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Bacterial Blight of Pomegranate and its Control Measures: A Review

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Abstract

India's most important cash crop is the pomegranate. It is one of the most demanding fruits due to its antioxidant, antiviral and antitumor activities and serves as a good source of essential vitamins and other nutrients. It is important to maintain the quality of pomegranate at a superior level. It is susceptible to many microorganisms including bacteria, fungi, etc. which degrades the quality of the fruit and results in nutritional and economic losses. *Botrytis cinerea, Alternaria alternata, Penicillium implicatum, Coniella granati, Aspergillus niger, Emericella variecolor, and Botrytis spp.* are the main causative agents of pomegranate diseases such as Black spot disease, Alternaria internal black rot, Black spot, Blackheart, heart rot, fruit rot, grey mould rot, Wilt, Endophyte and blue mould fruit rot. The most damaging pomegranate disease is bacterial blight. To maintain fruit quality, certain measures are to be followed like adaptation to different control methods during different phases of plant growth. Nowadays, there is a high demand for green and cost-effective strategies to control diseases over chemical agents. This review mainly focuses on the causes and causative microorganisms of many pomegranate diseases and a wide range of disease prevention and control strategies for pomegranate plants.

Key words: Pomegranate diseases, Fruit quality, Biopesticides, *Punica granatum*, Green approach

One of the most significant fruit crops worldwide, particularly in dry and semi-arid regions, is the pomegranate. This is mostly because of their toughness, flexibility in adapting to various environmental variables, low maintenance needs, dependable but high yields, remarkable preservation capabilities and medicinal benefits. In India, it has been challenging to expand the pomegranate-growing region because of temperature variations that might force plants to enter a resting phase when irrigation potential is often low. One of the most beneficial sources of antioxidants is pomegranates because of their excellent medical and nutritional worth. Date palm, fig, olive, grape and pomegranate are the first five fruits known to have been cultivated by humans [1].

Maharashtra is the country's largest producer of pomegranates, with 147.91 hectares under cultivation and an annual production of 1789.46 million tonnes. In Maharashtra, the most productive districts for pomegranate cultivation are Nashik (38.80 hectares under cultivation, 628.11 million tonnes produced annually), Solapur (25.50 hectares, 229.50 million tonnes annually), Ahmednagar (21.50 hectares 215.00 million annually), and Pune (13.50 hectares, 136.00 million annually) [2]. Pomegranate production was profitable for growers prior to outbreaks of bacterial blight in Maharashtra, with incomes per hectare ranging from 60,000 to 100,000 rupees. Since 2002 pomegranate prices have suddenly decreased due to the bacterial blight's predominance which has an impact on the fruit's quality and yield. Due to the disease's persistence and prevalence, pomegranate production will cease. So, it's important to develop efficient control strategies to increase yield [3].

It is now vital to concentrate on developing pre/post-harvest strategies for crop enhancement as a number of diseases that lead to pre- and post-harvest rots and deterioration, can have an impact on the long-term preservation of pomegranates. The tissue of the fruits is frequently damaged by these diseases which makes the fruit unfit for sale. This could lead to pomegranate losses due to numerous bacterial and fungal species [4-5]. The ability of the pomegranate fruit to be commercially marketed is also constrained by physiological problems such as breaking, freezing injury, husk scald and extreme weight loss [6]. Shelf life is one of the most important factors to consider while planning transportation.

Postharvest treatment practices have an impact on both the overall quality and shelf life of pomegranate fruits. Due to inadequate facilities available for packaging and storing of pomegranates in India losses may range from 25 to 38 percent [7-8]. Fruit shortages resulting from post-harvest losses affect both growers and consumers. Fruit producers' capacity to maintain and expand market share is hampered by postharvest losses, which leads to financial losses and price hikes [9-11]. Reduced availability and higher prices for consumers are the results of losses due to higher unit costs of fruit marketing and transportation as well as higher production costs of fruit that never gets to the consumer.

It also affects the nutritional quality of fruits and climatic conditions have an influence on storage. The losses also make it more difficult for the food to maintain and improve its nutritious value [12]. The storage may also be impacted by the climate. Fungal infections can spread over fruit that has been packed during cold storage [13-14].

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The term "fruit disease" refers to a group of diseases that result from plant material becoming infected and manifest because of both external and internal symptoms. Fruit surface rots, inner fruit infections, and stem end rots are the three main types of infectious diseases that affect fruit [15]. All growing situations are prone to fruit diseases, which can significantly reduce yields. 10 to 25 percent of postharvest losses are due to infections [16-17]. An entire orchard or fruit supply can be devastated by a severe disease outbreak in a short period of time [18-19].

Flowers can become infected via essential or non-essential whorls, also referred to as accessory whorls, such as the petals, stigmas, styles, or stamens; infect to fruit via stigmata, pedicels, wounds (caused by insect escape holes, bird pecks, thorn punctures, and natural breaking); or directly through the cuticle. These are some of the routes that microorganisms can enter pomegranate fruit [20]. Disease infections can spread through direct contact when healthy and infected fruit which are packaged together [21]. Diseases typically associated to losses in postharvest storage of pomegranates are frequently ignored because of the slow development and appearance of late symptom of quiescent pathogens [22]. Pathogens infect the fruit while it is in the developing stage.

In order to create efficient and long-term management plans, it is essential to understand the occurrence and impact of diseases.

Pathogens of pomegranate fruit

Pomegranate is susceptible to many pathogens which affect the quality and quantity of crops by various fungal and bacterial infections. Fungal pathogens are *Botrytis cinerea* (grey mold rot), *Alternaria alternata* (heart rot), *Aspergillus niger* (Tiegh), blue/green mold rot (*Penicillium* spp.), *Coniella granati*, *Colletotrichum gloeosporioides* and *Pestalotiopsis versicolor*. *Xanthomonas axonopodis pv punicae*, *Pseudomonas* [23] which are the causative agents of bacterial blight of pomegranate have been implicated in causing severe pre-harvest infections of pomegranate alongside *B. cinerea* [24], *Penicillium* spp. [25], *Al. alternata* [26], *C. granati* [27], which causes wood canker and branch dieback [28-29]. Severe branch dieback and wood canker of pomegranate were reported in Tunisia with symptoms including yellowing of leaf, canker formation and wood lesions [30]. Pomegranate pre-harvest disease infections can be dormant for a long period of time before becoming symptomatic during postharvest storage [31]. These pathogens lead to fruit spoilage and facilitate fruit rind and aril decay during storage [32].

Disease symptoms of pomegranate

Pomegranate is prone to a variety of bacterial and fungal infections, which can affect various locations of crops and cause significant harm. Wilting, stunted growth, weakened vigor, limb dieback, and overall tree degeneration are all signs that pomegranate fruit plants are diseased [33]. Occasionally, the wilting of the entire plant that results from leaf symptoms (such as discoloration, blotches, and lesions) can be seen [34-36]. Pomegranate fruit diseases can be seen as surface rots, shriveling, browning, and the appearance of unfavorable traits like spots or lesions.

Depending on the type of pathogen, mould can develop on the affected areas in either fluffy grey or powdery blue/green forms. All fruit diseases eventually result in rind breakdown, aril browning and decay. Some pathogens only affect the fruit from the inside, disrupting the mesodermal and endodermal germ layers, leaving the fruit's exterior symptom-free or with no morphological effects on crops. Fruit with diseases has low quality and short shelf life.

Changes include a decline in sugars and acids that give characteristic odor and lead to the development of unpleasant flavors due to fermentative metabolism and the transfer of unfavorable aromas, such as sulfurous chemicals primarily from fungi [37]. The protective calyx region, which mostly protects the flower when it is in bud condition, can occasionally exhibit different symptoms of crown rot and interior damage when affected fruits are carefully examined [38-40]. Therefore, for these diseases to be effectively controlled and managed, it is crucial to quickly identify and characterize their symptoms.

Bacterial blight of pomegranate

Bacterial blight caused by *Xanthomonas axonopodis pv. punicae* is a major disease of pomegranate. In recent years, bacterial blight has emerged as a serious threat to pomegranate cultivation in the major pomegranate-producing states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu in India. The disease was not of much concern until 1998 but thereafter, due to its widespread occurrence in epidemic proportion, particularly in subtropical and tropical states of the country, pomegranate cultivation received a severe jolt as crop production declined alarmingly. Blight was first reported in India from IARI, New Delhi [41] and subsequently reported the same disease in Bangalore, Karnataka who identified the causal organism as *Xanthomonas axonopodis pv. punicae*. Since then, several workers have reported the occurrence of blight and resultant losses from different parts of the country viz. Tamil Nadu [42], Himachal Pradesh [43], Haryana [44], Karnataka [45], Maharashtra [46], Punjab [47], and Rajasthan in 2009. Recent epidemics of bacterial blight have been reported in Maharashtra, Karnataka and Andhra Pradesh by various groups [48-50]. In 2018 Jagdale et al reported, *Pseudomonas* strain is now responsible for causing bacterial blight diseases in Maharashtra.

Distribution, incidence and severity

Surveys carried out by NRCP Solapur from 2005 to 2009 [51-53] revealed the prevalence of blight in all major pomegranate-producing states of Maharashtra 52.25% of orchards, Karnataka 58.33% and Andhra Pradesh 43.47% includes mild to the severe form [54]. Surveys conducted by the Scientists of NRCP Solapur in 2009 revealed that blight prevalence in mild to moderate proportions in some orchards of the Hanumangarh district of Rajasthan.

Symptoms

Bacterial blight affects aerial parts of pomegranate plants. Symptoms are observed on leaves, stems, flowers and fruits. On leaves minute spherical water-soaked lesions are observed on foliage, which later becomes dark brownish black with a necrotic canter surrounded by a translucent halo. In advanced lesions, however, a translucent halo may not be visible. Lesions may coalesce and often extend to veins and the midrib. Infected foliage normally turns yellow and falls off prematurely, known as the necrosis of leaves [55]. Twigs and stems reveal brownish-black lesions generally initiating at the nodes and extending along the bark and although infections are normally observed in the bark and cortex region, at times infections are also observed extending to the vascular region of the plant. Blight lesions on twigs often result in girdling, thereby, resulting in the breaking off of the twig at the point of infection and such twigs reveal drying with yellowing of leaves and remain attached to the plant until they become detached by some external pressure. Since blight infections are prominent at nodes, the disease is also popularly known as nodal blight whereas in Maharashtra bacterial blight is also commonly known by the name of oily spot. Old infections, particularly on the main stem and branches, seldom result in canker formation, thereby restricting the further movement of the pathogen [56]. On fruits, initial blight symptoms appear as small water-soaked lesions that increase in size and turn dark brownish-black and necrotic. Lesions on fruits often reveal Y- or L-shaped small fissures which are generally not observed in spots caused by some fungal pathogens like *Cercospora sp*. Lesions on fruits normally coalesce and may result in blight symptoms. Blighted fruits with one or more lesions reveal characteristic splitting rendering fruits unfit for consumption [57].

Detection and diagnostics

On the basis of the already specified symptoms, blight-infected foliage stems and fruits can be identified. By placing a piece of diseased tissue in a drop of water on a glass slide and checking it under a microscope for bacterial ooze, the pathogen (bacterium) can be found. It is confirmed that the section and the infected plant component are both affected by the blight bacterium by the exudation of bacterial ooze from the section. By using PCR-based molecular techniques, the pathogen can also be found and identified [3], [55].

Causal organism and its characterization

The causal organism of pomegranate bacterial blight has been identified as *Xanthomonas axonopodis pv. punicae* [51-52], [58]. Prior to 1995, the blight bacterium was classified as *Xanthomonas campestris pv. punicae*. However, it was not until 1995 that Vauterine, Haste, Kersters and Swings re-classified the bacterium on the basis of DNA hybridization and named it *Xanthomonas axonopodis pv. punicae* [59-60]. Now the novel organism responsible for bacterial blight was reported by Jagdale *et al*. [61]. The bacterium (*X. axonopodis pv. punicae*) is a Gram-negative rod with a single polar flagellum, non-spore forming and measures 0.4-0.75 × 1.0-3.0 µm. The colonies on nutrient glucose agar medium are smooth, circular, light yellow, glistening, mucoid, and convex with entire margins and do not impart any foul odor. The bacterium produces a non–diffusible yellow pigment xanthomonadin, which is positive for proteolysis, H_2S production, the KOH test and gelatin liquefaction [58]. Gopalakrishnan *et al*. [62], while screening pomegranate hybrids for resistance to bacterial blight through the pinprick method, found quick development of blight symptoms in inoculated leaves at 29 ± 2°C under laboratory conditions. Genomic fingerprinting of the blight pathogen has been generated employing ERIC (enterobacterial repetitive intergenic consensus) PCR technology and could be used in the detection, differentiation and virulence screening of the pathogen [58].

Epidemiology

Source of primary inoculum and survivability

Blight bacteria survive in the infected plant stems, buds and plant debris in the soil [63]. The bacterium can be isolated from infected leaves lying on the ground for up to 7 months. However, when the infected plant parts are kept under laboratory conditions the pathogen can be isolated for up to 8 months [64]. Studies at NRCP Solapur revealed that blight-infected leaves from the blighted orchard could exude ooze and bacterium could be isolated from such leaves up to 1 year of incubation under laboratory conditions at the temperature range of 25.0-40.0°C [53]. On the other hand, studies by Yenjerappa *et al*. [65] revealed the survivability of pomegranate bacterial blight for up to 4½ months in the infected leaf residues and up to 5 months in the infected fruit residues under field conditions.

Dissemination and secondary spread

The bacterium disseminates from the source of the inoculum to healthy plants and new orchards through rain splashes, irrigation water, pruning tools, infected planting material, insect vectors and man. Khan *et al*. [66] emphasized the role of insects like pomegranate butterfly (Deudorix isocrates), aphids, blister beetle and larvae of fruit borer in the dissemination of blight bacterium. The rate of bacterial spread is very rapid and multiplies very rapidly. Thus, the pathogen infects different plant parts through natural openings like stomata, lenticels, hydathode, or wounds. The incubation period of the bacterium varies depending on the prevailing conditions of the host and environment. Hingorani and Singh [67] observed disease symptoms in two-month-old cuttings of healthy pomegranate plants after 9 and 12 days of inoculations in injured and uninjured plant parts, respectively. Kanwar *et al*. [68] also proved pathogenicity on different plant parts by carrying out inoculations both with and without injury and observed that infections occurred more rapidly in injured parts within 4 to 7 days, while it took 8 to 12 days for symptom development on the uninjured plant parts. Rani *et al*. [69] reported the appearance of blight symptoms on injured surfaces of flowers, fruits and leaves within 7 to 10 days of incubation whereas it took 12 to 15 days for symptoms to develop on uninjured parts. It shows that the injured part shows results within a short period of time as compared to the uninjured part. During pathogenicity studies on detached leaves under laboratory conditions, blight symptoms were first observed on the abaxial surface of inoculated leaves after 3 days of incubation at 26.0 °C under moist conditions [51]. In another study, different methods of inoculation were evaluated on potted plants to get a suitable method for screening germplasm against bacterial blight and though symptoms were produced between 8 and 15 days of inoculations in different treatments, disease severity increased after 15 days in all the methods with or without injury, thereby, revealing the use of simple spray as suitable for screening of germplasm [52]. Mogle *et al*. [70] also observed typical blight symptoms on the undersurface of the injured leaves within 9 to 13 days of inoculations. Studies on transmission of bacteria revealed that planting material (stem cuttings, and air-layered cuttings) obtained from diseased plants (made apparently healthy by pruning of diseased parts) carried the blight pathogen in latent form probably in buds and resulted in infections of new plants produced from planting material even after 7 months of incubation as a bud from new plant arises [53]. Rani *et al*. [64] reported a fall in atmospheric temperatures (maximum and minimum), an increase in maximum and minimum relative humidity and moderate rainfall favored disease build-up. Bacterial blight remained prevalent throughout the year (at a temperature range of 9.0-43.0°C and RH between 30.0 and >80.0%). Although disease severity varied during different seasons [71]. Disease build-up was rapid during the summer rainy season from July to September due to the availability of free water and high humidity. The proportion of orchards with severe blight infections was 48.9% during the rainy season (July to September) vs the autumn crop (December to February) when only 10.5% of orchards had severe blight infections. Higher values of apparent infection rate ('r' 0.21/unit/day) during the rainy season compared to a lower r (0.08/unit/ day) in spring evidently explained the rapid spread of disease during the rainy season which indicates that as temperatures decrease 'r-value increases thus infection rate is inversely proportional to temperature [52].

Bacterial blight management

Recently, the disease has been effectively managed due to integrated blight management approaches, which include cultural practices, sanitation precautions, and chemical control methods.

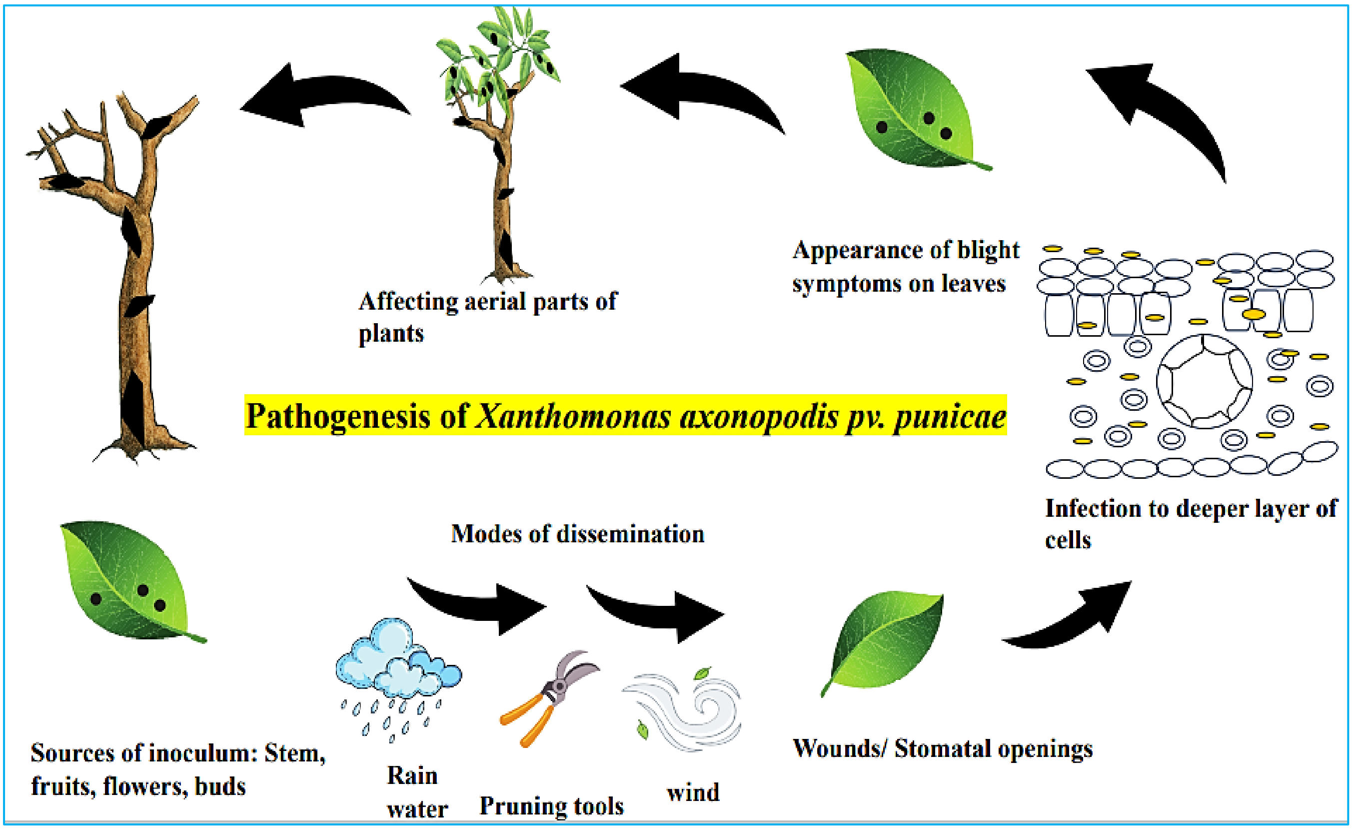

Fig 2 Pathogenesis of *Xanthomonas axonopodis pv. Punicae*

Cultural practices

A. *Disease-free planting material*

While establishing a new orchard, it is vital to use healthy, blight-free planting material (air-layered) that has been obtained from nurseries that appear to be blight-free in order to prevent the spread of infections to the orchard [52], [72].

B. *Sanitation precautions*

Removing and burning unhealthy fruit, branches, and leaves, as well as sprinkling orchard soil surface around the plants with bleaching powder (at a rate of 20 kg/ha) or 4% copper dust (at a rate of 20 kg/ha), are examples of sanitation techniques that reduce the bacterial inoculum. Pruning should be done on all twigs that have been impacted by the blight, and the cut ends should either be treated with Bordeaux paste or sprayed with a copper-based fungicide like Bordeaux combination (1.0%) or copper oxychloride (0.2%). The removal of fallen leaves, twigs, and fruits from outside the orchard is necessary because the bacterium can survive there for nine months. Additionally, workers should be prohibited from moving from the unhealthy orchid to the infected orchard since blight pathogens can spread through contact [73].

C. *Avoid crops during the rainy season*

The autumn crop (Rabi crop) should be encouraged instead of the rainy season crop (Kharif crop), as the season is characterized by little to no rain, which causes the blight to spread slowly. This is especially true in places with severe disease pressure [52], [72].

D. *Cultural control practices*

Cultural methods entail managing the environment to lower disease inoculum pressure and are non-chemical methods [34]. In pomegranate on-field management approaches, enhancement of soil drainage through ridging is vital as these enable air flow and drainage [74]. In fruit orchards, stress factors such as inadequate irrigation, fertilizer, and soil preparation might make plants more vulnerable [74]. Avoiding water stress is important since overwatering pomegranate trees might result in cracked fruit. In order to meet field requirements, it is necessary to remove old branches and fruit, teach pickers, graders, and other workers to recognize disease symptoms and prevent infection of pruning wounds. To shield the ends of branches that have been pruned, use protective pastes [34], [74]. To prevent bug and bird damage, fruit can be bagged while still on the tree, however, this may not be practical from an economic standpoint [34].

E. *Selective cultivar breeding*

When fungicides must be used to manage diseases, host plant resistance is a useful complementary disease control strategy. This requires selecting the proper cultivars with disease- and/or insect resistance [75-76]. The amount of sensitivity of different pomegranate cultivars to infections has only been the object of several studies. In one study, the detached leaf method was employed to test 19 pomegranate genotypes for anthracnose disease resistance produced by *C. gloeosporoides* in vitro conditions [77]. Araktha and Ganesh were the most susceptible cultivars studied, with none of the cultivars indicating disease resistance [77].

Chemical methods

Anonymous [52] found that streptocycline (500 ppm) was sprayed at intervals of 15 days alone or in combination with fungicides such copper oxy-chloride (0.2%) and carbendazim (0.1%), which led to 82.2% blight control and an increase in the production of high-quality fruit. They also reported that the use of copper oxychloride (0.2%) and the antibiotic Bactronol (2-Bromo-2-Nitro propane-1,3-diol) at 500 ppm also successfully reduces blight [51]. Sprays of bromopal (2-bromo-2-nitropropane-1,3-diol) (500 ppm) and streptocycline (500 ppm) in conjunction with copper oxychloride (0.2%) effectively controlled blight while increasing yield [72].

Biological method

A. *Integrated nutrient management*

Application of macro- and micronutrients at various stages of fruit growth as well as the incorporation of organic manures such as vermicompost and neem cake during the rest period or before flowering increase plant health, produce higher quality, and reduce blight [72]. The management of any disease involves the use of resistant variants. However, the current popular pomegranate varieties, including "Bhagawa," "Ganesh," "Arakta," "Mridula," and "Ruby," grown in the area, are all susceptible to bacterial blight.

B. *Genetic transfer technology*

According to Gomez-Lim *et al*. [78] and Terakami *et al*. [79], genetic engineering makes pomegranate plants to become more resistant to diseases, insects, and pests as well as to herbicides, salt and cold as well as increases their shelf life. Chauhan *et al*. [80] stated that a more effective method for plant breeding and the direct insertion of beneficial features into genotypes is the use of molecular markers in gene transfer technology.

Biological control measures

The basis of biocontrol research is the use of microorganisms, and plant extracts nanoparticles to control diseases of the soil, leaves, and fruits. This is a method for farming that is extremely suggested for sustainability [81]. Plant extracts showed antibacterial activity and could be utilized as an alternative to conventional antibiotics in the treatment of a wide range of plant diseases. Mottida *et al*. [82] investigated the antibacterial activity of 23 different plant extracts and found them to be effective against plant pathogen of bacterial blight. Thyme oil and lemon grass oil, two of these plant oils, effectively inhibited the development of pomegranate bacterial blight in vitro experiments [83]. Aqueous extracts of plants Abutilon *indicum, Prosopis juliflora,* and *Acacia arabica* are wild plant species that have been used as antibacterial agents against *Xanthomonas axonopodis pv. punicae*. The results indicate that the extracts of *Prosopis juliflora* and *Acacia arabica* are very effective against the *Xanthomonas axonopodis pv. punicae*, with *P. juliflora* showing the largest zone of inhibition and *A. indicum* showing the lowest zone of inhibition [84].

Biopesticides disease control mechanisms involve various modes of action: production of antibiotics, induction of host resistance, synthesis of phytoalexins and/or the accumulation of an extracellular matrix, competition for nutrients and space, siderophores production and direct interaction with the pathogen and/or volatile production. Chavan *et al*. [81] assessed the biocontrol potential of 40 actinomycete strains isolated from natural sources against *Xanthomonas axonopodis pv. punicae*, which causes oily spot disease of pomegranate. Other biocontrol agents include *Pseudomonas fluorescens, Ps. Aeruginosa, Bacillus subtilis and Lactobacillus spp.* have also been tested on the disease control but were not successful [81].

The mechanisms used by *Trichoderma* include the production of antibiotics, mycoparasitism, competition of nutrients and space with pathogenic fungi as well as stimulation of host resistance [85-86].

Through the development of nano pesticides, nanotechnology offered a long-term remedy in this area [87]. A simple and effective method of preventing the spread of diseases is provided by the potent antidote silver nanoparticles. It is cheaper, environmentally safe, and simple to create silver nanoparticles from the leaves of Bryophyllum, an *Allium sativum* plant. AgNPs were tested for their antibacterial efficacy against *Xanthomonas axonopodis pv. punicae*,. Consequently, they can be used in the treatment of pomegranate disease [88]. Because of their potent antibacterial action, copper nanoparticles (CuNPs) have received a significant amount of attention from scientists all over the world. One of the essential micronutrients, copper, is important to the growth and development of plants. Agriculture can utilize CuNP-based fertilizers and herbicide [89].

Cu-based nano formulation was effective in field level used against *Xanthomonas axonopodis pv. punicae*. Pathogens were effectively controlled at doses eight times lower than those of the typical copper-based antimicrobials. Thus, excessive Cu utilization and the resulting environmental risks are avoided by using nano formulations [90].

Use of sensors for pomegranate disease detection

To identify pomegranate infections in their earliest stages, farmers must use sensing technology. Farmers can benefit from using image sensors in the cultivation of the pomegranate plant by detecting disease in the plant at an early stage. Acoustic sensors detect the volume of insects making noise close to the grown plant. In the measurement of the Leaf Area Index, the entire leaf area of a plant is measured by sensors. This drops in chlorophyll because of bacterial or fungal growth also causes a reduction in the total leaf area.

Thermal imaging sensors are based on the fact that before a pomegranate plant displays visible indications of pathogen infection which causes a change in leaf and fruit surface temperature. Fluorescence measuring sensors can be used in the production of fruit and leaves to identify any pathogen contamination. Using 3D images of pomegranate fruit and leaves, hyperspectral disease detection cameras can identify all diseases' visible symptoms. The type and nature of infection can be precisely identified using gas chromatography which measures the chemical substance that the pathogens release.

CONCLUSION

Pomegranates are vulnerable to numerous diseases that cause deterioration. This review included a thorough summary of the diseases linked to pomegranates and outlined the need for more study into the epidemiology of diseases. Bacterial blight has been effectively managed by the application of integrated blight management approaches, which include cultural and sanitation precautions, the use of organic manures and nutrients, and chemical control techniques. Since there is now no disease-resistant pomegranate variety, developing a blight-resistant variety by transgenics and using molecular methods would be of enormous value in the control of blight. There has been an effort to establish the main pomegranate diseases, particularly those that are prevalent during pomegranate cultivation in the states of Karnataka and Maharashtra.

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