Journal of Agrometeorology

(A publication of Association of Agrometeorologists)

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 27 (4) : 503-506 (December - 2025)
https://doi.org/10.54386/jam.v27i4.3100
https://journal.agrimetassociation.org/index.php/jam

Short communication

Determining optimum weather parameters for higher yield of *kharif* maize in Punjab

PRABHJYOT-KAUR*, S. S. SANDHU, HARLEEN KAUR and JAGJEET KAUR

Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana-141004, India
**Corresponding author: E-mail: prabhksidhu@gmail.com*

Maize (*Zea mays*), generally known as 'Corn', is one of the most versatile cash crops, having wider adaptability under varied climatic conditions. Maize is also known as the 'Queen of cereals' as it is a rich source of protein and vitamins, and hence is used in a variety of edible products. In India, maize is cultivated throughout the year and is the third most important cereal crop after rice and wheat. At the global level among the maize-growing countries, India ranks 4th in area and 7th in production, which is equivalent to approximately 4% of the world's maize area and 2% of total production (DACNET 2020). In Punjab state during 2022-23, it was cultivated on 9.3 thousand ha area with a production of 410 thousand tonnes and a productivity of 4393 kg ha^{-1} (Anonymous 2024). The signals of climatic changes in the Punjab state are well documented (Prabhjyot-Kaur *et al.,* 2021).

Maize is a highly adaptable crop, but high yield can be realised only under an optimum combination of growing conditions, especially the meteorological parameters (Kaur and Prabhjyot-Kaur, 2019). In the Punjab state of India, maize crop can be raised during different parts of the year (*kharif*, winter and spring). However, as a food-grain cereal, it is cultivated during the *kharif* season (Anonymous 2024). Waqas *et al.,* (2021) reported that temperature and moisture are the two meteorological elements that have the greatest impact on the maize crop. Venkatraman and Krishnan (1992) have reported that temperatures between 18 to 27°C during the day and around 14°C at night are optimal for maize development. Extreme temperatures in the maize crop alter the photosynthetic process, damage biological membranes, hinder nutrient uptake, and restrict the activity of various enzymes (Hussain *et al.,* 2019). The most crucial stage of the maize growth cycle is the flowering stage, where brief or prolonged instances of high temperatures cause metabolic and/or morphological changes that result in irreversible yield losses (Shim *et al.,* 2017). When temperatures are between 10 and 35°C, maize leaf growth increases; however, when the temperature is over 35°C, it begins to slow down (Hussain *et al.,* 2006). High temperature during the flowering stage has a detrimental effect on the number of florets, the number of silks, and grain formation (Edreira *et al.,* 2011). Yang *et al.,* (2018) reported that high temperature (>35°C) is a significant environmental factor that affects the maize grain quality. The current study was conducted to determine the optimum limits of the meteorological parameters for getting high yields of maize in Punjab.

The data for phenology and yield of maize cultivars with similar growth characteristics have been collected from field experiments conducted under "All India Research Project on Agrometeorology" in the Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana, from 2017-2022. The maize cultivars were sown under three different thermal environments (D_1: 1st June, D_2: 15th June, D_3: 30th June) using a seed rate @20 kg ha^{-1}in 60 ×20 cm spacings. Fertilizers were applied @ 125 kg N, 60 kg P_2O_5 and 30 kg of K_2O per hectare as per recommendations. Nitrogen was applied in three equal doses, i.e. first dose at the time of sowing, second dose at the knee-high stage and third dose at the pre-tasselling stage.

Correspondingly, the weekly weather data on maximum & minimum temperatures (^{0}C), maximum & minimum relative humidity (%), sunshine hours and rainfall (mm) during the maize growing season, i.e. 23 to 36 Standard Meteorological Week (SMW) were collected from the meteorological observatory of the Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana located adjacent to the experimental site. The growth period of the maize crop was categorised into three major stages: vegetative (23-30 SMW), flowering (31-32 SMW), and grain filling (33-36 SMW) stages. To determine the relationship between these parameters and the grain yield of maize, a regression analysis was conducted. The optimum limits of meteorological parameters were determined by computing the range (mean ± standard deviation). The mean and standard

Article info - DOI: *https://doi.org/10.54386/jam.v27i4.3100*
Received:23 June 2025; Accepted: 1 September 2025; Published online : 1 December 2025

Table 1: Relationship of weather parameters during different stages of growth with the grain yield of maize

Parameters	Equation	R^2	P value
	Vegetative stage		
Maximum temp	$y = -28.782x^2 + 2160.7x - 34510$	0.0284	0.523
Minimum temp	$y = 217.02x^2 - 12133x + 175047$	0.1154	0.063
Maximum RH	$y = -3.4288x^2 + 440.16x - 7903$	0.1385	0.035
Minimum RH	$y = -1.5014x^2 + 123.88x + 3582.3$	0.0977	0.099
Bright sunshine	$y = -0.0078x^2 + 4.8023x + 5214.1$	0.005	0.893
Rainfall	$y = -0.0161x^2 + 6.3063x + 5601.2$	0.0856	0.134
	Flowering stage		
Maximum temp	$y = 45.174x^2 - 2820.8x + 49590$	0.0586	0.257
Minimum temp	$y = -45.808x^2 + 2912.3x - 39380$	0.1117	0.070
Maximum RH	$y = 9.3296x^2 - 1603.1x + 74552$	0.0694	0.198
Minimum RH	$y = 5.5188x^2 - 783.95x + 33439$	0.1126	0.068
Bright sunshine	$y = 0.0837x^2 - 10.595x + 5864$	0.2269	0.003
Rainfall	$y = -0.0313x^2 + 12.608x + 5447.4$	0.1682	0.016
	Grain development		
Maximum temp	$y = -577.6x^2 + 38480x - 634575$	0.1869	0.010
Minimum temp	$y = -53.76x^2 + 3027.2x - 36368$	0.2358	0.002
Maximum RH	$y = -36.943x^2 + 6032.2x - 239856$	0.2378	0.002
Minimum RH	$y = -5.8168x^2 + 718.78x - 16189$	0.1077	0.077
Bright sunshine	$y = 0.0003x^2 - 2.0554x + 6329.5$	0.0187	0.654
Rainfall	$y = -0.0108x^2 + 1.7422x + 5964.9$	0.0971	0.100

Table 2: Optimum range of meteorological parameters for higher productivity of maize in Punjab

Meteorological parameters	Crop growth stage		
	Vegetative stage	Flowering stage	Grain development stage
Maximum temperature (°C)	34.5 – 37.0	32.0-35.0	33.0-34.5
Minimum temperature (°C)	26.0-27.5	26.5-28.0	26.0-27.5
Maximum relative humidity (%)	60-80	80-85	80-88
Minimum relative humidity (%)	40-60	60-70	60-68
Rainfall (mm)		450-650	
Sunshine hours (hr)		550-650	

deviation were calculated using the 54 data points (06 years × 03 dates × 03 cultivars).

Relationship between weather parameters and maize yield

The daily meteorological data averaged during maize crop growth stages during the six study years (2017 to 2022) were statistically analyzed with maize yield. The results revealed that during the vegetative stage, grain yield and minimum temperature, maximum and minimum relative humidity had a statistically significant relationship at $p<0.10$, $p<0.05$ and $p<0.10$, respectively (Table 1). During the flowering stage, the grain yield showed a statistically significant relationship with minimum temperature, minimum relative humidity and bright sunshine hours at $p<0.10$, $p<0.10$ and $p<0.05$, respectively. Similarly, during the grain development stage of maize, grain yield exhibited statistically significant relationships with all the meteorological parameters, temperatures ($p<0.05$), maximum relative humidity ($p<0.05$), minimum relative humidity ($p<0.10$), and rainfall ($p<0.10$) except the bright sunshine hours. These results are in agreement with the findings of Sanchez *et al.,* (2014), who reported that maize growth stages (flowering and grain development) are highly sensitive to high-temperature stress (Table 1).

Optimum range of weather variables for maize

The relationship developed between weather parameters and maize yield were analysed to evaluate their optimum ranges for the three main growth stages of maize cultivars for their high yield. The regression analysis revealed for higher yield of maize the optimum values of maximum temperature ranged between 34.5-37.0, 32.0-35.0, 33.0-34.5°C, minimum temperature ranged between 26.0-27.5, 26.5-28.0, 26.0-27.5°C, maximum relative humidity ranged between 60-80, 80-85, 80-88%, and minimum relative humidity ranged between 40-60, 60-70, 60-68%, during the vegetative, flowering and grain development stages of maize, respectively (Table 2). Sanchez *et al.,* (2014) reported that among the different growth stages, the flowering and grain development stage of maize is highly sensitive to high temperature stress. Shao *et al.,* (2021) observed that temperatures more than 35°C have adverse

effects on maize yield.

The timely start of rainfall is more critical than its amount for high yield of maize. Kumar *et al.,* (2022) have reported in their analysis that the rainfall received during peak vegetative growth stages (31st SMW) had a significant positive correlation (r=0.68***) with maize yield (at p< 0.001), since these are critical growth stages in which moisture stress affects the yield adversely. But in the Punjab state, it is cultivated under irrigated conditions; therefore, timing and amount of rainfall have little effect on the final grain yield of maize. The statistically significant relationship between both might be due to the favourable effect of rainfall on yield up to a certain limit. So, excessive rainfall during the flowering and maturity stage is one of the main causes of a reduction in the yield of maize. Hence, a well-distributed rainfall of 450-550 mm was observed to be favourable for *kharif* season maize in Punjab. The cumulative sunshine duration of >550 hours is favourable for maize yield, though similar to rainfall, prolonged cloudy conditions lead to a reduction in yield. In a study by Yang *et al.,* (2021), it was observed that the light intercepted by the canopy and the photosynthetic rates both decreased with decreasing solar radiation. Hence, ample sunshine duration in the range of 550-650 hours is favourable for the growth and yield of maize. Such kind of information derived from long-term experiments on field crops can help the agronomist alter the crop management practices as well as help in developing term-sheets for weather-based crop insurance in the region.

ACKNOWLEDGEMENT

The field experiments conducted under the ICAR-CRIDA funded "All India Research Project on Agrometeorology" and the meteorological data used in this study were collected from the agrometeorological observatory, Ludhiana, of Punjab Agricultural University are duly acknowledged.

Funding: The field experiments were conducted using the funds received under the ICAR-CRIDA-funded "All India Research Project on Agrometeorology".

Data availability: The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflict of Interests: The authors have no relevant financial or non-financial interests to disclose.

Author Contributions: **Prabhjyot-Kaur***:* Conceptualisation and Designing of field experiments, Interpretation of results, Final draft; **S S Sandhu**: Conduct of experiments, Data collection, Material preparation; **Harleen Kaur***:* Analysis of data, Initial draft; **Jagjeet Kaur***:* Preparation of tables and figures.

Disclaimer: The contents, opinions, and views expressed in the research article published in the Journal of Agrometeorology are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

Publisher's Note: The periodical remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

REFERENCES

Anonymous. (2024). Package of Practices for *Kharif* Crops. Punjab Agricultural University, Ludhiana. https://www.pau.edu/content/ccil/pf/pp_kharif.pdf

DACNET. (2020). https://iimr.icar.gov.in/?page_id=51#:~:text=Among %20the %20 maize%20 growing%20countries,ha%20(DACNET%2C%20 2020

Edreira, J.R., Carpici, E.B., Sammarro, D. and Otegui, M. (2011). Heat stress effects around flowering on kernel set of temperate and tropical maize hybrids. *Field Crops Res.,* 123: 62–73. https://doi.org/10.1016/j.fcr.2011.04.015

Hussain, T., Khan, I.A., Malik, M.A. and Ali, Z. (2006). Breeding potential for high temperature tolerance in corn (Zea mays L.). *Pakistan J. Botany*, 38(4): 1185-1195. https://www.pakbs.org/pjbot/PDFs/38(4)/PJB38(4)1185.pdf

Hussain, H.A., Men, S., Hussain, S., Chen, Y., Ali, S., Zhang, S., Zhang, K., Li, Y., Xu, Q. and Liao, C. (2019). Interactive effects of drought and heat stresses on morpho-physiological attributes, yield, nutrient uptake and oxidative status in maize hybrids. *Sci. Rep.,* 9: 3890. https://doi.org/10.1038/s41598-019-40362-7

Kaur, N. and Prabhjyot-Kaur. (2019). Maize yield projections under different climate change scenarios in different districts of Punjab. *J. Agrometeorol.,* 21(2): 154-158. https://doi.org/10.54386/jam.v21i2.225

Kumar, D.A., Neelima, T.L., Srikanth, P., Devi, M.U., Suresh, K.and Murthy, C.S. (2022). Maize yield prediction using NDVI derived from Sentinel 2 data in Siddipet district of Telangana state. *J. Agrometeorol.,* 24(2): 165-168. https://doi.org/10.54386/jam.v24i2.1635

Prabhjyot-Kaur, Sandhu, S.S., Kaur, S., Dhir, A., Kaur, J., Singh, J. and Kothiyal, S. (2021). Agroclimatic atlas of Punjab-Trends and projections. AICRPAM, Dept of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. pp106 https://doi.org/10.13140/RG.2.2.34359.50089

Sanchez, B., Rasmussen, A. and Porter, J.R. (2014). Temperatures and the growth and development of maize and rice: A review. *Glob. Chang. Biol.,* 20: 408-417. https://doi.org/10.1111/gcb.12389

Shao, Rui-Xin, Yu, Kang-Ke, Li, Hong-Wei, Jia, Shuang-Jie, Yang, Qing-Hua, Zhao, X., Zhao, Ya-Li and Liu, Tian-Xue. (2021). The effect of elevating temperature on the growth and development of reproductive organs and yield of summer maize. *J. Integ. Agric.,* 20(7): 1783-1795. https://doi.org/10.1016/S2095-3119(20)63304-4.

Shim, D., Lee, Kyu-Jong and LeeByun-Woo. (2017). Response of phenology-and yield-related traits of maize to elevated temperature in a temperate region. *Crop J*., 5(4): 305-316.

https://doi.org/10.1016/j.cj.2017.01.004

Venkatraman, S. and Krishnan, A. (1992). Crops and weather. Publications and Information Division, ICAR, New Delhi.

Waqas, M.A., Wang, X., Zafar, S.A., Noor, M.A., Hussain, H.A., Azher, N. M. and Farooq, M. (2021). Thermal stresses in maize: effects and management strategies. *Plants,* 10(2): 293. https://doi.org/10.3390/plants10020293

Yang, H., Gu, X., Ding, M., Lu, W. and Lu, D. (2018). Heat stress during grain filling affects activities of enzymes involved in grain protein and starch synthesis in waxy maize. *Sci. Rep.*, 8: 15665. https://doi.org/10.1038/s41598-018-33644-z

Yang, Y.S., Guo, X.X., Liu, H.F., Liu, G.Z., Liu, W.M., Ming, B., Xie, R.Z., Wang, K.R., Hou, P. and Li, S.K. (2021). The effect of solar radiation change on the maize yield gap from the perspectives of dry matter accumulation and distribution. *J. Integ. Agric.*, 20 (2): 482-493. https://doi.org/10.1016/S2095-3119(20)63581-X