Review Article

Yield Predicationby DSSAT model of wheat crop: A review

ABSTRACT

Abstract: the DSSAT model predicting crop productivity under various crop management options and changing climatic conditions that require determination of genetic coefficient of a crop cultivar. Successful use of a crop model depends on the accuracy of calibration and validation of different parameters. The data on irrigation and nitrogen effect on wheat production was used for model calibration and date of sowing effect for model validation. Models results showed that the closer estimation of crop growth duration, grain and biomass yields. Percent error difference in grain yield of wheat varieties between simulated and observed values were 8.70% to 10.98% respectively. Relationship between simulated and observed grain yields, crop duration both at calibration and validation process are strong having higher R2 value.

Keywords:DSSAT Model, Wheat, Yield,Simulated, Validation

INTRODUCTION

Yield estimation of wheat crop by Decision Support System for Agro technology Transfer (DSSAT) is a package of 16 different crop growth models that access soil and weather data files along with management files of specific crops to predict crop growth and yield (*Jones et al., 2003).*DSSAT is a popular crop model used over 100 countries for more than 20 years [6]. It is amicrocomputer software package, that provides a shell program for the interface of crop-soil simulation models, data for soil and weather, and programs for evaluating management strategies. DSSAT includes more than 40 crop growth model. Among them, CERES-Wheat is most widely used crop simulation model. Crop modelling study especially DSSAT on different crops is meagre in Bangladesh. Cultivar coefficients of popular wheat varieties of Bangladesh are not included in the cultivar database of DSSAT (Choudhury *et al.*,2018).

The DSSAT generates future weather scenarios by helping the model to make more reliable predictions, anticipating the variability in weather conditions (Jame and Cutforth, 1996). CERES-Wheat crop simulation model has been widely tested and validated under diverse agro-climatic conditions in different states of India for various uses such as prediction of

UNDER PEER REVIEW

growth stages and crop duration, grain yield simulation, effect of planting dates on crop yield and water requirement, water scheduling, nitrogen management (Nain *et al*. 2004).Crop growth simulation models used to analyze the effect of various climatic factors on crop growth and yield with edaphic, biotic and agronomic factors. Several studies have been carried out to develop an integrated assessment of climate variability as well as climate change on regional and global supplies and demand using a dynamic modeling framework (Rosenweig and parr (1994), Adams *et al*., 1995, Alexandrov and Hoogenboom, 2000).

Validation of DSSAT model:

Baxla*et al.,* reported that the hind cast wheat yields for most of the districts are within the acceptable error limit (±10%) in all the years of validation; however, prediction was marginally higher in the year 2011-12 for Central Plain zone (Kanpur), 2012-13 for Buldelkhand Zone (Jhansi) and 2013-14 for Eastern Plain zone (Faizabad). Simulated yields are clearly able to indicate the variability due to rise of temperature encounter during booting or grain filling state in the wheat crop. The model validated for previous year grain yield 3 showed deviation of 9 to 10% which can be improved by further fine tuning the genetic coefficient and other input data at district level.

Impact of climate change on wheat yield estimation:

Aarya *et al*., (2020) examine that, climate change simulations with GCM projections under IMPs and elevated CO2 effect showed wheat yield remained unchanged (− 0.4 to + 9%) for all three genotypes. They propose that the IMPs and elevated CO2 were able to reduce the 11 negative effect of elevated Temp. on wheat yield as Temp. Stress did not go beyond optimal T range for wheat. Overall, climate change may not reduce wheat production in the climate of the location of study in the near future, mid century, or end century.Daloz*et al.,* (2021) reported that due to climate change, wheat yields have affected through changes in temperature and precipitation and selected four sites of the IGP: Punjab, Haryana, Uttar Pradesh and Bihar. Results showed the direct impact of climate change, via changes in temperature and precipitation, leads to wheat yield losses between −1% and −8%.Results determined by Pal *et al.,* (2015) that CERES-Wheat model used a tool to support decision-making for wheat production in Tarai region of Uttarakhand. CERES-Wheat model was used to simulate responses of two wheat cultivars under different growing environments.

An experiment was conducted for the period of 2007-08 and 2008-09, on three sowing dates viz. 20th November, 15th December, and 09th January with two varieties *viz.*,

UNDER PEER REVIEW

PBW-343 and WH-542. Results showed that model outputs was good agreement with observed values in terms of phonological, biomass accumulation and grain yields with crop sown in 20th November than other sowings of crop. Whereas, PBW-343 variety showed close good agreements between simulated and observed outcomes in all sowing dates.Junfang*et al.,* (2017) concluded that the relationships between climate changes with crop production will help tactical decision for future agricultural adaptation in China using Agricultural Production Systems Simulator (APSIM) model. Results showed that general yield reduction of spring wheat in return to the evident of climate warming from 1981 to 2014, with an standard of 3564 kg·ha-1. The regional differences in yields were found significant. Western region of China had founded that maximum yield potential of spring wheat. Whereas, the minimum potential yield was found in the middle region of the country. They observed the air temperature and soil surface temperature were the supreme climatic factors that shape the key phenophases of spring wheat at Inner Mongolia.

Evers *et al*., (2010) revealed that outgrowth of tiller buds made dependent on the ratio between assimilate supply and demand of the plants. Organ- level photosynthesis, biomass production and bus growth were simulated satisfactory. However to improve crop simulation results more efforts are needed mechanistically to model other major plant physiological process such as nitrogen uptake and distribution, tiller death and leaf senescence. Nevertheless, the work presented here is a significant step forwards a mechanistic functional structure plant model, which integrated plants architecture with key plant processes.

Temperature effect on wheat yield:

Hussain *et al.,* (2018) reported that the CERES-Wheat model used for over simulated grain yield showed increase in temperature model sensitivity was less after anthesis. CERES-Wheat simulation of days to anthesis and maturity did not show an effect of high temperature during grain filling stage on grain size and filling duration as in the field. Liu *et al.,* (2016) likewise reported that CERES-Wheat underestimate heat effects scheduled lying on grain filling length.

Rezzoug *et al*., (2008) showed that the root mean squared error (RMSE) were 9.5 d and 1.8 d for anthesis and maturity respectively for model calibration ; and was 4.4 d and 3.5 d for anthesis and maturity testing of the model, respectively. The RMSE of final grain yield was 0.7 t ha -1 for calibration and testing. This study showed that DSSAT may be used to predict the growth and yields of wheat genotypes in Algeria. In consequence to compare several crop management strategies in a wheat cropping area.Choudhury *et al.,* (2018) concluded that

UNDER PEER REVIEW

DSSAT (v4.6) crop model in Bangladesh for wheat production was validated. Genetic co-efficient of four wheat cultivars (BARI Gom-25, 26, 27 & 28) were determined through DSSAT. Experimental data on irrigation and nitrogen effect on wheat production was used for model calibration and date of sowing effect for model validation. Model evaluation results showed closer estimation of crop growth duration, 12 grain and biomass yields.

Per cent error difference in grain yield of wheat varieties (BARI Gom- 25, 26, 27 and 28) between simulated and observed values were 10.98 %, 8.70 %, 10.79 % and 8.94 %, respectively. Relationship between simulated and observed grain yields, and simulated and observed crop duration both at calibration and validation process are strong having higher R2 value (Table1,2,3)

Table-1: Description of different genetic characters of wheat for use in model

Name of parameters	
P1V	Days, optimum vernalizing temperature, required for vernalization
P1D	Photoperiod response (% reduction in rate/10 h drop in pp)
P5	Grain filling (excluding lag) phase duration (oC-d)
G1	Kernel number per unit canopy weight at anthesis (#/g)
G2	Standard kernel size under optimum conditions (mg)
G3	Standard, non-stressed mature tiller weight (incl grain) (g dwt)
PHINT	Interval between successive leaf tip appearances (oC-d)

Table-2: Genetic coefficient of different wheat varieties

Variety	P1V (Days)	P1D (% reduction in rate 10 h -1 drop in pp)	P5 (oC. d)	G1 (#/g)	G2 (mg)	G3 (g dwt)	PHINT (oC. d)
BARI Gom-25	0	92	725	23	46	3.6	70
BARI Gom-26	0	92	730	23	46	3.8	70
BARI Gom-27	0	93	740	24	46	3.9	70
BARI Gom-28	0	96	750	25	47	3.9	70

Table-3: Indicators of goodness of fit for crop duration and grain yield of different wheat varieties for model calibration in 2012-13.

UNDER PEER REVIEW

Variety	Parameter	Sim.	Obs.	PE (%)	R 2	NRMSE	EF	d
BARI Gom-25	Crop duration	113	111	1.80	0.87	4.04	0.49	0.88
	Grain yield	4931	4443	10.98	0.63	0.98	0.98	0.99
BARI Gom-26	Crop duration	115	113	1.76	0.85	4.19	0.83	0.95
	Grain yield	4937	4542	8.70	0.82	0.52	0.99	0.99
BARI Gom-27	Crop duration	110	107	2.80	0.93	5.29	0.19	0.81
	Grain yield	5278	4764	10.79	0.86	0.55	0.99	0.99
BARI Gom-28	Crop duration	111	107	3.74	0.59	4.44	0.05	0.79
	Grain yield	5608	5148	8.94	0.89	0.18	0.99	0.99

The study reported that comprehensive comparison of four broadly used wheat simulation models (DSSAT-CERES-Wheat, DSSAT-Nwheat, WheatGrow, and APSIM-Wheat) in quantifying and simulating the responses of wheat grain quality (GPC and GPY) under LTS and HTS at critical growth stages, and to identify gaps in simulating wheat grain protein concentration and protein yield for crop model improvement. Four-year environment-controlled phytotron experiments were conducted with two wheat varieties under LTS (at joining and booting stages) and HTS (at anthesis, grain filling, and combined stress at anthesis and grain filling stages). For per unit increase in cold degree days (CDD, degree days below 2 °C) at jointing and booting stages and heat degree days (HDD, degree days over 30 °C) at anthesis, grain filling and combined stress at anthesis and grain filling stages, GPC was increased by 0.2% to 0.4% and 1.1% to 1.6%, while GPY was decreased by 2.1% to 4.5% and 0.3% to 1.7%, respectively (Osman *et al*,. 2020).

Hussain *et al*,. (2018) conducted a field experiments of three cultivars across a wide range of sowing dates in two different climatic regions: Faisalabad (semi-arid) and Layyah 13 (arid), in Punjab-Pakistan. Wheat growing season temperature ranged from -0.1°C to 43°C. The wide series of sowing dates was a unique opportunity to grow the wheat in an environment where temperatures varies from -0.1°C to 43°C. The CERES-Wheat, Nwheat, CROPSIM-Wheat and APSIM-Wheat model were calibrated against the least-stressed treatment for each wheat cultivar. Overall, four models described performance of early, optimum and late sown wheat well, but poorly described yields of very late planting dates with associated high temperatures during grain filling. The poor accuracy of simulations of yield for extreme planting dates point to the need to improve the accuracy of model

UNDER PEER REVIEW

simulations at the high end of the growing temperature range, especially given the expected future increases in growing season temperature.

Conclusion:

CONCLUSION

Predication of wheat yield by DSSAT model after successfulcalibration and validation the performance through temporal course of above ground biomass, phenology and grain yield at harvest. It could be concluded that the model works well in different growing environment, and can thus be take for application in natural resource management and climate change impact analysis studies. Model output the simulated grain yield showed increase in temperature model sensitivity was less after anthesis. CERES-Wheat simulation of days to anthesis and maturity did not show an effect of high temperature during grain filling stage on grain size and filling duration as in the field

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UNDER PEER REVIEW

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UNDER PEER REVIEW

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UNDER PEER REVIEW