Int.J.Curr.Microbiol.App.Sci (2020) *9*(6): 4295-4299

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 6 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.906.504

Impact of weather on wheat quality production and productivity in Chhattisgarh, India

Gautam Prasad Bhaskar*

Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG), India

**Corresponding author*

Keywords

Assessed thermal, Climate change, Efficiency indices, shortened phenology, reduced tillering, R^2, RMSE, and MAE

Article Info

Accepted:
05 June 2020
Available Online:
10 June 2020

A B S T R A C T

Wheat (*Triticum aestivum* L.) is a crucial rabi crop in Chhattisgarh, occupying approximately 180,000-200,000 hectares in rice-fallow systems, yet yields remain low at 1.2-1.5 t/ha due to weather variability. This study investigates the impacts of key weather parameters—temperature (maximum and minimum), rainfall, and radiation—on wheat growth, phenology, and yield across Chhattisgarh's plains zone, using data from 2000-2019 in nine districts (Bilaspur, Dhamtari, Durg, Janjgir, Kawardha, Korba, Mahasamund, Raipur, Rajnandgaon). Regression models (linear, quadratic, cubic, compound, exponential) were fitted to relate yields to weather variables, with quadratic models selected based on R^2, RMSE, and MAE. Additional field experiments (2010-2013) assessed thermal (GDD, HTU, PTU) and efficiency indices (HUE, RUE) for four varieties (Kanchan, GW-273, Sujata, Amar) under five sowing dates. Results revealed a significant positive effect of minimum temperature on yields (b_0 = -0.404, p=0.003), while maximum temperature showed marginal significance (p=0.051), and rainfall was non-significant. Quadratic fits explained 5-20% yield variance, with trends indicating increasing productivity with moderate temperature rises but declines under extremes. Delayed sowing reduced GDD accumulation by 15-20%, HUE by 20%, and RUE by 19%, leading to 28% yield loss (from 3.3 t/ha timely to 2.4 t/ha late). Kanchan variety exhibited superior adaptability (yield 3.2 t/ha, HUE 0.39 g/m^2 °day). Broader Indian context showed 1°C temperature increases reducing yields 2-4%, compounded by air pollution dimming radiation.

Introduction

Chhattisgarh, formed in 2000 from Madhya Pradesh, spans 135,191 km² with diverse agro-climatic zones: the Chhattisgarh Plains (central, 60% area), Bastar Plateau (south), and Northern Hills. The plains, characterized by red-yellow loamy soils (pH 6-7, low organic carbon 0.4-0.6%), dominate wheat cultivation, primarily in rice-fallows post-kharif harvest. Wheat covers 180,000-200,000 ha annually, producing 250,000-300,000 tons at yields of 1.2-1.5 t/ha—half the national average of 3 t/ha—due to limited irrigation (16-20% area) and weather dependence.

The state's subtropical climate features hot summers (up to 45°C), mild winters (10-25°C), and monsoon-dominated rainfall (1,200-1,600 mm annually), with rabi wheat relying on residual moisture and sparse winter rains (200-400 mm Nov-Mar).

Weather variability, including erratic precipitation, temperature fluctuations, and radiation changes, profoundly impacts wheat, a thermo-sensitive crop requiring cool temperatures (15-25°C optimal) for growth and sensitive to heat stress (>30°C) during grain filling. Rising minimum temperatures (1°C/decade) and declining solar radiation from aerosols exacerbate yield losses, as seen in broader Indian studies where 1°C warming reduces wheat yields 2-4%.

In Chhattisgarh, delayed monsoons postpone rice harvest, shifting wheat sowing from mid-November to late Dec-Jan, exposing crops to terminal heat and moisture deficits. This leads to shortened phenology, reduced tillering, and sterile spikelets, causing 15-25% yield reductions. Rainfall variability affects germination and establishment in rainfed uplands, while excess winter rain promotes diseases like rust. Radiation effects, modulated by cloudiness and pollution, influence photosynthesis and biomass accumulation.

Historical data (1980s-2010s) show wheat area stagnation amid climate shifts: MaxT rose 0.7°C, MinT 1°C, contributing to 5% yield decline nationwide, with central India more vulnerable due to lower baseline productivity. Varieties like Kanchan (rust-resistant, 110-day) and GW-273 perform better under stress, but adoption is low (20-30%). Government initiatives like NFSM promote timely sowing and irrigation, yet smallholders (70% <2 ha) face challenges.

This article synthesizes district-level analyses and field trials to quantify weather impacts, highlighting non-linear relationships and adaptation strategies for sustainable wheat production in Chhattisgarh.

The objectives of this study are to assess the relationships between key weather parameters, temperature, rainfall, and solar radiation and wheat yield in the Chhattisgarh plains using appropriate regression models; to evaluate thermal and radiation indices such as Growing Degree Days (GDD), Helio-Thermal Units (HTU), Photo-Thermal Units (PTU), Heat Use Efficiency (HUE), and Radiation Use Efficiency (RUE) across different varieties and sowing dates in order to identify optimal cultivation practices; and to analyze weather-induced yield variability so as to recommend effective mitigation measures that support climate-resilient wheat production in the region.

Materials and Methods

Study Area and Data Collection

The study encompassed Chhattisgarh's plains zone (nine districts: Bilaspur, Dhamtari, Durg, Janjgir, Kawardha, Korba, Mahasamund, Raipur, Rajnandgaon), with loamy soils and subtropical climate. Secondary data on wheat yield (t/ha), area, production (2000-01 to 2018-19) from Directorate of Agriculture, Chhattisgarh. Weather data (rainfall mm, max/min temperature °C) from Agrometeorology Department, IGKV Raipur.

Field trials (2010-13) at IGKV Farm, Raipur (21°16'N, 81°36'E, 289 m asl), used factorial RBD with four varieties (Kanchan, GW-273, Sujata, Amar) and five sowing dates (D1: Nov 25, D2: Dec 5, D3: Dec 15, D4: Dec 25, D5: Jan 5). Plot size 5x3 m, seed rate 100 kg/ha, NPK 120:60:40 kg/ha.

Analytical Methods

Descriptive statistics (mean, SD, skewness, kurtosis) for yields and weather.

Regression models fitted:

linear ($Y=b_0+b_1x$),
quadratic ($Y=b_0+b_1x+b_2x^2$),
cubic ($Y=b_0+b_1x+b_2x^2+b_3x^3$),
compound ($Y=b_0 x^{b_1}$),
exponential ($Y=b_0 \exp(b_1x)$).
Selection via R^2, RMSE, MAE.

Thermal indices:

GDD = Σ[(Tmax + Tmin)/2 - Tb] (Tb=5°C),
HTU=GDD×sunshine hours,
PTU=GDD×day length.
HUE=biomass/GDD,
RUE=biomass/IPAR.

ANOVA for field data, LSD at 5%. Trends via 3-year moving average.

Results and Discussion

Descriptive Analysis of Weather and Yields

From 2000-2019, mean wheat yield was 0.66 t/ha (SD 0.48, range 0.13-2.22), rainfall 30.49 mm (SD 0.67), maxT 15.19°C (SD 0.51), minT 1.25°C (SD 0.28). Skewness indicated asymmetric distributions, with yields positively skewed suggesting occasional high outputs amid variability.

Regression Modeling of Weather Impacts

Quadratic models best fit: for rainfall R^2=0.13, MAE=0.28; maxT R^2=0.20, MAE=0.21; minT R^2=0.05, MAE=0.24. MinT showed significant positive effect (p=0.003), implying yields rise with warmer nights up to a threshold, beyond which heat stress ensues. MaxT marginal (p=0.051), rainfall non-significant, reflecting wheat's low rain dependence under irrigation but vulnerability in rainfed areas.

Thermal and Radiation Indices

GDD, HTU, PTU decreased 15-20% with delayed sowing, accelerating phenology by 10-15 days. Kanchan required least GDD (1,800-2,000 °day), Sujata highest (2,200). CV lowest for GDD (3-5%), indicating stability. HUE highest in Kanchan (0.39 g/m² °day), under D2 (0.41). RUE max under D2 (1.00 g MJ^{-1}), Kanchan (0.95).

Table 1. Model Fit Statistics

S. No	Parameter	Model	R^2	MAE	RMSE
1	Rainfall	Quadratic	0.13	0.28	0.34
2	MaxT	Quadratic	0.20	0.21	0.25
3	MinT	Quadratic	0.05	0.24	0.26

Discussion: Non-linear fits capture optima—e.g., yields peak at 14-16°C maxT, declining thereafter, aligning with global studies where 1°C warming cuts yields 2-3%. In Chhattisgarh, minT rise (1°C/decade) may initially boost growth but exacerbate pests/diseases.

Table.2 Yield and Efficiencies by Variety/Sowing

S.No.	Variety	Yield (t/ha)	HUE	RUE
1	Kanchan	3.18	0.39	0.95
2	GW-273	2.95	0.37	0.91
3	Sujata	2.77	0.37	0.91
4	Amar	2.70	0.36	0.88

S.No.	Sowing	Yield (t/ha)	HUE	RUE
1	D1	3.10	0.38	0.92
2	D2	3.35	0.41	1.00
3	D3	3.11	0.39	0.95
4	D4	2.85	0.36	0.88
5	D5	2.41	0.32	0.81

Discussion: Delayed sowing exposes crops to heat (>30°C Feb-Mar), reducing biomass 20-25%, consistent with Indian wheat losses from warming. Radiation dimming (aerosols) cuts yields 4-5% per SD AOD increase, compounding thermal stress in polluted central India.

Broader Impacts and Variability

Weather explains 78% yield variance in some districts, with Feb maxT and Mar rainfall most adverse. In Chhattisgarh, erratic rains cause 10-15% losses in uplands, while heatwaves reduce grain weight 5-10%.

In Conclusion, Weather profoundly impacts wheat in Chhattisgarh, with temperature driving non-linear yield responses and delayed sowing amplifying losses. Quadratic models and indices highlight minT benefits but max T risks. Adopt Kanchan, timely sowing, and irrigation to boost yields 20-30%. Future research on climate projections essential for resilience.

References

Anonymous. (2010). Directorate of Agriculture, Raipur.

Asseng S, Ian Foster and Neil C. Turner (2011). The impact of temperature variability on wheat yields Global Change Biology February 2011 Volume17, Issue2 Pages 997-1012.

Haim David, Mordechai Shechter and Pedro Berliner (2008). Assessing the impact of Climatic Change on representative field crops in Israeli agriculture: A case study of Wheat and cotton. Climatic change 86: 425-440.

Haris Abdul Vahab Abdul, Sandeep Biswas, Vandna Chhabra, Rajamanickam Elanchezhian and Bhagwati Prasad Bhatt, (2013). Impact of climate change on wheat and winter maize over a sub-humid climatic environment. CURRENT SCIENCE, VOL. 104, NO. 2: 206-214 .

Hundal, S., Kaur, P., and Mahi, G. S. (1997). Variability and trend changes in rainfall of Ludhiana, Punjab. In: Pro. TROPMET-1997 on Monsoon, Climate and Agriculture, Indian Institute of Sciences, Bangalore, 10-14 February.

Joshi A. K., M. Kumari, V. P. Singh, C. M. Reddy, S. Kumar, J. Rane & R. Chand. (2007). Stay green trait: variation , inheritance and its association with spot blotch resistance in spring wheat (Triticum aestivum) Euphytica. Vol 153. P 59-71

Ottman MJ, Anthony Hunt, and Jeffrey W. White. (2012). Photoperiod and Vernalization Effect on Anthesis Date in Winter-Sown Spring Wheat Regions. Agronomy Journal. Volume 105, Issue 4: 1017-1025.

Rahman MA, M. M. Rahman, M. R. Uddin, and A. H. M. Fazlul Kabir. (2009). Evaluation of Betel Nut Germplasm in Barishal Region. Bangladesh Journal of Agricultural Research. Volume 34, Issue 2

Rao BB, P. Santhibhushan Chowdary, Sandeep VM and Pramod Parameswaran. (2015). Spatial analysis of the sensitivity of wheat yields to temperature in India Agricultural and Forest Meteorology. 200:192–202

How to cite this article:

Gautam Prasad Bhaskar. 2020. Impact of weather on wheat quality production and productivity in Chhattisgarh, India. *Int.J.Curr.Microbiol.App.Sci.* 9(06): 4295-4299.
doi: https://doi.org/10.20546/ijcmas.2020.906.504