Journal of Agrometeorology 8(1) : 87 - 90 (June 2006)

Simulation of wheat yield using WTGROWS in Northern India

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ABSTRACT

The model WTGROWS was validated for two varieties (PBW 343 and UP 2382). The values of simulated grain yield for early, timely and late sown wheat were slightly higher than the observed values for all dates of sowing and for both the varieties. The mean of grain yield for early, timely, and late sown wheat were 52.5 q/ha , 57.5 q/ha and 47.5 q/ha with RMSE 1.08, 0.97 and 1.01 respectively for PBW 343 and 47.3 q/ha, 55.2 q/ha, 43.1 q/ha with RMSE 1.10, 0.99 and 1.09 respectively for UP 2382. The percent deviation in simulated yields compared to observed values ranged from - 0.8 to + 5.2. The results revealed that this model could be successfully used for Pantnagar environment after appropriate calibration for genetic and phenological coefficients.

Key words : Wheat, WTGROWS, model validation and simulation.

Wheat (*Triticum aestivum L*) is the second most important cereal crop after rice and its main areas are situated in the temperate to sub tropical climatic regions. Wheat production in India is 70.26 million tones with an average productivity of 2.9 tones per hectare. Weather plays an important role to a greater extent in blocking the targets in different agroclimatic zones of the country. In this paper an attempts have been made to simulate wheat yield using WTGROWS for early, timely and late sown conditions. WTGROWS Model simulates the effects of weather, soils, environment and agronomic management on crop growth and yield. Simulation models have been used for determining the production potential of a location knowing its resources, optimism agronomy, quantification of yield gaps, and to study the consequences of climatic variability and climatic change on agriculture (Aggarwal and Kalra, 1994). Model was validated using data sets collected from different locations including years, soil types, genotypes, and dates of sowing for irrigated conditions and the performance was evaluated in terms of above ground biomass and grain yield.

MATERIALS AND METHODS

The present study was carried out in experimental field of Crop Research Center of G.B. Pantnagar University of Agriculture and Technology, situated at latitude 29 °N, longitude 79 ° 3 'E and at a altitude of 243.84 meters amsl. The experiment was conducted during the *Rabi* (winter) seasons of 2002 – 003 and 2003 –

Table 1 : Soil properties of Haldi Loam series and Beni silty clay loam series used in the model validation.

Properties	Haldi Loam			Beni silty clay loam		
	LyrI	LyrII	LyrIII	LyrI	LyrII	LyrIII
Thickness (mm)	150	700	550	200	600	500
Sand (%)	36.2	32.2	35.6	31.7	31.2	31.2
Clay (%)	17.3	19.8	20.6	29.7	34.0	33.1
BD (Mg/m^{-3})	1.39	1.45	1.47	1.33	1.40	1.53
WCFC (%, w/w)	28	25.5	24.5	27.6	24.9	23.2
WCWP (%, w/w)	8.2	7.8	7.5	8.1	7.2	7.0

Table 2: Genotypic characterization and a list of parameters required in WTGROWS for UP 2382 and PBW 343.

Genotypic constants	Units	Potential data (UP2382)	Standard data (UP2382)	Potential data (PBW343)	Standard data (PBW343)
Base temperature	°C	3.6	3.6	3.8	3.8
Thermal time for-					
Germination	°C -d	70	70	70	70
Germination to 50% flowering	°C -d	800	800	800	800
50% flowering to maturity	°C -d	373	373	375	375
Relative growth rate of leaves	°C / d	0.005	0.0052	0.0060	0.0065
Specific leaf area	dm^2/mg	0.0020	0.0022	0.002	0.0022
Radiation use efficiency	g/MJ	2.75	2.75	2.8	2.8
Extinction coefficient of leaf at flowering	-	0.60	0.61	0.75	0.75
Root growth rate	mm /day	25	25	27	27
Potential storage organ weight	mg /grain	42	42	45	45
Nitrogen content (storage organ)	Fraction	0.02	0.02	0.021	0.022
Index of greenness of leaves	(Scale 0-1)	1	1	1	1

2004. This area enjoys humid sub-tropical type of climate with hot dry summers and cold winters. It has a dry season from October to mid of June and a wet season from mid June to October. During the year temperature are the highest in May – June and the lowest in December – January. The soils of this region (Tarai) have been

Table 3: Simulated and observed yield (q ha^{-1}) for early, timely and late sown conditions for PBW 343 and UP 2382

Sowing treatment	PBW 343		UP 2382	
	Observed	Simulated	Observed	Simulated
Early	47.5	50.8	46.0	48.3
Timely	51.0	57.6	50.1	55.2
Late	45.3	46.5	43.2	45.1

developed from calcareous, medium to moderately coarse textured materials under the pre-dominant influence of tall grass vegetation and moderately well to well-drained conditions. The area under study is fertile, having rich organic matter. The soil of Haldi loam series has the bulk density, moisture per cent and the hydraulic conductivity values in the range of 1.39 to 1.69x 10^{4} kg.m^{-3}, 28.6 to 8.2 % and 2.63 to 6.34 cm hr^{-1} respectively. The organic matter content ranges from 3.1 to 0.2 %, pH ranges from 5.7 to 8.0. The soil of Beni series has moisture percentage, bulk density, the hydraulic conductivity and the organic matter content values in the range of 34.6-28.4%, 1.33 to 1.58 x 10^{4} kg.m^{-3}, 0.818 to 1.48 cm hr^{-1} and 3.4 to 8.4 respectively.

The two varieties used in the study area UP 2382: and PBW 343. The crop was sown on 3 different dates early (29 Oct. to 5 Nov.), timely (12 Nov. to 18 Nov.) and late (10 Dec. to 16 Dec.). The entire life cycle of wheat crop has been divided into six physiological crop growth stages, viz. crown root initiation stage ($PCGS_1$), maximum tillering stage ($PCGS_2$), jointing stage ($PCGS_3$), flowering stage ($PCGS_4$), milk stage ($PCGS_5$) and harvest stage ($PCGS_6$). The cumulative growing degree-days were calculated for the total crop period and also for the different developmental stages of the crop.

The model wheat growth simulator (WTGROWS) was calibrated by computing the phenological and genetic coefficient evaluated from the first sowing. The parameters involved were growing degree days, potential grain weight, potential grain filling rate and final grain number per unit weight, dry matter accumulation. Validation of the model WTGROWS was carried out using second sowing by judging the performance in terms of grain yield, final ground biomass and days required for pre and post anthesis duration. After validation of the model WTGROWS for different varieties in different soils, it was run for two years (2002-03 to 2003-2004) for computing the climatic variability in terms of grain yield.

The inputs used to initialize the WTGROWS model for validation are presented in Table 1 & 2.

RESULTS AND DISCUSSION

The results showed the wide variation in grain yield of wheat varieties as also reported by Kalita and Chaudhary (1984) and Singh *et al*. (1997) (Table 3). The comparison of observed and simulated yields during 2003-2004 revealed that simulated yields were slightly higher than observed yields. The performance of the model was evaluated for judging the associated effects under different soils, different date of sowing and harvest, for different varieties. Over prediction of simulated yield ranged from 50-55 q ha^{-1}, 55-60 q ha^{-1}, 45-50 q ha^{-1} for PBW 343 and 45-50 q ha^{-1}, 50-55 q ha^{-1}, 40-45 q ha^{-1} for UP 2382 for early, timely, and late sown conditions respectively. The mean of simulated yields for early, timely, and late sown wheat were 50.8 q ha^{-1}, 57.6 q ha^{-1} and 46.5 q ha^{-1} with RMSE 1.08, 0.97 and 1.01 respectively for PBW 343 and 48.3 q ha^{-1}, 55.2 q ha^{-1}, 45.1 q ha^{-1} with RMSE 1.10, 0.99 and 1.09 respectively for UP 2382. From above data it is clear that there is a linear decrease in grain yield with delay in sowing. Delay in sowing also lead to early maturity of the crop. Sankaran *et al*. (2000) used WTGROWS simulation model and suggested that the rate of improvement in the wheat yield might vary strongly depending upon the cultivars under study.

CONCLUSION

WTGROWS could simulate the grain yield of two cultivars under different dates of sowing satisfactorily for Pantnagar environment after appropriate calibration for genetic and phenological coefficients.

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