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Sequential simulation of wheat and urd using DSSAT model in mollisol of Uttrakhand

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ABSTRACT

CERES wheat and CROPGRO urd model were used for sequential simulation to examine the stability of urd-wheat crop rotation as influenced by the interaction between environment and nutrient status. The results revealed that the CERES wheat and CROPGRO urd model satisfactorily simulated the growth and yield in sequential run. Therefore, the validated model can be further used for applications such as sequential study, crop growth, phenology, potential and actual yields etc. The effects of one crop on soil, water, and nutrient status are carried over to the next crop in the sequence or rotation. These sequences can be efficiently studied by the sequence analysisprogram of DSSAT.

Key words: CERES model, CROPGRO model, sequential simulation, wheat, urd

The DSSAT, developed by International Benchmark Sites for Agrotechnology Transfer (Tsuji. *et al. 1994*), contains crop simulation model; database for weather, soil crop; and strategy evaluation programs integrated with a user friendly interface. For simulating wheat development needs CERES model and for Urd CROPGRO model can be used meaningfully toward reducing additional experimentation and decision making to increase yield.The effects of one crop on soil, water, and nutrient statusare carried over to the next crop in the sequence or rotation.These sequences can be efficiently studied by the sequence analysisprogram of DSSAT model (Thornton *et al*., 1994). Mitchell (1996) has reported a close agreement between observed and predicted anthesis date. Singh *et al.* (1982) found a positive relationship between grain yield and days taken to flowering, where as a highly negative correlation was found between grain yield and days taken to flowering by Jain and Aulakh (1971). Aggrawal (2002) also reported a similar tendency of the model. The model showed almost a similar trend of predictions in both years; the model was under predicted LAI. Similar results have been reported by Kaur *et al.* (2007).Varietal character input is incorporated in the model in the form of "genetic coefficients". An inbuilt programme in DSSAT called GENCALC, calculates genetic coefficients.

MATERIALS AND METHODS

Pantnagar is situated at *Tarai* belt, foothills of the Shivalic range of Himalayas at 29°1'N, latitude, 79.28°E longitude and at an altitude of 215.00 m above the mean sea level. The climate of Pantnagar is temperate with severe cold winter and hot summer. The CERES-Wheat model (Godwin *et al*., 1990; Ritchie and Otter, 1985) was used for simulation of daily phenological development and growth in response to environmental factors (soils, weather and management). CROPGRO version v4.5 was used for Urd in this study. Sequence analysis program was run to simulate the combined situation of the experiment involving crop rotation for urd-wheat rotation. The data base included all relevant information including the different management practices adopted, location specific soil and weather conditions obtained from field experiment conducted during kharif and rabi seasons of 2007 and 2008 at Crop Research Center, GBPUAT Pantnagar, Uttraknad. In the present study replicated data were used in the model calibration and validation process. Urd (*Vigna mungo* L. Hepper) variety Pant Urd- 31 and Wheat *(Triticum aestivum* L.) UP-2565 were used in this study. The wheat crop was fertilized at the rate of 100 and 150 kg ha^{-1} N levels, 60 kg ha^{-1} P_2O_5, 40 kg ha^{-1} K_2O of which one third of nitrogen and whole phosphorus and potash were applied uniformly as basal dressing and incorporated in surface soil.

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Table 1: Genetic coefficients of wheat cultivars used in the CERES wheat version 4.5 model

Code	Gen.	Parameters
VAR#	IN0701	Identification code or number for a specific cultivar
VAR. NAME	UP-2565	Name of cultivar.
P1V	38	Relative amount that development is slowed for each day of un-fulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars
P1D	36	Relative amount that development is slowed when plants are grown in one hour photoperiod shorter than the optimum (which is considered to be 20 hours).
P5	750	Degree days above a base of 1^0C from 20^0C days after anthesis to maturity.
G1	30	Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (g-1)
G2	20	Kernel filling rate under optimum conditions (mg/day).
G3	1.3	Non stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases.
PHINT	80.0	In determining the vegetative development of wheat, it is necessary to define a term related to leaf appearance, the phyllochron. A phyllochron is defined herein as the interval of time between leaf tip appearances; in the CERES-Wheat model it is the variable PHINT.

Table 2: Genetic coefficients of urd cultivars used in the CROPGRO urd version 4.5 model

Code	*Gen.*	*Parameters*
ECO#	Pant urd- 31	Code for the ecotype to which this cultivar belongs
CSDL	11.17	Critical Sho Critical Short Day Length below which reproductive development
PPSEN	0.04	Slope of the slope of the relative response of development to photoperiod with time (positive for short-day short day plants (1/hour)
EM-FL	33.0	Time between plant emergence and flower appearance (R1)
FL-SH	2.0	Time between first flower and first pod (R3) (photothermal days)
FL-SD	11.0	Time between first flower and first seed (R5) (photothermal days)
SD-PM	28.5	Time between first seed (R5) and physiological maturity (R7) (photothermal days)
FL-LF	7.0	Time between first flower (R1) and end of leaf expansion (photothermal days)
LFMAX	1.0	Maximum Maximum leaf photosynthesis rate at 30 C, 350 vpm CO2, and high light (mg CO2/ m2-s)
SLAVR	295	Specific leaf area of cultivar under standard growth conditions (cm2/g)
SIZLF	133	Maximum size of full leaf (three leaflets) (cm2)
XFRT	1.0	Maximum fraction of daily growth that is partitioned to seed + shell
WTPSD	0.55	Maximum weight per seed (g)
SFDUR	11.0	Seed filling duration for pod cohort at standard growth conditions (photothermal days)
SDPDV	3.5	Average seed per pod under standard growing conditions (#/pod)
PODUR	3.5	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)
THRSH	78	The maximum ratio of (seed/(seed+shell)) at maturity (Threshing percentage).
SDPRO	0.235	Fraction protein in seeds (g(protein)/g(seed))
SDLIP	0.030	Fraction oil in seeds (g(oil)/g(seed)

Table 3: Comparison of observed and simulated values for grain yield, maximum LAI and bioman at different nitrogen and irrigation level in sequential run of CERES-wheat model

Nitrogen Level	2007						2008					
	Full Irrigation			Deficient Irrigation			Full Irrigation			Deficient Irrigation		
	O	SS	IS	O	SS	IS	O	SS	IS	O	SS	IS
100 kg	3800	3755	3965	3750	3854	3649	3850	4152	3961	3722	4179	3961
150 kg	4250	4276	4167	4100	4387	4144	3978	4143	3900	4000	4265	3978
Maximum LAI												
100 kg	4.76	3.1	2.7	4.56	3.7	2.7	4.81	3.1	2.8	4.81	3.3	2.8
150 kg	5.01	3.3	3.3	4.88	3.5	3.3	4.79	3.4	3.3	4.97	3.2	2.8
Bioman (kg ha^{-1})												
100 kg	9665	9758	9685	9655	9836	9579	8535	8842	8462	8426	8986	9986
150 kg	10553	11356	10421	10321	12543	10717	8975	8936	8466	8834	8845	8638

O= Observed, SS=Sequential Simulation, IS= Individual simulation

Table 4: Comparison of observed and simulated values of urd in sequential run of CROPGRO-urd model

Parameter	2008		
	Observed	Sequential Simulation	Individual simulation
Grain yield kg ha^{-1}	1584	1540	1577
Maximum LAI	6.98	6.35	6.41

Remaining doses of nitrogen levels was top dressed in two equal splits at crown root initiation (CRI) and vegetative stage of wheat crop. For wheat crop two irrigation levels were also provided (full and deficient). Under full irrigation, irrigations were applied as per requirements and under deficient irrigation, only three irrigations were given i.e. CRI, vegetative and milking stage. Similarly, urd crop was fertilized at the rate of 20:40:20 of N: P_2O_5: K_2O of which one third nitrogen and full dose of phosphorus and potash were applied homogeneously as basal dressing and remaining dose of nitrogen were top dressed at 21 days interval.

RESULTS AND DISCUSSION

The genetic coefficients determined in CERES model for wheat cultivar UP-2565 and CROPGRO model for urd cultivar Pant urd-31 using the identical management and other conditions as in the field experiments are presented in Table 1 and 2 respectively.

Grain yield (kg ha^{-1}) of wheat

Simulated grain yield for wheat at different nitrogen and irrigation levels were found to have close to observed yield. It is revealed form the data the grain yield for 2007 under sequential simulation oscillated between 3755 to 4387 kg ha^{-1}, individual simulation between 3649 to 4167 kg ha^{-1} and observed data was between 3750 to 4250 kg ha^{-1}. In 2008, the grain yield under sequential simulation ranged between 4143 to 4265 kg ha^{-1}, individual simulation between 3900 to 3978 kg ha^{-1} and observed between 3722 to 4000 kg ha^{-1} (Table 3). The model simulated more yield as comparison with the individual run due to the fixed nitrogen. These observations are in agreement with the findings of Grace *et al.* (2003) for sequential simulation of grain yield. The test of significance showed that the data were non significant in both the years at 5% level of significance for 2 d.f. The interaction effect of crops and fertilizer N dose indicated that wheat receiving 50-52 kg ha^{-1} N, grown after urd crop produced significantly higher yield.

Maximum LAI of wheat

The predictability of sequential simulation for leaf area index of wheat was comparatively better. It is revealed from the data that LAI in 2007 oscillated between 3.1 to 3.7, individual simulation were between 2.7 to 3.3 and observed data were between 4.56 to 5.01. In 2008 it ranged between 3.1 to 3.4, individual simulation were between 2.8 to 3.3 and observed data were between 4.81 to 4.79 (Table 3). The test of significance result showed that were non significant [t =0.80 and 0.50 respectively at 5% level of significance for 2 d.f].

Biomass (kg ha^{-1}) of wheat

The overall values indicated that the model over predicted the biomass of wheat (Table 3). It is exposed from the data for 2007 the sequential simulation oscillated between 9758 to 12543 kg ha^{-1}, individual simulation were between 9579 to 10421 kg ha^{-1} and observed data were between 9605 to 10553 kg ha^{-1}. In 2008 under sequential simulation ranged between 8842 to 8986 kg ha^{-1}, individual simulation were between 8462 to 9986 kg ha^{-1} and observed that were between 8426 to 8975 kg ha^{-1}. It is apparent that in 2008 both the nitrogen level and irrigation levels found to have close prediction over observed value. It is also evident from the data that in 2007 the model predictions was not good as compared to 2008. The t values for 2007 and 2008 were 2.81 and 2.30 respectively. The test of significance showed that the data were non-significant in both the years at 5% level of significance for 2 d.f. Difference between observed and simulated biomass has also reported by Rezzaug *et al.* (2008).

Grain yield (kg ha^{-1}) of urd

The sequential simulation studies were done to examine the stability of urd-wheat crop rotation as influenced by the interaction between environment and nutrient status. Sequentially simulated yield for 2008, the model did not provid good estimate for yield as compared with the observed data (Table 4). It is revealed form the data for 2007 under sequential simulation yield was 1540 kg ha^{-1}, individual simulation between 1577 kg ha^{-1} and observed 1584 kg ha^{-1}. A little decline in sequentially simulated yield was reported due to the wheat crop rotation effect.

Maximum LAI of urd

The predictability of maximum LAI was comparatively poor as evident from high value of difference as comparison with the observed data (Table 4). In 2007 under sequential analyni the maximum LAI was 6.35, individual simulation game LAI 6.41 and observed data was 6.98. The maximum leaf area index was under predicted in the sequential simulation as well as individual. Theses findings are in conformity with the results of Batwal *et al.* (2004).

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REFERENCES

Aggrawal, P.K. (2002). Crop growth modeling in India: Past, present and future. Potato global research and development proceedings of the Global conference on Potato, New Delhi, India; 6-11 Dec., 2 : 788-795 pp.

Batwal, G.D., Sabale, R.N. and Varshneya, M.C. (2004).Validation of CERES-Soyabean model of DSSAT 3.5. *J. Maharastra Agric. Univ.,* 29 (1): 68-71.

Godwin, S.A., Nielson, D.C., Ma, L.R. and Halvorson A.D. (1990). Modeling nitrogen management effects on winter wheat production using RZWQM and CERES wheat. *Agron. J.*, 96: 615-630.

Grace, P.R., Harrington, L., Jain, M.C. and Robertson, G.P. (2003). Long term sustainability of the tropical and subtropical rice-wheat system. *Crop Science Soci. America, Charlotte*, 27-43.

Jain, R.P. and Aulakha, H.S. (1971).Variability in wheat (*Triticum aestivum* L.). *Indian J. Agric. Sci*., 44: 201-203.

Kaur, M., Singh, K.N., Singh, H., Singh, P. and Tabasum, S. (2007). Evaluation of model CERES wheat under temperate conditions of Kashmir valley. *World J. Agric. Sci.,* 3 (6): 825-832.

Mitchell, R.A.C. (1996). Predicting the effects of environmental change on winter wheat yield in genotypes with different flowering dates. *Aspects Applied Biology*, 45 : 133-138.

Rezzoug,W., Gabrille, B., Suleiman, A. and Benabdeli, K. (2008). Application and evaluation of the DSSAT-Wheat in the Tiaret region of Algeria. *African J. Agril Res*., 3 (4): 284-296.

Ritchie, J.T. and D.C. Otter. (1985). Cereal growth, development abd yield In. Suji T.G. Hoogenboon and P.K. Thronton (Eds.) "Understanding options for agricultural production", Kluwar Academic Pub.Dordrechet, Netherlands. pp. 79-97.

Singh, U., Godwin, D.C., Humphries, C.G. and Ritchie, J.T. (1982).A computer model to predict the growth and development of cereals. Summer computer simulation conference: July 24-27. San Diego, CA (USA). pp. 668-675.

Thornton, P.K., Wilkens P.W., Hoogenboom G. and Jones, J.W. (1994). Sequence analysis. *In* DSSAT v 3. Vol. 3–2, G.Y. Tsuji *et al.* (ed.). Univ. of Hawaii, Honolulu.

Tsuji, G.Y., Uehara, G., Balas, S., (1994). International Benchmark Sites Network for Agrotechnology Transfer, DSSAT version 3, Vol. 1. University of Hawaii, Honolulu, Hawaii.

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PAPER 11