

**Meta analysis on the evaluation and application of DSSAT in South Asia and China: Recent studies and the way forward.**

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**Supplementary Tables S1 to S6**

**Table S1: Summary of the performance of CSM-CERES-Wheat model to simulate phenology, growth, and yield for different management practices in south Asia and China.**

S. No	Experiment	Anthesis	Maturity	LAI/ Leaf area	Variables					Countries	References	
					Grain yield	Flowering other stages	Above ground biomass	Grain size/ No. of ears/ m <sup>2</sup>	Grain filling duration	Grain/Biomass/ canopy protein/ Nitrogen		
1	Climate change	✓	✓	✓	✓						China	Ye et al., 2013
	RMSSE	8.4	7.1		1600						China	He et al., 2013
2	Water stress					✓					Pakistan	Anser et al., 2020
	RAE, %					0.6-6.7					India	Sheila et al., 2019
3	Climate change	✓	✓	✓		✓					India	Mall et al., 2018
	RMSSE	1.58	2.91		237		247				India	Liu et al., 2016
4	Sowing dates					✓					India	Sharma et al., 2010
	RMSSE				617						India	Wajid et al., 2021
5	Climate change					✓					China	Chen et al., 2021
	RMSSE				900-2200						China	Ishaque et al., 2020
6	Heat stress/two wheat cultivars					✓					China	Wang et al., 2020
	R <sup>2</sup>				0.65-0.70	✓	0.75-0.78	✓	0.65-0.70	✓	China	Lang et al., 2020
7	Climate change/Arid Climate					✓					China	Yao et al., 2020
	ABS DIFF				0.5		✓		0.26-0.22	✓	China	Wang et al., 2019
8	Spring wheat phenology simulations/different cultivars	✓	✓	✓							China	Gill et al., 2018
	RMSSE	5.7-6.9	8.3-10.3			✓					China	271
9	Three cultivars/4 Nitrogen rates %diff	✓	✓	✓	0.1-87	2.08-7.92	0.32-4.84		✓		Pakistan	Wajid et al., 2021
	R <sup>2</sup>				✓		✓		1.62-3.32		China	Shi et al., 2021
10	Future Climate	✓	✓	✓							Pakistan	Zeng et al., 2021
	R <sup>2</sup>	0.9	0.99						0.95-0.99		China	Si et al., 2021
11	Different irrigation schedules/ precipitation category/ years d-value	✓	✓	✓	1.00	0.99	0.88		✓	✓	Pakistan	Rizwan Shahid et al., 2020
	Different N treatments	✓	✓	✓			✓		✓	✓	Pakistan	Ishaque et al., 2020
	nRMSE	1.47	0.97			6.19	10.97			✓	China	Wang et al., 2020
13	6 sowing dates/ 5 N levels					✓		✓		✓	China	Lang et al., 2020
	R <sup>2</sup>					0.98-0.99	0.99			✓	China	Yao et al., 2020
14	Nitrogen levels/planting dates RMSEn% =			✓	3	✓	✓	✓	✓	✓	China	Zhou et al., 2019
	Long-Term Fertilization /rainfed					✓	✓	✓			China	Wang et al., 2019
16	Well irrigated/fertilized										China	Gill et al., 2018
17	Soil water conditions/deficit irrigation					✓	✓	✓		✓	India	21
	RMAE	2.1	2.2			28		228		17.0		
18	Winter Wheat/varied sowing dates/ cultivars	✓	✓	✓		✓		✓			China	Wang et al., 2020
	RMSSE	(0.9-1.5)	4.7-7.7			4.8-8.2		3.3-6.6			China	Zhang et al., 2019
19	Irrigation management/ varieties										India	21
	RMSSE					529-892		60-115	1.9-2.3	1.7-10.4		
20	Plant density/Nitrogen levels NSME					32.6-120.1		✓		✓	India	Gill et al., 2018
	3 cultivars/ 3 sowing dates MBE					✓		88.5-75.0		31.4-9		

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22	Planting dates/varieties/irrigation schedules	✓
	RMSFE	0.04-0.05
23	Different dates of sowing/cultivars	✓
MAE		✓
24	No deficit	✓
RE%		✓
25	Crop planning	✓
RE%		✓
26	Drip Irrigation timing and depth	✓
MBE		✓
27	Climate change/adaptation strategies	✓
d-value		✓
28	Different Sowing Dates and Varieties	✓
R <sup>2</sup>		✓
29	Irrigation scheduling/4 Cultivars	✓
d-value		✓
30	No deficit	✓
RE		✓
31	Planting dates	✓
RMSFE%		✓
32	Sowing dates	✓
Mean Abs Diff		✓
33	Cultivar/sowing dates	✓
d-value		✓
34	Cultivars	✓
PE		✓
35	No deficit	✓
RMSFE		✓
36	Climate change/drought	✓
RMSFE%		✓
37	Hyperspectral Data	✓
R <sup>2</sup>		✓
38	Water and nitrogen N limitations	✓
Abs diff		✓
39	Climate change	✓
ME		✓
40	Cultivar/fertilizer/weather	✓
MAE		10%
41	Gridded data	✓
RMSFE		382.5
42	Climate change/3 dates and 5 cultivars	✓
Abs deviation		-30 to +38
43	Date of sowing x Irrigation	✓
MAE		463-1160

Table 2: Summary of the performance of CSM-CERES-Rice model to simulate phenology, growth, and yield for different management practices in south Asia and China.

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S.	No	Experiment	Variables	Variables	Variables	Variables	Variables	Variables	Variables	Countries	References	
		Anthess	Maturity	LAI/Leaf area	Grain yield	Flowering /P/other stages	Above ground biomass	Grain No./ No. of ears/ m <sup>2</sup>	N uptake	ET	SWC/ moisture	HI grain/N
1	Elevation and precipitation/ multiple planting methods and cultivars	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhou <i>et al.</i> , 2022
2	RMSE	2.8 to 5.9	2.7 to 6.2	✓	✓	✓	✓	✓	✓	✓	China	Tian <i>et al.</i> , 2021
2	Different irrigation methods/water-saving irrigation	0.6-0.8	0.6-0.8	✓	✓	✓	✓	✓	✓	✓	Pakistan	Anser <i>et al.</i> , 2020
3	R <sup>2</sup>	1.58	2.91	✓	✓	✓	✓	✓	✓	✓	India	Jha <i>et al.</i> , 2020
3	Adaptation Strategies/ Climate Change	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Gua <i>et al.</i> , 2019
4	RMSE	2.73%	1.04%	✓	✓	✓	✓	✓	✓	✓	China	Zhang <i>et al.</i> , 2019
4	Different management strategies	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Kant <i>et al.</i> , 2018
5	RMSEn	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Debnath <i>et al.</i> , 2018
5	Climate Change	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhang <i>et al.</i> , 2018
6	RMSE%	13-17	11-15	✓	✓	✓	✓	✓	✓	✓	India	Shrivastava <i>et al.</i> , 2018
6	Climate change	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Ly <i>et al.</i> , 2018
7	RMSE	2.1-6.12	5.9-9.8	✓	✓	✓	✓	✓	✓	✓	India	Mehdi <i>et al.</i> , 2017
7	Rice cultivars/different N-levels	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Goswami <i>et al.</i> , 2016
8	RMSE	3.5%	4.6%	✓	✓	✓	✓	✓	✓	✓	India	Vysakh <i>et al.</i> , 2016
8	Different varieties and N rates	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Mote and Kumar., 2016
9	R <sup>2</sup>	0.64	0.71	✓	✓	✓	✓	✓	✓	✓	India	Subba Rao <i>et al.</i> , 2016
9	Irrigated/rainfed/soil variation	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Bhuvaneswari <i>et al.</i> , 2014
10	RMSEn	5.4%	6.9%	✓	✓	✓	✓	✓	✓	✓	China	Zhou <i>et al.</i> , 2019
10	Soil moisture and evapotranspiration simulations	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Zhang and Tao, 2013
11	RMSE	60-100 mm	0.07-0.17	✓	✓	✓	✓	✓	✓	✓	India	Sudharan <i>et al.</i> , 2013
11	Climate change	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Dass <i>et al.</i> , 2012
12	RMSE	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sri Lanka	Dharmarajna <i>et al.</i> , 2014
12	Sowing dates/cultivars	✓	✓	✓	✓	✓	✓	✓	✓	✓	Pakistan	Ahmad <i>et al.</i> , 2013
13	RMSE	2.3-2.31	2.45-5.87	✓	✓	✓	✓	✓	✓	✓	India	Kadiyala <i>et al.</i> , 2015
13	R <sup>2</sup>	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Bhuvaneswari <i>et al.</i> , 2014
13	Climate change	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhou <i>et al.</i> , 2019
14	RMSE	3.3	19.1	✓	✓	✓	✓	✓	✓	✓	India	Zhang and Tao, 2013
14	Dates of planting/ rice varieties	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Sudharan <i>et al.</i> , 2013
15	RMSE	2.1-2.4	1039-1186	✓	✓	✓	✓	✓	✓	✓	China	Dass <i>et al.</i> , 2012
15	Cultivars/varying levels of nitrogen.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sri Lanka	Dharmarajna <i>et al.</i> , 2014
15	Error	✓	✓	✓	✓	✓	✓	✓	✓	✓	Pakistan	Ahmad <i>et al.</i> , 2013
16	RMSE	0.86	1.8	✓	✓	✓	✓	✓	✓	✓	India	Kadiyala <i>et al.</i> , 2015
16	Climate Change/irrigated/rainfed.	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Bhuvaneswari <i>et al.</i> , 2014
17	R <sup>2</sup>	0.83	0.79	✓	✓	✓	✓	✓	✓	✓	China	Zhou <i>et al.</i> , 2019
17	Establishment methods/rainfed, aerobic and flooded systems.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sri Lanka	Dharmarajna <i>et al.</i> , 2014
18	RMSE	0.86	0.97	✓	✓	✓	✓	✓	✓	✓	Pakistan	Ahmad <i>et al.</i> , 2013
18	R <sup>2</sup>	0.83	0.77	✓	✓	✓	✓	✓	✓	✓	India	Bhuvaneswari <i>et al.</i> , 2014
19	Climate change/Variability in different climatic zones	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhou <i>et al.</i> , 2019
19	Difference	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sri Lanka	Dharmarajna <i>et al.</i> , 2014
20	Planting date/4 varieties	✓	✓	✓	✓	✓	✓	✓	✓	✓	Pakistan	Ahmad <i>et al.</i> , 2013
21	Three plant densities/five irrigation regimes	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Bhuvaneswari <i>et al.</i> , 2014
22	RMSE	✓	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhang and Tao, 2013
22	Weather-based rice yield models	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Sudharan <i>et al.</i> , 2013
23	R <sup>2</sup>	2.2-6.2	1.2-4.3	✓	✓	✓	✓	✓	✓	✓	India	Dass <i>et al.</i> , 2012
24	Two rice varieties/SRI/three irrigation schedules and two planting spacings	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Shamini <i>et al.</i> , 2012
24	%d:	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Shamini <i>et al.</i> , 2012
25	Simulating the phenology, growth and yield of aromatic rice cultivars	✓	✓	✓	✓	✓	✓	✓	✓	✓	India	Shamini <i>et al.</i> , 2012

**Table S3: Summary of the performance of CSM-CERES-Maize model to simulate phenology, growth, and yield for different management practices in south Asia and China.**

S. No	Experiment	Anthesis	Maturity	LAI/Leaf area	Grain yield	Emergence/other stages	Above ground biomass	Variables	Variables	Countries	References	
1	Planting density and cultivars RMSE	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhang <i>et al.</i> , 2022	
2	Temperature and heat stress/different cultivars in different maize planting regions	✓	✓	✓	✓	✓	✓	✓	✓	China	Huang <i>et al.</i> , 2021	
3	In-season N recommendation strategy for maize/6 N rates and 3 planting densities R <sup>2</sup> RMSE%	33.3-9	3.2-3.6	✓	✓	✓	✓	✓	✓	China	Wang <i>et al.</i> , 2021	
4	Simulating summer maize growth under film mulching RMSE%	✓	✓	✓	0.65-0.86	0.32-0.94	✓	0.88-0.95	✓	✓	China	Shen <i>et al.</i> , 2021
5	Irrigation Management and Sowing Dates/3 rainfed treatment RMSE%	19.3-6	0.8-2.65	9-11	✓	0.16%	7-8.5	✓	✓	✓	Rugirra <i>et al.</i> , 2021	
6	Sowing Window and Yield Forecasting for Maize/5 sowing dates/3 Maize hybrids MAPE	0.99-2.42	0.81-1.16	17	✓	✓	✓	✓	✓	Bangladesh	Choudhary <i>et al.</i> , 2021	
7	Sustainable crop intensification RMSE	✓	✓	✓	✓	✓	✓	✓	✓	China	Ren <i>et al.</i> , 2021	
8	Nitrogen fertilizer schedule under drip irrigation MAE	2.54-3	3.59-3.77	13.2-14.01	✓	1070	✓	✓	✓	China	Bai and Gao 2021	
9	Climate change d-value	✓	✓	✓	✓	✓	✓	✓	✓	India	Srivastava <i>et al.</i> , 2021	
10	Adaptation strategies/future climate change RA%	✓	✓	✓	✓	✓	✓	✓	✓	China	Saddique <i>et al.</i> , 2020	
11	Effect of Drought on Summer Maize RMSE%	1.3	1.4	8.0	4.2	✓	3.3	✓	✓	China	Shen <i>et al.</i> , 2020	
12	Genotype-environment-management interactions/Climate change/Different agro-ecological zones R <sup>2</sup>	✓	✓	✓	✓	✓	✓	✓	✓	China	Zhang <i>et al.</i> , 2020	
13	Simulating maize growth and yield under water stress conditions ARE%	0.97	0.89	0.82	✓	✓	✓	✓	✓	China	Song and Jin 2020	
14	Simulating water consumption and yield of maize/ using the two different ET options, i.e., Priestley-Taylor/Ritchie PT and FAO-56 Penman-Monteith PM	3.5	✓	✓	✓	✓	✓	✓	✓	China	Ran <i>et al.</i> , 2020	
15	NSE Dynamic within-season irrigation scheduling for maize production ARE%	✓	✓	✓	✓	✓	✓	✓	✓	China	Chen <i>et al.</i> , 2020	
16	Optimization of irrigation and fertilization of drip-irrigated corn ARE%	✓	✓	✓	✓	✓	✓	✓	✓	China	Fu <i>et al.</i> , 2020	
17	Adaptation strategies for maize production under climate change for semiarid	✓	✓	✓	✓	✓	✓	✓	✓	Pakistan	Ahmad <i>et al.</i> , 2020	



**Table S4: Summary of the performance of CSM-CERES-Sorghum (a), CSM-CERES-Millet (b), CSM-CROPGRO-Soybean (c) and CSM-CROPGRO-Peanut (d) models to simulate phenology, growth, and yield for different management practices in south Asia and China.**

S. No	Experiment	Variables	Variables	Variables	Variables	Variables	Countries	References
<b>a CSM-CERES-Sorghum</b>								
1	Climate change	✓					India	Chatalavada <i>et al.</i> , 2022
	RMSE		✓				China	Hao <i>et al.</i> , 2018
2	Sweet Sorghum-Based Fuel Ethanol	✓	✓				India	Sandeep <i>et al.</i> , 2018
3	Climate change	✓	✓				China	Yan <i>et al.</i> , 2018
	RMSE		✓				India	Singh <i>et al.</i> , 2014
4	Ethanol Potential	✓	✓				China	Asmat Ullah <i>et al.</i> , 2019
5	Drought and heat tolerance Plant spacing/N rates	✓	✓				India	Singh <i>et al.</i> , 2017
<b>b CSM-CERES-Pearl millet</b>								
1	Climate change impacts	✓	✓	✓	✓	✓	Pakistan	
	RMSE		✓				India	
2	Climate change impacts/ multiflocation/cultivars	1.4-2.1	1.6-2.8	0.2-0.5	172-193	✓	China	Liu <i>et al.</i> , 2013
	RMSE				117-379		0.05-0.11	
<b>c CSM-CROPGRO-Soybean</b>								
1	Conventional and conservation tillage	✓	✓	✓	✓	✓	China	Wei <i>et al.</i> , 2021
	RMSE						5.8-6.3	
2	Soybean drought risk	✓	✓	✓	✓	✓	India	Halder <i>et al.</i> , 2017
	RRMSE%	2.9	66-426	66-426	209-572	✓	India	Kadiyala <i>et al.</i> , 2015
3	Climate/different sowing dates	✓	✓	✓	✓	✓	India	Walkar <i>et al.</i> , 2018
	RMSE						0.05-0.11	
<b>d CSM-CROPGRO-Peanut</b>								
1	Sowing date and phosphorus fertilizer	✓	✓	✓	✓	✓	India	Parmar <i>et al.</i> , 2013
2	Climate change/drought tolerant cultivars/supplemental irrigation	✓	✓	✓	✓	✓	India	Guled <i>et al.</i> , 2012
3	Two Sowing dates/2 cultivars	✓	✓	✓	✓	✓	China	
	RMSE/Error%	2.8-3.8/13	5.3-5.5/5.2-6.2	0.78-0.87/0.3-13.6	115-1128/3.5-11.6	✓	0.54-5/5.3-6.9	4.5-4.7/4.2-6.6
4	Three cultivars/2 environments	✓	✓	✓	✓	✓	India	

**Table S5: Summary of the performance of CSM-CROPGRO-Cotton model to simulate phenology, growth, and yield for different management practices in south Asia and China.**

S. No	Experiment	Variables	Variables	Variables	Variables	Variables	Variables	Variables	Variables	Countries	References
<b>Cotton</b>											
1	Future climate/2 RCPs	✓	✓	✓	✓	✓	✓			Pakistan	Arshad Awan <i>et al.</i> , 2021
	E%/RMSE	9.9/5.4	6.6/0.33	9.5/9.63	6.8/184					India	Mishra <i>et al.</i> , 2021
2	Four cultivars/3 sowing dates	✓	✓	✓	✓	✓	✓			China	Li <i>et al.</i> , 2019
	RMSE	1.7-2.3	1.5-4.9	0.30-0.40	73-126	0.15-0.26	216-706			Pakistan	Habibur Rahman <i>et al.</i> , 2018
3	Pre-planting soil moisture/drip irrigation	✓	✓	✓	✓	✓	✓			China	Wang <i>et al.</i> , 2020
	RMSE	0.4	4.5-5.9	2075-5341	602-769					Pakistan	Arshad <i>et al.</i> , 2017
4	Film-mulched drip irrigation	✓	✓	✓	✓	✓	✓			China	
5	Future climate/uncertainty assessment	✓	✓	✓	✓	✓	✓			Pakistan	
	Error%	0-1.6	1.3-2.5	0.4-0.7	1.3-4.4	0.9-5.1	0.8-2.9	1-4.6	0.8-1.3	Pakistan	
6	Nitrogen Levels and Planting Dates	✓	✓	✓	✓	✓	✓			India	
	RMSE	0.57-0.81	0-1.12	0.23-0.40	274-582	133-582				China	
7	Two cultivars/ 3 P rates	✓	✓	✓	✓	✓	✓			Pakistan	Amin <i>et al.</i> , 2017
	%Error/RMSE	0-1.5/0-1	0-1.2/0-2	7-19/0.57-1.47	4.4-15/0.09-0.32					Pakistan	

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**Table S6: Summary of the performance of CSM-CANEGRO-Sugarcane (a), CSM-OILCROP-Sunflower (b), and CSM-SUBSTOR-Potato (c) models to simulate phenology, growth, and yield for different management practices in south Asia and China.**

S.	Experiment No	Variables	Countries	References	
a	<b>Sugarcane</b>				
1	Four cultivars/3 sowing dates	Emergence      Anthesis      Tuber initiation      Peak tillering      Total dry matter/ yield	✓      ✓      ✓      ✓      ✓	India Singh <i>et al.</i> , 2018	
	RMSE	2.29-4.07	7.32-8.42      3.37-4.79	0.19-0.34      467-865	
2	Ten cultivars			✓      ✓	
	RMSE		5960- 9250-11750 7500	India Bhengra <i>et al.</i> , 2016	
b	<b>Sunflower</b>				
1	N productivity//4 irrigation/3 N rates	✓	✓      ✓      ✓	Pakistan Awais <i>et al.</i> , 2017	
Error%	0-6	0-4	0.4-18      25 to +6	0.16-0.71	
	RMSE		5 - 17      15 to 12 5.22	Pakistan Nasim <i>et al.</i> , 2016	
2	Sunflower hybrids under different agro-meteorological conditions	✓	✓      ✓		
	RMSE		1.66		
c	<b>Potato</b>				
1	Climate warming/potato phenology	✓	✓	Pakistan Naz <i>et al.</i> , 2022	
2	Climate change/potato productivity	✓		India Goswami <i>et al.</i> , 2018	
	RMSE		2730-3810		