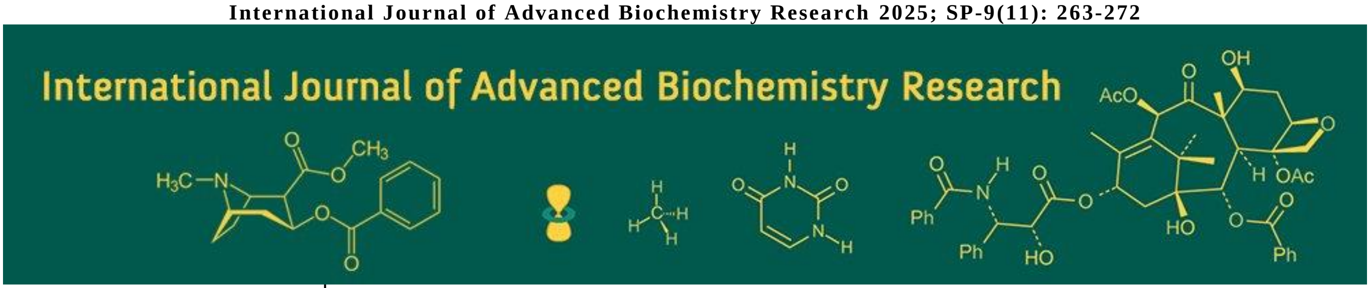

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Studies on impact of weather parameters on flowering and production of mango crop in Raipur district

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Abstract
The present study entitled "Studies on the impact of weather parameters on quality and production of mango crop in Raipur district" was conducted at the Department of Agricultural Meteorology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. Utilizing MS-Excel and Weather Cock software, the research investigated the relationships between weather variables and key mango crop metrics, including quantitative yield and flowering behavior. Daily weather data spanning three years (2019-2022) were obtained from the Department of Agricultural Meteorology, IGKV, Raipur. Concurrently, three years of production data (2019-2022) were collected from 15-20year-old trees of five mango cultivars ('Dashehari', 'Langra', 'Mallika', 'Amrapalli', and 'Chhattisgarh Nandiraj') cultivated at the Horticulture Farm, Department of Fruit Science, College of Agriculture, IGKV Raipur. Correlation coefficients were calculated to quantify the relationships between the aforementioned variables. Analysis of daily weather data and phenological observations revealed that evaporation (EVP) had a strong positive correlation with flowering duration suggesting that warm, sunny, and moderately dry conditions with adequate soil moisture promote extended flowering periods. Conversely, wind speed exhibited a moderate negative relationship with flowering, likely reflecting physical damage or pollination disruption. Temperature, humidity, rainfall and sunshine were found to be statistically insignificant within the observed ranges. In terms of yield both cultivar- and stage-specific**:** maximum temperature and EVP were primary positive drivers of yield in Dashehari, Langra, Mallika and C.G. Nandiraj while rainfall and relative humidity exerted significant negative effects in these cultivars. Amrapali exhibited a more complex pattern with yield positively associated with sunshine hours, mid-to-latestage temperatures and late- stage EVP but negatively affected by wind speed and late-stage RH.

Keywords: Mango, Correlation coefficient, Yield, Flowering behaviour

Introduction

Mango (*Mangifera indica* L.) is a commercially important fruit crop and is known as the "king of fruits" in India, which is the world's largest producer. The crop is well-adapted to tropical and sub-tropical climates and thrives in areas receiving 250 mm to 2500 mm of annual rainfall. The Raipur district in Chhattisgarh, the location of the study, is in a dry, moist sub-humid region and receives an average of 1200-1400 mm of rain each year. India is the world's largest producer of mangoes, accounting for 54% of global mango production. Mango harvest in 2022 is poor according to Insram Ali president of All India Mango Growers' Association. (The Hindustan Times). Mango production in the state Chhattisgarh was reported at 410.63 Tonnes in 2024. This records a decrease from the previous number of 471.14 Tonnes for the year 2023. (CEIC). Amrapalli (Dashehari × Neelum) is a late season hybrid whereas Mallika (Neelum × Dashehari), Dashehari and Langra are mid-season varieties. (National Horticulture Board). Palanisamy *et al*. noted that mango flowering is certainly controlled by the photoperiodic effect. However, temperature variations were more critical then photoperiods. It is due to the different times of flowering at different parts of the country. Mango is andromonoecious plant, which bears both hermaphrodite and staminate flowers on the same inflorescence (Coetzer). The percentage of hermaphrodite flowers influences the fruit set and productivity of a particular cultivar (Ramirez and Davenport, 2010). Temperatur is one of the main environmental factors that affects the flowering phenomenon in the majority of fruit crops, including mango crops. Similar to litchi, mango flower initiation is directly influenced by temperature rather than photoperiod

(Nakata and Watanabe, 1966). It is reported that the temperature below 15 °C induces flowering in mango whereas higher temperatures of above 20 °C promotes vegetative shoots production (Nunez-Elisea and Devenport,; Nunez-Elisea). Low temperatures (10 °C-15 °C) during flower bud differentiation resulted in predominantly staminate flowers, while high temperatures dominated a higher percentage of hermaphrodite/bisexual flowers (Tsang and Chang; OU *et al*.; Singh). Higher percentage of hermaphrodite flowers in the panicle is an important yield attribute since it is directly related to fruit set and it leads to higher productivity of particular cultivar (Iyer *et al*., 1989; Chaikiattiyos *et al*., 1997). Temperature during ripening is very important for biosynthesis of carotenoid pigments leading to development of both external and internal colour (Palafox-carlos, Khilladi). Thus, optimum temperature is a crucial factor determining the quality as well as shelf life of fruits. Rao and Rao (1984) also highlighted that the production of higher proportion of hermaphrodite flowers in some of the south Indian mango hybrid cultivars, which probably being one of the contributing factors for higher yields. Climate and weather play a significant role in crop growth and productivity. Variations in air temperature and rainfall, for instance, influence the vegetative and phenological phases in horticultural crops. High temperature with low humidity and high winds can adversely affect the mango tree, while high humidity, rainfall, and frost during flowering are particularly harmful. This study aimed to determine the most important characteristics affecting mango quantitative yield and flowering behavior in five cultivars by analyzing their correlations with weather parameters.

Materials and Methods

The study was conducted at the Department of Agricultural Meteorology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV) in Raipur. The research investigated the relationship between weather variables and key mango crop metrics using MS-Excel and Weather Cock software.

Data Sources

Weather Data: Daily weather data for a three-year period (2019-2022) were collected from the Department of Agricultural Meteorology at IGKV, Raipur.

Crop Data: Three years of production data (2019-2022) were collected from 15-20 year-old trees of five mango cultivars: 'Dashehari', 'Langra', 'Mallika', 'Amrapalli' and' Chhattisgarh Nandiraj'. These trees were grown at the Horticulture Farm, Department of Fruit Science, College of Agriculture, IGKV Raipur.

Statistical Analysis: Correlation coefficients were calculated to quantify the relationship between the weather parameters and the crop metrics.

Results and Discussion

In order to identify the most crucial characteristics for quantitative yield and flowering behavior, this study was conducted to establish the relationships between the five mango cultivars and their meteorological factors of direct and indirect effects in mango in Raipur district.

Correlation coefficient between maximum Temperature and five varieties of mango (Flowering to harvesting)

(Table 1) showed the relationship between temperature and yield in different mango varieties at various growth stages. For the Dashehari variety, a significant correlation was observed between maximum temperature and yield during the mid-stage of development. In the case of the Langra variety, significant relationships were found during both the early and mid-stages. For the Mallika variety, similar patterns were noted, with significant relationships observed during the early and mid-stages. The Amrapali variety exhibited as ignificant correlation primarily during the mid and later stages. It indicates that mid-stage temperatures are the most influential across all varieties. Amrapali uniquely retains temperature sensitivity well into later stages. *Amrapali* is a dwarf, regular-bearing hybrid that remains physiologically active later in the season, likely maintaining its temperature-driven metabolic processes beyond mid-stage. Regular-bearing cultivars like Amrapali maintain consistently high levels of non- structural carbohydrates (NSC) starch, sugars and proteins throughout the season. This steady energy reserve fuels ongoing metabolic and reproductive activity, even into later stages. In contrast, other regular bearers deplete these reserves more quickly or have less robust storage systems. High temperature stress disrupts the biochemical reactions fundamental to normal cell functioning and it primarily affects the photosynthetic functions of higher plants (Weis and Berry, 1988). Reproductive processes are also highly affected by heat stress in most plants (Wahid). High temperature causes a variety of morphological, physical, physiological and biochemical changes in the plants which influences development and improvement and may prompt the extraordinary decrease of yield.

Table 1: Correlation coefficient between Maximum Temperature and yield for five varieties of Mango. (Flowering to harvesting)

		Tmax (°C)				
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarh nandiraj**
Early stage	W52	0.32	-	-	-	-
Early stage	W1	0.64	-	-	-	-
Early stage	W2	0.10	-	-	-	-
Early stage	W3	-0.52	-	-	-	-
Early stage	W4	-0.38	-0.22	-0.22	-0.80	-0.33
Early stage	W5	0.90	1.00**	0.96*	0.26	0.92
Early stage	W6	0.88	0.95	0.95*	0.22	0.91
Early stage	W7	-0.37	0.96*	-0.21	-0.95*	-0.32
Early stage	W8	0.31	0.97*	0.15	0.92	0.26
Mid stage	W9	0.70	0.81	0.80	-0.09	0.73
Mid stage	W10	0.75	0.85	0.84	-0.02	0.78
Mid stage	W11	1.00**	1.00**	0.98*	0.67	1.00**

Mid stage	W12	0.91	0.83	0.83	0.91	0.89
Mid stage	W13	0.96*	0.99	0.99**	0.40	0.97*
Mid stage	W14	0.97*	1.00	1.00**	0.46	0.98*
Mid stage	W15	0.57	0.43	0.43	1.00**	0.53
Mid stage	W16	0.47	0.31	0.32	0.98*	0.42
Mid stage	W17	1.00**	0.98	0.98*	0.66	1.00**
Later stage	W18	0.58	0.44	0.44	1.00**	0.54
Later stage	W19	0.34	0.18	0.18	0.94	0.29
Later stage	W20	0.39	0.24	0.24	0.95*	0.35
Later stage	W21	-0.73	-0.83	-0.83	0.05	-0.76
Later stage	W22	0.62	0.48	0.48	1.00**	0.58
Later stage	W23	0.90	0.81	0.81	0.92	0.87
Later stage	W24	-	0.30	0.30	0.97*	0.41
Later stage	W25	-	0.90	0.90	0.83	-

*Only significant values taken into consideration

Table 2: Correlation coefficient between minimum temperature and yield for five varieties of mango (Flowering to harvesting)

		Tmin (°C)				
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarh Nandiraj**
Early stage	W52	0.36	-	-	-	-
Early stage	W1	-0.15	-	-	-	-
Early stage	W2	0.96*	-	-	-	-
Early stage	W3	-0.87	-	-	-	-
Early stage	W4	-0.44	0.31	0.30	-0.97*	-1.00**
Early stage	W5	-0.91	0.20	0.20	-0.29	-0.93
Early stage	W6	-0.84	0.26	0.26	-0.13	-0.99**
Early stage	W7	0.32	0.38	0.38	-0.51	-0.96*
Early stage	W8	-1.00**	0.30	0.30	-0.58	0.37
Mid stage	W9	0.54	0.43	0.43	0.99**	0.50
Mid stage	W10	-1.00**	0.22	0.22	-0.69	-0.99
Mid stage	W11	-0.97*	0.21	0.21	-0.80	-0.96
Mid stage	W12	0.78	0.45	0.44	0.98*	0.75
Mid stage	W13	-0.99**	0.27	0.27	-0.72	-0.99
Mid stage	W14	0.58	0.46	0.45	1.00**	0.54
Mid stage	W15	0.91	0.57	0.57	0.90	0.89
Mid stage	W16	0.33	0.43	0.43	0.93	0.29
Mid stage	W17	0.60	0.44	0.44	1.00**	0.56
Later stage	W18	0.65	0.40	0.40	1.00**	0.61
Later stage	W19	0.81	0.64	0.64	0.97*	0.78
Later stage	W20	0.99**	0.51	0.51	0.53	0.99
Later stage	W21	0.05	0.35	0.34	-0.73	0.10
Later stage	W22	0.48	0.40	0.40	-0.35	0.53
Later stage	W23	0.83	0.60	0.60	0.96*	0.81
Later stage	W24	-	0.66	0.66	0.98*	0.45

Impact of minimum temperature on the fruit production has been studied for all the five varieties on weekly basis. Table-2 showed that high value of minimum temperature is found to have adverse impact on fruit production which is indicated by negative values of correlation coefficient. It may be due to the fact of plant physiological mechanisms and high respiration rate which is prevailing in Dashehari and Chhattisgarh Nandiraj variety due to high values of minimum temperature.

It indicates that Dashehari exhibits strong Tmin sensitivity during early/mid stages because these cool nights are critical for floral induction and panicle initiation; inadequate Tmin disrupts this process, reducing yield. Chhattisgarh Nandiraj, with negative early-stage Tmin yield correlation, likely suffers from cooler nights causing poor pollen function and reduced initial fruit set. Langra and Mallika showed no significant Tmin-yield relationships, indicating their developmental processes are less sensitive to Tmin fluctuations.

Parmer *et al* found that warm evening in December which occur during flower induction period had a detrimental impact on flowering in mangoes and thus leading to decrease in crop output. Consequently, there was a substantial decrease in the yield of mango. Low temperatures have a negative impact on the process of pollen tube germination and growth. Growth is totally halted when temperatures drop below 15 °C. Low temperature stress also manifests increased oxidative damage in plants.

Correlation coefficient between Rainfall and Mango Yield for five varieties of Mango (Flowering to harvesting)

Table 3 showed that For Dashehari variety, rainfall was found to have negatively significant correlation with mango fruit production. The reason for the adverse impact on fruit production may be due to the fact that it may be accompanied with high wind speed which may result in fruit drop. The results revealed that rainfall had a negative effect on the mango crop production because of the occurrence of stress conditions due to high rainfall. On the other hand, rainfall and high temperature is also necessary for plant growth and better fruit quality. The related effects were also observed by Rachel *et al*. (2014) who observed that crop production had significant and non-significant correlation and regression with weather parameters.

Excessive rainfall during the flowering period significantly disrupts reproductive success by washing away pollen or degrading grains, thereby hindering pollination and reducing fruit set (Rahan Shailendra *et al*. 2012 Additionally, continuous rainfall increases soil moisture to the extent that key nutrients especially calcium and potassium are leached away, weakening cell walls and further exacerbating fruit disorders. Thus, heavy rainfall initiates a cascade of physiological stressors pollination failure, fruit cracking, pathogen invasion, reduced ripening and nutrient loss all contributing to a measurable decline in mango yield and quality. Unseasonal rains encourage pests which also lower fruit yield. Mangoes grow best in climates which have low rainfall and low relative humidity at flowering, fruit setting and harvesting, and that are warm to hot during fruiting. Although mango tolerates a wide range of climates from warm temperate to tropical, anthracnose can become a serious problem for mango cultivation in humid, high rainfall environments (Ploetz *et al*.2003).

Table 3: Correlation coefficient between Rainfall and mango Yield for five varieties of Mango (Flowering to harvesting)

		RF (mm)				
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarh nandiraj**
Early stage	W52	0.74	-	-	-	-
Early stage	W1	-0.95*	-	-	-	-
Early stage	W2	0.59	-	-	-	-
Early stage	W3	0.00	-	-	-	0.00
Early stage	W4	0.74	0.62	0.54	0.99**	0.71
Early stage	W5	0.21	0.36	0.36	-0.61	0.26
Early stage	W6	-0.90	-09.96*	-1.00**	-0.26	-0.92
Early stage	W7	0.21	0.36	0.36	-0.61	0.26
Early stage	W8	-0.96*	-0.99**	-0.97*	-0.41	-0.97*
Mid stage	W9	-0.95*	-0.99**	0.35	-0.38	-0.97*
Mid stage	W10	-0.95*	-0.99**	0.27	-0.38	-0.97*
Mid stage	W11	-0.99**	-1.00**	-0.92	-0.52	-0.99**
Mid stage	W12	-0.82	-0.71	0.29	-0.97*	-0.79
Mid stage	W13	-0.95*	-0.99**	-0.05	-0.38	-0.97*
Mid stage	W14	-0.95*	-0.99**	0.32	-0.38	-0.97*
Mid stage	W15	-0.95*	-0.99**	0.29	-0.38	-0.97*
Mid stage	W16	-0.31	-0.46	0.33	0.52	-0.97
Mid stage	W17	-0.85	-0.92	0.24	-0.15	-0.36
Later stage	W18	0.74	0.62	0.89	0.99**	-0.87
Later stage	W19	-0.33	-0.17	-0.84	-0.93	0.71
Later stage	W20	-0.55	-0.68	0.34	0.27	-0.28
Later stage	W21	0.74	0.62	0.88	0.99**	-0.60
Later stage	W22	-0.89	-0.95*	-0.70	-0.22	0.71
Later stage	W23	-0.21	-0.05	-0.89	-0.88	-0.91
Later stage	W24		-0.85	-0.97*	-0.89	-0.16
Later stage	W25		-1.00**	-0.99**	-0.58	-0.91

Correlation coefficient between Relative Humidity I and Yield for five varieties of Mango (Flowering to harvesting)

Table 4 indicates that impact of RH I on Mango fruit production is found to have overall negative correlation except on few occassions. The reason for this may be that higher value of morning relative humidity is favouring fruit disease development and also mango insect-pests. High relative humidity (RH), particularly above approximately 85%, undermines mango yield by disrupting multiple critical stages: during flowering. Excess moisture within pollen grains can cause over-hydration, swelling and loss of viability, drastically reducing germination rates and resulting in poor fertilization (high RH ≥85%and low values ≤ 50% are both unfavorable). Navarro *et al.* 2023 also interpreted that as unviable pollen translates to fewer fertilized ovules, fruit set drops. Concurrently, high RH fosters pathogens like *Colletotrichum gloeosporioides*, which requires near-saturation humidity (>95%) for conidial germination and appressorium formation infecting flower buds and young fruit, often leading to bud abortion and fruit rot that further deplete yield. These infections also exacerbate during fruit development, where anthracnose severity approaches ~100% under wet, humid, tropical conditions. Finally, high RH environments can elevate fruit respiration and ethylene production, speeding ripening and senescence, causing pre-mature fruit drop and reduced shelf-life. Though direct mango-specific data are scarce, this physiological response is well documented in moist conditions. The cumulative impact is a strong negative correlation between elevated RH and mango crop productivity compromising pollen viability, flower retention, fruit integrity and post-harvest longevity. Pandey *et al.* 2004 reported that higher humidity (85-90%) and moderate temperature (33- 34 °C) provided favourable conditions for the initiation of Ber powdery mildew disease.

Table 4: Correlation coefficient between Relative Humidity I and Yield for five varieties of Mango. (Flowering to harvesting)

RH I (%)						
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarh Nandiraj**
Early stage	W52	1.00**	-	-	-	-
Early stage	W1	0.81	-	-	-	-
Early stage	W2	0.03	-	-	-	-
Early stage	W3	0.17	-	-	-	-
Early stage	W4	-0.21	-0.36	-0.36	0.61	-0.26
Early stage	W5	0.95*	0.89	0.89	0.85	0.94
Early stage	W6	-0.61	-0.73	-0.73	0.20	-0.65
Early stage	W7	-0.67	-0.78	-0.78	0.13	-0.70
Early stage	W8	-0.89	-0.95*	-0.95*	-0.23	-0.91
Mid stage	W9	-0.41	-0.55	-0.55	0.43	-0.45
Mid stage	W10	-0.72	-0.83	-0.82	0.06	-0.76
Mid stage	W11	-0.99**	-0.96*	-0.96*	-0.72	-0.99**
Mid stage	W12	-0.77	-0.87	-0.86	-0.02	-0.80
Mid stage	W13	-0.58	-0.71	-0.71	0.24	-0.63
Mid stage	W14	-0.81	-0.89	-0.89	-0.08	-0.84
Mid stage	W15	-0.81	-0.90	-0.89	-0.08	-0.84
Mid stage	W16	-1.00**	-0.98*	-0.98*	-0.68	-1.00**
Mid stage	W17	-0.94	-0.98*	-0.98*	-0.35	-0.96*
Later stage	W18	-0.99**	-1.00**	-1.00**	-0.57	-1.00**
Later stage	W19	-0.69	-0.56	-0.57	-1.00**	-0.65
Later stage	W20	-0.85	-0.75	-0.75	-0.95*	-0.82
Later stage	W21	0.74	0.62	0.63	0.99**	0.71
Later stage	W22	-0.98*	-1.00**	-1.00**	-0.48	-0.99**
Later stage	W23	-0.73	-0.60	-0.60	-0.99**	-0.99
Later stage	W24	-	-0.65	-0.65	-0.99**	-0.69
Later stage	W25	-	-0.89	-0.88	-0.06	-0.73

Correlation coefficient between Relative Humidity II and Yield for five varieties of Mango (Flowering to harvesting)

Table 5 shows that relative Humidity-II was found to have significantly negative relationship. There are generally negative correlation in all the varieties when mango fruit production is intervening related with RH-II. However, there is an exception in SMW21 when four varieties i.e, Dashehari, Langra, Mallika and Chhattisgarh Nandiraj are found to have significant positive correlation. This may be due to the fact that evening Relative Humidity during this week is positively interveining with the plant physiological mechanism and results in proper hydration of the plant tissues without any favourable conditions for insect pests.

Relative Humidity (RH) significantly influences various physiological processes in mango trees ultimately impacting yield. Here's a breakdown of how RH II influences mango physiology and yield. High relative humidity (RH) exerts profound physiological effects on mango trees by influencing key processes such as photosynthesis, transpiration, fruit development, reproductive success and the interaction with temperature. Optimal RH supports balanced stomatal opening maintaining gas exchange efficiency, boosting photosynthetic rates and sugar production while excessive or low RH disrupts this balance. Low RH increases vapor pressure deficit (VPD) prompting stomatal closure and limiting CO_2 uptake, whereas very high RH reduces transpiration, leading to nutrient uptake deficits and lower photosynthesis. *agritech.tnau.ac.in*. During fruit development and flowering, adequate RH fosters proper cell division and enlargement, resulting in larger, high-quality, sugar-rich mangoes and facilitates successful pollination and fertilization by maintaining pollen viability and flower retention. Conversely, suboptimal RH especially when coupled with high temperature increases water stress shortening photosynthetic activity and impairing fruit set. Furthermore, elevated RH during fruit maturation supports turgor and reduces premature ripening and post-harvest loss but persistently high humidity can lead to internal pressure imbalances, cracking and disease susceptibility due to spore germination and reduced transpiration-driven nutrient flow. Fruit Size and Weight: Proper RH management during fruit development leads to larger and heavier fruits contributing to higher yields.

Table 5: Correlation coefficient between Relative Humidity II and mango Yield for five varieties (Flowering to harvesting)

RH II (%)						
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**chhattisgarhNandiraj**
Early stage	W52	0.57	-	-	-	-
Early stage	W1	-0.61	-	-	-	-
Early stage	W2	0.43	-	-	-	-
Early stage	W3	-0.32	-	-	-	-
Early stage	W4	-0.21	-0.36	-0.36	0.61	-0.26
Early stage	W5	-0.87	-0.94	-0.94	-0.18	-0.89
Early stage	W6	-0.85	-0.93	-0.93	-0.16	-0.88
Early stage	W7	0.54	0.67	0.67	-0.29	0.58
Early stage	W8	-0.95*	-0.99**	-0.99**	-0.38	-0.97*
Mid stage	W9	-0.32	-0.47	-0.47	0.51	-0.37

Mid stage	W10	-0.94	-0.98*	-0.98*	-0.35	-0.96*
Mid stage	W11	-1.00**	-1.00**	-1.00**	-0.59	-1.00**
Mid stage	W12	-0.97*	-1.00**	-1.00**	-0.46	-0.98*
Mid stage	W13	-0.92	-0.97*	-0.97*	-0.31	-0.94
Mid stage	W14	-0.59	-0.72	-0.72	0.23	-0.63
Mid stage	W15	0.53	0.38	0.39	0.99**	0.49
Mid stage	W16	-0.95*	-0.99**	-0.99**	-0.38	-0.97*
Mid stage	W17	-0.92	-0.97*	-0.97*	-0.31	-0.94
Later stage	W18	-0.82	-0.71	-0.71	-0.97*	-0.79
Later stage	W19	-0.20	-0.04	-0.04	-0.87	-0.15
Later stage	W20	0.36	0.50	0.50	-0.48	0.40
Later stage	W21	1.00**	0.99**	0.99**	0.61	1.00**
Later stage	W22	-0.98*	-0.93	-0.93	-0.79	-0.97*
Later stage	W23	-0.67	-0.54	-0.54	-1.00**	-0.63
Later stage	W24	-	-0.60	-0.61	-0.99**	-0.69
Later stage	W25	-	-0.68	-0.68	-0.98*	-

Correlation coefficient between Wind speed and Yield for five varieties of Mango crop (Flowering to harvesting)

Table 6 showed that wind speed is negatively influencing the mango fruit production particularly week no. 5 onwards. Amrapali variety was found to be particularly very sensitive to wind speed. There are some positive values in the initial flowering stage which means the wind speed during this period positively impact mango fruit production. Wind speed has a significant influence on mango crop physiology, with both positive and negative effects. Moderate winds can be beneficial for pollination, transpiration and photosynthesis. Strong winds can have detrimental effects including excessive water loss, flower damage, fruit drop and mechanical damage to trees. Understanding these physiological impacts is essential for developing effective wind management strategies such as windbreaks and shelterbelts to optimize mango production and mitigate the adverse effects of strong winds.

Wind speed significantly influences mango physiology, with both beneficial and detrimental outcomes. During early flowering (first 1-2 weeks), moderate winds improve air circulation, assisting pollination, transpiration and photosynthesis. However, starting around week5, stronger winds begin to disrupt these processes excessive transpiration, flower damage and mechanical stress lead to flower and developing fruit drop, notably in the sensitive Amrapali variety. Physiologically, increasing wind up to a point benefits plants by enhancing stomatal CO_2 uptake and photosynthesis through turbulence and altering hormone dynamics like ethylene and gibberellins. Beyond a threshold, however, strong winds elevate transpiration particularly cuticular loss leading to water stress, flower withering and fruit scarring or detachment. a*gritech.tnau.ac.in*. Mechanically, wind abrasion, branch or limb breakage and foliage loss further contribute to reduced productivity.

Table 6: Correlation coefficient between Wind speed and Yield for five varieties of Mango (Flowering to harvesting)

Wind speed (kmph)						
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarhnandiraj**
Early stage	W52	0.01	-	-	-	-
Early stage	W1	-1.00**	-	-	-	-
Early stage	W2	0.88	-	-	-	-
Early stage	W3	1.00**	-	-	-	0.99**
Early stage	W4	0.99**	1.00**	1.00**	0.55	1.00**
Early stage	W5	-0.83	-0.72	-0.72	-0.97*	-0.80
Early stage	W6	-1.00**	-0.98*	-0.98*	-0.68	-1.00**
Early stage	W7	-0.35	-0.19	-0.19	-0.94	-0.30
Early stage	W8	-0.66	-0.53	-0.53	-1.00**	-0.62
Mid stage	W9	-0.13	0.04	0.04	-0.84	-0.07
Mid stage	W10	-0.80	-0.69	-0.69	-0.98*	-0.77
Mid stage	W11	-0.61	-0.48	-0.48	-1.00**	-0.57
Mid stage	W12	-0.42	-0.26	-0.26	-0.96*	-0.37
Mid stage	W13	-0.45	-0.30	-0.30	-0.97*	-0.41
Mid stage	W14	-0.63	-0.49	-0.50	-1.00**	-0.59
Mid stage	W15	0.79	0.88	0.88	0.04	0.82
Mid stage	W16	-1.00**	-0.99**	-0.99**	-0.61	-1.00**
Mid stage	W17	-0.96*	-0.90	-0.90	-0.84	-0.94
Later stage	W18	-0.23	-0.06	-0.07	-0.89	-0.18
Later stage	W19	-0.59	-0.45	-0.45	-1.00**	-0.55
Later stage	W20	-0.33	-0.17	-0.18	-0.93	-0.28
Later stage	W21	-0.43	-0.28	-0.28	-0.97*	-0.39
Later stage	W22	-0.82	-0.71	-0.72	-0.97*	-0.79
Later stage	W23	-0.56	-0.41	-0.42	-0.99**	-0.52
Later stage	W24	-	0.01	0.01	-0.85	-0.10
Later stage	W25	-	-0.61	-0.62	-0.99**	-

Correlation coefficient between Evaporation and Yield for five varieties of Mango. (Flowering to harvesting)

Table 7 shows that evaporation rate was found to have positively significant relationship with mango fruit production because this is the most critical parameter which develop soil-plant-atmosphere continuum. Therefore, all the nutrient and water translocation is influenced by this parameter and it has been found to be significant in almost all the 6-7 weeks for all the mango varieties except in SMW7 for Amrapali variety, correlation coefficient is coming out to be negative.

The observation that evaporation generally has a positive correlation with mango fruit production which aligns with several key physiological principles: Overall, the mid stage shows the strongest and most stable correlation, indicating it's the most favorable period for mango development across all varieties. It indicates that impact of evaporation is having positively significant correlation with Mango fruit production because this is the most critical parameter which develop soil- plant-atmosphere continuum. So all the nutrient and water translocation is influenced by this parameter. The observation that evaporation generally has a positive correlation with mango fruit production aligns with several key physiological principles i.e,

Evaporation as an Indicator of Energy Demand: Evaporation is a strong indicator of the energy available in the environment. Higher evaporation rates typically coincide with increased solar radiation and higher temperatures. This energy availability is crucial for driving photosynthesis, the process where plants convert light energy into chemical energy (sugars) that fuel fruit growth and development.

Soil-Plant-Atmosphere Continuum (SPAC): Evaporation plays a central role in the SPAC. It drives the movement of water and nutrients from the soil, through the plant and into the atmosphere. Adequate water uptake and nutrient transport are essential for optimal plant growth and fruit production.

Transpiration and Cooling: Evaporation contributes significantly to plant transpiration. As water evaporates from the leaf surface, it cools the plant and preventing excessive heat stress that can negatively impact fruit development. The negative correlation observed in SMW7 for the Amrapali mango can be attributed to three primary factors: First, Variety-Specific Response: Different mango varieties may exhibit varying degrees of sensitivity to environmental conditions. Amrapali might have a specific physiological response to high evaporation rates during SMW7, potentially leading to water stress or other physiological limitations that negatively impact fruit production. Second Microclimatic Variations: Even within the same orchard, microclimatic variations can occur. Local factors such as wind patterns, soil moisture gradients and shade can influence the microclimate experienced by individual trees, leading to variations in the relationship between evaporation and fruit production. Finally, Data Variability and Sample Size: The negative correlation in SMW7 for Amrapali might be an outlier or a result of limited data points orvariability within that specific time window.

Table 7: Correlation coefficient between Evaporation and Yield for five varieties of Mango. (Flowering to harvesting)

EVP (mm)						
Stage	**WEEK**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**Chhattisgarh Nandiraj**
Early stage	W52	-0.53	-	-	-	-
Early stage	W1	-0.05	-	-	-	-
Early stage	W2	-0.23	-	-	-	-
Early stage	W3	-0.05	-	-	-	-
Early stage	W4	0.34	0.49	0.49	-0.49	0.31
Early stage	W5	0.93	0.98*	0.97*	0.31	0.18
Early stage	W6	0.87	0.94	0.94	0.18	-0.95*
Early stage	W7	-0.85	-0.75	-0.75	-0.95*	0.64
Early stage	W8	1.00**	0.99**	0.99**	0.64	-0.48
Mid stage	W9	0.36	0.50	0.50	-0.48	-0.21
Mid stage	W10	0.60	0.73	0.73	-0.21	0.62
Mid stage	W11	1.00**	0.99**	0.99**	0.62	0.88
Mid stage	W12	0.93	0.86	0.86	0.88	-0.11
Mid stage	W13	0.68	0.79	0.79	-0.11	-0.31
Mid stage	W14	0.52	0.66	0.66	-0.31	0.79
Mid stage	W15	0.98*	0.93	0.93	0.79	0.81
Mid stage	W16	0.08	-0.08	-0.08	0.81	0.61
Mid stage	W17	1.00**	0.99**	0.99**	0.61	0.75
Later stage	W18	0.99**	0.95*	0.95	0.75	1.00**
Later stage	W19	0.63	0.50	0.50	1.00**	0.76
Later stage	W20	0.99**	0.95*	0.95	0.76	-0.92
Later stage	W21	-0.89	-0.81	-0.81	-0.92	0.66
Later stage	W22	1.00**	0.98*	0.98*	0.66	0.84
Later stage	W23	0.96	0.90	0.90	0.84	1.00**
Later stage	W24	-	0.58	0.58	1.00**	0.17
Later stage	W25	-	0.93	0.93	0.17	-

Correlation coefficient between sunshine hours and Yield for five varieties of Mango. (Flowering to harvesting)

Table 8 the relationship between sunshine hours and mango crop yield varies across different varieties and growth stages. For the Dashehari variety, the early stage generally exhibited a positive correlation with yield, except during week 2, where a negative correlation was observed. In contrast, the mid stage predominantly showed a significant negative relationship with yield, with the exception of week 10, which displayed a positive correlation. For the Langra variety, a significant negative relationship was observed during most weeks of the mid and late stages. The Amrapali variety, on the other hand, showed a negatively significant relationship with yield in only two weeks: week 11 in the mid stage and week 24 in the late stage. Lastly, for the Chhattisgarh Nandiraj variety, some weeks in the early and mid stages demonstrated a positive and significant relationship with yield while other weeks in the mid stage exhibited a significant negative correlation.

The finding of both positive and negative correlations between sunshine hours and mango fruit production highlights the complex relationship between this environmental factor and crop yield. It indicates that adequate sunshine plays a central role in mango production primarily through its effect on photosynthesis. During meteorological weeks SMW3, SMW5, SMW10, SMW11, SMW22 and SMW24, increased sunshine hours positively correlate with yield. This is because more sunlight enables leaves to capture greater light energy, driving photosynthetic activity that converts light into the chemical energy needed for fruit growth, sugar accumulation and overall yield enhancement. However, this correlation can invert during the middle period SMW14 through SMW19 when excessive sunshine may harm yield. Prolonged exposure leads to heat stress that damages delicate flowers and fruits, causing fruit and flower drop, as well as smaller, less sweet fruits. Simultaneously, increased sunshine heightens evapotranspiration, potentially leading to water stress if irrigation is insufficient, compounding the negative impact on fruit development. These observations suggest the presence of threshold values for sunshine in mango orchards. Below the lower threshold, insufficient light limits photosynthesis, reducing growth, flowering, and yield. Beyond the upper threshold, excessive sunshine triggers heat and water stress, again diminishing yield. Thus, optimal mango production requires managing sunshine exposure within a balanced range enough sunlight to fuel photosynthesis and flowering without tipping over into stress-induced damage.

Table 8: Correlation coefficient between sunshinehours and Yield for five varieties of Mango. (Flowering to harvesting)

	SS (hr)					
Stage	**Week**	**Dashehari**	**Langra**	**Mallika**	**Amrapali**	**ChhattisgarhNandiraj**
Early stage	W52	-0.88	-	-	-	-
Early stage	W1	0.69	-	-	-	-
Early stage	W2	-1.00**	-	-	-	-
Early stage	W3	0.95*	-	-	-	0.97*
Early stage	W4	-0.34	-0.49	-0.49	0.49	-0.39
Early stage	W5	0.99**	0.95*	0.95*	0.76	0.98*
Early stage	W6	0.83	0.91	0.91	0.11	0.86
Early stage	W7	-0.58	-0.71	-0.71	0.24	-0.62
Early stage	W8	-0.06	0.11	0.10	-0.80	-0.01
Mid stage	W9	-0.29	-0.13	-0.14	-0.92	-0.25
Mid stage	W10	0.98*	1.00**	1.00**	0.47	0.99**
Mid stage	W11	0.59	0.45	0.45	1.00**	0.55
Mid stage	W12	-0.31	-0.47	-0.46	0.52	-0.36
Mid stage	W13	-0.17	-0.01	-0.01	-0.86	-0.12
Mid stage	W14	-1.00**	-0.99**	-0.99**	-0.61	-1.00**
Mid stage	W15	-0.97*	-1.00**	-1.00**	-0.46	-0.98*
Mid stage	W16	-1.00**	-0.99**	-1.00**	-0.60	-1.00**
Mid stage	W17	-0.95*	-0.88	-0.88	-0.86	-0.93
Later stage	W18	-0.91	-0.96	-0.96*	-0.27	-0.93
Later stage	W19	-0.93	-0.98*	-0.98*	-0.32	-0.94
Later stage	W20	-0.01	0.16	0.15	-0.77	0.04
Later stage	W21	-0.63	-0.75	-0.75	0.18	-0.67
Later stage	W22	-0.68	-0.79	-0.79	0.12	-0.72
Later stage	W23	0.44	0.58	0.58	-0.40	0.48
Later stage	W24	-	0.48	0.48	1.00**	0.58
Later stage	W25	-	0.96	0.96*	0.24	-

Weather parameters and their potential influence on the "Total flowering period" of mango trees

Evaporation is the most influential factor followed by wind speed. Evaporation will result in better translocation of nutrients and water from the soil resulting in positive impact on flowering period.

Wind can have a direct physical impact on flowers, causing damage or dislodging them. It can also interfere with pollination by affecting pollen dispersal and insect activity. This justifies the negative correlation observed between wind speed and flowering period (Table- 9).

Table 9: Weather parameters and total period of flowering for 5 varieties of mango

Total period of flowering	Tmax (°C)	Tmin (°C)	RF (mm)	RH 1 (%)	RH2 (%)	WS (Kmph)	EVP (mm)	SS (hr)
28	27.2	13.6	49.6	85.	44.3	2.7	89.6	6.2
24	30.7	16.1	37.8	87.	41.7	2.6	89.3	7.7
19	30.7	15.3	36.0	87.	38.3	2.5	70.6	7.8
23	25.9	13.4	49.6	85.	47.1	2.9	65.5	5.5
20	29.5	13.6	36.0	88.	35.4	2.2	71.0	8.1
47	30.2	12.9	4.6	80.	27.8	2.4	163.9	5.3
26	30.0	13.0	7.0	79.	32.2	2.9	96.4	5.6
10	29.55	13.15	4.60	80.2	33.1	2.91	36.70	4.21
46	31.5	13.6	7.0	77.2	26.8	2.9	197.9	6.6
38	30.3	12.8	4.6	79.9	26.7	2.5	137.7	5.9
41	26.2	12.6	4.6	90.1	44.0	2.53	107.4	6.4
41	27.9	12.2	7.0	86.5	34.3	2.19	133.4	7.1
54	29.1	13.0	23.2	85.3	32.6	1.90	152.1	7.2
45	29.8	13.4	7.0	83.5	30.4	1.78	167.1	7.4
39	26.8	12.4	4.6	87.1	38.6	2.30	115.4	6.6
correlation coefficient	-0.005	-0.448	-0.457	-0.139	-0.415	**-0.54***	**0.91****	0.17

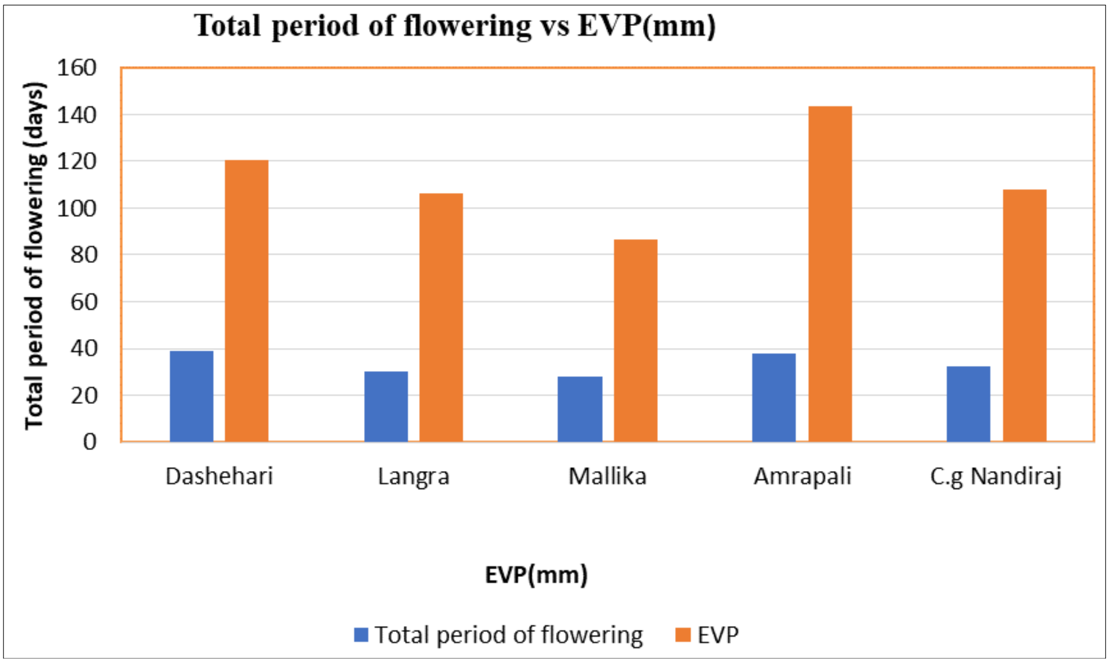

Fig 1: Relationship between Total period of flowering and evaporation amount

Table 10: Evaporation amount and total period of flowering in five mango varieties at Raipur

Variety	Total period of flowering	EVP
Dashehari	39	120.3
Langra	30	106.4
Mallika	28	86.5
Amrapali	38	143.5
C.g Nandiraj	32	108.0

Conclusion
It was found that mango production is influenced by various weather conditions, with warmer temperature boosting production while unusual warmnights can be detrimental. Rainfall, strong winds, high humidity and wind speed can lead to fruit drop and lower yields, while optimum evaporation and sunshine are crucial for healthy growth. This study revealed that Evaporation has significantly positive correlation whereas wind speed has negatively significant relationship with the total flowering period of mangoes in Raipur district. Among cultivars, Dashehari and Amrapali achieved the longest flowering periods, while Mallika variety displayed the shortest.

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