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DISEASES OF MOTH BEAN [*VIGNA ACONITIFOLIA* (JACQ.) MARECHAL]

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ABSTRACT Pulses are obtained from leguminous plants that have many bioactive components and good nutritional value, being rich in protein, vitamins, and abundant macro- and micronutrients and thus contribute to global food security. Moth bean is compatible with the climatic conditions of Rajasthan because it is a drought-resistant crop though it is affected by many pathogenic microorganisms as fungi, bacteria, and viruses. Infection of these microorganisms causes damage to plants which results in loss of productivity. In the current context, a review on fungal, bacterial, and viral diseases of moth bean has been dealt with. The major diseases of moth bean reported are leaf blight, leaf spots, seedling stem and root rot, pod rot, web blight, common bacterial blight, and mung bean yellow mosaic virus (MYMV) causing yield loss.

KEYWORDS : Moth bean, Diseases, Fungi, Bacteria, Viruses.

INTRODUCTION

A drought-resistant Kharif legume crop from the Asian *Vigna* genus is the moth bean (Norihiko et al., 2017).. This crop, which is primarily farmed in the eastern part of India, is regarded as a good source of nutrients (Adsule, 1996). The moth bean crop is compatible with the climatic conditions of Rajasthan that's why it is a larger producing state for this crop. In India, it is cultivated in June-July and harvested in August-September. The moth bean appears to be a flexible crop that can be used to provide green manure, fodder, feed, and food for livestock. It serves as a cheap form of supplementation for deficiency of protein (Sedani et al., 2021).

In India, the annual production of moth bean is 0.4 million tons in 1.5 million hectares (Senthilkumar and Ngadi, 2020; Bhadkaria et al., 2020).Rajasthan State enjoys the distinction of being at the top of the production chain nationally, providing 75–80% of the entire national production.

The moth bean is promoted as a food source because it contains macro- and micronutrients as well as several bioactive substances that have antioxidant, anti-diabetic, and antihypertensive properties. This was shown by analysing the phytochemical profiles of various accessions of moth bean seeds and the nutrients they contained (Bhadkaria et al., 2021; Sharma et al., 2022).

In the present paper, the research work done on the various fungal, bacterial, and viral diseases of moth bean has been reviewed.

Fungal Disease

The majority of agricultural and horticultural plants tolerate significant losses due to fungal infections. Fungi are responsible for more than 70% of all serious crop diseases (Agrios, 2005).

The common fungal diseases of moth bean are *Fusarium rot* (*Fusarium moniliforme*), seedling rot and pod rot (*Colletotrichum truncatum*), seed rot (*F. moniliforme*, *M. phaseolina*), leaf spots by (*Alternaria alternata*, *C. truncatum, Curvularia lunata*) and leaf blight (*M. phaseolina*) (Desai et al., 1970; Senecha and Srivastava, 1982; Sharma and Gupta, 1982a; Singh and Srivastava, 1984a, b; Singh and Srivastava, 1989).

Numerous fungal infections that harm the moth bean crop are to blame for the crop's decreased productivity. A study of moth bean seeds was collected from 5 major districts of Rajasthan viz. Jaipur, Ajmer, Bharatpur, Kota, and Alwar. In 50 seed samples studied, 6 fungal species were obtained viz. *Chaetomium* sp., *Rhizopus nigricans, Aspergillus flavus, A. niger,* and *Penicillium* (Agarwal *et al.,* 2012).

Leaf blight

The leaf blight-causing *Macrophomina phaseolina* is characterized by the old leaves gradually turning yellow and drying out. Affected leaf margins have a burnt appearance, and bear black pycnidia at maturity on the adaxial surface (Senecha and Srivastava, 1982, Richardson, 1990).

This fungal pathogen could be soil-borne or seed-borne (Richardson, 1990) and could infect the plant at any stage of the life cycle. Maximum damage was observed at the seed germination and seedling stages (Aghnihotri *et al*., 1987; Byadgi and Hedge, 1988; Rathore and Rathore, 2000, Shakya and Lakhey; 2007).

The antifungal activity of root extracts from 25 arid zone plants was tested in the laboratory against *M. phaseolina.* The alcoholic and aqueous root extracts of *Fagonia cretica, Tribulus terrestris, Ocimum americanum, Calotropis procera,* and *Euphorbia antiquorum* plants drastically reduced *M. phaseolina* growth (Dushyent and Bohra, 1999). The antagonistic activity against *M. phaseolina* by bioagents viz. *Trichoderma viride, T. harzianum*, *T. atroviride* and *Bacillus subtilis* isolated from moth bean fields has been found effective (Kumar, 2002; Kumar et al., 2013).

By treating the seeds with Topsin M70 at 2 g kg^{-1}, Captan at 3 g kg^{-1}, and Bavistin at 2 g kg^{-1}, the severity of the infection and post-emergence, plant death may be significantly decreased. When the soils get dry and the temperature rises, the fields may be irrigated to minimise the infection.

Leaf spots

In moth bean crop five leaf spot diseases are known to occur which are caused by *Colletotrichum truncatum*, *Alternaria alternata*, *Cercospora columaris*. *Curvularia lunata* and *Myrothecium roridum* (Singh, 2001; Agrios, 2005).

A. Alternaria leaf spot

The causative agent is *Alternaria alternata.* Significant damage to the moth bean crop was noted in the Jodhpur district of Rajasthan in 1982 due to this disease which was later on identified to be caused by *A. alternata* (Singh and Srivastava, 1984b, 1989). The symptoms appear as pale-yellow spots either on tips or on margins of the leaves which gradually advance towards the petiole and to the middle of the lamina. In starting, the disease spots remain separated from the healthy tissues by a dark-colored band, but later on, the lesions dispersed over the whole leaf and turn irregular, brittle, and dark olive green to black due to fungal growth (Neergaard, 1977; Singh and Srivastava, 1989).

B. *Colletotrichum leaf spot*

The disease is caused by *Colletotrichum truncatum.* It was first observed by Desai et al., (1970) from Jobner (Rajasthan) and later in other parts of the state (Mathur and Tyagi, 1982; Singh and Srivastava, 1989). The disease is characterized by yellow round spots, 5- 10 mm in

diameter. The leaf margins and the tip also become irregular and brittle. The lower surface of the infected leaves is scorched and in severely infected plants, the mature spots become papery and turn into shot holes. The leaves are blighted and the infected plant parts frequently develop acervuli of *C. truncatum.*

C. Cercospora leaf spot

The disease is caused by *Cercospora columaris* and *C. conescens* (Munjal *et al.,*1961; Munjal *et al.,* 1962). In this disease, numerous angular spots, olivaceous in colour with fructifications at the lower part of the leaves are formed. The disease occurs in the humid tropical regions of Asia. To determine the severity of the Cercospora leaf spot disease of moth bean, a thorough study was carried out during the 2019 Kharif season. During the survey, Gusainsar village showed the highest severity of leaf spot (32.6%), followed by Norangdesar village in the Bikaner tehsil (28.72%), and Parwa village in the Nokha tehsil (21.28%) (Kumar et al., 2022). Depending on how early the plants are affected, *Cercospora leaf spot* reduces yield (Poehlman, 1978). 6-28 percent of the leaf surface area is affected. Lalpora and (J&K) had the high disease intensity (26-31%) (Bhat, 2019).

Wide spacing, 50 x 30 cm, was employed to treat this disease in moth bean plants so that air movement quickly dries the leaves following rain and crop overlapping is prevented. To stop spores from spreading further during plant growth, trimming of older infected leaves as soon as spots are visible, weeding frequently, and utilizing drip irrigation are suggested. Crop rotation by planting maize, sorghum, or root crops in between plantings of legumes on the same piece of land, application of resistant varieties, chemical therapy using mancozeb, thiram, or captan has been suggested (Jackson, 2017).

D. Curvularia leaf spot

The causative agent is *Curvularia lunata* (Desai et al., 1970; Singh and Srivastava, 1989). This fungus mainly infects immature plants. After 2-3 weeks of infection discolored spots are developed either on the tips or on the margins of the leaves which gradually extend towards the petiole.

E. Myrothecium leaf spot

The causative pathogen is *Myrothecium roridum* (Sharma and Gupta,1982b). This fungus produces reddish-brown to deep red spots measuring 4-8 mm in diameter on the leaf as well as minute spots on the petiole.

Seedling stem and root rot

M. phaeolina causes Macrophomina rot, mainly observed in Haryana (Sharma and Gupta, 1981a, 1982a). It causes blight of the cotyledonary leaves which later fall off leaving the stem naked. Such seedlings are collapsed or rotted (Sharma and Gupta, 1981a). Singh and Srivastava (1984a) described *M. phaseolina* associated with 80 seed samples and the seed-borne inoculums caused seed rot, blightening of roots or leaves, dry root rot, and stem necrosis at ground level.

Singh and Srivastava (1989) observed the seedling rot in Jodhpur. The plants were infected with *F. moniliforme*, show symptoms after 2 weeks as discoloration of the seedlings, blightening of the cotyledonary leaves, and premature leaf fall leaving behind the naked stem. The heavily affected plants are wilted. Other fungi causing seedling rot are *Colletotrichum truncatum*, *Myrothecium roridum* and *Mucor* sp. (Sharma and Gupta, 1982b). These show similar types of symptoms as spherical dark brown spots of necrosis in leaves, and brown lesions on drying of the infected leaf as well as on the stem.

Numerous diseases in legumes are brought on by *Rhizoctonia bataticola* (*M. phaseolina*) which is widely dispersed, highly competitive, lethally viable, and adaptable fungus and significant from an economic stand point. The fungus causes complex disease syndromes like charcoal rot, seed rot, root rot, and seedling blight (Khare *et al*., 1973; Nene, 1977; Singh and Srivastava,1989; Lodha, 1998). Although this fungus can cause disease in plants at any stage of growth from seed-to-seed maturation, the majority of the harm occurred during these stages (Aghnihotri *et al*., 1987; Byadgi and Hedge, 1988; Shakya and Lakhey, 2007). The bio-agent seed treatment considerably decreased the dry root rot incidence on moth beans (4.7%) (Mawar et al., 2019).

Pod rot

Myrothecium pod infection caused by *Myrothecium roridum* was first observed in Rajasthan (Singh and Srivastava, 1989). It causes discoloured lesions in the scattered form on the pods which later cover the whole pod and form the black sporodochia. The pod rot occurs within 5 to 7 days. Heavily infected pods bear no seeds or a few small and shrivelled seeds.

The causal organism for Colletotrichum pod infection is *Colletotrichum truncatum* starts with discoloration of young as well as mature pods which soon turn dark brown with the advancement of the disease. Abundant acervuli looking like black dots are formed and cover the whole pod within 15 to 20 days. Seeds in such pods remain free from infection (Singh and Srivastava, 1989).

The causal organism for Choanephora pod rot is *Choanephora cucurbitarum,* was described by Mathur and Tyagi (1984). The pathogen forms water-soaked areas in green pods which turn brownish-black. Soon after the whitish growth of the fungus, black pinhead-like bodies consisting of conidial and sporangial fructification develop on the infected parts. Such pods succumb and rot within a few days (Mathur and Tyagi, 1984).

Web Blight

This disease is caused by *Rhizoctonia solani*. There are a few light, circular patches that resemble webs are the symptoms present on both the leaf surfaces. On leaves, there are tiny necrotic lesions that range from 2 to 10 mm, with an olive-green edge and a brown center. The lesion absorbs water, grows quickly, coalesces to seem scalded, and is covered in whitish to brown mycelium with tiny sclerotia (Fatehpuria and Sasode, 2020). The fungus attacks bean plants at any growth stage, leading to quick deforestation and frequent total crop loss (Zaumeyer and Thomas, 1957; Crispin et al., 1963; Galvez *et al.,* 1979). A web blight outbreak in Costa Rica's northern Guanacaste region that year caused a 90% crop decrease (Anonymous, 1980).

Root and stem rots in temperate zone crops are caused by *R. solani* soil-borne isolates and have been employed in the majority of ecological, epidemiological, and genetic investigations. Although these isolates critically infect the above-ground plant sections of commercially significant crops such corn, rice, tobacco, bean, and sorghum in the tropics and subtropics, aerially distributed *R. solani* groups have received little attention (Sumner, 2001).

For the management of this disease in moth bean rotational planting of non-leguminous crops should be used. Close planting may be avoided. Seeds were treated with benlate and brassicol @ 2 g kg^{-1} seed, which may result in the total eradication of seed-born infection (Kumar, 2002). Use of resistant varieties, close planting may be avoided with the rotational planting of non-leguminous crops have been suggested. The formation of *R. solani* mycelium and sclerotium is greatly decreased by the incorporation of *Trichoderma viride, T. harzianum,* and *Gliocladium virens* (Dubey, 1998). Pyrochlostrobin foliar spray at 0.1 mg/kg seed may completely eradicate seed-born infecion (Fatehpuria and Sasode, 2020).

Bacterial Diseases

Many bacterial species are responsible for various diseases in legume plants, but *Xanthomonas axonopodis* pv. *phaseoli* (XAP), which affects common beans, causes the most serious seed-borne infection, resulting in a decrease in yield (Sallam, 2011).. Plant pathogenic bacteria are responsible for the worst effect on the production system of agriculture, and minimize the yield of the crop and also the economy (Pedroza et al., 2013).. The genus *Xanthomonas*, an example of a large group of bacteria known as proteobacteria, has harmed numerous crops (Gram-negative) (Pedroza et al., 2013; Corzo et al., 2015). XAP and *X. citri* subsp. *fuscans* cause a worldwide disease, the common bacterial blight in crops (Corzo et al., 2015).

Common bacterial blight (CBB) and bacterial leaf spot disease

Patel and Jindal (1972, 1973) for the first time reported bacterial blight caused by *Xanthomonas phaseoli* on infected plants of moth bean from Maharashtra in India. It caused numerous small or large irregular brown necrotic spots which were more prominent on the leaf's top surface than its lower. Large necrotic blotches were formed due to the coalescence of spots, the center in several such patches dropped off and gave a ragged appearance to the leaf. Severely diseased leaves became yellow but do not fall off prematurely. The petiole, stem, and pods showed extended brown spots. They (Patel and Jindal, 1972, 1973) also suggested the pathogen to be the seed-borne. Pathogenic bacteria

associated with the bean plants are responsible for a significant loss in production and quality in Turkey (Bastas and Sahin, 2017). In Turkey XAP and *Xanthomonas citri* subsp. *fuscans* were also reported in some research (Kahveci and Maden, 1994; Demir and Gundagdu, 1994; Dönmez, 2004; Bastas and Sahin, 2017).

In hot areas, XAP is a dangerous threat, causing common bacterial blight (CBB) and bacterial leaf spot. The bacterium is vigorously dispersed and is one of the serious diseases (Silue et al., 2010). CBB disease is present widely in the production areas of legumes, and it is a highly destructive disease, responsible for decreasing the growth of the economy and yield from 10% to 45% according to climatic conditions and genetics of plants (Gillard et al., 2009).

Firstly, it was observed that *X. axonopodis* is responsible for disease in common bean (*Phaseolus vulgaris*). In further studies, many other legume hosts were also reported viz. moth bean (*Vigna aconitifolia*), lablab bean (*Lablab purpureus*), mung bean (*Vigna radiata*), and lima bean (*Phaseolus lunatus*) (Saettler, 1991; Schwartz et al., 2005). When bacterial the pathogen penetrates the leaf, initially water-soaked angular spots are generated. In starting the spots are randomly distributed at the leaf surface, then slowly aggregated at the periphery of areas that start to blight (Chaves et al., 2021).

The first appearance of degrading tissues on legume plants gives an idea about XAP that its turns from biotrophic to necrotrophic after the 8-15 days after inoculation (Foucher et al., 2020). In tropical and temperate environments two bacterial pathogens viz. "*X. axonopodis* pv. *phaseoli* var. fuscans", are the organisms responsible for the disease fuscous blight of legumes as well as common blight (Gilbertson and Maxwell. 1992; Broughton et al.,2003). *X. axonopodis* pv. *phaseoli* (Vauterin *et al*., 1995) and its brown-pigmented variant *X. axonopodis* pv. *phaseoli* var. *fuscans* (Leben, 1981; Schaad, 1982). Ecology of plant pathogen and epidemiology and symptoms of these two diseases found similar (Vidaver, 1993).

In the bacterial leaf spot, the leaves develop many, sporadic, big, and irregular brown necrotic patches that are extremely severe. The spots are more pronounced on the upper leaf surface. Little, erratically shaped, water-soaked dots appear on the leaf's surface in groups and deepen with time from brown to black. In extreme circumstances, the leaf can drop. Eventually, expanded brown patches may appear on petioles, stems, and pods.

Mathur and Tyagi (1986) studied the effect of *X. phaseoli* under artificial inoculation with pure culture. The disease symptoms were found to appear on the third day of the inoculation and manifested within 12-15 days.

By the lesion generated by the plant pathogenic bacteria, discoloration of testa could occur. It is a general sign of the bacterial blight disease produced by *X. phaseoli* and the halo blight disease caused by *Pseudomonas phaseolicola* in bean plants. Due to these diseases, red-brown and slightly sunken lesions (water soaked) are generated on the pods of legumes, and via these lesions, the bacteria are invaded into seeds (Neergaard, 1977).

For the isolation of bacterium from seeds, many processes are done viz. isolation on semi-selective media and pathogenicity determination of the isolated strains. PCR and ELISA have mostly used methods for the identification and confirmation of bacterial strains (Popovi et al., 2010).

The genotypes PLM-11, Amravati local, and IC-8833 were found to be resistant to bacterial leaf spot after artificial inoculation. The cultivars, RDM-182, RDM-63, and RDM-168, also demonstrated resistance to the disease. Seed treatment using Streptocyline (0.01%) + Captan (2 g kg^{-1} seed), the primary bacterial infection of leaf spot/blight was found to be more effectively suppressed. Three sprays of Blitox (0.3%)/ Bavistin (0.05%) + Blitox (0.3%)/ Streptocycline (0.01%) + Blitox (0.3%) could lessen the severity of the disease (Kumar, 2002).

Viral Diseases

Only a few reports are available on viral diseases of moth bean. Deokar et al., (1983) studied the yellow mosaic disease in genotype for viral disease resistance.

Vir (1984) has reported the heavy incidence of the yellow mosaic virus in Rajasthan. The disease symptoms first manifest themselves on the leaves as mild scattered yellow spots and in severe cases, the entire leaf becomes yellow, sometimes the yellow patches become brownish exhibiting necrotic areas, as chlorophyll pigments are destroyed. He also proposed a 0.04 percent spray of monocrotophos three times at fortnightly intervals from 15 days after germination.

The moth bean crop is seriously endangered by the mung bean yellow mosaic virus (MYMV) disease in North India, especially in the arid regions. MYMV belongs to the genus Begomovirus and the family Geminiviridae and is spread by the white fly (*Bemisia tabaci*). MYMV disease not only lower the grain and fodder output but also have an impact on the quality of the seed (Mathur and Sharma, 2002).

The YMV disease can be controlled by the insecticide methyldemelon followed by phosphamidon and malathion (Jain, 1985). Bhati et al., (1987) concluded that the cultivar Jwala was fully field resistant to the virus. The seed samples from Rajasthan's dry region have been reported to contain the seed-borne viral inoculum (Lodha et al., 1986). The traditional varieties which mature late are resistant to the yellow mosaic virus (Kumar, 2005).

CONCLUSION

Moth bean crop suffers largely from leaf blight, leaf spots, seedling stem and root rot, pod rot, web blight, common bacterial blight, and mung bean yellow mosaic virus (MYMV), caused by fungi, bacteria, and viruses. These pathogens cause severe yield losses and also affect the seed quality adversely. Further research is required to be carried out on economic and eco-friendly management of the disease in moth bean.

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