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Simulation of wheat genotypes for grain yield using info crop model at enhanced CO_2 level

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Abstract: Inforcrop simulation for prediction of grain yield of wheat genotypes at normal and enhanced level of $C0_2$ during 2013-14 & 2014-15 were performed in rabi season of 2013 and 2014. Eight varieties of wheat namely, PBW443, PBW343, HD2733, UP262, HP1744, NW1014, HUW234 and HD2643 were sown at three dates of sowing viz., 30th November, 15th December, 30th December in split plot design with three replications. The mean error percent of simulated yield over observed was minimum 3.4% in UP262 genotype followed by PBW343 3.9%, NW1014 4.3% and PBW443 4.5%. Among the varieties highest error percentage 6.3% was reported in HD2643 followed by 6.2% in HUW234, 5.4% in HP1744, 4.8% in HD2733, 4.5% in PBW443, 4.3% in NW1014, 3.9% in PBW343 and lowest 3.4% in UP262. Maximum change in yield percentage of simulated yield with increase of CO_2 level at normal temperature with info crop model was reported at 470ppm of CO2 level in all the varieties. Both Inforcrop and ceres Models confirmed that among the varieties under test HD2643, UP262 and HUW234 possess maximum accurate simulated yield .Among the model ceres responded better over Info crop as to have the lower error % among all the varieties at highest CO_2 level (470ppm). And among the varieties HD2643 possess highest error percentage over base yield i.e.28.43% from Ceres model and 31.0% from Inforcrop and the least error percentage was reported in HUW234 from both the model i.e. 24.9% from ceres and 27.5% from Inforcrop respectively.

Keywords:, Normal Temperature, Enhanced CO_2, Sensitivity analysis and Inforcrop

Introduction

The crop growth models are helpful to assess the impact of climate change on the stability of crop production under different management options (Hoogenboom *et al*., 1995). Crop growth simulation models provide means to quantify the effect of climate on soil, crop growth, productivity and sustainability of agriculture production. These tools can reduce the need for expensive and time consuming of field experimentation and can be used to analyze yield gaps in various crops including wheat. Crop simulation model is quite useful as it forms a bridge between crop process analysis and performance assessment in which process operations are in their natural context. Info Crop, a Decision Support System (DSS) is a dynamic crop-yield simulation model developed by Aggarwal P.K. and his co-workers from the Center for Application of Systems Simulation, IARI New Delhi. It is a generic crop model that has been developed to provide a platform to scientists to build their applications around it and to meet goals of stake holders need for information. The models in this DSS have similar structure as in CERES and are designed to simulate the effects of weather, soils, agronomic management including planting, nitrogen, residues and irrigation with major pests on crop growth and yield (Van Laar *et al*., 1997). It is a mechanistic dynamic crop simulation model, which can deal with the interaction among weather, crop/variety, soils and management besides major pest. It has capacity to evaluate the production of major annual crops *viz*, rice, wheat, sorghum, millet, sugarcane, chickpea, pigeon pea, cotton, mustard, groundnut, potato and of course maize and has a data base in respect of Indian soils (Aggarwal *et al*., 2005). The Info Crop model has also the capability of analysis of experimental data, to estimate the potential yield, yield gaps and also assess the impacts of climate variability and climate change. The model also efficiently works for management optimization and assess environmental impact study. Thus, this model is most versatile and has many agricultural applications used for decision support system for agro technology transfer (Kumar and Glinni, 2002).

Material and Methods

The present investigation has been carried out during Rabi season of 2013-14 and 2014-15 at instructional farm of N.D. University of Agriculture and Technology. The details of experimental site and technical programme has been described elsewhere (Pandey *et al.*, 2015).The experiment was conducted in split plot design (SPD) and replicated three times.

The following varieties in main plots were sown as per recommended package and practices during course of investigation.

PBW-443	V_1	:	HD-2733	V_3
PBW-343	V_2	:	UP-262	V_4
HP-1744	V_5	:	HUW-234	V_7
NW-1014	V_6	:	HD-2643	V_8

The files of info crop model are organized into input, output and experiment performance data file. The experiments performance files are needed only when simulated results are to be compared with data recorded in a particular experiment. In some cases, they could be used as input files to reset some variable during the course of a simulation run. Model input files are organized to allow some flexibility in their use with specific models e.g. there is a soil nutrient management section that users could pass when their crop model does not include a soil fertility component.

Results and Discussion

Inrocrop simulation for prediction of grain yield of wheat genotypes at different dates of sowing during 2013-14 and 2014-15 were given in table-1. Simulated yield of all genotypes were validated with the observed yield during two years of experimentation. From table it was revealed that all the varieties at all dates of sowing during both the years were over estimated for simulated yield. The mean error percent of simulated yield over observed was minimum (3.4%) in UP262 genotype followed by PBW343 (3.9%), NW1014 (4.3%) and PBW443 (4.5%). The mean error percent of rest of the variety were 4.8% in HD2733, HP1744 (5.4%), HUW234 (6.2%) and HD 2643 (6.3%). It is remarkable to record that variety PBW343, PBW443, NW1014 and HD2733 possess higher error percent of simulation over observed during 2013-14 as compared to 2014-15, while rest of variety UP262, HP1744, HUW234 and HD2643 posses lower value of simulation over observed during first year of experiment 2013-14 as compare to 2014-15. The range of error percentage of all the variety during 2013-14 was 1.2 to 7.1% where as during 2014-15 the higher

Table-1: Infocrop simulation for prediction of grain yield of wheat genotypes at different dates of sowing during 2013-14 & 2014-15

Sowing	PBW-443			PBW-343			HD-2733			UP-262		
Dates	Obs	Sim	Error%	Obs	Sim	Error%	Obs	Sim	Error%	Obs	Sim	Error%
D_1 (2013)	4521	4752	5.1	4721	4926	4.3	4621	4832	4.5	3451	3528	2.2
D_2 (2013)	4321	4512	4.4	4521	4715	4.2	4421	4613	4.3	3211	3251	1.2
D3 (2013)	4123	4403	6.7	4323	4505	4.2	4223	4494	6.4	2955	3106	5.1
D_1 (2014)	4428	4585	3.5	4628	4697	1.4	4528	4528	2.8	3321	3399	2.3
D_2 (2014)	4220	4363	3.3	4420	4592	3.8	4320	4521	4.6	3145	3218	2.3
D_3 (2014)	4045	4222	4.3	4245	4486	5.6	4145	4406	6.2	2844	3061	7.6
Mean			4.5			3.9			4.8			3.4
Sowing	**HP-1744**			**NW-1014**			**HUW-234**			**HD-2643**		
dates	**Obs**	**Sim**	**Error%**	**Obs**	**Sim**	**Error%**	**Obs**	**Sim**	**Error%**	**Obs**	**Sim**	**Error%**
D_1 (2013)	3751	3906	4.1	2988	3091	3.4	3288	3488	6.0	3188	3376	5.8
D_2 (2013)	3511	3602	2.5	2745	2802	2.0	3045	3112	2.2	2945	3026	2.7
D3 (2013)	3255	3489	7.1	2564	2689	4.8	2864	3032	5.8	2764	2931	6.0
D_1 (2014)	3621	3811	5.2	2897	3056	5.4	3197	3406	6.5	3097	3289	6.1
D_2 (2014)	3445	3631	5.3	2655	2813	5.9	2955	3251	10.0	2855	3143	10.0
D_3 (2014)	3144	3416	8.6	2311	2416	4.5	2611	2786	6.7	2511	2687	7.0
Mean			5.4			4.3			6.2			6.3

Table-2: Infocrop simulation for prediction of grain yield of wheat genotypes at different enhanced level of CO_2 and normal temperature during 2013-14 & 2014-15

CO_2 (ppm)	PBW443 Base Yield 4472kg/ha		PBW343 Base Yield4150 kg/ha		HD2733 Base Yield3880 kg/ha		UP262 Base Yield3520 kg/ha		HP1744 Base Yield4180 kg/ha		NW1014 Base Yield3720 kg/ha		HUW234 Base Yield3850 kg/ha		HD2643 Base Yield3310 kg/ha	
	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield
380	4663	4.28	4391	5.81	4092	5.47	3929	11.62	4357	4.2	4034	8.4	4092	6.3	3725	12.5
410	5020	12.26	4439	6.96	4452	14.75	4177	18.66	4714	12.8	4082	9.7	4452	15.6	3973	20.0
440	5394	20.61	4815	16.03	4744	22.27	4414	25.38	5088	21.7	4458	19.9	4744	23.2	4210	27.2
470	5611	25.47	4877	17.51	4908	26.50	4540	28.98	5305	26.9	4520	21.5	4908	27.5	4336	31.0

Table-2.1: Ceres Simulation for prediction of grain yield of wheat genotypes at different enhanced level of CO_2 and normal temperature during 2013-14 & 2014-15

CO_2 (ppm)	PBW443 Base Yield 4472kg/ha		PBW343 Base Yield4150 kg/ha		HD2733 Base Yield3880 kg/ha		UP262 Base Yield3520 kg/ha		HP1744 Base Yield4180 kg/ha		NW1014 Base Yield3720 kg/ha		HUW234 Base Yield3850 kg/ha		HD2643 Base Yield3310 kg/ha	
	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield	Sim.	Change (%) yield
380	4572	2.24	4305	3.73	4012	3.40	3852	9.43	4272	2.20	3955	6.32	4012	4.21	3652	10.33
410	4922	10.06	4352	4.87	4365	12.50	4095	16.34	4622	10.57	4002	7.58	4365	13.38	3895	17.67
440	5288	18.25	4721	13.76	4651	19.87	4327	22.93	4988	19.33	4371	17.50	4651	20.81	4127	24.68
470	5501	23.01	4781	15.20	4812	24.02	4451	26.45	5201	24.43	4431	19.11	4812	24.99	4251	28.43

error percentage ranged between 1.4-10%. Among the varieties highest error percentage (6.3%) was reported in HD2643 followed by 6.2% in HUW234, 5.4% in HP1744, 4.8% in HD2733, 4.5% in PBW443, 4.3% in NW1014, 3.9% in PBW343 and lowest 3.4% in UP262.

Sensitivity analysis of wheat genotypes for grain yield simulation with infocrop model over base yield at normal temperature and at enhanced CO_2 level *i.e.* 380, 410, 440, and 470 ppm has been shown in table-2. From the table it was observed that subsequent enhanced level of CO_2 from normal increased the grain yield over base yield in all the varieties. Maximum change in yield percentage of simulated yield with increase of CO_2 level at normal temperature was reported at 470 ppm of CO_2 level in all the varieties .Quantitively maximum yield 31.0% was recorded in HD2643 followed by UP262 (28.98%) and HUW234 (27.5%). The increased in yield with enhanced level of CO_2 at normal temperature may be due to more photosynthetic activity occurred at higher CO_2 level. Though enhanced CO_2 maybe the causing factor to increase the ambient temperature hence detrimental to the yield of atmosphere therefore necessary weather modification to maintain the normal temperature will be required (Akula, 2003).

Sensitivity analysis of wheat genotypes for grain yield simulation with ceres model over base yield at normal temperature and at enhanced CO_2 level *i.e.* 380, 410, 440,and 470 ppm has been shown in table-2.1. From the table it was observed that subsequent enhanced level of CO_2 from normal increased the grain yield over base yield in all the varieties. Maximum change in yield percentage of simulated yield with increase of CO2 level at normal temperature was reported at 470ppm of CO_2 level in all the varieties. Quantitively maximum yield 28.43% was recorded in HD2643 followed by UP262 (26.45%) and HUW234 (24.99%). The increased in yield with enhanced level of CO_2 at normal temperature may be due to more photosynthetic activity occurred at higher CO_2 level. Though enhanced CO_2 maybe the causing factor to increase the ambient temperature of atmosphere hence necessary weather modification to maintain the normal temperature will be required.

Simulation prediction for grain yield of eight wheat genotypes at enhanced level of CO_2 and normal temperature from infocrop and ceres model has been shown in table 2 and 2.1 respectively. Models confirmed that among the varieties under test HD2643, UP262 and HUW234 were observed maximum simulated yield with both the model. Among the model ceres crop responded better as to have the lower error % among all the varieties at highest CO_2 level (470ppm). Among the varieties HD2643 possess highest error percentage over base yield i.e.28.43% from ceres model and 31.0% from infocrop and the least error percentage was reported in HUW234 from both the model i.e. 24.9% from ceres and 27.5% from infocrop respectively. The change in yield error percentage was calculated from base yield at normal CO_2 and temperature instead of base yield observed at different enhanced level of CO_2 hence systematic in depth investigation will be required to come out the final conclusion.

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