

## Review Article

### Yield Prediction by 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. ~~Rephrase to make meaning.~~ 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 ~~stronger~~ having higher R<sup>2</sup> 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]. ~~use one ref style, probably APA in text citation.~~ It is a microcomputer 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 models. 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

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

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#### 40 **Validation of DSSAT model:**

41 ~~Baxlaet al. (year of publication)~~, reported that the hind cast wheat yields for most of the  
42 districts are within the acceptable error limit ( $\pm 10\%$ ) in all the years of validation; however,  
43 prediction was marginally higher in the year 2011-12 for Central Plain zone (Kanpur), 2012-  
44 13 for Buldelkhand Zone (Jhansi) and 2013-14 for Eastern Plain zone (Faizabad). Simulated  
45 yields are clearly able to indicate the variability due to rise of temperature encounter during  
46 booting or grain filling state in the wheat crop. The model validated for previous year grain  
47 yield 3 showed deviation of 9 to 10% which can be improved by further fine tuning the  
48 genetic coefficient and other input data at district level.

#### 49 **Impact of climate change on wheat yield estimation:**

50 Aarya et al., (2020) examine that, climate change simulations with GCM projections  
51 under ~~IMPs~~ ~~Write in full~~ and elevated CO<sub>2</sub> effect showed wheat yield remained unchanged ( $-$   
52  $0.4$  to  $+ 9\%$ ) for all three genotypes. They propose that the ~~IMPs~~ and elevated CO<sub>2</sub> were able  
53 to reduce the 11 negative effect of elevated ~~Temp~~ ~~Write in full~~, on wheat yield as Temp.  
54 Stress did not go beyond optimal ~~T~~ range for wheat. Overall, climate change may not reduce  
55 wheat production in the climate of the location of study in the near future, mid century, or  
56 end century. ~~Dalozet et al. (2021)~~ reported that due to climate change, wheat yields have ~~been~~  
57 ~~affected~~ through changes in temperature and precipitation and selected four sites of the IGP:  
58 Punjab, Haryana, Uttar Pradesh and Bihar. Results showed the direct impact of climate  
59 change, via changes in temperature and precipitation, leads to wheat yield losses between  
60  $-1\%$  and  $-8\%$ . Results determined by ~~Pal et al. (2015)~~ that CERES-Wheat model used a tool  
61 to support decision-making for wheat production in Tarai region of Uttarakhand. CERES-  
62 Wheat model was used to simulate responses of two wheat cultivars under different growing  
63 environments.

64 An experiment was conducted for the period of 2007-08 and 2008-09, on three  
65 sowing dates viz. 20th November, 15th December, and 09th January with two varieties viz.,  
66 PBW-343 and WH-542. Results showed that model outputs was **good in agreement** with  
67 observed values in terms of phenological, biomass accumulation and grain yields with crop  
68 sown in 20th November than other sowings of crop. Whereas, PBW-343 variety showed  
69 close good agreements between simulated and observed outcomes in all sowing  
70 dates. **Junfang et al. (2017)** concluded that the relationships between climate changes with  
71 crop production will help tactical decision for future agricultural adaptation in China using  
72 Agricultural Production Systems Simulator (APSIM) model. Results showed that general  
73 yield reduction of spring wheat in return to the evident of climate warming from 1981 to  
74 2014, **with an standard** of 3564 kg·ha<sup>-1</sup>. The regional differences in yields were found  
75 significant. Western region of China had founded that maximum yield potential of spring  
76 wheat. Whereas, the minimum potential yield was found in the middle region of the country.  
77 **They observed the that air temperature** and soil surface temperature were the supreme  
78 climatic factors that shape the key phenophases of spring wheat at Inner Mongolia.

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

#### 87 **Temperature effect on wheat yield:**

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

94 **Rezzouget al. (2008)** showed that the root mean squared error (RMSE) were 9.5 d and 1.8 d  
95 for anthesis and maturity respectively for model calibration ; and was 4.4 d and 3.5 d for  
96 anthesis and maturity testing of the model, respectively. The RMSE of final grain yield was

97 | 0.7 t ha<sup>-1</sup> for calibration and testing. This study showed that DSSAT may be used to predict  
 98 | the growth and yields of wheat genotypes in Algeria. In consequence to compare several crop  
 99 | management strategies in a wheat cropping area, Choudhury *et al.*, (2018) concluded that  
 100 | DSSAT (v4.6) crop model in Bangladesh for wheat production was validated. Genetic co-  
 101 | efficient of four wheat cultivars (BARI Gom-25, 26, 27 & 28) were determined through  
 102 | DSSAT. Experimental data on irrigation and nitrogen effect on wheat production was used  
 103 | for model calibration and date of sowing effect for model validation. Model evaluation results  
 104 | showed closer estimation of crop growth duration, 12 grain and biomass yields.

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105 | Per cent error difference in grain yield of wheat varieties (BARI Gom- 25, 26, 27 and  
 106 | 28) between simulated and observed values were 10.98 %, 8.70 %, 10.79 % and 8.94 %,  
 107 | respectively. Relationship between simulated and observed grain yields, and simulated and  
 108 | observed crop duration both at calibration and validation process are strong having R2  
 109 | value (Table 1, 2, 3 Tables 1, 2 and 3)

111 | **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)

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113 | **Table-2:** Genetic coefficient of different wheat varieties

Variety	P1V (Days)	P1D (% reduction in rate 10 h <sup>-1</sup> 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

114  
115 Table-3: Indicators of goodness of fit for crop duration and grain yield of different wheat  
116 varieties for model calibration in 2012-13.

Variety	Parameter	Sim.	Obs.	PE (%)	R <sup>2</sup>	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

117  
118 The study reported that comprehensive comparison of four broadly used wheat  
119 simulation models (DSSAT-CERES-Wheat, DSSAT-Nwheat, WheatGrow, and APSIM-  
120 Wheat) in quantifying and simulating the responses of wheat grain quality (GPC and  
121 GPY) under LTS and HTS at critical growth stages, and  
122 to identify gaps in simulating wheat grain protein concentration and protein yield for crop  
123 model improvement. Four-year environment-  
124 controlled phytotron experiments were conducted with two wheat varieties under LTS (at  
125 joining and booting stages) and HTS (at anthesis, grain filling, and combined stress at  
126 anthesis and grain filling stages). For per unit increase in cold degree days (CDD, degree  
127 days below 2 °C) at jointing and booting stages and heat degree days (HDD, degree days over  
128 30 °C) at anthesis, grain filling and combined stress at anthesis and grain filling stages, GPC  
129 was increased by 0.2% to 0.4% and 1.1% to 1.6%, while GPY was decreased by 2.1% to  
130 4.5% and 0.3% to 1.7%, respectively (Osman *et al.*, 2020).

131 Hussain *et al.* (2018) conducted a field experiments of three cultivars across a wide  
132 range of sowing dates in two different climatic regions: Faisalabad (semi-arid) and Layyah  
133 (arid), in Punjab-Pakistan. Wheat growing season temperature ranged from -0.1°C to 43°C.  
134 The wide series of sowing dates was a unique opportunity to grow the wheat in an

135 environment where temperatures varies from -0.1°C to 43°C. The CERES-Wheat, Nwheat,  
136 CROPSIM-Wheat and APSIM-Wheat model were calibrated against the least-stressed  
137 treatment for each wheat cultivar. Overall, four models described performance of early,  
138 optimum and late sown wheat well, but poorly described yields of very late planting dates  
139 with associated high temperatures during grain filling. The poor accuracy of simulations of  
140 yield for extreme planting dates point to the need to improve the accuracy of model  
141 simulations at the high end of the growing temperature range, especially given the expected  
142 future increases in growing season temperature.

143 **Conclusion:**

144  
145 **CONCLUSION**

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

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