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Testing Of Infocrop Model for Growth and Yield Prediction of Wheat Cultivars in Central Irrigated Plains of Punjab State

Mr.Baljinder Singh[1], Ms.Veerpal Kaur[2]
[1,2]University College of Agriculture
[1,2]Guru Kashi University, Talwandi Sabo

ABSTRACT

Field experiments were conducted during rabi 2006-07, 2007-08, and 2009-10 to start generating field data for evaluating the response of three wheat cultivars, PBW 343, PBW 502, and PBW 550, to three sowing dates (D1–1st week of October; D2–3rd week of October; D3–2nd week of November) under variable environmental conditions. By comparing simulated and actual field data on phenological events (anthesis date and physiological maturity date), growth (maximum LAI), and yield (grain yield) for wheat cultivars, the INFOCROP model has been validated. These occurrences were both overestimated and underestimated by the model. Anthesis and physiological maturity dates for wheat cultivars were simulated at -15 to +4 days and -13 to +14 days, respectively, from the actual observed dates. For wheat cultivars in various conditions, the highest LAI and grain yield were simulated at -23 to +39 percent and -17 to +17 percent of the actual observed values, respectively. However, for wheat cultivars seeded in December, the model predicted a relatively low grain yield, indicating that the partitioning of dry matter between grain and straw under late-sown circumstances requires additional investigation. According to the findings of this study, the calibrated INFOCROP model may be used to estimate wheat growth and production in the Punjab. A well-validated model may also be utilised for yield forecasting at the regional level when combined with GIS and remote sensing.

INTRODUCTION

Wheat (Triticum species) is a globally important crop. It may be cultivated in a variety of settings. Millions of people eat it every day. Wheat is grown on around one-sixth of the world's total arable land. Unlike rice, which is mostly grown in Asia, wheat is grown on every continent. It provides around 20% of the calories needed to feed the world's expanding population. In 2007-08, global wheat output reached 622.2 million tonnes. After China, India is the world's second-largest wheat producer. Wheat occupies a unique position among food grain crops. Wheat is mostly composed of carbohydrate and protein. Wheat provides 11-12 percent protein on average. Dynamic crop growth simulation modelling tries to simulate day-to-day photosynthetic material absorption based largely on the exchange of energy and mass among the numerous development processes occurring in a plant. These dynamic models aid in not only understanding the climate-crop interaction and the processes that contribute to crop development and production, but also in evaluating the potentials of alternative soil and crop management choices (Hoogenboom et al, 1997) and are a key component in systems approach research. Weather, soils, agronomic management (planting, nitrogen, residues, and

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irrigation), and significant pests all have an impact on crop growth, yield (Aggarwal et al., 2006a), soil carbon, nitrogen, and water, and greenhouse gas emissions, according to INFOCROP, a general crop model. The model takes into account the many crop development and growth processes that influence yield. The model divides the total crop growth time into three phases: planting to seedling emergence, seedling emergence to anthesis, and storage organ filling. Thermal time for phenological phases, potential grain weight, specific leaf area, maximum relative growth rate, and maximum RUE of crop types are all required by the model. The results are based on the crop's source-sink balance in respect to its surroundings. Various scientists in India have utilised this model to predict growth and yield aspects of various crops such as potato (Singh et al., 2005), wheat and rice (Aggarwal et al., 2006), rice (Ebrayi et al., 2007), and coconut (Kumar et al., 2008).

MATERIALS AND METHODS

Site description:

The study's soil, crop, and meteorological data came from the Punjab Agricultural University's research farm in Ludhiana (300 54 N, 750 48 E, 247 m above mean sea level). The region receives 700 mm of yearly rainfall, with roughly 80% of it falling between June and September. This region is characteristic of the Indian Punjab's central irrigated plains, which have a sub-tropical, semi-arid climate. During the rabi season, the average maximum and lowest temperatures in Ludhiana are 24.4 oC and 9.5 oC, respectively. Table 1 shows the monthly mean weather data for the three trial years.

Data description:

Field experiments were conducted during rabi, 2006-07, 2007-08 and 2009-10 to compare phenology, growth and yield of three wheat cultivars, viz PBW 343, PBW 502, and PBW 550 under three dates of sowing (D_1–1st week of October; D_2–3rd week of October; D_3–2nd week of November). The crop was sown with a row – row spacing of 22.5 cm. Wheat crop for each date of sowing was sown following pre-sowing "rauni" irrigation. Subsequently, irrigation was applied as per recommendations. Fertilizer were applied @125Kg N / ha, 62 Kg P_2O_5 / ha, and 30 kg MOP / ha as per recommendations. At the time of sowing, one half of nitrogen and all P_2O_5 were applied as a basal dose. The remaining half dose of nitrogen was given at the time of first irrigation, i.e. at CRI stage of wheat crop.

Table 1: Mean monthly meteorological data during three wheat crop seasons at Ludhiana

Months	Maximum Temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	Maximum Relative Humidity (%)	Minimum Relative Humidity (%)	Sunshine hour (Hrs)	Evaporation (mm)
Rabi 2006-07							
October	32.0	18.5	6.8	89	46	7.4	113.7
November	26.4	12.8	14.0	94	45	5.8	59.6
December	20.1	7.2	8.7	95	54	6.1	44.2
January	19.5	4.2	10.0	97	48	7.3	53.0
February	20.4	10.1	84.7	96	64	5.5	47.1

March	26.1	12.4	41.3	91	44	9.1	110.3
Rabi 2007-08							
October	32.5	15.2	0.0	91	33	8.9	115.7
November	27.5	11.2	1.3	93	34	4.5	65.1
December	19.9	5.7	17.7	97	52	6.4	46.0
January	16.9	4.5	16.3	93	48	6.1	53.2
February	20.2	6.4	3.2	95	49	6.9	68.4
March	30.4	14.0	0.0	90	39	9.1	131.9
Rabi 2009-10							
October	31.8	16.4	26.2	91	44	8.7	101.8
November	25.1	10.6	5.1	93	41	4.7	52.3
December	21.2	6.8	0.0	96	46	5.5	42.5
January	15.7	6.6	18.4	99	74	2.8	26.5
February	22.5	9.0	25.0	94	50	7.3	71.4
March	31.0	14.8	1.0	92	38	9.4	132.8

Input data for INFOCROP model :

The daily weather data needed to run the INFOCROP model, i.e., minimum and maximum air temperature (^oC), solar radiation (k $Jm^{-2}d^{-1}$), vapour pressure (k Pa), wind speed (ms^{-1}) and rainfall (mm) were collected at the Agromet observatory of the Punjab Agricultural University, Ludhiana. The layer-wise soil profile data used in the model was generated from the actual soil profile data of experimental field. The INFOCROP model requires crop management data such as date of sowing, depth of sowing, seed rate, row-row spacing, , amount and time of irrigation, amount and time of fertilizer application was collected from the field experiments conducted during the three consecutive crop years.

The "INFOCROP" model was calibrated for three wheat cultivars, viz PBW 343, PBW 502, and PBW 550 for three dates of sowing (D_1–1st week of October; D_2–3rd week of October; D_3–2nd week of November) using the actual crop data for the crop year 2007-08. Since the true values of the local cultivars used in the study are not known, the procedure for determining genetic coefficients initially involves running the model with values, derived elsewhere and then re-running the model using a range of values for each coefficient until a satisfactory level of agreement between simulated and observed values is reached. Finally, those values of the coefficients which most realistically simulated the growth and yield of wheat crop were selected.

RESULTS AND DISCUSSION

Crop phenology :

Figures 1 and 2 show the phenological events, such as anthesis date and physiological maturity date, simulated by the INFOCROP model and those observed in the field for wheat cultivars. The model underestimated as well as inflated the crop phenological phases for the

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three wheat cultivars under varied conditions, according to the data. For wheat cv PBW 343, the INFOCROP model predicted days to anthesis within –12 to +4 days and physiological maturity within –4 to +5 days of the observed dates. The model predicted anthesis within –11 to -4 days and physiological maturity within –8 to +14 days of the observed dates for wheat cv PBW 502. For wheat cv PBW 550, the anthesis date was anticipated to be between -17 to 8 days and the physiological maturity date to be within –5 to +5 days of the observed dates.

Crop growth and yield:

For the three wheat cultivars, the "INFOCROP" model replicated crop development and yield features such as maximum LAI, 1000-seed weight, seed yield, and biomass yield in close agreement with field measurements under various planting dates. Under various growth conditions, maximum LAI varied from 3.5 to 6.7 for cv PBW 343, 3.3 to 5.6 for cv PBW 502, and 3.9 to 6.4 for cv PBW 550. (Fig 3). The highest LAI was both underestimated and overestimated based on the model results. When compared to field observed maximum LAI, the model underestimated maximum LAI by 12 percent in one of nine data sets for PBW 343, overestimated maximum LAI by more than 30 percent in four data sets, between 10-20 percent in one data set, and between 0-10 percent in three data sets. In the instance of cv PBW 502, the model underestimated maximum LAI by more than 20% in one data set, overestimated maximum LAI by more than 20% in three data sets, and between 0 and 10% in two data sets when compared to field observed maximum LAI. In two of the nine data sets for PBW 550, the model underestimated maximum leaf area index by less than 10%, while overestimating maximum leaf area index by more than 30% in three data sets, between 10-30% in three data sets, and between 0-10% in one data set, as compared to field observed maximum LAI.

Grain yields for PBW 343, 4016 to 5490 kg/ha for PBW 502, and 2260 to 5660 kg/ha for PBW 550 varied from 2934 to 5300 kg/ha (Fig 4). The model both underestimated and overestimated the grain yield for the three wheat varieties under different settings. In three of the nine data sets for PBW 343, the model underestimated grain yield by more than 30%, by 10-30% in three data sets, and by 0-10% in two data sets; however, the model overestimated grain yield by 30% in one data set when compared to field observed grain yield. When compared to field observed grain yield, the model underestimated grain yield by more than 10% in one data set and between 0-5 percent in three data sets for PBW 502; meanwhile, the model overestimated grain yield by more than 10% in two data sets. When compared to field observed grain yield, the model underestimated grain yield by more than 20% in three data sets and by 0-10% in two others. When compared to field observed grain yield, the model overestimated grain yield by more than 30% in one data set and by 0-10% in three others.

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