and methods

The crop data of *kharif* sorghum hybrid CSH-16 to calibrate and validate DSSAT-CERES model were collected from the AICRP on Sorghum scheme experiment carried out during *kharif* season of 2016-17 and 2017-18 under rainfed condition on deep black soils at Main Agricultural Research Station (MARS) of University of Agricultural Sciences, Dharwad, which is located at 15°26' N latitude, 75°07' E longitude and at an altitude of 678 m above mean sea level. The crop data collected were used to build i) A-file which included the data recorded at the end of crop season *i.e.*, yield and yield attributes. ii) T-file which included time series data from sowing to harvest *i.e.*, plant height, number of leaves, phenology *etc*., at different growth stages, and iii) X-file which included crop management data *i.e.*, sowing date, planting method, spacing, sowing depth, plant population (number $m^{-2}$) and plant stand at emergence (number $m^{-2}$), tillage operations and its dates of operation, implement type used, depth of tillage and compost / FYM (kg $ha^{-1}$), application dates, sources of inorganic fertilizer (N, P and K), amount applied, method and depth of placement. These three files *viz*., A, T and X files of the crop were built separately for each year of 2016-17 and 2017-18, whereas one X-file was built for the entire period of 31 years (1988-2018) following standard production practices recommended for *kharif* sorghum across NIK.

The soil module within DSSAT model requires data/ information on soil texture, soil colour, slope (%), nutrients like N, P, K (kg $ha^{-1}$), pH, OC (%) and BD (g $cm^{-3}$) across depth. The experiment from which the crop data collected were laid out on black clay soil. Hence, soil sample was collected and analysed. The soil profile data of both black (125 cm) and red (35 cm) soils of all 12 districts were collected from ICAR Krishi Geoportal website (http://geoportal.icar.gov.in). N, P, K (kg $ha^{-1}$) data of all the 12 districts for initial management was collected from soil health card web portal of the Ministry of Agriculture and Farmers Welfare, Govt. of India (https:soilhealth2.dac.gov.in/HealthCard). This information was used built 12 (district) × 2 soils (black and red) soil profile for *kharif* sorghum.

The data on weather parameters such as daily rainfall (mm), mean maximum and minimum temperature (˚C) and solar radiation (MJ $m^{-2}$ $day^{-1}$) required to build weather file within the DSSAT model were recorded at the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad for the experimental year 2016-17 and 2017-18 which were used for calibration and validation. The historic weather of 31 years (1988-2018)of 12 district of NIK were downloaded from NASA power web portal (www.power.larc.nasa.gov) for solar radiation, Tmax, Tmin, and rainfall these files were used to run the model for 31 years (1988-2018). A total of 11 genetic coefficients were optimised by the DSSAT-CERES model for *kharif* sorghum hybrid CSH-16 and are represented in Table1.

**Results and discussion**

On black soils, simulated average grain yield of *kharif* sorghum hybrid CSH-16 for whole of NIK under current climate (1988-2018) was 2272 kg $ha^{-1}$ and it ranged between the lowest

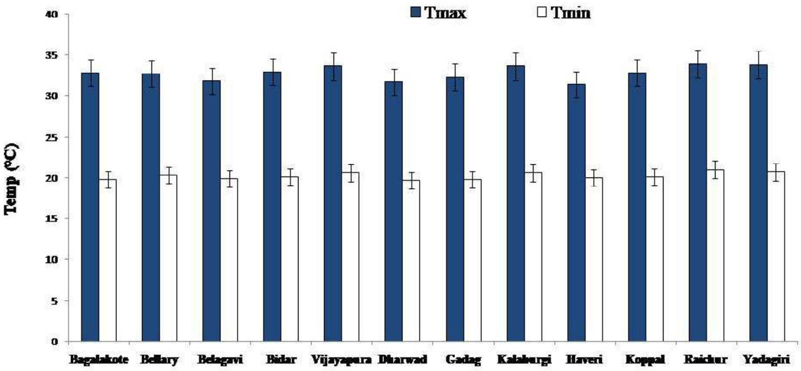


Fig.1. Minimum and maximum temperature in °C (average of 31years) under current climate (1988-2018) across 12 districts of NIK (± SE with n=372).

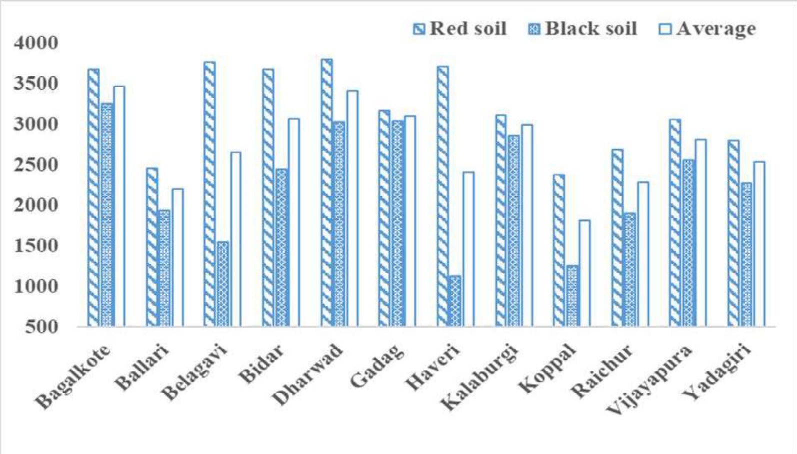


Fig. 2. Annual rainfall in mm (average of 31 years) under current climate (1988-2018) across 12 districts of NIK (± SE with n=372).

Table 1. Optimized genetic coefficients after calibration for *kharif* sorghum hybrid CSH-16 along with coefficient codes and description.

| Coefficient | Description | Code |
|---|---|---|
| P1 | Thermal time (TT) from seedling emergence to the end of the juvenile phase | 214.10 |
| P2 | TT from the end of the juvenile stage to tassel initiation under short days | 80.0 |
| P2O | Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. | 12.46 |
| P2R | Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O | 88.16 |
| PANTH | TT from the end of heading to fertilization | 580.5 |
| P3 | TT from to end of flag leaf expansion to fertilization | 133.0 |
| P4 | TT from fertilization to beginning grain filling | 92.0 |
| P5 | TT from beginning of grain filling to physiological maturity | 656.0 |
| PHINT | Phylochron interval; the interval in TT between successive leaf tip appearances | 54.02 |
| G1 | Scaler for relative leaf size | 7.261 |
| G2 | Scaler for partitioning of assimilates to the head. | 5.652 |

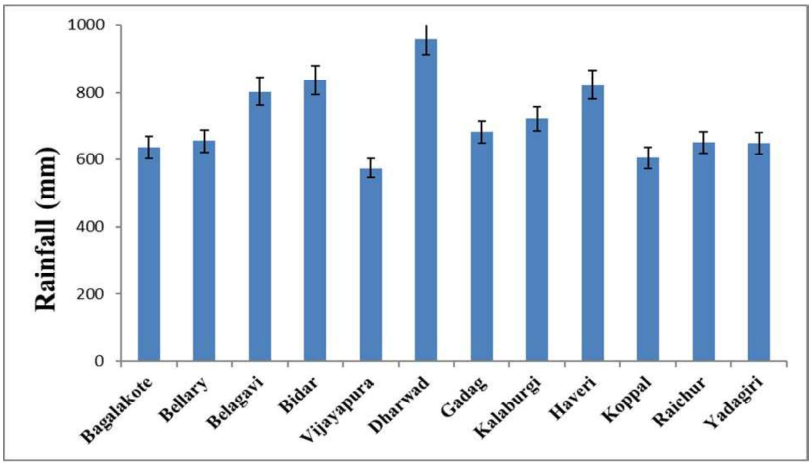


Fig. 3. Simulated average grain yield of *kharif* sorghum hybrid CSH 16 under current climate (1988-2018) on black and red soils for 12 districts of NIK (average of 31 years)

Table 2. Simulated average grain yield (kg ha[1]) of *kharif* sorghum hybrid CSH-16 under current climate (1988-2018) on both black and red soils across 12 districts of NIK over 31 years (values in parenthes is indicate standard error with n=279).

| Districts | Black soil | | Red soil | |
|---|---|---|---|---|
| | Rainfed | Ranking | Rainfed | Ranking |
| Bagalkote | 3265 | I | 3687 | III |
| Ballari | 1942 | VIII | 2463 | XI |
| Belagavi | 1549 | X | 3768 | II |
| Bidar | 2452 | VI | 3682 | V |
| Dharwad | 3028 | III | 3804 | I |
| Gadag | 3041 | II | 3167 | VI |
| Haveri | 1122 | XII | 3717 | IV |
| Kalaburgi | 2866 | IV | 3116 | VII |
| Koppal | 1257 | XI | 2378 | XII |
| Raichur | 1904 | IX | 2693 | X |
| Vijayapura | 2563 | V | 3064 | VIII |
| Yadagiri | 2279 | VII | 2805 | IX |

of 1122 kg ha$^{-1}$ for Haveri district and the highest of 3265 kg ha$^{-1}$ for Bagalkote district. This showed wide variability in minimum and maximum yields recorded over the simulation period among districts with as much as 65.6 per cent difference. However, the highest grain yield was simulated for Bagalkote (3265 kg/ha) followed by Gadag (3041 kg/ha) and Dharwad (3028 kg/ha) districts, whereas the lowest yield was simulated for Haveri (1122 kg/ha) followed by Koppal (1257 kg/ha) and Belagavi (1549 kg/ha) districts among 12 districts of NIK. The productivity was primarily governed by the climatic conditions (temperature and rainfall) including soil, hence the hypothesis that performance of *kharif* sorghum is not uniform across the districts of NIK was proved (Sannagoudar *et al.,* 2020).

On red soils, simulated average grain yield of *kharif* sorghum hybrid CSH-16 under current climate (1988-2018) was 3195 kg ha[1] with a range between the lowest of 2378 kg ha$^{-1}$ for Koppal district and the highest of 3804 kg ha$^{-1}$ for Dharwad district. Here also awide variability in minimum and maximum yields recorded over the simulation period among districtswith 37.4 per cent difference between the highest and lowest yield. Simulate dgrain yield under current climate on red soils in rainfed conditions was the highest in Dharwad (3804 kg/ha) which was closely followed by Belagavi (3768 kg/ ha) and Bagalkot (3687 kg/ha) districts, and the lowest yield was recorded in Koppal (2378 kg/ha) which was closely followed by Ballary (2463 kg/ha) and Raichur (2693 kg/ha) districts among 12 districts of NIK.

This study showed that in NIK across all 12 districts *kharif* sorghum hybrid CSH-16 performed well on red loamy soils than in black clay soils. On average of 37 per cent yield gap existed between the highest yielding district and lowest yielding district. This shows that farmers must grow *kharif* sorghum in Bagalkote, Gadag, and Dharwad districts on black clay soils and Dharwad, Belagavi and Bagalkote on red loamy soils.

## Conclusion

The DSSAT model simulated grain yield of *kharif* sorghum hybrid CSH-16 under current climate (1988-2018), averaged across NIK and both soils, showed that CSH-16 performs better on red soil (3195 kg/ha) than on clay soil (2272 kg/ha). Model further suggests that on black clay soils the highest yields are realizable in Bagalkote, Gadag, Dharwad, Kalaburgi and Vijayapura districts in that decreasing order, whereas on red soils the highest yields are achievable in Dharwad, Belagavi, Bagalkote, Haveri and Bidar in that decreasing order. Hence, cultivation of CSH-16 in NIK region must be done based on the findings of this study.

## References

Gebrekiros G , Araya A and Yemane T, (2016) Modelling impact of climate change and variability on sorghum production in southern zone of Tigray, Ethiopia. *Journal of Earth Science and Climatic Change,* 7 (2) : 322–351.

Hoogenboom G, Jones J W, Porter C H, Wilkens P W, Boote K J, Batchelor W D, Hunt L A and Tsuji G Y (1994). Overview Decision Support System for Agrotechnology Transfer version 3.0. Univ. of Hawaii, Honolulu.

Jones J W, Hoogenboom G, Porter C H, Boote K J, Batchelor W D Hunt L A, Wilkens P W, Singh U, Gijsman A J and Ritchie J T (2003). TheDSSAT cropping system model. *European Journal Agronomy,* 18: 235-265.

Sandeep V M, Bapuji Rao B, Bharati G Rao, V U M Pramod V P Chowdary P S, Patel N R and Vijayakumar P, 2018, Impact of climate change on sorghum productivity in India and its adaptation strategies. *Journal of Agrometeorology,* 20 (2): 89-96.

Sannagoudar M S, Patil R H and Rajanna G A, 2019, Calibration and evaluation of DSSAT-CERES model for *kharif*sorghum genotypes. *Journal of Experimental Agriculture International*, 30 (3): 2457-0591.

Sannagoudar M S, Patil R H, Kumar R V, Singh A K, Ghosh A and Halli H M, 2020, Simulated impacts of rise in temperature on *kharif* sorghum genotypes in Northern Transitional Zone of Karnataka, India. *Cereal Research Communications,* (2020) 48:113-120.