International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 10, 2018, pp.-6121-6123.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

# DURATION AND GRAIN YIELD ASSESSMENT OF WHEAT (*Triticum aestivum*) IN SOUTHERN RAJASTHAN UNDER PROJECTED CLIMATE CHANGE SCENARIOS

**SOLANKI N.S.* AND SAMOTA SANTOSH DEVI**
AICRP on Agrometeorology, Department of Agronomy, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India
*Corresponding Author: Email - solanki.narayan@rediffmail.com

Received: May 17, 2018; Revised: May 26, 2018; Accepted: May 27, 2018; Published: May 30, 2018

**Abstract:** The impact of projected climate during 2030-2090 on the duration and yield of wheat in Southern part of Rajasthan has been analyzed using DSSAT model v 4.5. Data from field experiments conducted at Udaipur, with wheat variety Raj-4037 grown during *rabi* season of 2008-09 to 2010-11, was used for calibration and validation of model. The crop sown on 5th November showed projected decline in grain yield from 9.3 % in the year 2030 to 35.4 % in 2090. Delayed sowing (5th December and 20th December) showed lower decline in the projected grain yield and duration for physiological maturity. Advance sowing resulted higher decline in grain yield and days to attain physiological maturity of wheat. Incremental unit of maximum and minimum temperatures (0.5 to 3.0ºC) during the entire growth period showed that days required for maturity as well as grain yield under each sowing environment decreased as compared to normal durations and grain yield.

**Keywords:** *Climate change, crop duration, crop yield, temperature, wheat*

**Citation:** Solanki N.S. and Samota Santosh Devi (2018) Duration and Grain Yield Assessment of Wheat (*Triticum aestivum*) in Southern Rajasthan under Projected Climate Change Scenarios. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 10, pp.- 6121-6123.

**Academic Editor / Reviewer:** Sagar Kamna, Radhakrishnan Kalidoss

## Introduction

Climate change and variability cause a wide range of direct and indirect impact on crop productivity. Studies on crop production are carried out by conducting field experiments, in which crop production functions are derived from statistical analysis without referring to biological processes. It is expected that the increasing concentration of greenhouse gases in the atmosphere would affect the climate; global mean surface temperature is projected to increase by 2.0 to 5.4ºC for A2 scenario during 2090 to 2099 relative to 1980-1999[1]. In India major part of the population is engaged in agriculture or agriculture-based enterprises so, changing climate may impair India's food security by hampering agricultural production. To overcome the negative effect of climate change, a pre-assessment of the approaching situation can be quite helpful in managing the change for benefit. Dynamic crop growth models are widely used to project the effects of rising atmospheric $CO_2$ concentration and associated climate change on crop yield. Simulation studies for wheat in India showed declined in yield from 3 to 38 percent in Patna and 3 to 28 percent in Ranchi for 2020, 2050 and 2080[2]. Wheat crop matured 10-20 days earlier and wheat production decline by more than 4 million tonnes in Indo-Gangatic plains when temperature increased by 3-6ºC in March 2004 equivalent to average 1ºC per day rise in the crop season [3]. Fifty one percent decrease in the most favorable and high yielding regions of India due to heat stress, likely to reduce wheat yield [4]. This study was under taken to assess the impact of climate change on the wheat yield grown in southern Rajasthan

## Materials and Methods

The CERES wheat model was calibrated and validated with data sets generated during *rabi* season of 2008-09, 2009-10 and 2010-11through field experiment laid out in split plot design with four replications on clay loam soil of the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur, Rajasthan, India. The treatment comprised four dates of sowing (5th November, 20th November, 5th December and 20th December).

The crop was fertilized with 120 kg N and 40kg $P_2O_5$/ha and received six irrigations. Udaipur is situated in the southern part of Rajasthan at 24º35' N latitude, 73º 42' E longitude and altitude 582.2m above mean sea level. CERES wheat model was used to simulate the yield of wheat variety Raj 4037 under hypothetical increase or decrease in both maximum and minimum temperatures throughout the crop period that may be arising due to climate change in future. The climate scenarios were simulated for temperature ± 0.5 to ±3ºC. The DSSAT (Decision Support System for Agro technology Transfer) v 4.5, comprehensive software developed by International Consortium for Agricultural Systems Applications (ICASA, Hawaii) was used for impact assessment studies. The IPCC's Special Report on Emission Scenario (SRES) describes future scenarios projecting greenhouse gas emissions. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). A1B scenario assumes a balanced mix of technologies and supply sources, with technology improvements and resource assumptions such that no single source of energy is overly dominant [5]. The baseline weather data of Udaipur for the period from 1971-2000 was used to generate 2030,2050,2080 and 2090 climate scenarios and this data later used to simulate wheat duration and yield.

## Results and Discussion

Results on effect of maximum and minimum temperatures on simulated duration of maturity and grain yield of wheat under four dates of sowing are presented in [Table-1 and 2]. Simulated duration of maturity of wheat by using CERES wheat model under incremental unit of maximum and minimum temperatures (0.5 to 3.0ºC) during the entire growth period showed that days required for maturity as well as grain yield under each sowing environment decreased as compared to normal durations and yield that observed in all sowing.

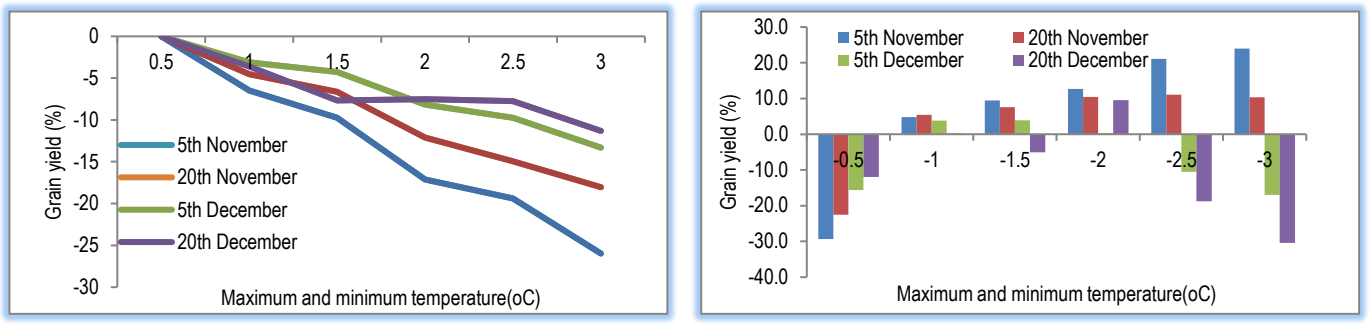


Fig-1 Grain yield of wheat as influenced by increase and decrease of maximum and minimum temperature during entire growing period

Table-1 Simulated days required to attain physiological maturity under change in temperature (maximum and minimum) during growth period of wheat variety

| | Change in temperature (°C) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date of sowing | Observed | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | -0.5 | -1 | -1.5 | -2 | -2.5 | -3 |
| 5th November | 125 | 122 | 119 | 117 | 114 | 111 | 109 | 128 | 131 | 134 | 136 | 138 | 139 |
| 20th November | 123 | 121 | 119 | 116 | 114 | 112 | 110 | 126 | 127 | 128 | 129 | 130 | 131 |
| 5th December | 118 | 117 | 115 | 113 | 111 | 109 | 107 | 119 | 119 | 120 | 120 | 121 | 122 |
| 20th December | 112 | 112 | 110 | 108 | 106 | 105 | 102 | 111 | 111 | 110 | 110 | 111 | 113 |

Table-2 Simulated grain yield (kg/ha) under change in temperature (maximum and minimum) during growth period of wheat

| | Change in temperature (°C) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date of sowing | Observed | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | -0.5 | -1 | -1.5 | -2 | -2.5 | -3 |
| 5th November | 6933 | 6933 | 6484 | 6259 | 5747 | 5589 | 5132 | 4902 | 7266 | 7590 | 7813 | 8397 | 8594 |
| 20th November | 6983 | 6983 | 6667 | 6520 | 6138 | 5939 | 5723 | 5409 | 7359 | 7511 | 7710 | 7756 | 7704 |
| 5th December | 6799 | 6799 | 6587 | 6509 | 6244 | 6136 | 5894 | 5734 | 7055 | 7065 | 6823 | 6081 | 5642 |
| 20th December | 5871 | 5871 | 5659 | 5420 | 5429 | 5417 | 5207 | 5169 | 5882 | 5573 | 5311 | 4768 | 4084 |

Table-3 Projected days required for physiological maturity of wheat under changing climate scenario at Udaipur

| Date of sowing | Expected Grain yield (kg/ha) | | | | |
|---|---|---|---|---|---|
| | Normal | 2030 | 2050 | 2080 | 2090 |
| 5th November | 6933 | 6290 | 5186 | 4894 | 4482 |
| 20th November | 6983 | 6767 | 5476 | 4882 | 4692 |
| 5th December | 6799 | 6380 | 5748 | 5654 | 4999 |
| 20th December | 5871 | 5295 | 5032 | 5411 | 4153 |

Table-4 Projected wheat yield under changing climate scenario at Udaipur

| Date of sowing | Expected Grain yield (kg/ha) | | | | |
|---|---|---|---|---|---|
| | Normal | 2030 | 2050 | 2080 | 2090 |
| 5th November | 6933 | 6290 | 5186 | 4894 | 4482 |
| 20th November | 6983 | 6767 | 5476 | 4882 | 4692 |
| 5th December | 6799 | 6380 | 5748 | 5654 | 4999 |
| 20th December | 5871 | 5295 | 5032 | 5411 | 4153 |

Table-5 Observed and DSSAT simulated values of wheat variety Raj-4037

| Variable | Mean | | Standard Deviation | | $R^2$ | Mean Diff. | RMSE | d-Stat. |
|---|---|---|---|---|---|---|---|---|
| | Observed | Simulated | Observed | Simulated | | | | |
| Emergence (days) | 5 | 4 | 0.484 | 0.500 | 0.600 | -2 | 1.904 | 0.360 |
| Anthesis(days) | 78 | 80 | 4.717 | 4.241 | 0.686 | 2 | 3.41 | 0.856 |
| Grain Yield (kg/ha) | 5751 | 6132 | 1189 | 1109 | 0.793 | 381 | 663.36 | 0.914 |
| Biological yield(kg/ha) | 15307 | 12712 | 2450.4 | 1723.6 | 0.573 | -2595 | 3051.4 | 0.640 |
| Harvest index | 0.374 | 0.480 | 0.041 | 0.031 | 0.552 | 0.106 | 0.109 | 0.426 |
| Physiological maturity (days) | 116 | 111 | 8.985 | 5.883 | 0.671 | -6 | 7.68 | 0.761 |

On the contrary, under -0.5 to -3.0°C of maximum and minimum temperatures during the entire growth period showed increase in duration required to attain physiological maturity and grain yield with successive decrease of temperature except some cases [Fig-1]. The grain yield was not affected with the increase in temperature by 0.5°C under all sowing environments. The extent of reduction in grain yield of wheat is highest under 5th November sown crop in each category of temperature increase. The magnitude of reduction in grain yield with the increase in temperature (Maximum and minimum) by 1.0, 1.5, 2.0 ,2.5 and 3.0°C was in the order of 6.5, 9.7, 17.1, 19.4 and 26.0 % under 5th November sowing, 4.5,6.6,12.1,15.0 and 18.0 % under 20th November sowing, 3.1,4.3,8.2,9.8, and 13.3 % under 5th December sowing and 3.6, 7.7,7.5,7.7 and 11.3 % under 20th December sowing. Similarly, in case of gradual decrease in both maximum and minimum temperatures during the entire growth period of wheat in the range of 1.0 to-3.0°C, increase in duration of maturity and yield of wheat were observed [Fig-1].

**Assessment of duration and grain yield of wheat under A1B climate change scenario**

The current variety(Raj-4037), cultivation and management practices, the impact of temperatures regimes in future scenario on wheat duration and grain yield under A1B climate scenario by using DSSAT v4.5 CERES-wheat model are explored at Udaipur for four dates of sowing *viz*., 5th November, 20th November, 5th December and 20th December. Results are drawn by comparing the simulated duration and yield between future (2030, 2050, 2080 and 2090) and baseline (Normal).

Under 5th November sown crop, the expected duration of physiological maturity decreased by 10, 19, 24 and 25 days as compared to normal value (125 days) in future years *i.e*., 2030, 250, 2080 and 2090 respectively. Under 20th November sown crop, the expected duration of physiological maturity reduced by 11,15,19 and 22 days in future years 2030, 2050, 2080 and 2090, respectively as compared to base line duration (123 days). It is interesting to note that the extent of reduction in duration of physiological maturity was less under late sown wheat *i.e*., 5th November and 20th November sown crops. It was ranged from 5 to 19 days under 5th December and 4 to 15 days under 20th December sown crop [Table-3]. Results further showed that maximum yield reduction (26.5 to 35.4 %) was expected by the year 2090 followed by 16.8 to 30.1 % reduction by the year 2080, 14.3 to 25.2 % by the year 2050 and 3.1 to 9.8 %. With respect to grain yield under 5th November sown crop, the reduction from baseline yield ranged from 9.3 to 35.4 percent as compared to normal yield (6933 kg/ha). The reduction in grain yield was increased when move in future scenario from 2030 to 2090 under each sowing dates. Under 2030, the maximum expected grain yield reduction was observed under 20th November sown crop (9.8 %) followed by 5th November (9.3%), 5h December (6.2%) and 20th November (3.1%). However, the expected reduction in grain yield in the year 2050, 2080 and 2090 was highest under 5th November sown crop [Table-4]. When simulation done for delayed sowing (5th December and 20th December), grain yield reduction is lesser as compared to other two dates of sowing (5th November and 20th November). Abdul, *et al*., [1,6] also reported that projected wheat and potato yield decline in the future scenario of 2020, 2050 and 2080.

**Validation and calibration of CERES wheat model**

Anthesis, maturity days, yield attributes and yields of wheat *var*. Raj -4037 were simulated using DSSAT v4.5 model. The simulated values [Table-5] showed that days taken for anthesis were predicted closely but model under estimated days taken for physiological maturity. However, grain yield was over estimated by 6.6 percent while harvest index was also over estimated by 28.3 percent.

**Conclusion**

CERES wheat model predicted that incremental unit of maximum and minimum temperatures (0.5 to 3.0°C) during the entire growth period shows that gradual decrease in days as well as grain yield under each sowing environment as compared to normal durations and yield.

**Application of research:** Model predicted days taken to anthesis were more closely but model under estimated days taken to physiological maturity. However, grain yield was over estimated by 6.6 percent.

**Research Category:** Agrometeorology

**Abbreviations**

CERES: Crop Estimation through Resource and Environment Synthesis
SRES: Special Report on Emission Scenario

**Acknowledgement / Funding:** Author thankful to Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India. Author also thankful to Dr VUM Rao, Project Coordinator, AICRPAM, CRIDA, Hyderabad and Project Incharge, AICRPAM, PAU, Ludhiana

***Principle Investigator: N.S. Solanki**
University: Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan
Research project name or number: Nil

**Author Contributions: All author equally contributed**

**Author statement:** All authors read, reviewed, agree and approved the final manuscript

**Conflict of Interest: None declared**

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

**References**

[1] IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulne*rabil*ity. Summary for Policymakers, Contribution of Working Group II to the Fourth Assessment Report of the IPCC.
[2] Abdul H.A., Pragyan Kumari, Chhabra V. and Biswas S. (2011) Journal of Agrometeorology, 13(2),116-118.
[3] Aggarwal P.K. (2008) Indian Journal of Agricultural Sciences, 78(10),911-19.
[4] Govindasami B., Caldeira K. and Duffy P.B. (2003) Global Planet Change, 37,157-168.
[5] IPPC (2000) IPCC (Intergovernmental Panel on Climate Change) Special Report Emissions Scenarios, Summary for Policy Makers. A Special Report of IPCC Working Group III, Published for the Intergovernmental Panel on Climate Change https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf
[6] Abdul H.A., Chhabra V., Bhatt B.P. and Sikka A.K. (2015) Journal of Agrometeorology, 17(1), 67-73.