Pest Management in Horticultural Ecosystems
Vol. 32, No.1 pp 1-21 (2026)

DOI Number : 10.5958/0974-4541.2026.00001.9

REVIEW ARTICLE

Powdery mildew of mango: Etiology, epidemiology and integrated management strategies

SANGEETHA G., SUPRIYA, M. L. and SRIRAM, S.*

ICAR– Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, Karnataka, India, 560064.

***E-mail:** Subbaraman.Sriram@icar.org.in

ABSTRACT: Mango flower and fruit drop in early developmental stage is one of the key reasons for low fruit set which is largely attributed to diseases and pest incidence. Powdery mildew of mango, incited by the fungus *Pseudoidium anacardii* formerly known as *Oidium mangiferae* Berthet, is one of the most widespread diseases of mango world over that can cause up to 80–90% crop loss. The fungus attacks the young tissues of inflorescences, young fruits and leaves. The affected flowers and fruits drop pre–maturely reducing fruit set. High costs of fungicides and their application for its management have further amplified economic importance of this disease. Hence, extensive information on symptomatology, disease cycle, perpetuation and management has been generated worldwide in recent years. There has been a tectonic shift in powdery mildew management strategies which were so far dominated by a couple of sulphur-based fungicides. More effective molecules and non–chemical sustainable strategies have been devised in recent past. There has also been more acceptance of integrated disease management (IDM) strategy for powdery mildew on mango involving disease surveillance-based forewarning, cultural methods, biological control, application of safer and more effective fungicides and some salts. This review discusses the recent worldwide information generated especially on pathogen, disease progress, management strategies and role of nanotechnology in respect of powdery mildew of mango.

Keywords: *Mangifera indica,* Powdery mildew, *Pseudoidium anacardii*, Integrated disease management, Nanotechnology

INTRODUCTION

Mango (*Mangifera indica* L.) produces profuse inflorescences bearing hundreds of ovule-bearing flowers; however, only a small proportion of the initially set fruits reach maturity, making fruit retention a critical determinant of yield. Among the multiple biotic and abiotic factors influencing fruit drop, diseases affecting flowers, leaves, and young fruits play a decisive role, particularly during the flowering to early fruit set stages (Chadha, 1993; Palti *et al*., 1974). Mango is affected by numerous diseases throughout its growth cycle, from nursery to postharvest, many of which significantly limit productivity (Prakash, 1998; Prakash and Raoof, 1994; Iqbal *et al*., 2024). The major diseases affecting mango during the flowering stage include powdery mildew, blossom blight, blossom malformation, and blossom spot. Among these, powdery mildew and blossom blight are particularly damaging, as they directly infect floral tissues on the panicle and markedly increase flower and young fruit abscission (Palti *et al*., 1974; Prakash and Raoof, 1994). Powdery mildew is the most widespread, economically important, and destructive disease of mango, occurring in nearly all mango-growing regions of the world (Hewitt, 1998; Nasir *et al*., 2017; Iqbal *et al*., 2024). It infects multiple aerial parts of the host, including young leaves, inflorescences, flowers, and developing fruits. On young leaves, infection appears as white powdery growth on both surfaces, leading to curling, distortion, and reduced photosynthetic efficiency. On inflorescences, the pathogen colonizes panicle branches, flowers, and pedicels, causing flower necrosis, failure of anthesis, and extensive blossom shedding. Infection of flowers and peduncles directly interferes with pollination and fertilization, thereby exacerbating early fruit drop. Young fruits, when infected, often become completely covered with fungal growth, resulting in epidermal damage, cracking, and premature abscission (Sridhar and Sohi, 1973; Prakash and Mishra, 1986; Lonsdale and Kotze, 1993; Sinha *et al*., 2001; Iqbal *et al*., 2024).

Powdery mildew of mango is caused by the obligate fungal pathogen *Pseudoidium anacardii* (syn. *Oidium mangiferae*) and is one of the most destructive diseases affecting mango production. The disease is particularly severe under cool, dry, and humid conditions prevailing during flowering, when infection coincides with the most susceptible phenological stage of the crop. Epidemics during this critical stage can markedly reduce fruit set and fruit retention, resulting in substantial yield losses. Depending on disease severity and prevailing environmental conditions, yield losses have been reported to range from 20–25% under moderate infection to as high as 90% during severe epidemic years (Reuveni and Reuveni, 1995; Nasir *et al*., 2014; Reuveni *et al*., 2018; Iqbal *et al*., 2024; Abou El-Nasr *et al*., 2025). Powdery mildew diseases, in general, represent one of the most important groups of plant pathological problems worldwide, infecting nearly 10,000 species of angiosperms and accounting for a substantial proportion of fungicide use in agriculture (Briton, 1923; Hewitt, 1998; McGrath, 2021). In mango, the disease has emerged as a major limiting factor in recent years, particularly in tropical and subtropical regions where favourable climatic conditions during flowering frequently lead to epidemics (Raut *et al*., 2020; Deshmukh *et al*., 2021; Iqbal *et al*., 2024). Despite its significant economic impact, management of mango powdery mildew remains challenging due to its strong dependence on weather conditions during flowering, limited availability of stable host resistance, and increasing concerns over fungicide resistance and residue accumulation (Reuveni *et al*., 2000; McGrath, 2021). Accordingly, this review summarizes recent advances in symptomatology, epidemiology, host response, and chemical, biological, and nanotechnology-based management strategies, to support the development of sustainable disease management strategies.

Distribution and economic importance

Powdery mildew, one of the earliest identified diseases on mango, was first recorded in Brazil in 1914, where the pathogen was illustrated by Berthet (Briton, 1923). In India, it was reported very early by Wagle (1928), Galloway (1935) and Uppal (1937). According to Johnson (1994), the disease was most likely present throughout the Indian Subcontinent since late 1980s. In India, this disease continues to be one of the major limiting factors in mango cultivation, despite having been reported nearly a century ago. In the past, this disease was sporadic, but now it has become a disease of regular occurrence not only in India but also in other mango growing countries worldwide (Prakash, 2004; Nasir *et al.,* 2014).

In general, losses caused by powdery mildew of mango depend upon several factors like agroclimatic region, cultivar, weather conditions during flowering and disease management practices. Because of the variation in these factors and their interaction, losses caused by the disease are highly fluctuating and often lead to inaccurate estimation of losses. Blossom infection is the major cause of losses rather than leaf infection in the most susceptible mango cultivars (Ruehle and Ledin, 1956; Gupta and Dang, 1980; Lonsdale and Kotze, 1993; Ploetz, 2003). In the major mango growing countries, loss estimates up to 70% have been reported (Ihsan *et al.,* 1999), but on an average basis 15– 20% losses have been estimated worldwide (Nasir *et al.,* 2014). In normal infection conditions, 20– 40% of flowers and fruits are destroyed but during epidemics, which may result in complete failure of the mango crop (Prakash and Srivastava, 1987). This disease can cause up to 80% yield losses when outbreaks occur during early flowering (Johnson, 1994). Prakash and Srivastava (1987) reported 30– 90% losses in India and 80– 90 % in South Africa (Kotze, 1985), while it can cause up to 80–90% crop loss under favourable conditions (Schoeman *et al.,* 1995). Powdery mildew incidence of 97% was recorded with 88% severity in Uttar Pradesh, India during the last week of March (CISH, 2014). Even complete crop failure was observed in South Africa by Joubert *et al*. (1993). Another estimate in India reported losses ranging from 22.35 to 90.41% (Prakash and Mishra, 1993; Prakash and Raoof, 1994).

Recent evidence confirms that powdery mildew remains a major constraint to mango production across all major growing regions, with disease incidence approaching 100% under favourable conditions and average yield losses of 20–25%, occasionally resulting in near-complete crop failure (Iqbal *et al*., 2024). Increasing climate variability is further influencing disease epidemiology, as cool and dry conditions during flowering continue to favour infection, while altered rainfall and temperature patterns intensify disease severity and unpredictability. Consequently, losses associated with powdery mildew are becoming more variable and severe, driven not only by cultivar and agronomic factors but also by climate-driven shifts that exacerbate disease pressure and economic impact on mango production (Singh and Singh, 2023).

Pathogen

The use of molecular tools has greatly improved our knowledge in recent years regarding taxonomy of pathogens inciting powdery mildews (Takamatsu *et al.,* 2007). A major limitation in the study of powdery mildew pathogens lies in their obligate biotrophic lifestyle as they cannot be cultured on artificial media. Due to their obligate biotrophic nature, the relationship between powdery mildews and their host plant is highly conserved. Recently, an updated taxonomic monograph of the powdery mildews has been published (Braun and Cook, 2012). Erysiphales in its current circumscription encompass 873 known species. The taxonomy and nomenclature of the Erysiphales follows Braun (1987). Further, it was updated and supplemented by Braun and Takamatsu (2000). Major changes have recently occurred in the taxonomy and nomenclature of the family Erysiphaceae. In 1914, Berthet first described as *Oidium mangiferae* Berthet (Briton, 1923). On the basis of conidial germination and histological studies (globular haustoria), the pathogen was later kept in the *Erysiphe polygoni* group. As the perfect stage of the pathogen was not described by Uppal (1937), the name of the conidial stage *O. mangiferae* Berthet was preferred. The *Oidium* sp. infecting mango was suspected to also infect oak and other trees (Gorter, 1984; Joubert *et al*., 1993) because the characters of the two species were similar however the evidence was insufficient. Joubert *et al*. (1993) differentiated two powdery mildew fungi based on their conidiophore characters and several workers characterized the morphological features of *O. mangiferae* (Akhtar *et al.,* 1999; Palti *et al.,* 1974). It was subsequently established as the causal agent of mango powdery mildew worldwide, with mango recognised as its only known host (Palti *et al.,* 1974). The pathogen was subsequently renamed as *Pseudoidium anacardii* (F. Noack) (Braun and Cook, 2012). The conidia are produced in a basipetal fashion and are sometimes seen singly or in pairs. Conidia measure 25 to 48.9 μm in length and 16 to 23.9 μm in width, mostly 33 to 42.9 x 18 to 21.9 μm and germinate by a germ tube. A survey of conidial characters useful for powdery mildew species identification has been provided by Braun and Cook (Braun and Cook, 2012).

The telemorph of the pathogen is not known in many locations (Nasir *et al.,* 2014). According to Limkaisang *et al.* (2006) and (Takamatsu *et al.*, 2007), the anamorphic powdery mildews occurring on several tropical trees*, viz. Acacia, Anacardium, Bixa, Citrus* and *Mangifera* spp*.* relate to the oak powdery mildew *Erysiphe quercicola. E. quercicola* was first described on oak in Japan by Takamatsu *et al.* (2007). The species name *Quercicola* refers to the host genus Oak (*Quercus*). Cunnington *et al*. (2003) reported that the ITS sequence of *O. mangiferae* on mango was identical to that of *E. alphitoides* from *Q. robur*. This report also suggests a close relationship between *E. alphitoides* and anamorphic powdery mildews distributed in tropical and subtropical areas, hence these molecular studies of the ITS- ribosomal DNA region have provided useful links between anamorphic Erysiphales and their respective teleomorphs. Differences in the nucleotide sequences of ITS regions of rDNA and PCR using species-specific primers have been used very effectively for detection or identification of powdery mildew pathogens (Takamatsu and Kano, 2001). The powdery mildew pathogen associated with mango inflorescences, collected during 2011-2012 from the Kent and Keith varieties in northern Sinaloa, Mexico, were analysed by molecular and phylogenetic analysis of the ITS rDNA region (Felix *et al.,* 2013). These samples were found to be closely related to *P. anacardii* specimens collected from mango trees in various countries. However, the teleomorph was not found. Studies on ecology and classification of the powdery mildew fungi of mango in tropical region are limited due to limited number of researcher groups and lack of teleomorphs in these regions necessary for species identification. Hence, the names of powdery mildew fungi used in this review are identical with those used in the corresponding references to avoid confusion.

Host plant resistance

Host plant resistance is one of the most desirable and sustainable approaches for managing powdery mildew in mango. However, studies conducted across different mango-growing regions consistently report wide variation in cultivar responses, with disease expression strongly influenced by prevailing weather conditions during susceptible phenological stages, particularly flowering. Consequently, the literature often presents contradictory assessments of cultivar performance. In highly susceptible cultivars, powdery mildew may infect flowers, fruits, and leaves simultaneously, resulting in severe yield losses (Ploetz and Ploetz, 2003). Early screening studies identified limited variability in disease incidence among mango cultivars, with only a few cultivars such as Neelum, Zardalu, Banglora, and Totapuri exhibiting comparatively lower incidence (Gupta, 1976). Subsequent evaluations confirmed that most commercially important mango cultivars exhibit variable to moderate levels of powdery mildew incidence depending on agro-climatic conditions, rather than stable resistance (Palti *et al*., 1974; Datar, 1983; Prakash and Raoof, 1994; Akhtar *et al*., 1999).

Marked variation in powdery mildew incidence among mango cultivars has been reported across different agro-climatic regions, highlighting strong genotype × environment interactions. In southern India, the disease has been observed to persist for most of the year on cultivars such as Pairie and Alphonso, indicating sustained susceptibility under favourable climatic conditions (Rawal, 1998). In contrast, field evaluations in Bihar recorded comparatively low disease incidence in cultivars Totapuri, Totapuri Red Small, Vashi Badami, and Ladavio, whereas cultivars such as Mahmood Bahar, Kesar, Neelum, Samar Bahisht Chaunsa, Sensation, and Bangalora exhibited low to moderate disease incidence (1–15%), suggesting partial tolerance rather than complete resistance (CISH database; http: www.cishlko.org/pccell.php).

Similarly, varietal screening conducted in Andhra Pradesh during 2008 revealed low disease incidence in Totapuri and Kesar (≈10%), intermediate incidence (11–20%) in Beneshan, Peddarasam, Chinnarasam, and Cherukurasam, and high incidence (>40%) in Neeluddin, Surya Amrutham, and Nuzivid Thiyamamidi (APHU Annual Report, 2008–09). Earlier studies also indicated that Totapuri consistently exhibits comparatively lower disease incidence across locations, although its response is influenced by environmental conditions (Datar, 1983). Comparative analyses synthesizing quantitative disease data from multiple studies have further classified mango cultivars according to severity scales. Using such approaches, cultivars such as Ghanya, Jahangir, Yellamondela Thiamandi, Bablipunasa, Kharbuja, and K.O.7 have been reported to exhibit relatively low disease incidence, while Zill, Kent, Alphonso, and Nam Dok Mai were categorized as highly susceptible. Intermediate incidence levels were observed in cultivars including Haden, Glenn, Carrie, Keitt, Sensation, Tommy Atkins, and Kensington (Johnson, 1994; Prakash and Raoof, 1994).

Recent multi-location field evaluations across India and Pakistan have consistently demonstrated wide variability in powdery mildew incidence among mango cultivars, reinforcing the strong influence of genotype × environment interactions. In Rajasthan, high disease incidence was recorded in Bombay Green and Dashehari (57.3%), moderate incidence in Amrapali (50.2%), and comparatively lower incidence in Mallika (23.7%), Chaunsa (19.2%), Kesar (19.2%), and Langra (15.6%) (Yadav *et al*., 2014). Comparable variability has also been reported in Pakistan, where among 25 mango cultivars evaluated in 2011, the lowest disease incidence (3.66%) was observed in Almas and Sensation, while high incidence occurred in cultivars such as Dashehari, Chaunsa Samar Bahisht, Malda, and Ratole No. 12 (Naqvi *et al*., 2014). Notably, despite relatively high disease incidence, some cultivars maintained satisfactory yields and were therefore classified as tolerant rather than resistant.

Further field-based screening under natural epiphytotic conditions at Dhaulakuan and Jachh (Nurpur) showed that cv. Totapuri consistently exhibited comparatively low disease incidence (14.15–16.33%), along with the lowest apparent infection rate (0.02–0.04 day^{-1}) and AUDPC values (1.08–1.39), indicating relatively stable performance across environments (Kaur *et al*., 2020). Similarly, multi-season evaluations conducted under western Vidarbha conditions of Maharashtra (2016–2019) revealed disease incidence ranging from 31.9% to 47.9%, with cv. Dashehari recording the lowest pooled incidence and cv. Vanraj the highest, highlighting the limited availability of strong resistance among commercial cultivars (Deshmukh *et al*., 2021). Collectively, these studies confirm that powdery mildew incidence in mango is highly variable across cultivars and environments, and that no cultivar consistently expresses complete immunity, emphasizing the need for continued multi-location screening and integration of host response data into disease management strategies.

Susceptibility of host parts

More precise knowledge of when to expect the first appearance of the disease, based on prevailing weather conditions and the susceptible host part, would govern correct timing of fungicide applications. Young leaves and panicles are attacked more frequently. On young leaves, both sides of the leaf are attacked, and the upper side may even be affected more severely (Burnett, 1975). Mildew on the undersurface is frequently restricted to the area of the central rib and such leaves are often twisted, curled and distorted (Romero *et al.,* 2003; Palti *et al.,* 1974; Cook, 1975). Infection is frequently noticed on young leaves, when their colour changes from brown to light green and distortion of leaves is more common in plains (Mishra and Prakash, 1995). However, this fungus predominantly infects and colonizes all parts of the panicle, including flowers and young fruits (Fig. 1). The sepals are relatively more susceptible than the petals. The main branches of the inflorescence are affected partially on the less susceptible cultivars (Prakash, 2004).

Powdery mildew severity in relation to developmental stages was studied in detail by Schoeman *et al.* (1995). The mango inflorescences were classified into a number of developmental stages and among the various stages, from the protected stage (elongation of inflorescence still protected by bracts) susceptibility increased with inflorescence development to the full- bloom stage. On normal flowering inflorescences, the first symptoms were detected 2 weeks after 20% of the inflorescences were between the red– coloured and fruit-set stages. The green-coloured and red-coloured stages of inflorescence were only slightly susceptible and full-bloom stage appeared to be the most susceptible stage. Inflorescence developmental stages before the protected stage were immune to infection, even when disease levels had reached a peak on other inflorescences in the field (Schepers, 1983). The powdery mildew affected flowers turn brown, grey and brittle and can be easily crumbled. Infection often causes flowers and small fruits to abort and fall off. When infection occurs on the flower stalks and flowers of mango, the flowers usually cease to grow, fail to open, and shed; however, they sometimes persist and set fruit (Palti *et al.,* 1974). In highly susceptible varieties, all branches, including the central axis of the inflorescence, may be completely covered with mildew and eventually blacken. On less susceptible varieties, only portions of the branches are affected; the upper part of the stalk is more often mildewed; however, the centre stalk is not severely affected at its base. Acute blossom infection may cause complete damage to fruit; the flower remains closed and drops from the inflorescence. Almost all the inflorescence showed a pattern of disease from tip to downward (Singh, 1960; Palti *et al.,* 1974). Fungal development stops when infected tissues become necrotic (Palti *et al.,* 1974). Recent reviews emphasize that panicles and young fruits remain the highest-risk host parts under favourable weather conditions, particularly during cool and dry flowering periods, while also highlighting the lack of comprehensive field-based data across diverse climatic regimes and developmental stages, underscoring the need for further research on temporal susceptibility windows and tissue-age-dependent infection dynamics (Iqbal *et al*., 2024).

Similarly, in peach, only certain developmental stages were susceptible to powdery mildew caused by *Sphaerotheca pannosa* var. *persicae*, and infection appeared only one month after flowering. Fruits were susceptible during the early stages of their development and became completely resistant two months after flowering (Weinhold, 1961). A study on the biochemical changes in powdery mildew infected panicles revealed that there is a continuous decrease in the percentage of moisture according to infection level. Further, pH increases with increasing infection in affected host tissue and contents of total sugars and tannins decrease with the severity of the disease (Prakash *et al.,* 1989). Researchers have hypothesized that metabolites, phytoalexins, phenolic compounds, inhibitors, and calcium/ phosphate ions may play a role in such host pathogen interactions (Nasir *et al.,* 2014). However, the main reasons for the susceptibility of certain host tissues at specific developmental stages are not known and need to be studied further.

In India, the disease has been noticed on young mango fruits in varieties such as Dashehari, Kishan Bhog. In such varieties, fruits may remain on the tree until they reach pea size and then drop prematurely. As infected newly– set fruit develop, the epidermis of the infected area cracks and corky tissue is formed (Palti *et al.,* 1974; Joubert *et al.,* 1993). In Mexico, along with powdery mildew infection on inflorescences, a scabby appearance was also observed on a high percentage

Fig. 1. Powdery mildew symptoms during flowering and fruit set of mangoes

of fruits (Felix *et al*., 2013). Such discolouration and distortion of fruits have serious bearing on the fruit quality. These symptoms and the factors leading to such infections need to be investigated further.

Disease cycle and perpetuation

The fungus produces spores abundantly all over the surface of affected tissues. The fungal spores disseminate through wind and produce germ tubes on susceptible host tissues to initiate infection. Wagle (1928) had elaborated on the life cycle of mango powdery mildew pathogen. The life cycle from conidia to conidia is completed in about five days. No teleomorph of the pathogen is known from mango (Fig. 2) (Nasir *et al.,* 2014). Studies have revealed that the powdery mildew pathogen of mango perpetuates in older infected mango leaves and intact green malformed inflorescences in the form of mycelium, conidia or dormant mycelium (Prakash and Raoof, 1985; Gupta, 1988). Under Indian conditions, pathogen survives in the form of mycelium, conidiophores and conidia from April to August and only in mycelial stage from September to December on older infected leaves during off-season. It also perpetuates on infected green inflorescences which remain hidden under dense foliage of mango tree during off– season in mycelial form (Singh, 2000). During favourable weather conditions, the dormant mycelium is activated and profuse spores are produced and blown on to new susceptible tissues leading to initiation of fresh infection (Mougy *et al.,* 2014).

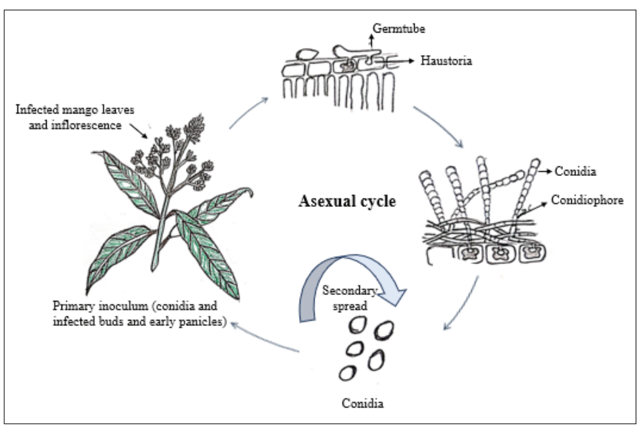

Fig. 2. The life cycle of a powdery mildew fungus on mango

Role of epidemiological factors

For a powdery mildew epidemic to occur, weather conditions favourable for conidia release are necessary and susceptible tissue must be available at the same time (Schoeman *et al.,* 1995) Powdery mildew epidemics exhibit distinct temporal and spatial patterns and are influenced by a complex interplay of factors, including weather conditions, host susceptibility, pathogen virulence, and crop management practices (Sinha *et al.,* 2004). For forewarning, information on these factors is used as input. Development of powdery mildew is characterized by an initial slow growth when favourable conditions just set in during susceptible stage of the host. But suddenly epidemic starts in a devastating appearance leaving no time for taking any appropriate control measure. The pathogen grows very fast (4 to 5 days latent period) and therefore, timely decisions are vital for its management. Spores blown from infected areas readily adhere to hairy, un-opened flowers near tip of the inflorescence and germinate within 5 to 7 hrs (Weinhold, 1961). Overall disease development is favoured by high humidity (Palti *et al.,* 1974). The released spores of powdery mildew germinate and cause infection even if there is no film of water on plant surface as long as the relative humidity in the air is fairly high and once the infection starts the mycelium continues to spread on host regardless of the moisture condition of the atmosphere (Agrios, 2005). Butt (1978) reported that free water generally causes damage to superficial mycelium of powdery mildews and that spore number is low for several days after rain though the rains can also stimulate the pathogen by raising the atmospheric humidity. According to Kotze (1985), outbreaks of powdery mildew do not have to be preceded by rain or dew. The disease appearance and incidence are greatly influenced by the sunshine (hours) per day and it is inversely proportional to the disease having a correlation coefficient of r =0.5943. The pathogen causes maximum infection on the host plant at 26°C and 100% relative humidity (Gupta, 1989). A similar kind of study revealed that consecutive occurrence of high RH (>80%) and minimum temperature above 10°C for 4– 5 days is conducive for powdery mildew development on floral parts (Jones, 1923).

The disease symptoms appear in February and March in India, on flower scales, flower heads, young leaves, stalks and fruits (Singh, 1960). During flowering, periodical monitoring of mildew severity was carried out using the standard meteorological week (SMW) as the time scale, starting with January 1-7 as first SMW of the year. The mean maximum (32.6°C) and minimum (10.84 to 11.19°C) temperature and relative humidity (50 to 60%) recorded between 5th to 8th SMWs were found very congenial for the appearance and spread of powdery mildew in Maharashtra state. In Uttar Pradesh, first incidence of powdery mildew was observed on Dashehari during the last week of January and maximum incidence (97%) with severity (88%) was recorded in the last week of March. At Central Institute for Subtropical Horticulture (CISH) farm, powdery mildew was observed with moderate incidence (37.6%) with severity of 34.1 per cent during end of March (13th SMW) (CISH Annual Report, 2013-14). In Andhra Pradesh, disease incidence was first noticed during last week of January (4th SMW), 2014 in mango cv. Dashehari (susceptible) and Baneshan (moderately susceptible) cultivars and continued up to February last week (8th SMW). In both the varieties the maximum disease severity was observed during 2nd week of February (6th SMW). Appearance of powdery mildew was first noticed on panicles during 4th week of February and on leaf and twigs during second week of February at FRS, Sangareddy (https://drysrhu.ap.gov.in/). Sinha *et al.* (1960, 2000) studied in detail about the statistical modelling and forecasting methods for mango powdery mildew and analysed the critical weather factors for the development of powdery mildew to develop a forewarning model. CISH, Lucknow has also developed an expert system (mango decision support system) for weather based forewarning of powdery mildew disease. It takes into account four weather parameters viz., max. and min. temperature, relative humidity and wind speed which favours the development of powdery mildew and also recommends a fungicide spray schedule for its effective management (CISH, 2014). Since this disease is weather sensitive and necessitates regular monitoring of weather factors and trapping of conidia in the area to apply control measures (Mishra and Prakash, 1995; Mishra, 2001).

Powdery mildew development in mango is strongly governed by weather conditions prevailing during flowering and early fruit set, with epidemics closely linked to temperature, relative humidity, and airborne inoculum levels. In Mexico, disease outbreaks were associated with high temperatures (>30 °C), elevated relative humidity (≥90%), and increased conidial density, with full bloom and early fruit set (8–15 mm fruits) identified as the most susceptible stages (Pérez-Rodríguez *et al*., 2017). Similarly, in the Konkan region of Maharashtra, disease onset typically occurs in January and peaks by the second fortnight of March, reaching up to 85.6% severity, with incidence showing a significant positive correlation with minimum temperature (Raut *et al*., 2017). Complementary regression analyses indicate that temperature, relative humidity, and rainfall together explain 85–94% of disease variability, identifying moderate temperatures (≈16–26 °C) combined with high but fluctuating relative humidity (61–95%) as most conducive for epidemics and underscoring the value of weather-based forecasting models for timely disease management (Mamta *et al*., 2021).

Epidemiological studies have demonstrated that mango powdery mildew epidemics are strongly governed by short-term weather fluctuations during flowering. A seven-year field study (2012–2018) showed that disease initiation coincided with panicle emergence, with peak incidence and severity occurring between the 11th and 13th standard meteorological weeks, and that disease incidence and severity were negatively correlated with average relative humidity ($r = -0.766$ to -0.787) but positively correlated with maximum temperature ($r \approx 0.71$–0.75); stepwise regression analysis further indicated that average relative humidity alone explained 59–62% of the variability in disease development, highlighting its dominant role in epidemic progression (Bana *et al*., 2020). Complementary findings from a three-year study (2016–2019) under western Vidarbha conditions reported 31.9–47.9% disease incidence during flowering, with positive correlations with rainfall and relative humidity and a significant negative correlation with bright sunshine hours, confirming that humid, low-radiation conditions during flowering are the principal drivers of mango powdery mildew epidemics (Deshmukh *et al*., 2021).

Management of powdery mildew of mango

Fungicides in the management of mango powdery mildew

Chemical control has played a crucial role in the management of mango powdery mildew, particularly during flowering and early fruit-set stages when the crop is most vulnerable. Earlier disease management relied on inorganic fungicides such as copper compounds and sulphur, which provided limited and inconsistent control and were constrained by phytotoxicity under high temperature conditions (Palti *et al*., 1974; Prakash and Raoof, 1994). The introduction of contact fungicides such as dinocap and systemic fungicides including morpholines and benzimidazoles improved disease suppression, though their efficacy declined under high disease

Table 1: Fungicide-based management strategies for powdery mildew of mango

Fungicide group / strategy	Active ingredient(s)	Dose / formulation	Crop stage / timing	Key Findings	Location / cultivar	Reference
Systemic fungicide (Morpholine)	Tridemorph	–	Flowering	Effective disease control	India	Gupta and Yadav (1984)
Triazole (DMI)	Difenoconazole	0.05%	Flowering	97.9% disease reduction over control	–	Peterson *et al*. (1991)
Inorganic contact fungicide	Bordeaux mixture, Copper oxychloride	–	Flowering	Limited control; historical use	India	Prakash and Raoof (1994)
Contact fungicide (multisite)	Sulphur (wettable / dust)	0.2%	Flower cluster expansion to fruit set	Preventive control; inexpensive; phytotoxic above 30 °C; frequent sprays required	India, Israel	Palti *et al*. (1974); Peterson *et al*. (1991); Nelson (2008)
QoI (Strobilurin)	Trifloxystrobin	–	Bloom clusters	Best control of powdery mildew on bloom clusters	Israel	Reuveni (2000)
Contact fungicide (nitrophenol)	Dinocap	0.05%	Flower initiation to fruit set (fortnightly)	Effective in disease control under low–moderate disease pressure	Andhra Pradesh, India	Vijay and Satyanarayana (2002)
Triazole (DMI)	Penconazole	–	Pre-flowering to fruit set	Superior to non-triazoles	Punjab, cv. Dashehari	Thind *et al*. (2005)
Triazole (DMI)	Hexaconazole	0.05%	Flowering	Lowest disease incidence (21.2%); highest fruit retention	Maharashtra, cv. Kesar	Chavan *et al*. (2009)
Integrated spray schedule	Sulphur → Hexaconazole + Zineb	Sulphur 0.2%; Hexaconazole 0.1%	15–20 days interval	Disease maintained below Economic threshold	India	Shukla and Adak (2016)
Premix (DMI + QoI)	Tebuconazole + Trifloxystrob	3 bloom sprays	Flowering	>90% disease control	Pakistan	Nasir *et al*. (2017)

Premix (SDHI + DMI)	Fluopyram + Tebuconazole	750 ml ha^{-1}	Flowering	Powdery mildew incidence reduced to 25.10%	Maharashtra (Konkan)	Patil *et al*. (2017)
Fungicide strategy	Systemic + contact multisite	Rotational sprays	Flowering	Improved disease suppression; reduced resistance risk	Mexico	Pérez-Rodríguez *et al*. (2017)
QoI (Strobilurin)	Azoxystrobin 23% SC	2 ml L^{-1}	Flowering–fruit set	≈67% disease reduction; highest yield (28.63 t ha^{-1}); non-phytotoxic	Karnataka	Ravikumar *et al*. (2017)
Timing-based fungicide strategy	Sulphur / mineral oil + DMI fungicides	10-day interval	Panicles 5–10 cm	70–90% disease suppression; better than 14-day schedule	Israel	Reuveni *et al*. (2018)
Mineral oil–based fungicide	Mineral oil + D-limonene + Penconazole + Myclobutanil + Tetraconazole + Difenconazole	–	Flowering	71–86% disease reduction; Addition of D-limonene to mineral oil has improved efficacy compared to commercially available mineral oil	Israel	Reuveni *et al*. (2018)
Premix (DMI + DMI)	Pydiflumetofen + Difenoconazole	0.6 ml L^{-1}	Flowering	Minimum PDI (8.88%); 82.88% disease control	Maharashtra, cv. Alphonso	Raut *et al*. (2020)
Triazole (DMI)	Hexaconazole 5% EC	1 ml L^{-1}	Flowering	low per cent disease index (≈9–10%) and ≈83% disease control, highest fruit yield	Punjab, India	Arora *et al*. (2021)
Systemic fungicides	Tebuconazole + Trifloxystrobin, propiconazole	-	Flowering	62–63% disease reduction	Pakistan	Majeedano *et al*. (2021)
Premix (DMI + QoI)	Tebuconazole + Trifloxystrobin	0.5–0.75 g L^{-1}	Flowering	Lowest PDI (3.33–3.84%); 85.7–87.5% reduction	India	Basha *et al*. (2024)

pressure. Over the last two decades, triazole (DMI) fungicides have become central to powdery mildew management due to their protectant, curative, and eradicant properties (Thind *et al*., 2005; Chavan *et al*., 2009). More recently, strobilurins (QoIs) and premix formulations combining multiple modes of action have been evaluated to enhance control and delay resistance development, highlighting the importance of fungicide rotation and integrated disease management strategies (Reuveni et al., 2018; Arora *et al*., 2021). Key studies on fungicide-based management of mango powdery mildew are presented in Table 1.

Timing of fungicide application

Precise knowledge of the first appearance of the disease and its subsequent development, based on weather conditions and susceptibility of different developmental stages, would aid growers in ascertaining optimum timing of fungicide applications (Schoeman *et al.,* 1995). Quick identification and diagnosis of powdery mildew especially on inflorescence is very important. Unfortunately, as powdery mildew can quickly colonize the entire inflorescence, the most effective way to counter the disease is to use prophylactic control measures to prevent any losses in the forthcoming season. First disease symptoms were detected 2-3 week after 20% of the inflorescences attained the red–coloured to red–open stages. Therefore, fungicide application is necessary before 50% of the inflorescences attain the full-bloom stage. The red-coloured and red-open stages are well–defined stages in the mango and make it easier for the grower to determine when spraying should start. Further, growers should monitor the development of the inflorescences and apply the first fungicidal spray as soon as axes of inflorescences change colour (Schoeman *et al.,* 1995). According to Nelson (2008) the first spray application should be done not later than at 50% of full flowering, and spraying should continue every 7-14 days thereafter until fruit set. Cultural practices and phytosanitation can also minimize disease to certain extent, but time of application of fungicides remains the mainstay of powdery mildew disease management (Nasir *et al.,* 2014, Schoeman *et al.,* 1995).

Importantly, recent field studies from Mexico reinforce and refine these recommendations, demonstrating that fungicide applications precisely timed to the period of full bloom and early fruit set (8–15 mm) provide significantly superior disease control compared with sprays applied outside this window. Moreover, scheduling applications *in* anticipation of conducive weather conditions, rather than after disease establishment, markedly enhances fungicide efficacy, underscoring the value of epidemiology-driven, time-sensitive spray programs for effective mango powdery mildew management (Pérez-Rodríguez *et al*., 2017).

Effect of fungicide application on flowers

Several studies have documented the adverse effects of agrochemical sprays on pollen germination, fruit set, and yield in different crops. In most fruit crops, early-season fungicide applications are essential to protect susceptible floral tissues and foliage; however, the timing of these sprays often coincides with the full-bloom stage, when pollination occurs. Successful pollination in higher plants involves a sequence of critical events, including stigma receptivity, pollen transfer and adhesion, pollen germination, pollen tube growth, and subsequent fertilization leading to fruit set (Raghavan, 1978; Wetzstein and Sparks, 1989). Disruption of any of these processes can negatively affect fertilization and yield, and several fungicides have been reported to interfere with one or more of these steps. In mango, information on the effects of fungicides on pollen viability and fertilization is extremely limited, with only a single study by Dag *et al*. (2002) addressing the impact of fungicides on pollen germination. In contrast, extensive research has been conducted in apple and other temperate fruit crops. Kovach *et al*. (2000) reported that fungicides such as benomyl, captan, vinclozolin, and iprodione, when applied at bloom, significantly reduced seed number per berry and berry weight in strawberry. Similarly, Church *et al.,* (1983) demonstrated that captan and dinocap significantly inhibited pollen germination and pollen tube growth in apple flowers under orchard conditions when applied two hours after pollination.

Mechanistic studies have shown that several fungicides can inhibit pollen germination and pollen tube growth through different mechanisms. Benomyl and triazole fungicides inhibit pollen tube elongation by disrupting microtubule organization, as demonstrated in *Tradescantia* (He et al., 1995, 1996). Similarly, in cranberry, captafol and cupric hydroxide reduced pollen germination by more than 50% when applied to stigmatic surfaces one hour prior to pollination. Numerous *in vitro* studies on apple pollen have also reported inhibitory effects of fungicides such as benomyl,

Table 2: Non-chemical and integrated approaches for management of powdery mildew in mango

Category	Control agent / approach	Mode of action	Effectiveness reported	Key advantage	Limitation	Reference
Integrated disease management	Cultural practices (sanitation, removal of infected leaves and panicles)	Reduction of primary inoculum	Reduced disease severity; improved fungicide efficacy	Environmentally safe; preventive	Labour-intensive; not curative	Joubert (1991); Prakash and Mishra (1993a); Prakash and Raoof (1994)
Inorganic salts	Phosphate and potassium salts (KH_2PO_4, K_2HPO_4)	Direct antifungal action; host resistance induction	Significant reduction in powdery mildew severity	Eco-friendly; residue-free	Requires repeated sprays	Reuveni *et al*. (1994); Reuveni (1996); Mahrous (2003)
Salt–fungicide integration	Phosphate salts + DMI fungicides (penconazole, myclobutanil, diniconazole)	Contact + systemic protection	Comparable or superior control vs full-dose fungicide sprays	Resistance management; reduced residues	Requires optimized scheduling	Reuveni and Reuveni (1995); Reuveni (2000)
Commercial biofungicide	*A. quisqualis*	Hyperparasitism	Moderate to good disease control	Registered product	Limited standalone efficacy	Hofstein *et al*. (1996)
Inorganic salts	Mono-potassium phosphate (KH_2PO_4 / MKP)	Host defense induction	Effective disease suppression; allowed 50% reduction in fungicide use	Reduces fungicide load; improves nutrition	Preventive; timing dependent	Napier and Ooshyes (2000)
Biological control	*Ampelomyces quisqualis*	Hyperparasitism of powdery mildew	Reduced disease severity; increased yield	Target-specific; eco-friendly	Slow action; variable field efficacy	Sztejnberg *et al*. (1989); Kiss (2003)
Integrated bio-based approach	BCAs + KH_2PO_4 (0.5%)+ kaolin (0.5%) + antioxidants (1 mM, ascorbic acid)	Multiple modes: antagonism, physical barrier, resistance induction	Strong reduction in disease severity and conidial germination	IPM-compatible	Complex mixtures; field validation needed	Nofal and Haggag (2006)
Inorganic salts	Mono-basic potassium phosphate	Host defense induction	Significant reduction in powdery mildew severity	Eco-friendly	Requires repeated applications	Azmy (2014)

Salt–fungicide integration	Sulphur / mineral oil + DMI fungicides	Contact + systemic protection	70–90% disease suppression with 10-day spray interval	Reduced fungicide dose	Timing critical	Reuveni *et al*. (2018)
Commercial BCA	*A. quisqualis*	Hyperparasitism	Moderate to good disease control	Registered biofungicide	Limited standalone efficacy	Azmy (2014)
Biological control	*Bacillus subtilis* / *Ampelomyces quisqualis*	Antagonism & hyperparasitism	>90% disease reduction under field conditions	Eco-friendly	Repeated sprays required	Kaur *et al*. (2018)
Botanicals / natural fungicide	garlic oil + chili oil + sulphur + copper	Antifungal activity of essential oils + micronutrients	Very low disease severity (≈2–15%); 70–94% efficacy; increased yield	Eco-friendly, cost-effective	Multi-component formulation; needs validation across regions	Alkolaly *et al*. (2022)
Botanicals	Neem leaf extract (10%)	Antifungal & growth-regulating effects	Lowest disease severity (≈10.83%); 76.67% disease reduction	Organic alternative	Reduced efficacy under high disease pressure	Patel and Mahatma, (2024)
Integrated bio-nutrient approach	Organic inputs (panchagavya, vermiwash, jeevamrut)	Nutrition-mediated resistance	Reduced powdery mildew severity; improved yield and fruit quality	Suitable for organic farming	Lower efficacy than fungicides	Kulkarni *et al*. (2023); Dalvi *et al*. (2021)
Eco-friendly chemical alternatives	Acetic acid, sulphur, salicylic acid	Direct antifungal action + induction of host resistance	Acetic acid (16.5 ml L^{-1}) comparable to propiconazole; enhanced phenols, proline, PPO & POD	Residue-free; induces systemic resistance	Phytotoxicity risk at higher doses	El-Meslamany *et al*. (2020)

Table 3: Nanoparticle-based formulations for the management of powdery mildew

Nanoparticle	Particle size	Crop	Dose / application	Key outcome	Reference
Silica–silver nanoparticles	–	Cucurbits	Field application	Complete disease control within 3 weeks; phytotoxic only at very high dose	Park *et al.* (2006)
Nanosilica	–	Rose	500 mg L^{-1}	Comparable efficacy to penconazole; improved vegetative growth, floral traits, and vase life; hyphal ultrastructural damage and PAL upregulation	Elsharkawy *et al.* (2015)
Nano-silver colloids	~1.5 nm	Rose	Field spray	>95% disease suppression within 2 days; no recurrence for one week	Kim *et al.* (2008)
Silver (AgNPs)	–	Cucumber & pumpkin	100 ppm (field spray)	Strong inhibition of mycelial growth and conidial germination under field conditions	Lamsal *et al.* (2011)
	~17–23 nm	Grapevine	Foliar spray	Improved control of *Erysiphe necator*; enhanced leaf adhesion, sugar accumulation, and grape yield	Vizitiu *et al.* (2022)
Sulphur (SNPs)	50–90 nm	General	–	Developed stable nanoformulation and standardized sulphur estimation method	Choudhury *et al.* (2010); Kumar *et al.* (2011)
	–	Okra	1000 ppm (in vitro)	Minimum conidial germination (2.95%); disruption of cleistothecia; superior to commercial sulphur	Gogoi *et al.* (2013)
	~85 nm	Mango (*Mangifera indica* cv. Keitt)	100 ppm (foliar spray)	Reduced powdery mildew incidence (14.6%); markedly increased productivity (342%) and fruit quality; higher doses caused phytotoxicity	Abou El-Nasr *et al.* (2025)
	12.2–23.5 nm	Cucumber	Foliar spray	Superior disease suppression vs. bulk sulphur; efficacy comparable to systemic fungicides; highest yield and fruit quality; safe residue levels within 2 days	Abdel-Rahman and Alkolaly (2020)
Copper oxide (CuO-NPs)	–	Rose	Greenhouse application	81.71% disease control; effective in non-encapsulated form under controlled conditions	Adnan and Waleed (2025)
Chitosan (nano/ biopolymer)	Oligomer-based	Grapevine	Field & laboratory	Significant reduction of powdery mildew	Ruano-Rosa *et al.* (2022)
	–	Jalapeño pepper (*Capsicum annuum*)	0.1–0.2%	Highest control efficacy (up to 70%); disrupted spore and mycelial cell walls; effective alternative to fungicides	Jiménez-Pérez *et al.* (2024)

sulphur, thiophanate-methyl, binapacryl, bupirimate, triforine, captan, dithianon, mancozeb, zineb, and dinocap on pollen germination and tube growth (Church and Williams, 1977, 1978; Marcucci and Filiti, 1984). However, field and greenhouse studies have yielded contradictory results, with some reports indicating no significant effects of fungicides such as captan, binapacryl, dinocap, dithianon, thiophanate-methyl, and benomyl on fruit set under orchard conditions (Church and Williams, 1977). These inconsistencies may be attributed to environmental factors that modulate fungicide activity under field conditions. Despite widespread fungicide use during mango flowering, conclusive studies evaluating the effects of commonly used fungicides on pollen germination, floral fertility, and fruit set in mango are lacking, highlighting a critical gap that warrants systematic investigation.

Alternative methods of control

Alternative and integrated approaches for the management of mango powdery mildew have gained importance due to concerns over fungicide resistance, environmental safety, and negative effects on pollination and fruit set. Cultural practices such as orchard sanitation and removal of infected panicles reduce primary inoculum and enhance the effectiveness of other control measures (Joubert, 1991; Prakash and Mishra, 1993a). Among non-chemical options, inorganic salts particularly potassium and phosphate salts have shown promising results by suppressing pathogen development and inducing host resistance, either alone or in combination with reduced doses of fungicides, thereby lowering chemical inputs by up to 50% (Reuveni and Reuveni, 1995; Napier and Ooshyes, 2000). Biological control agents, especially mycoparasites such as *Ampelomyces quisqualis*, have demonstrated the ability to parasitize powdery mildew fungi and reduce disease severity across several crops, including mango, although field performance can be variable (Sztejnberg *et al*., 1989; Kiss *et al*., 2004). More recent studies indicate that integrated use of biological agents, mineral salts, and protective materials such as kaolin can significantly reduce conidial germination and disease severity under field conditions, supporting their inclusion in environmentally safe integrated disease management programs for mango powdery mildew (Table 2).

Role of nanotechnology in the management of powdery mildew

Recent advances in nanotechnology have led to the development of nanoformulations (<100 nm) with enhanced chemical reactivity and bioactivity, enabling effective disease control at very low doses (Gogoi *et al.*, 2009). Several studies have explored the formulation, characterization, and application of nanoparticles such as nanosilver, nano-sulphur, and silica–silver composites for plant disease management (Al-Samarrai, 2012; Soni and Prakash, 2012). Although relatively few studies have focused specifically on powdery mildew, available evidence indicates that nanoparticles can significantly inhibit mycelial growth, conidial germination, and pathogen development under both in vitro and field conditions. Key studies evaluating nanoparticle-based interventions against powdery mildew are summarized in Table 3.

CONCLUSION

Mango powdery mildew is one of the most serious diseases of mango affecting almost all the cultivars, causes poor fruit setting and up to 90 percent crop loss occurs during flowering time every year and the severity depends on prevailing weather conditions. The critical flowering stage particularly full bloom and fruit set stages are most susceptible for infection; therefore, all management efforts have to be concerted to protect these stages from pathogen. With advent of new safer and effective molecules, chemical management still remains the mainstay of powdery mildew management in mango. Apprehensions about using fungicides is growing based on the evidence that the powdery mildew pathogen is developing resistance against some systemic fungicides and application of fungicides during full blooms may hinder pollination and fruit set. Further, risks associated with fungicide residues on fruits have highlighted the need for more effective and safer alternative control measures. Biocontrol of powdery mildew pathogen by *A. quisqualis* has been established on several crops. Though efficacy of *Ampelomyces* mycoparasites is reported to be different on different crops, it’s applicability on mango has not yet been evaluated under Indian conditions. This mycoparasite is known to have problems with the efficacy at lower humidity levels and due to their slow development on powdery mildew colonies. However, as Indian mangoes are normally cultivated in high humid areas, *Ampelomyces* might still be an appropriate candidate for management strategy against mango powdery mildew in India. While there is ample of information pertaining to the characterisation of the pathogen, there is still a need to develop integrated management module to manage powdery mildew of mango with more of non– chemical components.

ACKNOWLEDGEMENT

All authors are thankful to ICAR, New Delhi, ICAR-Indian Institute of Horticultural Research, Bengaluru for the support and encouragement.

AUTHOR'S CONTRIBUTION

SG, SML, SS- conceptualisation, writing the original draft, SG and SS final draft correction.

CONFLICT OF INTEREST

Authors do not have conflicts of interest to express

REFERENCES

Abdel-Rahman, H. R. and Alkolaly, A. M. A. 2020. Comparative studies on nanosulfur and certain fungicides to control cucumber powdery mildew disease and their residues in treated fruits. *Scientific Exchange Journal*, **41**: 54–70.

Abou El-Nasr, M. K., Nasser, M. A., Ebrahim, M. and Samaan, M. S. 2025. Alleviating biotic stress of powdery mildew in mango cv. Keitt by sulphur nanoparticles and assessing their effect on productivity and disease severity. *Scientific Reports*, **15**(1): 5537.

Adnan, I. and Waleed, M. 2025. Evaluation of the effectiveness of biologically synthesized copper and zinc nanoparticles in controlling powdery mildew on *Rose hybrida*. *Natural Engineering Sciences*, **10**: 552–562.

Agrios, G. N. 2005. *Plant Pathology*. 5th edn. Elsevier Academic Press, Burlington, Massachusetts.

Akhtar, K. P., Khan, M. A., Kazmi, M. R., Hussain, R. I., Fatima, B. 1999. Preventive control of powdery mildew disease of mango. *Agricultural Sciences, Sultan Qaboos University Journal of Scientific Research*, **4**: 23–28.

Alkolaly, A. M., Hassan, R. A. and Monir, G. A. 2022. Impact of powdery mildew and sooty mold diseases on mango by natural fungicide. *International Journal of Scientific Research Updates*, **3**(2): 127–133.

Al-Samarrai, A. M. 2012. Nanoparticles as alternative to pesticides in management of plant diseases – a review. *International Journal of Scientific and Research Publications*, **2**: 1–4.

APHU. 2008–09. *Annual Report*. Andhra Pradesh Horticultural University, Andhra Pradesh, India.

Arora, A., Singh, H., Kaur, Y., Singh, M., Kaur, S. 2021. Management of powdery mildew (*Oidium mangiferae*) of mango with fungicides. *Plant Disease Research*, **36**: 58–61.

Azmy, A. M. 2014. Controlling of mango powdery mildew by some salts, growth regulators and the biofungicide AQ10 compared with punch fungicide in Egypt. *American Journal of Life Sciences*, **2**(6-2): 33–38.

Bana, J. K., Choudhary, J. S., Ghoghari, P. D., Sharma, H., Kumar, S. and Patil, S. J. 2020. Influence of weather parameters on powdery mildew of mango inflorescence in humid tropics of South Gujarat. *Journal of Agrometeorology*, **22**(4): 488–493.

Basha, C. R. J., Manjula, C. P., Bevanur, A. and Indhu, P. 2024. Bioefficacy of novel chemical fungicides for management of mango powdery mildew. *Journal of Advances in Biology & Biotechnology*, **27**(9): 325–332.

Braun, U. 1987. *A Monograph of the Erysiphales (Powdery Mildews)*. *Beihefte zur Nova Hedwigia*, **89**: 1–700.

Braun, U. and Cook, R. T. A. 2012. Taxonomic Manual of the Erysiphales (Powdery Mildews). CBS Biodiversity Series No. 11, CBS-KNAW Fungal Biodiversity Centre, Utrecht, The Netherlands, pp. 1–707.

Braun, U. and Takamatsu, S. 2000. Phylogeny of *Erysiphe*, *Microsphaera*, *Uncinula* (Erysipheae) and *Cystotheca*, *Podosphaera*, *Sphaerotheca* (Cystotheceae) inferred from rDNA ITS sequences – some taxonomic consequences. *Schlechtendalia*, **4**: 1–33.

Briton-Jones, H. R. 1923. Mycological work in Egypt during the period 1920–1922. Ministry of Agriculture, Egypt, Technical Series Bulletin No. 49, pp. 1–129.

Burnett, H. C. 1975. Powdery mildew of mango. Plant Pathology Circular No. 156, Florida Department of Agriculture and Consumer Services, Division of Plant Industry.

Butt, D. J. 1978. Epidemiology of powdery mildews. In: Spencer, D. M. (Ed.), *The Powdery Mildews*. Academic Press, London, pp. 51–81.

Chadha, K. L. 1993. Fruit drop in mango. In: K. L. Chadha and O. P. Pareek (eds.), *Advances in Horticulture*. Malhotra Publishing House, New Delhi, **3**: 1131–1166.

Chavan, R. A., Deshmukh, V. D., Tawade, S. V. and Deshmukh, J. D. 2009. Efficacy of fungicides for managing powdery mildew of mango. *International Journal of Plant Protection*, **2**(1): 71–72.

Choudhury, R. S., Nair, K. K., Kumar, R., Gogoi, R., Srivastava, C., Gopal, M., Subhramanyam, B. S., Devakumar, C. and Arunava Goswami, A. 2010. Nanosulfur: a potent fungicide against food pathogen *Aspergillus niger*. *AIP Conference Proceedings*, **1276**: 154–157.

Church, R. M. and Williams, R. R. 1977. The toxicity to apple pollen of several fungicides, as demonstrated by in vivo and in vitro techniques. *Journal of Horticultural Science*, **52**: 429–436.

Church, R. M. and Williams, R. R. 1978. Fungicide toxicity to apple pollen in the anther. *Journal of Horticultural Science*, **53**: 91–94.

Church, R. M., Morgan, N. G., Cooke, B. K. and Williams, R. R. 1983. The effects of spray volume on the toxicity of captan and dinocap to apple pollen in the orchard. *Journal of Horticultural Science*, **58**: 165–168.

CISH. 2013–14. *Annual Report*. Central Institute for Subtropical Horticulture, Lucknow, India.

Cook, A. A. 1975. Diseases of Tropical and Subtropical Fruits and Nuts. Hafner Press, New York.

Cunnington, J. H., Takamatsu, S., Lawrie, A. C., Pascoe, I. G. 2003. Molecular identification of anamorphic powdery mildews (Erysiphales). *Australasian Plant Pathology*, **32**: 421–428.

Dag, A., Eisenstein, D., Gazit, S. 2002. The effect of fungicides used to control powdery mildew in mango on pollen germination and pollen tube growth. In: *Proceedings of the 45th International Society for Tropical Horticulture*, Lima, Peru.

Dalvi, M. B., Patil, P. D., Pawar, H. D., Raut, R. A., Bhure, S. S. and Desai, V. S. 2021. Efficacy of different bio-organics for the management of important diseases of mango (*Mangifera indica* L.). *Crop Research*, **56**(6): 308–312.

Datar, V. V. 1983. Reaction of mango varieties to powdery mildew incited by *Oidium mangiferae*. *Indian Journal of Mycology and Plant Pathology*, **13**: 111–112.

Deshmukh, P. L., Bharad, S. G., Mane, S. S., Panchbhai, D. M. and Kale, V. S. 2021. Influence of weather parameters on powdery mildew and malformation incidence in different mango (*Mangifera indica* L.) cultivars under western Vidarbha region of Maharashtra. *Research on Crops*, **22**(1): 171–177.

El-Meslamany, R. A., Abd-Elkader, D. A. and Atia, M. M. 2020. Efficacy of eco-friendly compounds in enhancing biochemical resistance of mango to powdery mildew disease. *Plant Archives*, **20**(1): 1755–1764.

Elsharkawy, M. M., El-Kot, G. A. N. and Hegazi, M. 2015. Management of rose powdery mildew by nanosilica, diatomite and bentocide. *Egyptian Journal of Biological Pest Control*, **25**: 545–553.

Felix Gastelum, R., Herrera Rodríguez, G., Martínez Valenzuela, C., Longoria Espinoza, R. M., Maldonado Mendoza, I. E., Quiroz Figueroa, F. R., Martínez Álvarez, J. C., García Pérez, L. M., Espinosa Matías, S. 2013. First report of powdery mildew (*Pseudoidium anacardii*) of mango trees in Sinaloa, Mexico. *Plant Disease*, **97**: 994.

Galloway, L. D. 1935. New plant diseases recorded in 1934. *International Bulletin of Plant Protection*, **9**: 176–268.

Gogoi, R., Dureja, P., Singh, P. K., 2009. Nanoformulations– a safer and effective option for agrochemicals. *Indian Farming*, **59**: 7–12.

Gogoi, R., Singh, P. K., Kumar, R., Nair, K. K., Alam, I., Srivastava, C., Yadav, S., Gopal, M., Choudhury, S.R. and Goswami, A. 2013. Suitability of nano-sulphur for biorational management of powdery mildew of okra (*Abelmoschus esculentus* Moench) caused by *Erysiphe cichoracearum*. *Journal of Plant Pathology and Microbiology*, **4**: 171.

Gorter, G. J. M. A. 1984. The identity of oak powdery mildew in South Africa. *South African Forestry Journal*, **129**: 81–82.

Gupta, J. H. 1976. Reaction of mango varieties to powdery mildew (*Oidium mangiferae*) in Uttar Pradesh. *Progressive Horticulture*, **8**: 63–64.

Gupta, J. H. 1988. Dispersal of *Oidium mangiferae* Berthet causing powdery mildew of mango. *Progressive Horticulture*, **20**: 341–342.

Gupta, J. H. 1989. Perpetuation and epidemiology of powdery mildew of mango. *Acta Horticulturae*, **231**: 528–533.

Gupta, J. H. and Yadav, A. S. 1984. Chemical control of powdery mildew of mango. *Indian Journal of Mycology and Plant Pathology*, **14**: 297–298.

Gupta, P. C. and Dang, J. K. 1980. Occurrence and control of powdery mildew of mango in Haryana. *Indian Phytopathology*, **33**: 631–632.

He, Y., Wetzstein, H. Y., Palevitz, B. A. 1995. Effects of a triazole fungicide on pollen germination, tube growth and cytoskeleton distribution in *Tradescantia virginiana*. *Sexual Plant Reproduction*, **8**: 210–216.

He, Y., Wetzstein, H. Y., Palevitz, B. A. 1996. Pollen germination, tube growth and morphology, and microtubule organization after exposure to benomyl. *Physiologia Plantarum*, **95**: 39–44.

Hewitt, H. G. 1998. *Fungicides in Crop Protection*. CAB International, Wallingford, UK.

Hofstein, R., Daoust, R. A., Aeschlimann, J. P. 1996. Constraints to the development of biofungicides: the example of “AQ10”, a new product for controlling powdery mildews. *Entomophaga*, **41**: 455–460.

Ihsan, J., Ahmed, I., Sajid, M., Muhammad, F., Saleem, A. 1999. Incidence of powdery mildew of mango in the Punjab and evaluation of protective and curative fungicides for the control of disease. *Pakistan Journal of Phytopathology*, **11**: 67–69.

Iqbal, S., Atiq, M., Fayyaz, M., Ahmad, I. and Ahmad, S. 2024. Powdery mildew of mango: current status, perspectives and emerging tools for management. *Asian Journal of Agriculture and Biology*, **12**(2): 1–12.

Jiménez-Pérez, O., Gallegos-Morales, G., Espinoza-Ahumada, C. A., Delgado-Luna, C., Rangel, P. and Espinosa-Palomeque, B. 2024. Potential of chitosan for the control of powdery mildew (*Leveillula taurica* (Lév.) Arnaud) in a jalapeño pepper (*Capsicum annuum* L.) cultivar. *Plants*, **13**: 915.

Johnson, G. I. 1994. Powdery mildew. In: Ploetz, R. C. (Ed.), *Compendium of Tropical Fruit Diseases*. American Phytopathological Society, St. Paul, Minnesota, pp. 38–39.

Joubert, M. H. 1991. Implications of epidemiological studies on strategies for control of powdery mildew and anthracnose. In: *South African Mango Growers' Association Yearbook*, **11**: 26–28.

Joubert, M. H., Manicom, B. Q., Wingfield, M. J. 1993. Powdery mildew of mango in South Africa: a review. *Phytophylactica*, **25**: 59–63.

Kaur, L. 2020. Management of powdery mildew (*Oidium mangiferae* Berthet) of mango through divergent germplasm. *Plant Cell Biotechnology and Molecular Biology*, **21**(67–68): 47–53.

Kaur, L., Gupta, B., Sharma, I. M. and Joshi, A. K. 2018. Eco-friendly management of powdery mildew of mango through biocontrol agents. *International Journal of Current Microbiology and Applied Sciences*, **7**(10): 392–396.

Kim, H. S., Kang, H. S., Chu, G. J. and Byun, H.S. 2008. Antifungal effectiveness of nanosilver colloid against rose powdery mildew in greenhouses. *Solid State Phenomena*, **135**: 15–18.

Kiss, L. 2003. A review of fungal antagonists of powdery mildews and their potential as biocontrol agents. *Pest Management Science*, **59**: 475–483.

Kiss, L., Russell, J., Szentiványi, O., Xu, X. and Jeffries, P. 2004. Biology and biocontrol potential of *Ampelomyces* mycoparasites, natural antagonists of powdery mildew fungi. *Biocontrol Science and Technology*, **14**: 635–651.

Kotze, J. M. 1985. Powdery mildew of mangoes. In: *South African Mango Growers' Association Yearbook*, **5**: 25–26.

Kovach, J., Petzoldt, R., Harman, G. E. 2000. Use of honey bees and bumble bees to disseminate

Trichoderma harzianum to strawberries for *Botrytis* control. *Biological Control*, **18**: 235–242.

Kulkarni, S., Chavan, T. and Vijaykumar, K. N. 2023. Management of mango powdery mildew through potential organic products. *International Journal of Bio-resource and Stress Management*, **14**(5): 756–761.

Kumar, R., Nair, K. K., Alam, M. I., Gogoi, R., Singh, P. K., Srivastava, C., Yadav, S., Gopal, M., Roy Chaudhary, S., Pradhan, S., Goswami, S. A. 2011. Simple method for estimation of sulphur in nanoformulations by UV spectrophotometry. *Current Science*, **100**: 1542–1546.

Lamsal, K., Kim, S. W., Jung, J. H., Kim, Y. S., Kim, K. S., Lee, Y. S. 2011. Inhibition effects of silver nanoparticles against powdery mildews on cucumber and pumpkin. *Mycobiology*, **39**: 26–32.

Limkaisang, S., Cunnington, J. H., Wui, L. K., Salleh, B., Sato, Y., Divarangkoon, R., Fangfuk, W., To-Anun, C. and Takamatsu, S. 2006. Molecular phylogenetic analyses revealed a close relationship between powdery mildew fungi on several tropical trees and *Erysiphe alphitoides*, an oak powdery mildew. *Mycoscience*, **47**: 327–335.

Lonsdale, J. H. and Kotze, J. M. 1993. Chemical control of mango blossom diseases and the effect on fruit set and yield. *Plant Disease*, **77**: 558–562.

Mahrous, H. A. H. 2003. Effectiveness of foliar spraying with phosphate salts fertilizer, sodium bicarbonate and a fungicide in controlling powdery mildew disease of grapevine. *Journal of Agricultural Science*, **28**: 7043–7049.

Majeedano, A. Q., Jiskani, A. M., Khaskheli, M. I., Jiskani, M. M., Majidano, T. and Shah, S. S. A. 2021. Fungicide efficacy for control of mango powdery mildew caused by *Oidium mangiferae*. *International Journal on Emerging Technologies*, **12**(1): 80–86.

Mamta, K. P., Singh and Pandey, S. 2021. Multiple regression analysis for prediction of powdery mildew in mango (*Mangifera indica* L.). *Biological Forum – An International Journal*, **13**(3): 648–651.

Marcucci, M. C. and Filiti, N. 1984. Germination of pear and apple pollen as influenced by fungicides. *Gartenbauwissenschaft*, **49**: 29–32.

Misra, A. K. 2001. Powdery mildew – a serious disease of mango. *Journal of Applied Horticulture*, **3**: 63–68.

Misra, A. K. and Prakash, O. 1995. Epidemiological parameters of mango powdery mildew. In: *Proceedings of the Annual Conference and Symposium on Recent Trends in Management of Biotic and Abiotic Stresses in Plants*. H.P.K.V., Palampur, India.

Mougy, E. L., Abdel, S. N., Kader, M. M., Lashin, S. M. 2014. Protective foliar approaches against downy and powdery mildews of cantaloupe under plastic house conditions. *International Journal of Engineering and Innovative Technology*, **3**(9): 324–329.

Napier, D. R. and Ooshyse, S. A. 2000. Use of mono potassium phosphate in the integrated control of powdery mildew. *Rivista di Frutticoltura e di Ortofloricoltura*, **62**: 57–60.

Naqvi, S. A. H., Perveen, R., Manzoor, S. A., Umar, H. M. I., Iqbal, M. T., Liaquat, F., Majid, T., Irshad, A., et al. 2014. Evaluation of various mango varieties against the infection dynamics of powdery mildew (*Oidium mangiferae* Bert.). *American Journal of Plant Science*, **5**: 2372–2377.

Nasir, M., Iqbal, B., Idrees, M., Sajjad, M., Niaz, M. Z., Anwar, H., Shehzad, M. A. and Tariq, A. H. 2017. Efficacy of some organic fungicides against anthracnose and powdery mildew of mango. *Pakistan Journal of Agricultural Sciences*, **54**(3): 489–496.

Nasir, M., Mughal, S. M., Mukhtar, T. and Awan, M. Z. 2014. Powdery mildew of mango: A review of ecology, biology, epidemiology and management. *Crop Protection*, **64**: 19-26.

Nelson, S. C. 2008. Mango powdery mildew. In: *College of Tropical Agriculture and Human Resources*, Department of Plant and Environmental Protection Sciences, University of Hawaii at Mānoa, *Plant Disease*, PD–46.

Nofal, M. A. and Haggag, W. M. 2006. Integrated management of powdery mildew of mango in Egypt. *Crop Protection*, **25**: 480–486.

Palti, J., Pinkas, Y., Chorin, M. 1974. Powdery mildew of mango. *Plant Disease Reporter*, **58**: 45–49.

Park, H. P., Kim, S. H., Kim, H. J., Choi, H. S. 2006. A new composition of nanosized silica–silver for control of various plant diseases. *Plant Pathology Journal*, **22**: 295–302.

Patel, R. C. and Mahatma, L. 2024. Evaluation of botanicals against powdery mildew (*Oidium mangiferae* Berthet) of mango (*Mangifera indica* L.). *Asian Journal of Advances in Agricultural Research*, **24**(12): 59–64.

Patil, P. D., Raut, R. A., Karande, R. A. and Haldavanekar, P. C. 2017. Bio-efficacy and phytotoxicity study of fungicide fluopyram 200 + tebuconazole 200–400 SC against powdery mildew and postharvest diseases of mango. *International Journal of Chemical Studies*, **5**: 667–670.

Pérez-Rodríguez, A., Monteón-Ojeda, A., Mora-Aguilera, J. A. and Hernández-Castro, E. 2017. Epidemiology and strategies for chemical management of powdery mildew in mango. *Pesquisa Agropecuária Brasileira*, **52**(9): 715–723.

Peterson, R. A., Schipke, L. G., Clarkson, P. R. 1991. Significance of two mango flower diseases in the dry tropics. *Acta Horticulturae* (ISHS), **291**: 338–345.

Ploetz, R. C. 2003. Diseases of mango. In: Ploetz, R. C. (Ed.), *Diseases of Tropical Fruit Crops*. CABI Publishing, Oxford, U.K., pp. 327–363.

Ploetz, R. C. and Ploetz, R. 2003. Diseases of mango. In: *Diseases of Tropical Fruit Crops*. CABI Publishing, Wallingford, U.K., pp. 327–363.

Ploetz, R. C. and Prakash, O. 1997. Foliar, floral and soil-borne diseases. In: *Diseases of Tropical Fruit Crops*. CAB International, Wallingford, U.K., pp. 28–326.

Prakash, O. 1998. Diseases of mango. In: Srivastava, R. P. (Ed.), *Mango cultivation*. International Book Publishing Co., Publishing Division, Lucknow, U.P., India, pp. 409–505.

Prakash, O. 2004. Diseases and disorders of mango and their management. In: Naqvi, S. A. M. H. (Ed.), *Diseases of Fruits and Vegetables*, Vol. 1. Kluwer Academic Publishers, Dordrecht, pp. 511–620.

Prakash, O. and Misra, A. K. 1986. Evaluation of mango germplasm against powdery mildew under natural conditions. *Annual Report*, CIHNP, Lucknow, pp. 62–63.

Prakash, O. and Misra, A. K. 1993. Fungal diseases of sub-tropical horticultural fruit crops. In: Chadha, K. L. (Ed.), *Advances in Horticulture*. Malhotra Publishing House, New Delhi, pp. 1275–1372.

Prakash, O. and Raoof, M. A. 1985. Perpetuation of powdery mildew of mango. *Indian Journal of Plant Pathology*, **3**: 273–274.

Prakash, O. and Raoof, M. A. 1994. Studies on powdery mildew (*Oidium mangiferae*) disease of mango: distribution, perpetuation, losses and chemical control. *Biological Memoirs*, **20**: 31–45.

Prakash, O. and Srivastava, K. C. 1987. *Mango diseases and their management: A world review*. Today and Tomorrow Printers and Publishers, New Delhi, p. 175.

Prakash, O., Kalra, S. K., Tandon, D. K., Raoof, M. A. 1989. Incidence of powdery mildew in mango panicles and associated biochemical changes. *Indian Phytopathology*, **42**: 185–186.

Raghavan, V. 1997. *Molecular embryology of flowering plants*. Cambridge University Press, Cambridge.

Raut, R. A., Dalvi, M. B., Dheware, R. M., Munj, A. Y., Sanas, M. P., Shedge, M. S. and Baviskar, S. B. 2020. Efficacy of pydiflumetofen 7.5% + difenoconazole 12.5% against anthracnose and powdery mildew diseases in mango cv. Alphonso. *Journal of Plant Disease Sciences*, **15**: 112–115.

Raut, R. A., Patil, P. D., Haldavnekar, P. C., Munj, A. Y., Baviskar, S. B. and Sanas, M. P. 2017. Epidemiological studies on mango powdery mildew (*Oidium mangiferae* Berthet) cv. Alphonso. *International Journal of Chemical Studies*, **5**(3): 525–526.

Ravikumar, M. R., Vithal, N., Yashaswini, S. and Tippesh, C. 2017. Bio-efficacy and phytotoxicity of azoxystrobin 23% SC against powdery mildew (*Oidium mangiferae*) and anthracnose (*Colletotrichum gloeosporioides*) diseases in mango. *International Journal of Current Microbiology and Applied Sciences*, **6**(10): 314–321.

Rawal, R. D. 1998. Management of fungal diseases in tropical fruits – Part IV: Diseases and pests – diversity and management: perpetuation and epidemiology of powdery mildew of mango. *Acta Horticulturae* (ISHS), **231**: 528–533.

Reuveni, M. 2000. Efficacy of trifloxystrobin (Flint), a new strobilurin fungicide, in controlling powdery mildews on apple, mango and nectarine and rust on prune trees. *Crop Protection*, **19**: 335–341.

Reuveni, M. and Reuveni, R. 1995. Efficacy of foliar sprays of phosphates in controlling powdery mildews in field-grown nectarine, mango trees and grapevines. *Crop Protection*, **14**: 311–314.

Reuveni, M., Agapov, V., Reuveni, M. 1996. Controlling powdery mildew caused by *Sphaerotheca fuliginea* in cucumber by foliar sprays of phosphate and potassium salts. *Crop Protection*, **15**: 49–53.

Reuveni, M., Agapov, V., Reuveni, M., Raviv, M. 1994. Effects of foliar sprays of phosphates on powdery mildew (*Sphaerotheca pannosa*) of roses. *Journal of Phytopathology*, **142**: 331–337.

Reuveni, M., Gur, L. and Farber, A. 2018. Development of improved disease management for powdery mildew on mango trees in Israel. *Crop Protection*, **110**: 221–228.

Romero, D., Rivera, M. E., Cazorla, F. M., de Vicente, A., Pérez-García, A. 2003. Effect of mycoparasitic fungi on the development of *Sphaerotheca fusca* in melon leaves. *Mycological Research*, **107**: 64–71.

Ruano-Rosa, D., Sánchez-Hernández, E., Baquero-Foz, R., Martín-Ramos, P., Martín-Gil, J., Torres-Sánchez, S. and Casanova-Gascón, J. 2022. Chitosan-based bioactive formulations for the control of powdery mildew in viticulture. *Agronomy*, **12**: 495.

Ruehle, G. D. and Ledin, R. B. 1956. *Mango growing in Florida*. University of Florida Agricultural Experiment Station, Bulletin No. 57.

Schepers, H.T.A.A. 1983. Decreased sensitivity of *Sphaerotheca fuliginea* to fungicides which inhibit ergosterol biosynthesis. *Plant Pathology*, **32**: 185–187.

Schoeman, M. H., Manicom, B. Q., Wingfield, M. J. 1995. Epidemiology of powdery mildew in mango blossoms. *Plant Disease*, **79**: 524–528.

Shukla, P. K. and Adak, T. 2016. Seasonal dynamics of powdery mildew of mango and its management under subtropics. *GERF Bulletin of Biosciences*, **7**: 10–16.

Singh, L. B. 1960. *The mango: botany, cultivation and utilization*. Interscience Publishers Inc., New York.

Singh, R. and Singh, V. 2023. Climate change and its impact on mango pests and diseases: A brief review. *Journal of Agrometeorology*, **25**(3): 357–365.

Singh, R. S. 2000. Powdery mildew of mango. In: *Diseases of Fruit Crops*. Oxford and IBH Publishing Co., New Delhi, pp. 157–159.

Sinha, P., Chakrabarti, U., Varma, A. 2001. Critical weather factors for the development of mango powdery mildew. *Annals of Plant Protection Sciences*, **9**: 264–267.

Sinha, P., Prajneshu, Varma, A. 2004. Statistical modelling and forecasting of powdery mildews affecting agricultural crops: An overview. *Journal of the Indian Society of Agricultural Statistics*, **57**: 257–270.

Soni, N. and Prakash, S. 2012. Efficacy of fungus-mediated silver and gold nanoparticles against *Aedes aegypti* larvae. *Parasitology Research*, **110**: 175–184.

Sridhar, T. S. and Sohi, H. S. 1973. Powdery mildew of mango and its control. *Indian Phytopathology*, **26**: 362–363.

Sztejnberg, A., Galper, S., Mazar, S., Lisker, N. 1989. *Ampelomyces quisqualis* for biological and integrated control of powdery mildews in Israel. *Journal of Phytopathology*, **124**: 285–295.

Takamatsu, S. and Kano, Y. 2001. PCR primers useful for nucleotide sequencing of rDNA of the powdery mildew fungi. *Mycoscience*, **42**: 135–139.

Takamatsu, S., Braun, U., Limkaisang, S., Kom-Un, S., Sato, Y., Cunnington, J. H. 2007. Phylogeny and taxonomy of the oak powdery mildew *Erysiphe alphitoides* sensu lato. *Mycological Research*, **111**: 809–826.

Thind, S. K., Josan, J. S., Vij, V. K. 2005. Fungicidal management of powdery mildew of mango in Punjab, India. In: *Proceedings of the International Conference on Mango and Date Palm: Culture and Export*, 20–23 June 2005, University of Agriculture, Faisalabad, Pakistan.

Uppal, B. N. 1937. Summary of work done under the Plant Pathologist, Bombay Presidency, Poona, for the year 1935–36. *Report of the Department of Agriculture, Bombay*, pp. 203–207.

Vijaya, N. and Satyanarayana, G. 2002. *Advances in mango research: Mango research in Andhra Pradesh*. Acharya N. G. Ranga Agricultural University, Fruit Research Station, Sangareddy, Medak District, Andhra Pradesh.

Vizitiu, D. E., Sardarescu, D. I., Fierascu, I., Fierascu, R. C., Soare, L. C., Ungureanu, C., Buciumeanu, E. C., Guta, I. C. and Pandelea, L. M. 2022. Grapevine plants management using natural extracts and phytosynthesized silver nanoparticles. *Materials*, **15**: 8188.

Wagle, P. V. 1928. Studies in the shedding of mango flowers and fruits. Part I. *Memoirs of the Department of Agriculture, India (Botanical Series)*, **8**: 219–249.

Weinhold, A. R. 1961. The orchard development of peach powdery mildew. *Phytopathology*, **51**: 478–481.

Wetzstein, H. Y. and Sparks, D. 1989. Stigma–pollen interactions in pecan (*Carya illinoensis*). *Journal of the American Society for Horticultural Science*, **114**: 355–359.

Yadav, R. K., Sarolia, D. K., Singh, V., Kaushik, R. A. 2014. Flowering and fruiting behavior of mango cultivars in relation to weather parameters. In: Ravikumar, H., et al. (Eds.), *Souvenir, National Seminar cum Workshop on Physiology of Flowering in Perennial Fruit Crops*, pp. 275–278.

MS Received: 02 January 2026
MS Acceptance: 28 April 2026