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Studies on production and potential yield of wheat in eastern plain zones of UP

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Abstract
The experimental site is located at the main campus of university on the left side of Faizabad-Raibareilly road at a distance of 43 km away from Faizabad district headquarter. The local of experimental site lies between a latitude of $24^0$47' and $26^0$56' N and longitude of $82^0$12' and $83^0$98' E and an altitude of 113 m mean sea level, in the genetic alluvium of eastern Uttar Pradesh. Comparisons were made between simulated data of various parameters viz., yield, total dry matter, LAI, soil moisture, test weight, harvest index, grain weight and their corresponding observed data through regression analysis. Measures of accuracy were worked out with coefficient of determination (R^2).The crop yield data for the respective districts as obtained from the reports of The Directorate of Agriculture, Government of U.P. were considered as actual yield for the respective district which was nothing but the average of the district yield data collected from farmers' fields in the district concerned.

Keywords: wheat, LAI, PI, yield component

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important staple food crop cultivated in at least 43 countries and provides 20% of food calories to the mankind, covering 223.6 million hectares area and producing 690.0 million tones with an average productivity of 3.08 t/ha (Anon., 2010). The major wheat growing countries are USSR, USA, China, India, Canada, Australia, France, Turkey and Pakistan. In India, wheat is next to paddy in area and production and grown over an area of 27.75 million hectares with an annual production of 80.68 million tones. India rank second after China in wheat growing countries. It is considered to be the backbone of the food security in India. Wheat is cultivated in almost all the states of India, but its extensive cultivation is confined to Uttar Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh and Gujarat. In semiarid and arid regions, there is increasing competition for water resources between agricultural irrigation and other ecological water uses due to a growing population (Molden, 1997) [15]. Efficient management of water resources in agriculture is needed to balance water supply and demand (Ines *et al.*, 2002) [10]. In the last 20 yr, irrigation planning methods have switched from the allocation approach, e.g., based on socio-political considerations, to quantitative management (Raman *et al.*, 1992) [16]. The development of mathematical models is a fundamental step to guide quantitative irrigation. Th e accurate estimation of temporal and spatial variations in soil moisture, evaporation, and transpiration is crucial to determine the availability of water resources (Aggarwal, 1995; Addiscott *et al.*, 1995) [3, 2] and sustainable management of limited water resources in arid and semiarid regions (e.g., Garatuza-Payan *et al.*, 1998) [8]. Simulation models of crop physiological growth are widely accepted tools for field study of efficient and sustainable water use in agricultural production in various agro-ecological zones. Such models can aid in understanding the interactions between crops and environments (Kropff and Goudriaan, 1994; Yin *et al.*, 2004) [13, 17] and provide optimal agricultural management strategies under uncertain weather conditions and climatic change (Meinke *et al.*, 2001; Booltink *et al.*, 2001; Kersebaum í 2002) [14, 6, 12]. Several crop physiological growth models (e.g., Simple and Universal Crop Growth Simulator [SUCROS] and ORYZA [Goudriaan and van Laar, 1994] [9]; World Food Studies [WOFOST; Boogaard *et al.*, 1998]; Decision Support System for Agrotechnology Transfer [DSSAT; Jones *et al.*, 2003] [11] have been developed from photosynthesis modeling based on the complex biochemical approach (Farquhar *et al.*, 1980) [7], the constant light use efficiency approach, or the C assimilation approach (Arora and Boer, 2005) [4].

Materials and Methods

An experiment was conducted during *Rabi* seasons of 2012 & 2013 and 2013 & 2014 at student instructional farm NDUA&T Kumarganj Faizabad (U.P.), India on the topic entitled "Studies on estimation of production & potential yield of wheat in Eastern Plain Zones of U.P." The experimental site is located in the main campus of NDUA&T, Kumarganj, (Faizabad) situated at a distance of about 42 km. away from Faizabad district headquarter on Faizabad Raibarelly road. The geographical situation of experimental site lies at latitudes 26^0 47' North longitude 82^0 12′ East and altitude of 113 meter from mean sea level in the Indo genetic alluvium of eastern Uttar Pradesh. The details of materials and methods employed & techniques adopted during the course of experimentation has been described in this paper. The experiment was conducted in Split Plot Design (S.P.D) and replicated the three times. The different growth parameters studied were white as anthesis stage, leaf area index, biomass, maturity, Grain yield, Test weight, Potential yield.

Results

The comparison between observed and simulated days to anthesis and their Mean error, SD, CV%, RMSE and R^2 are presented in (Table-1). It is revealed from the data, that days taken to anthesis ranged between 70 to 77 and 75 to 81 for observed and simulated data, respectively. Among the dates of sowing and variety, the simulated data on attaining anthesis stage was near to the observed data during both year 2011-12 and 2012-13 under timely sowing the error percent was less 5.2 and 3.9 percent as compare to delay sowing the error percent was 8.6 and 8.7 percent respectively while RMSE was 7.23 in both year and both sowing dates of cultivar HUW 234. The crop sown on 15th November was in close proximity with the simulated values, followed by 15th December sowing. The correlation coefficient between observed and simulated values was found to be significant for the number of days to attain anthesis (0.81 in both the years). Model overestimated the days taken to anthesis stage during both the years with both sowing dates. The mean error percent, SD and CV was 6.6, 2.4 and 36.4 respectively in both year and both sowing dates.

The comparison between observed and simulated maximum leaf area index and their mean error, SD, CV%, RMSE and R^2 are presented in (Table-2). Results showed that mean measured LAI in cultivar HUW 234 varied from 3.8 (D_2-2012-13) to 4.5 (D_1-2011-12) and the simulated maximum LAI varied between 3.4 (D_2-2012-13) to 4.1 (D_1-2011-12). The error percent between observed and simulated ranged between -2.3 percent to -11.6 percent, while mean error percent was -8.3 percent. The average percent error was under estimated by the model for both the year and sowing dates. The correlation coefficient between observed and simulated values was found to be significant for the maximum leaf area index (0.69* in both the years). The mean error percent, SD, CV and RMSE was -8.3, 4.3, -50.3 and 6.3 respectively (Table-2) in both year and both sowing dates.

The comparison between observed and simulated days to maturity and their Mean error, SD, CV%, RMSE and R^2 are presented in (Table-3) Results showed that above ground biomass in cultivar HUW 234 varied from 8319 kg/ha (D_2-2012-13) to 10644 kg/ha (D_1-2011-12) and the simulated above ground biomass varied between 8965 kg/ha (D_2-2012-13) to 11251 kg/ha (D_1-2011-12). The error percent between observed and simulated above ground biomass ranged between 4.7 percent to 11.9 percent. The average percent error indicated the above ground biomass was over estimated by the model for both the year and sowing dates. The test criteria indicated that the mean percent error, SD, CV, RMSE and R^2were7.4, 3.2, 43.1, 7.8 and 74* respectively (Table-3) in both year and both sowing dates.

The comparison between observed and simulated days to maturity and their Mean error, SD, CV%, RMSE and R^2 are presented in (Table-4). It is revealed from the data, that days taken to anthesis ranged between 113 (D_2-2012-13) to 77 (D_1-2011-12) and 118 (D_2-2012-13) to 127 (D_1-2011-12) for observed and simulated data, respectively. Among the dates of sowing and variety, the simulated data on attaining maturity stage was near to the observed data during both year 2011-12 and 2012-13 under timely sowing the error percent was less 4.1 and 2.5 percent as compare to delay sowing the error percent was 6.1 and 4.4 percent respectively while RMSE was 4.29 in both year and both sowing dates of cultivar HUW 234. The crop sown on 15th November was in close proximity with the simulated values, followed by 15th December sowing. The correlation coefficient between observed and simulated values was found to be significant for the number of days to attain physiological maturity (0.85 in both the years). Model overestimated the days taken to maturity stage during both the years with both sowing dates. The mean error percent, SD and CV was 4.3, 1.5 and 34.4 respectively (Table-4) in both year and both sowing dates.

The comparison between observed and simulated Grain yield and their Mean error, SD, CV%, RMSE and R^2 are presented in (Table-5). Results showed that Grain yield in cultivar HUW 234 varied from 4011 kg/ha (D_2-2012-13) to 4120 kg/ha (D_1-2011-12) and the simulated grain yield varied between 4403 kg/ha (D_2-2012-13) to 4750 kg/ha (D_1-2011-12). The error percent between observed and simulated above grain yield between 5.1 percent to 9.7 percent. The average percent error indicated the grain yield was over estimated by the model for both the year and sowing dates. The test criteria for grain yield of wheat cultivar HUW 234 indicated that the mean percent error, SD, CV, RMSE and R^2 were 7.5, 2.0, 26.8, 8.1 and 86* respectively (Table-5) in both year and both sowing dates.

The comparison between observed and simulated test weight and their Mean error, SD, CV%, RMSE and R^2 are presented in (Table-6) Results showed that Test weight in cultivar HUW 234 varied from 42.1% (D_1-2012-13) to 49.3 (D_2-2011-12) and the simulated Test weight varied between 42.2 (D_1-2011-12) to 49.1% (D_2-2012-13). The error percent between observed and simulated Test weight between -2.0 percent to 3.7 percent. The average percent error indicated the harvest index was over estimated by the model for both the year and sowing dates. The test criteria for Test weight of wheat cultivar HUW 234 indicated that the mean percent error, SD, CV, RMSE and R^2 were 5.3, 2.3, 43.2, 6.2 and 76* respectively (Table-6) in both year and both sowing dates.

Potential yield of wheat and yield gap analysis in different districts Faizabad, Azamgarh, Varanasi, Allahabad and Gorakhpur of eastern plain Zone of U.P. are presented in (Table-7) The actual yield of eastern plain zone was ranged between 2890 kg/ha to 3200 kg/ha the highest yield was observed in Faizabad district and lowest was in Azamgarh.

Table 1: Comparison between measured and simulated values for Anthesis (DAS) at different dates of sowing and variety

Treatments	HUW- 234			
	Obs	Sim	Deviatin	Error%
D_1-15th November (2011-12)	77	81	4	5.2
D_2-15th December (2011-12)	70	76	6	8.6
D_1-15th November (2012-13)	76	79	3	3.9
D_2-15th December (2012-13)	69	75	6	8.7
Mean				6.6
SD				2.4
CV%				36.4
RMSE				7.23
R^2				0.81*

Table 2: Comparison between measured and simulated values for maximum Leaf Area Index at different dates of sowing and variety

Treatments	HUW 234			
	Obs	Sim	Deviation	Error%
D_1-15th November (2011-12)	4.5	4.1	-0.4	-8.9
D_2-15th December (2011-12)	4.3	3.8	-0.5	-11.6
D_1-15th November (2012-13)	4.4	4.3	-0.1	-2.3
D_2-15th December (2012-13)	3.8	3.4	-0.4	-10.5
Mean				-8.3
SD				4.2
CV%				-50.3
RMSE				6.3
R^2				69*

Table 3: Comparison between measured and simulated values for total biomass (kg/ha) at different dates of sowing and variety

Treatments	HUW 234			
	Obs	Sim	Deviation	Error%
D_1-15th November (2011-12)	10644	11251	607	5.7
D_2-15th December (2011-12)	8351	9311	992	11.9
D_1-15th November (2012-13)	10473	10965	492	4.7
D_2-15th December (2012-13)	8319	8965	614	7.4
Mean				7.4
SD				3.2
CV%				43.1
RMSE				7.8
R^2				74*

Table 4: Comparison between measured and simulated values for physiological maturity (DAS) at different dates of sowing and variety

Treatments	HUW 234			
	Obs	Sim	Deviation	Error%
D_1-15th November (2011-12)	122	127	5	4.1
D_2-15th December (2011-12)	115	122	7	6.1
D_1-15th November (2012-13)	120	123	3	2.5
D_2-15th December (2012-13)	113	118	5	4.4
Mean				4.3
SD				1.5
CV%				34.4
RMSE				4.29
R^2				0.85*

Table 5: Comparison between measured and simulated values for grain yield (kg/ha) at different dates of sowing and variety

Treatments	HUW 234			
	Obs	Sim	Deviation	Error%
D_1-15th November (2011-12)	4521	4750	229	5.1
D_2-15th December (2011-12)	4120	4406	394	9.7
D_1-15th November (2012-13)	4424	4801	377	8.5
D_2-15th December (2012-13)	4011	4403	283	6.9
Mean				7.5
SD				2.0
CV%				26.8
RMSE				8.1
R^2				86*

Table 6: Comparison between measured and simulated values for test weight (g) at different dates of sowing and variety

Treatments	HUW 234			
	Obs	Sim	Deviation	Error%
D_1-15th November (2011-12)	52.5	54.1	1.6	3.0
D_2-15th December (2011-12)	48.8	51.9	3.1	6.1
D_1-15th November (2012-13)	51.2	53.2	2	3.9
D_2-15th December (2012-13)	47.9	51.8	3.9	8.1
Mean				5.3
SD				2.3
CV%				43.2
RMSE				6.2
R^2				76*

Table 7: Potential yield of wheat and yield gap analysis in eastern plain Zone of U.P.

Yield (kg/ha)				
S. No.	Districts	Actual yield	Potential yield	Yield Gap
1	Faizabad	3200	4500	1362
2	Azamgarh	2890	3954	1064
3	Varanasi	2933	4101	1168
4	Allahabad	2917	3966	1049
5	Gorakhpur	3047	3856	809

Conclusion

It is concluded that study in phenological stages (*viz*., anthesis and physiological maturity) with error percent less than ±9.0. Similarly, for simulation of grain and biomass production error percent was less than ±10. Hence, this model can be used for simulating the phenology and yield of wheat

cultivars but model under estimate the leaf area index with error percent up to ±15. And highest yield gap was observed in Faizabad district and lowest was in Azamgarh district of eastern plain zone of Uttar Pradesh.

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