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Weather variability and production constraints in Mango (*Mangifera indica* L.) Cultivation in Jagtial District of Telangana

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Abstract

Mango (*Mangifera indica* L.) is a commercial fruit crop grown in the district of Jagtial contributing its major share of Telangana state where recent yield fluctuations have been increasingly associated with climatic variability and elevated pest incidence. This study was conducted in Jagtial district of the Northern Telangana Zone during 2024–25 to assess recent weather variability and identify major constraints affecting mango cultivation under changing climatic conditions. Long-term weather data (1998–99 to 2017–18) were compared with observed data from 2018–19 to 2024–25 for the post-monsoon and winter seasons to examine changes in relative humidity, temperature and diurnal temperature range (DTR). A survey was conducted in mandals with over 1,500 acres under mango cultivation. From each mandal, one village with the highest mango area was selected, and 10 farmers per village were randomly chosen making a total of 100 respondents for the study and constraints were prioritized using Garrett's ranking technique. Weather analysis indicated consistently higher morning and afternoon relative humidity, moderately elevated minimum temperatures and a reduced DTR during winter compared to long-term averages, reflecting warmer and more humid conditions. Garrett ranking revealed sucking pests, mainly hoppers and thrips during flowering, as the most severe constraint (Garrett score 77.2), followed by cloudy weather during full bloom to fruit-set (70.8), delayed flowering and excessive flower and fruit drop (54.4), and unseasonal rainfall during April–May (52.1). Increased cost of cultivation due to repeated pesticide applications and limited awareness of appropriate plant protection and nutrient management practices further constrained productivity. The predominance of pest-related constraints was closely associated with enhanced humidity and temperature anomalies, which favored pest multiplication and secondary fungal growth, causing significant yield and quality losses. The findings emphasize the need for climate-resilient pest management strategies, strengthened extension services and location-specific advisories to sustain mango productivity under changing climatic conditions in Telangana.

Keywords: Mango cultivation, weather variability, diurnal temperature range, sucking pests, production constraints

Introduction

Mango (*Mangifera indica* L.) is one of the oldest and the fifth most important fruit crops in the world (Boudon *et al.*, 2020) ^[5]. India is the world's largest producer of mangoes, contributing nearly half of the global mango production. (APEDA, 2024). Mango reflects Indian culture and traditions and is recognized as the national fruit of India (Singh, 2019) ^[17]. The Indian subcontinent harbors a rich diversity of mango (*Mangifera indica* L.) and is widely recognized as the centre of origin of this fruit (Jena & Chand, 2021) ^[8]. In Telangana state, mango is being cultivated in an area of 321,434 acres with a production of 936.52 metric tonnes during the year 2024-25 (Ministry of Agriculture and Farmers Welfare, Government of India 2025) ^[13].

The State of Telangana, is known for its rich soils and favourable climate with numerous varieties grown across the region, mangoes are an integral part of its culture and economy. In Telangana, Nagarkurnool, Khammam, Jagtial, Nalgonda, Sangareddy are major growing districts. Among these districts, Jagtial district is situated in northern part of Telangana making it ideal for growing mangoes because of

its favorable agroclimatic conditions, which include high temperatures and moderate relative humidity brought on by the Godavari River. The water content of mangos falls and enhances their quality and soluble sugars because of these favourable conditions during the fruit growth stage (Wei *et al.*, 2017) ^[19]. Its cultivation is aided by other variables, such as soils that are primarily red and black and have a good capacity to hold water. The primary sources of water are open wells and canals, which allow for supplementary irrigation during the fruit-growing season.

According to the database of Department of DHSE, Jagtial, Mango is cultivated in 20 mandals of Jagtial district covering an area of 38,277 acres in 288 villages by 13,367 farmers with an average production of 3 Metric Tonnes per acre during 2024-25. Telangana is a hub of commercial varieties such as Bangainpalli, Dasheri, Himayath, Mallika, Kesar, and Totapuri. Though in Jagtial, Bangainpalli is the leading variety sharing 95% of the area and received a Geographical Indication (GI) tag in 2017 (GI Application Number 241), making Telangana the proprietor of this variety known for its sweetness (APEDA, 2017).

According to the recent studies, mango yields are found to

be declining in recent years due to changes in climatic factors like rainfall and temperature, coupled with the incidence of pests such as hopper and thrips (Bana *et al.*, 2024; Prajapati *et al.*, 2023) [4, 14]. Keeping in view of present problems faced by mango growers, a survey was conducted in Jagtial during the year 2024-25 to identify and address the major issues facing by the farming community in production of mango under changing climate.

Methodology

Study Area

The study was conducted in Jagtial district (Fig.1) of Telangana, which was purposively selected due to its prominence in mango cultivation. The district recorded the highest area under mango cultivation in the state, covering 38,277 acres during 2024–25, making it an appropriate location for examining the constraints faced by mango growers.

Weather Data and Analysis of Recent Variability

Daily weather data recorded at the Agrometeorological Observatory of the Regional Agricultural Research Station

were used for the study and aggregated into standard meteorological weeks. A long-term average for the period 1998–99 to 2017–18 was used as the reference period to assess recent interannual changes during 2018–19 to 2024–25 in the post-monsoon (October–December) and winter (January–February) seasons in Jagtial district, considering the weather-related problems reported by farmers during recent Zonal Research and Extension Advisory Committee meetings.

Sampling Procedure and Sample Size

To ensure adequate representation of mango-growing regions, mandals having more than 1,500 acres under mango cultivation were purposively selected. From each selected mandal, one village with the highest area under mango cultivation was chosen. Accordingly, a total of 10 mandals and 10 villages were selected (Fig.1). At the final stage, a random sampling technique was employed to select the respondent farmers. From each village, 10 mango growers were selected randomly, resulting in a total sample size of 100 farmers (Kothari, 2004) [10].

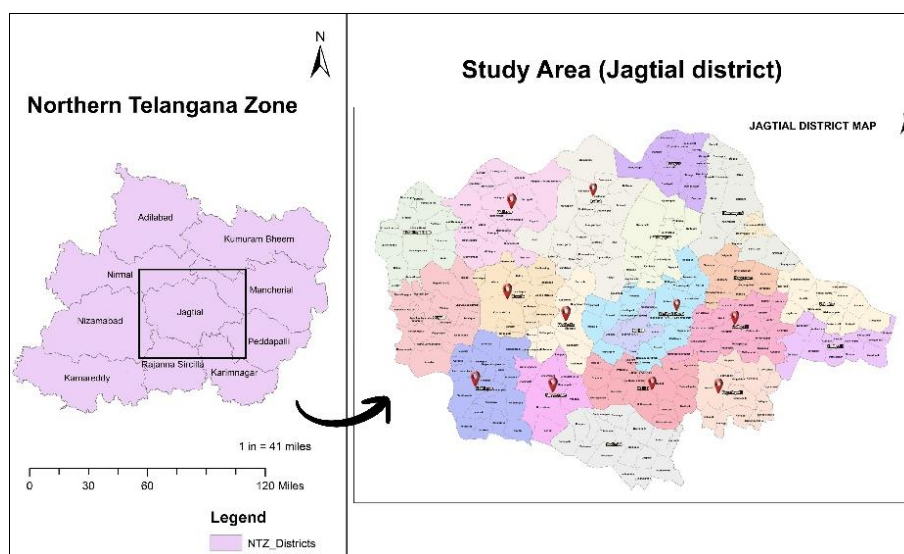


Fig 1: Study area of Jagtial district showing the selected mandals for the survey

Analytical Technique

The constraints faced by mango growers were analyzed using Garrett's ranking technique. The respondents were asked to rank the identified constraints according to their perceived importance. The ranks were converted into percent positions using the following Equation (1).

$$\text{Percent Position (PP)} = \frac{100(R_{ij} - 0.5)}{N_j} \quad (1)$$

Where,

R_{ij} = Ranking given to i^{th} attribute by the j^{th} individual.

N_j = Number of attributes ranked by the j^{th} individual.

The percent positions were converted into scores using Garrett's conversion table. The scores for each constraint were summed across respondents and the mean score was calculated. The constraints were then ranked in descending

order based on their mean scores, with the highest mean score indicating the most severe constraint (Garrett & Woodworth, 1973) [6].

Results and Discussion

Weather variability during post-monsoon and winter seasons in Jagtial district

Weather data for the study area were analyzed by comparing the long-term average (1998–99 to 2017–18) with the observed period (2018–19 to 2024–25).

The weekly variation in relative humidity (RH) in Jagtial district during the post-monsoon and winter periods (SMW 40–9) showed distinct differences between the long-term averages (1998–99 to 2017–18) and the observed means during 2018–19 to 2024–25. Morning relative humidity (RH I) remained consistently high throughout the period, with observed values generally exceeding the long-term average by about 8–18% during most weeks, particularly from

October to December, indicating more humid morning conditions than normal. Afternoon relative humidity (RH II) exhibited greater week-to-week variability; however, observed RH II values were also generally higher than the long-term average across the season, with positive deviations dominating most weeks. The deviations in RH I peaked during late December, while RH II deviations

showed notable fluctuations, with relatively lower positive departures during early November and mid-February. Overall, the results indicated enhanced morning humidity and moderately increased afternoon humidity during the post-monsoon and winter periods in Jagtial district compared to the long-term averages (Fig.2).

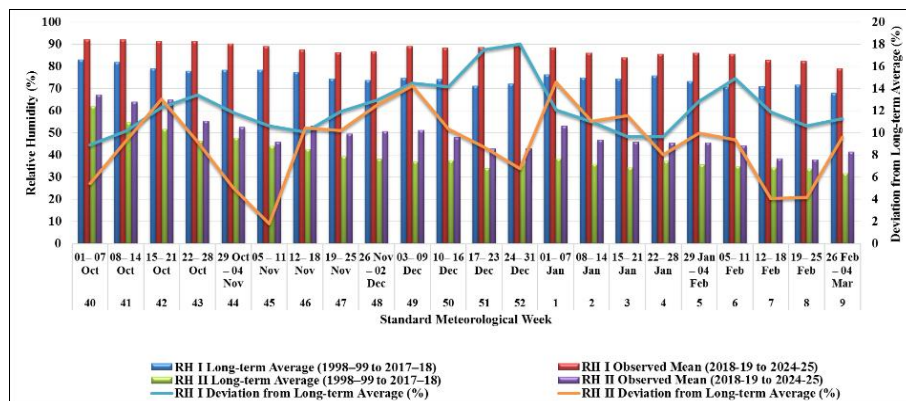


Fig 2: Weekly variation in morning (RH I) and afternoon (RH II) relative humidity showing deviations from the long-term average (1998–99 to 2017–18) and observed mean during 2018–19 to 2024–25 for the post-monsoon and winter seasons in Jagtial district.

According to the classification of the India Meteorological Department (IMD), departures of actual temperatures from the long-term average are categorized as normal (-1.5 to $+1.5$ °C), below normal (-1.6 to -3.0 °C), above normal ($+1.6$ to $+3.0$ °C), appreciably below normal (-3.1 to -5.0 °C), appreciably above normal ($+3.1$ to $+5.0$ °C), markedly below normal (< -5.1 °C), and markedly above normal ($> +5.1$ °C). The departures of observed mean maximum and minimum temperatures from their respective long-term averages in Jagtial district during the post-monsoon and winter periods (SMW 40–9) were assessed using this classification. The deviations in maximum temperature predominantly remained within the normal category (-1.5 to $+1.5$ °C) throughout the study period, with sporadic occurrences of below-normal (-1.6 to -3.0 °C) conditions

during late December and early January. In contrast, minimum temperature deviations were more pronounced, with several weeks from November to January falling under the above-normal category ($+1.6$ to $+3.0$ °C), indicating relatively warmer night-time conditions. Instances of appreciably above or appreciably below normal temperatures were infrequent, and no episodes of markedly above-normal ($> +5.1$ °C) or markedly below-normal (< -5.1 °C) departures were observed. Overall, temperature anomalies during the post-monsoon and winter seasons in Jagtial district were largely confined to normal and moderately above-normal ranges, with elevated minimum temperatures contributing to a reduction in the diurnal temperature range (Fig.3).

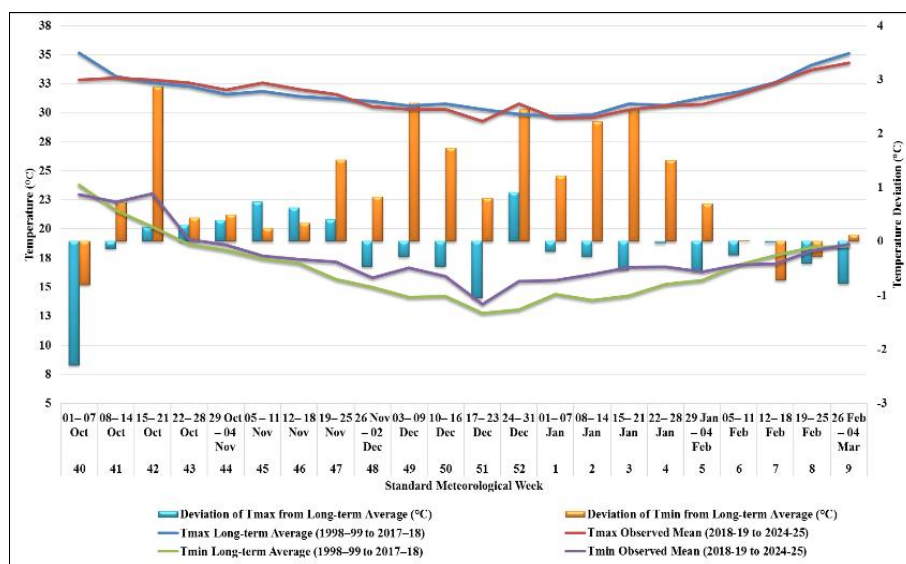


Fig 3: Weekly variation in mean maximum and minimum temperatures showing deviations from the long-term average (1998–99 to 2017–18) and the observed mean during 2018–19 to 2024–25 for the post-monsoon and winter seasons in Jagtial district

The weekly mean diurnal temperature range (DTR) in Jagtial district during the post-monsoon and winter periods (SMW 40–9) exhibited a clear seasonal progression. The long-term average DTR increased from about 11–12 °C in early October to a peak of 17–18 °C during mid-December, followed by a slight decline in January and a gradual rise towards late February. The observed mean DTR (2018–19 to 2024–25) broadly followed this seasonal pattern but

remained consistently lower than the long-term average during most weeks, particularly during December and January, when the observed DTR was reduced by approximately 2–4 °C. This reduction indicated a narrowing of the diurnal temperature range during winter, largely attributable to relatively higher minimum temperatures, with observed DTR values approaching the long-term average towards late winter (Fig.4).

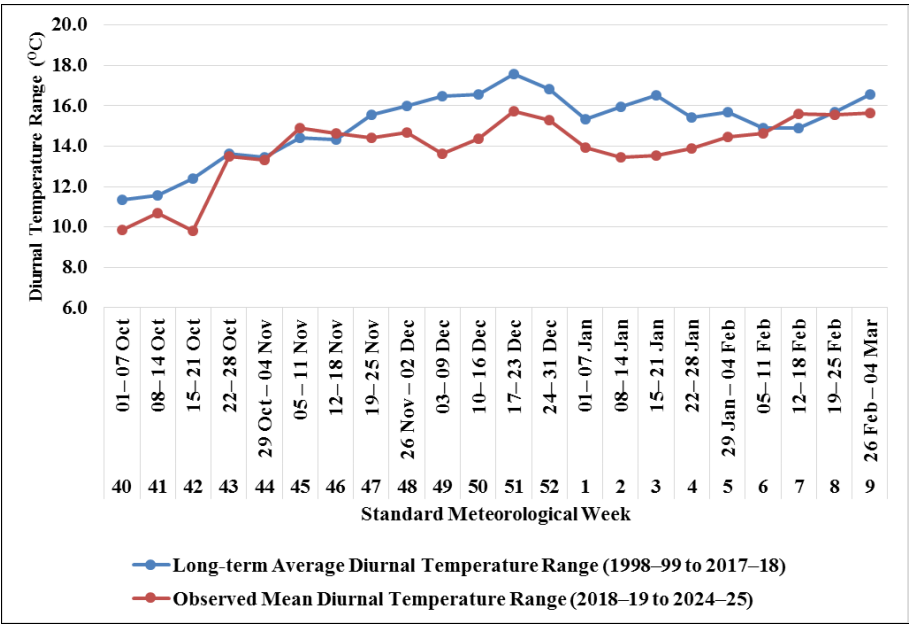


Fig 4: Weekly variation in diurnal temperature range (DTR) under long-term average (1998–99 to 2017–18) and observed mean conditions (2018–19 to 2024–25) during the post-monsoon and winter seasons in Jagtial district

Fig. 5 illustrates the mandal-wise distribution of area under mango cultivation in Jagtial district during 2024–25,

supporting the purposive selection of mandals for the survey.

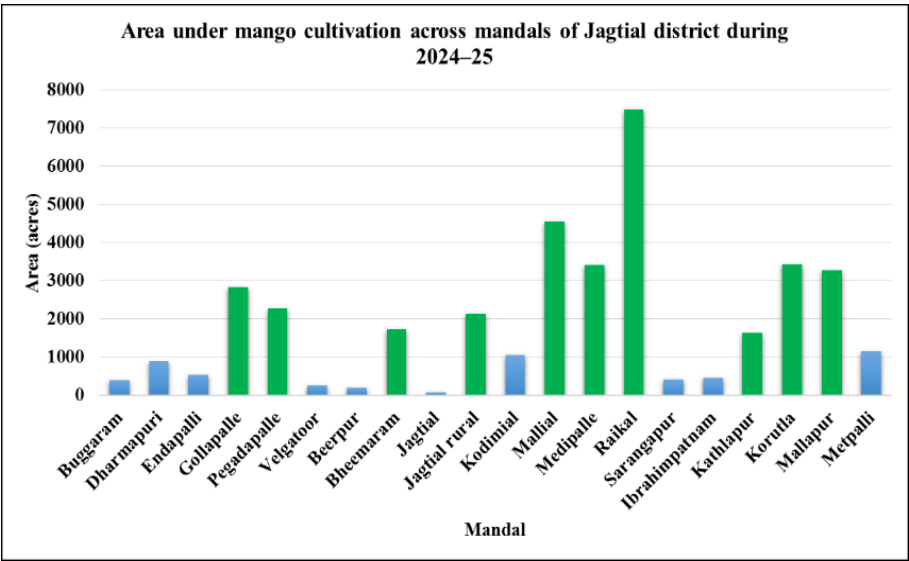


Fig 5: Area under mango cultivation (acres) across mandals of Jagtial district during 2024–25. [Source: Department of Horticulture, Government of Telangana (2024–25)].

Constraints in Mango Cultivation: Garrett Ranking Analysis

The constraints faced by mango growers were analyzed using the Garrett ranking technique, and the results are

presented in Table 1. The analysis revealed that mango cultivation in the study area was affected by a combination of biotic, climatic, and knowledge-related constraints, which significantly influenced productivity and profitability.

Table 1: Constraints in Mango Cultivation: Garrett Ranking Analysis

S. No.	Problems noted during survey	Garrett score	Rank
1	Sucking pests mainly hoppers and thrips during flowering	77.2	1
2	Cloudy weather at the time of full bloom to fruitset stage	70.8	2
3	Delayed flowering, flower and fruit drop	54.4	3
4	Unseasonal rains during April-May months	52.1	4
5	Increased cost of cultivation due to increased number of sprays	44.01	5
6	Not aware of suitable plant protection chemicals to control pest and diseases	40.69	6
7	Rejection of the fruits due to scars caused due to hoppers and other sucking pests	28.04	7
8	Lack of awareness on recommended dose of fertilizers, time of application and other management practices	23.96	8

The most severe constraint, ranked first with a Garrett score of 77.2, was the incidence of sucking pests, particularly hoppers and thrips during the flowering stage. These pests suck sap from tender shoots and panicles, leading to withering and drying of flower buds, poor flower opening and in severe cases, up to 90% flower drop, often accompanied by sooty mold formation. The high incidence of these pests was largely attributed to warm and humid weather conditions during flowering. To manage these pests, farmers resorted to repeated pesticide applications at 15–20 day intervals, which substantially increased the cost of cultivation.

The second most important constraint was cloudy weather during the full bloom to fruit-set stage, with a Garrett score of 70.8. Cloudy and humid conditions adversely affected pollination, reduced solar radiation and limited photosynthate production, resulting in weak flowers and a higher rate of flower drop. Additionally, such conditions favored pest and disease incidence, making this stage highly vulnerable to climatic uncertainty.

The third-ranked constraint was delayed flowering, flower drop and fruit drop (Garrett score 54.4). Irregular flowering patterns and excessive flower and fruit drop were commonly associated with climatic stress, particularly higher winter temperatures, lack of cool nights and cloudy, humid weather, which delayed floral induction and increased the proportion of male flowers. Flowering is also depends on the variety, age of the tree. As far, the district is covered with Bangainpalli variety in which percent of perfect flowers is about% and the other probable reason for delayed flowering is age of the tree as majority of the trees are more than 20 years old. Nutrient imbalances, hormonal disturbances and pest infestations further aggravated this problem.

The fourth-ranked constraint was unseasonal rainfall during April–May (Garrett score 52.1). Gusty winds coupled with unseasonal rains (hailstorms) during fruit development, mature stages results in heavy fruit drop and incidence of fruit borer and fruit rot. As part of a recent climatological analysis by Subba Rao *et al.* (2025) ^[18], it was reported that hail events in India are most frequent in the pre-monsoon season, with March recording the highest number of hail events followed by April causing heavy fruit drop and yield loss upto 20-30% leading to rejection of fruits by bidders during grading analysis (Raju *et al.*, 2024) ^[15].

The increased cost of cultivation due to a higher number of pesticide sprays, ranked fifth with a Garrett score of 44.01, reflected the economic burden on mango growers. Frequent pest outbreaks compelled farmers to apply repeated chemical sprays, resulting in higher input costs and reduced net returns.

The lack of awareness about suitable plant protection chemicals for pest and disease management, ranked sixth (Garrett score 40.69), indicated gaps in extension services and access to technical knowledge. Improper selection and application of chemicals often led to ineffective pest control and increased pest resistance problems.

The rejection of fruits due to scars caused by hoppers and other sucking pests, ranked seventh (Garrett score 28.04), highlighted quality-related constraints in mango production. Pest-induced blemishes reduced the market acceptability and price of fruits, leading to economic losses.

The least-ranked constraint was the lack of awareness regarding recommended fertilizer doses and appropriate time of application, with a Garrett score of 23.96. Although ranked lower, improper nutrient management still affected tree vigor, flowering, and fruit development, ultimately influencing overall productivity.

The predominance of sucking pests such as hoppers and thrips, which was identified as the most severe constraint in mango cultivation (Rank 1, Garrett score 77.2), corresponded with enhanced humidity conditions observed in Jagtial district. Morning and afternoon relative humidity during post-monsoon and winter weeks were consistently above the long-term averages, creating a humid microclimate conducive to pest survival and reproduction (Fig. 2). Elevated humidity was reported to increase mango pest pressure by favouring hopper and thrips populations leading to secondary fungal growth on honeydew excretions, resulting in flower and fruit drop and sooty mold formation, which substantially reduced yield and marketable quality (Adnan *et al.*, 2014, Shukla *et al.*, 2017, Bana *et al.*, 2024;) ^[1, 16, 4]. These conditions explained the frequent pesticide applications (Rank 5) and rejection of fruits due to pest-induced scars (Rank 7), highlighting the economic impact of biotic stress under humid conditions.

Climatic stressors such as cloudy weather and temperature anomalies contributed to other ranked constraints (Ranks 2–4). Elevated minimum temperatures and a reduced diurnal temperature range (DTR) (Figs. 3–4) were found to disrupt floral induction and pollination, contributing to delayed flowering and higher rates of flower and fruit drop. Studies demonstrated that temperature stress affected pollen germination, tube growth and fruit set in mango (Xinyu *et al.*, 2023; Halder *et al.*, 2024) ^[20, 7]. Erratic rainfall and increased moisture further exacerbated fungal diseases during flowering, reducing fruit set and quality (Kouser *et al.*, 2025) ^[11]. These climatic factors favored both pest and disease proliferation, reinforcing the link between weather anomalies and biotic constraints.

Finally, the observed weather deviations highlighted knowledge and management gaps identified in lower-ranked

constraints (Ranks 6 and 8). High humidity and temperature variability required tailored pest and nutrient management practices, yet many growers lacked awareness of suitable chemicals and optimal application schedules. Reviews on mango cultivation under changing climatic conditions indicated that variable weather disrupted traditional agronomic schedules and necessitated adaptive strategies to minimize losses from pests, diseases and climatic uncertainty (Yadav *et al.*, 2023, Lee *et al.*, 2023 and Khalifa *et al.*, 2023) ^[21, 12, 9]. These findings suggested that climatic influences not only directly affected phenology and pest dynamics but also indirectly amplified the consequences of limited technical knowledge in the study area.

Conclusion

The present study highlights that mango cultivation in Jagtial district of Telangana is increasingly constrained by a combination of climatic variability, pest incidence, and knowledge gaps among farmers. Weather analysis revealed consistently higher morning and afternoon relative humidity, moderately elevated minimum temperatures, and a reduced diurnal temperature range during post-monsoon and winter seasons, creating conditions favorable for the proliferation of sucking pests such as hoppers and thrips. Garrett ranking analysis identified these pests as the most severe constraint, followed by cloudy weather during full bloom to fruit-set, delayed flowering with excessive flower and fruit drop and unseasonal rainfall during April–May. The economic burden of repeated pesticide applications and limited awareness of appropriate pest and nutrient management further compounded production challenges. The study underscores the strong interaction between climatic anomalies and biotic stress, which not only directly affects mango phenology and yield but also amplifies the impact of limited technical knowledge and suboptimal management practices. These findings highlight the urgent need for climate-resilient pest and disease management strategies, enhanced extension services and location-specific advisories tailored to the agro climatic conditions of Jagtial. Implementing such adaptive measures can help mitigate yield losses, improve fruit quality and sustain the economic viability of mango cultivation under changing climatic conditions.

Statements and Declarations

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Authors' contributions

Srilaxmi Bottu conceptualized the study, designed the methodology, analyzed data and wrote the manuscript as corresponding author. Swathi Koraboina coordinated field surveys and handled data collection and entry. Dandugudumu Rajini Devi compiled survey data, performed statistical analysis and interpreted results. Eligeti Rajanikanth reviewed and edited the manuscript and

supervised the study.

Competing Interests

The Authors do not have any conflict of interest to declare.

Compliance with Ethical Standards

Ethical issues: None

Data availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

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