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Prevalence of Walnut Anthracnose in Kashmir (Western Himalayas)

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The walnut tree (*Juglans regia* L.) is a globally important woody nut and edible oil tree. Walnut production, on the other hand, is hampered by walnut anthracnose, caused by *Marssonina juglandis* (Lib.) Magnus, a devastating disease that results in huge yield losses. The disease first appears as brown to black circular to irregularly round dots on the leaves. These spots grow in size and finally combine into massive necrotic areas. These diseased leaves eventually turn yellow and fall off prematurely. Among major biotic factors, walnut anthracnose or black spot/blotch has been reportedly considered as most serious fungal disease of black walnut (*J. nigra* L.). In India, Kaul (1962) reported the occurrence of walnut anthracnose disease for the first time from Kashmir valley. Although the Agro-climatic conditions of Kashmir valley are congenial for cultivation of the walnut, yet its productivity has been relatively low compared to other parts of the world owing to many biotic and abiotic factors that inflict significant yield loss to walnut industry. For successful control, researchers should look at the aetiology of walnut anthracnose, as well as the pathogens' virulence and fungicide sensitivity.

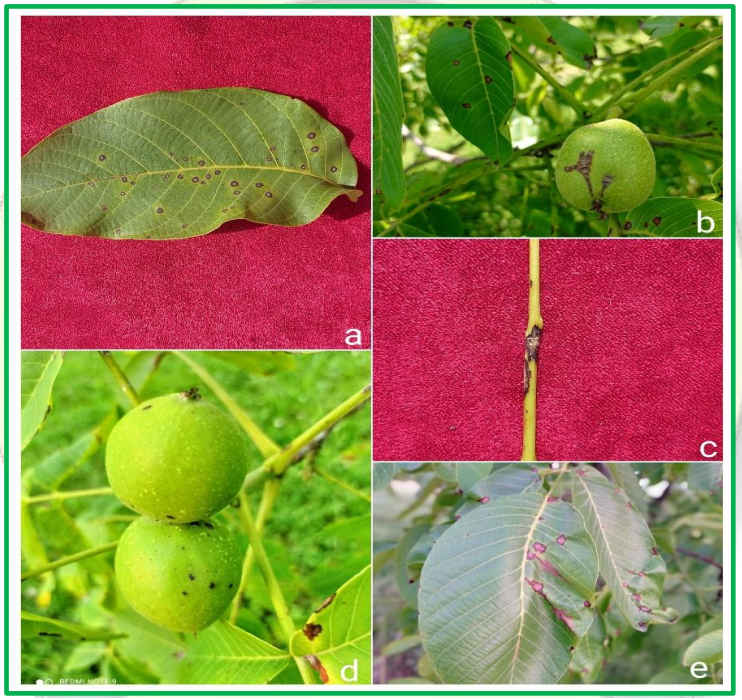

Fig 1. a, b, c, d and e depicts typical symptoms of walnut anthracnose on leaves, petiole and fruits.

1. Introduction

J&K is India's largest commercial walnut producer, accounting for 98 percent of the country's output, and the state has been designated as "Agri-Export Zone for Walnuts". The agroclimatic conditions in India's Western Himalayan area are ideal for growing high-quality walnuts. The Indian state, Jammu and Kashmir provides the majority of export-quality walnut because the panting material are obtained from different seedling trees, the nuts delivered to

market are usually a mix of various sizes and shapes. In Jammu and Kashmir's horticultural business, walnut plays a significant role. It has a stranglehold on producing high-quality walnuts, accounting for more than 90% of all walnut output in India. The mild climatic conditions that favour walnut growing provide Jammu and Kashmir an advantage over other states in terms of walnut production.

Despite the fact that the agro-climatic conditions in Kashmir valley are ideal for walnut growth, productivity has been low in comparison to other regions of the world due to a number of biotic and abiotic factors that produce considerable yield losses in the walnut industry. Among major biotic factors, disease like Anthracnose is most wide spread foliar disease in Kashmir and it was found with an incidence and intensity of 97.34 per cent and 51.66 per cent on leaves during summer 2013. Maximum disease incidence of 97.94 per cent and intensity of 55.76 per cent was reported in district Anantnag and minimum in district Kupwara.

2. Occurrence and Economic Significance

Walnut anthracnose, also known as black spot/blotch, is a deadly fungal disease that affects black walnut (*Juglans nigra* L.), Persian or English walnut (*Juglans regia* L.) and other Juglans species throughout the world, including North and South America, Europe, Iran, and other Asian nations. This disease has wreaked havoc on walnut trees in India's J&K UT in recent years, particularly high-density dwarf walnut plantations (grafted walnuts). Walnut anthracnose causes a decrease in quantitative indicators such as nut size, mass, and yield, as well as failure of metabolic processes in leaves and changes in biochemical indices. Fruit distortion and premature dropping can occur because of early infection. Defoliation produced by walnut anthracnose can have a severe impact on plant development, leading to plant collapse in some cases. Walnut production is impeded by walnut anthracnose, which causes crop losses of up to 50%.

3. Symptomatology

Walnut anthracnose symptoms are mostly seen on current year leaves, twigs, and rarely on fruits. In the initial stages, brown to black circular to irregularly round spots on the leaves appear. These spots then grow in size until they turn into immense necrotic regions. In the later stages these infected leaves become yellowish and then followed by premature drop, however leaf infection and leaf drop occur severely usually late in the season. Brown to black slightly sunken patches with uneven borders on the leaves and nuts, followed by yellowing of the leaflets, are signs of walnut anthracnose disease. Walnut anthracnose can develop irregular necrotic patches surrounded by tiny chlorotic halos on the current year's leaves, twigs, shoots, and husk, reducing fruit output. Fruit distortion and premature dropping can occur as a result of early infection. Defoliation produced by walnut anthracnose can have a severe impact on plant development, leading to plant collapse in some cases.

4. Causal Agent

The ascomycetous fungus *Gnomonia leptostyla* (Fr.) Ces. et de Not. Anamorph: *Marssonina juglandis* (Lib.) Magnus causes walnut anthracnose, which is one of the most deadly and widespread walnut disease in practically all walnut-growing locations across the world. *Marssonina juglandis* (Lib.) Magnus has been identified as the cause of walnut anthracnose, with *Gnomonia leptostyla* (Fr.) Ces. and de Not as its perfect stage. Asexual fruiting body acervuli formed by the fungus developed early in the season as little black dots on the underside of infected leaves. Conidiophores were hyaline, short, simple, elliptical, and one celled, packed together in a minute layer at the tips carrying conidia. These were enteroblastic, phialidic, cylindrical, and ampulliform, and conidiogenous cells were enteroblastic, phialidic, hyaline, cylindrical, and ampulliform. The conidia shape varies as

being straight, oval, crescent or with only one end rounded and the other pointy. One septum was present, and two uneven cells with conspicuous oil globules measured 12- 30 × 3-6 µm. Hyphae and conidia in the leaf spots were both characterized as hyaline in colour, whereas the acervuli were darkish black. Appressoria were brown in colour, ovoid to ellipsoid in shape, or slightly irregularly to irregularly shaped, and the averaged s was 6.8–9 × 5.1–6.5 µm in length. The hyphae exhibited a smooth, branching, and septate form. Conidia infection causes secondary infection in the mid-spring to summer season, with a number of cycles. Brown perithecia are also present on fallen leaves that were submerged in the leaf tissues and petioles, with the beak protruding significantly from the leaf surface and petiole wood. These were amphigenous, solitary, scattered, globose, reddish brown with long cylindrical beak. The beak measures 135-180µm in length and 25-42 µm in breadth, with a globose base of diameter 120-130 µm. The perithecial cavity was lined interiorly with fusiode asci that were club shaped, while the asci were hyaline aparaphysate, 8 spored, and measured 56-62 14-16 m. The ascospores were 15-194-5 m long, hyaline, fusiode, straight to slightly curved septate, and hyaline. Primary infection occurs due these sexual spores (ascospores) in the early spring.

5. Disease Management

In plant pathology, management is vital, and the goal is to manage a disease so that we may obtain more economic benefits from a crop by reducing disease losses. Various management strategies had been suggested by researchers for the management of anthracnose in walnut.

5.1 Cultural Practices

The management of walnut anthracnose includes burying (ploughing in) fallen leaves to a depth of 10-15 cm in autumn and winter, trimming of infected twigs and branches, rouging, planting healthy material and proper nitrogen feeding. Planting herbaceous legumes in walnut orchards may reduce the severity of anthracnose by increasing soil nitrogen or disrupting ascospore dispersal, whereas planting new walnut seedlings with annual and perennial legumes has been shown to increase foliage nitrogen content. It is recommended that removal of walnut plant residue, particularly fallen leaves is very effective in minimizing the disease.

5.2 Biological control

It is reported that *Bacillus velezensis* CE 100 is an excellent anthracnose disease biocontrol agent and a possible plant growth-promoting bacteria in walnut tree production. It was found that *Bacillus amyloliquefaciens* strain SDF-005 has a promising future in the biological control of walnut anthracnose disease. The biocontrol efficacy of 36 walnut endophytic bacterial isolates against *Gnomonia leptostyla*, an anthracnose fungus was tested, it was found 36 endophytic bacteria in total, with 8 strains from roots accounting for 22.2 percent of the total and coded with XWR and number, 12 strains from stems accounting for 33.3 percent and coded with XWS and number, and 16 strains from leaves accounting for 44.4 percent and coded with XWL and number. All endophytes have an antagonistic effect on *Gnomonia leptostyla*. It was advocated *Corcus mas* and *Morus nigra* leaf extracts against *Marsonina juglandis*.

5.3 Resistance

It was noticed that the Hinds (*Juglans hindsii*) and Arizona (*Juglans major*) walnuts were more vulnerable than black walnut (*Juglans nigra*). Little walnut (*Juglans microcarpa*), Japanese walnut (*Juglans ailantifolia*), butternut (*Juglans cinerea*), heartnut (*Juglans ailantifolia* var. *cordiformis*), and different hybrids were less vulnerable than black walnut, while English walnut (*Juglans regia*) clones showed the widest range of sensitivity. It was found that a well-known cultivar, 'chandler,' which is also a high-yielding variety, was resistant to *Gnomonia leptostyla* infection. On comparative study of two varietie results

showed that, the leaflets from 'Sparrow' showed practically no symptoms when compared to the leaflets from 'Football,' indicating a stronger resistance to anthracnose. In a another study, Z67 and K73 cultivars also showed better resistance than others, with Z67 being the most resistant.

5.4 Chemical management

To manage the disease caused by various *Marssonina* sp. in different host crops, the use of chemicals has been suggested by various workers. It was found that zineb, dodine, zinc-metiram, phaltan, PMC, maneb, captan, and thiram (3-6 treatments per year) were effective in controlling walnut anthracnose, whereas it was also found that 2-6 sprays of Bordeaux mixture and urea treatment in alternative manner were more effective than treatments with 1 per cent Bordeaux alone against walnut anthracnose. Various researchers reported that fungi toxicants such as carbendazim, benomyl, DNOC, dodine, cupric oxide, zineb, maneb, and chlorothalonil were effective against *Marsonina juglandis* and reduced disease severity significantly. Applying benomyl to the soil lowered the incidence and severity of anthracnose in black walnut for several years. It was recommended that spraying with 0.5 per cent copper oxychloride and 0.4 per cent zineb throughout the growing season for the management of walnut anthracnose. Spraying with Bordeaux mixture (1%), Dithane M-45 (0.3%), and Cupromixin (0.6%) is recommended against walnut anthracnose while as some researchers recommended spraying with Bordeaux mixture at 2 per cent during winter and 1 per cent before flowering and once after flowering against *Gnomonia leptostyla*. Using Bordeaux solution in the winter and copper fungi toxicants in the early spring could be quite efficient in reducing walnut anthracnose. Among systemic fungicides difenoconazole, metiram+pyraclostrobin, flusilazole etc. are recommended for management of walnut anthracnose. However, among non-systemic fungicides mancozeb, captan, chlorothalonil etc. are recommended for management of walnut anthracnose.

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