

REVIEW ARTICLE

Diseases of Pulse Crops and their Management in India

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ABSTRACT

Pulses are annual leguminous crops and one of the most important food crops globally due to their high protein content and rich sources of dietary fiber, minerals and vitamins. Legume crops belong to the family Fabaceae (Leguminosae). Its contribute approximately 20–25% of the protein consumed in the form of dal as an source of plant-based protein in the human diet. The crop residues viz., leaves, pod coats, and bran are used as dry fodder for livestock. Mung bean plants are also utilized as green manure, improving soil health and enhancing nutrient. Pulses crops maintaining soil fertility through biological nitrogen fixation, their root nodules harbor Rhizobium bacteria in a symbiotic relationship. The bacteria receive carbohydrates such as sugars and starch from the host plant. These bacteria fix atmospheric nitrogen and convert it into nitrates. Each nodule remains functional for about four weeks before decomposing and releasing nitrogen into the soil. India is the largest producer of pulses in the world. Major pulse crops grown in India include chickpea (*Cicer arietinum* L.), pigeon pea (*Cajanus cajan* L.), mung bean (*Vigna radiata* L.), urad bean (*Vigna mungo* L.), lentil (*Lens culinaris* Medik.), pea (*Pisum sativum* L.), and various other beans. Pulse crops are cultivated during the Kharif, Rabi, and Zaid seasons. However, pulse production is constrained by several biotic and abiotic stresses, including diseases, insect pests, drought, water logging, salinity, and other environmental stresses. Among these, diseases significantly reduce crop yield. Legumes are susceptible to a wide range of pathogens, including fungi, bacteria, viruses, and nematodes. Major diseases of legumes include rusts, powdery and downy mildews, Ascochyta blights, Botrytis grey mould, anthracnose, root rots, collar rots, wilts, viral diseases, bacterial blights, and nematode infestations. These pathogens are transmitted through air, soil, and seed, posing a major constraint to yield. Seed serves as the primary source of inoculums for many pathogens. Seed-borne diseases of pulses include Ascochyta blight, Botrytis (grey) mould, Stemphylium blight, anthracnose, Alternaria leaf spot, bacterial blight, and mosaic diseases, all of which require effective management strategies. Among major pulse crops, chickpea is affected by Fusarium wilt (*Fusarium oxysporum* f. sp. ciceri), blight (*Mycosphaerella pinodes*), and rust (*Uromyces ciceris-arietini*). Pigeon pea suffers from wilt (*Fusarium oxysporum* f. sp. *udum*) and sterility mosaic disease. Pea is mainly affected by powdery mildew (*Erysiphe polygoni*) and rust (*Uromyces viciae-fabae*), along with several other minor diseases.

KEYWORDS

• Pulses • Diseases • Cause • Losses • Management

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INTRODUCTION

Pulses are an important of the Indian diet; and a major source of dietary proteins, minerals, and vitamins. They are important for enriching the soil through nitrogen fixation in sustainable agriculture. Legume species are the largest source of plant-based proteins, for human and livestock feeding.¹ The requirement of protein per capita per day for an adult man about 60 g, an adult woman 50 g and lactating woman requires 75 g per day. The major pulses are grown in the country are chickpea, pigeon pea, mung bean, urd bean, field pea, and lentil which together have about 80.7% production of pulses in the country. Minor pulses which have regional importance are horse gram, moth bean, Lathyrus, cowpea, and rajmash. The availability of pulses is around 40.0 g, the recommended level of 50 g/capita/day by ICMR. India has 37% of the area and 27% of the world production as about 90% of the total global pigeon pea, 65% of chickpea, and 37% of lentil area falls in India. Legumes crops are suffering from diseases, caused by fungi, bacteria, viruses, nematodes and parasitic angiosperms. The symbiotic associations of soil-borne bacteria allow for atmospheric nitrogen fixation and improve soil fertility.² Legume crops viz., pigeon pea, black gram and green gram, grown in the warm season and in the cool season are pea chickpeas and lentils in India and Southeast Asia.³ More than 50% of the crop is grown in the world by Canada, Russia, and China.⁴ Chickpea (*Cicer arietinum* L.), are one of the most important leguminous crops around the world.⁵ It is a better source of carbohydrates and proteins several vitamins and minerals.⁶ Collar rot disease caused by

Sclerotium rolfsii is a serious threat to chickpeas that may cause 55 to 95 % mortality. Pigeonpea [*Cajanus cajan* (L.) Millsp.] is the second most important legume crop after chickpeas in India and is predominantly grown in the Kharif season. Pigeon pea cultivation is increasing in semi-arid areas.⁷ Fusarium wilt and sterility mosaic disease and Phytophthora blight are very important.⁸ Pigeon pea sterility mosaic disease (SMD), caused by *Pigeonpea sterility mosaic virus* (PPSMV), is the economically most important viral disease in India, mostly endemic to India, Nepal, Bangladesh, and Myanmar, causing loss of more than US\$300 million.⁹ It was first reported in 1931 from Pusa (Bihar).¹⁰ The disease has also been reported in Thailand¹¹ and Sri Lanka.¹² The first occurrence of Phytophthora blight on pigeon peas in India was reported in 1966.¹³ The disease is soil-borne and the pathogen overwinters as chlamydospores, oospores, and dormant mycelium in soil and plant debris.¹⁴ Typical symptoms of the disease are water-soaked lesions on the leaves and brown-colored lesions and girdle on stems, followed by drying of foliage.¹⁵ The pea crop has been growing in Asian, European, and African countries, suffering from anthracnose, wilt, ascochyta blight, root rot, rust, and other diseases.¹⁶ In the epiphytotic of ascochyta blight can damage pea leaves up to 75% and seeds up to 40%, ascochyta can survive up to 9 years in the seeds.¹⁷ In Indian conditions temperatures of 25⁰-30⁰C plants in fields were damaged by 60-100%.¹⁸ Leguminous crops are suffering from many diseases caused by fungi, bacteria, viruses, nematodes, and abiotic stresses. (Table.1)

Table 1: Pulse crops and their diseases

Diseases	Causal organism
Chickpea (<i>Cicer arietinum</i> L.)	
Wilt	<i>Fusarium oxysporum</i> f. sp. ciceri Matuo and Sat),
Rust	<i>Uromyces ciceris-arietini</i> (Grogn.) Jacz. & Boy),
Ascochyta blight,	<i>Didymella rabiei</i>
Grey mold	<i>Botrytis cinerea</i>
Collar rots	<i>Sclerotium rolfsii</i>
Root lesion nematodes	<i>Pratylenchus</i> spp.
Pigeon pea (<i>Cajanus cajan</i> L.)	
Wilt	<i>Fusarium udum</i>
Phytophthora blight	<i>Phytophthora cajani</i>
Leaf spot	<i>Cercospora indica</i>
Dry root-rot	<i>Rhizoctonia bataticola</i> (Pycnidial stage- <i>Macrophomina phaseolina</i>)

table Cont...

Diseases	Causal organism
Sterility mosaic	Virus
Nematode	<i>Heterodera cajani</i>
Pea (<i>Pisum sativum</i> L.)	
Powdery mildew	<i>Erysiphe pisi</i> DC
Downy mildew	<i>Peronospora viciae</i>
Rust	<i>Uromyces vicia-fabae</i> (Pers.) Schroet.
Ascochyta blight	<i>Ascochyta pisi</i>
Septoria leaf blotch	<i>Septoria pisi</i>
Wilt	<i>Fusarium oxysporum</i> f.sp. <i>pisi</i>
Lentil (<i>Lens culinaris</i> Medikus)	
Wilt	<i>Fusarium oxysporum</i> f.sp. <i>lentis</i>
Ascochyta blight	<i>Ascochyta lentis</i>
Anthracnose	<i>Colletotrichum truncatum</i>
White mould	<i>Sclerotinia sclerotiorum</i>
Rust	<i>Uromyces viciae-fabae</i>
Seed and seedling root rot	<i>Rhizoctonia solani</i>
Mung bean (<i>Vigna radiata</i> (L.) Wilczek), Urad bean (<i>Vigna mungo</i> (L.) Hepper), Common bean (<i>Phaseolus vulgaris</i> L.) and Broad bean (<i>Vicia beans</i>)	
Powdery mildews,	<i>Erysiphe polygoni</i> DC
Rust	<i>Uromyces phaseoli-typica</i> (Syn: <i>Uromyces appendiculatus</i>)
Anthracnose	<i>Colletotrichum lindemuthianum</i>
Cercospora leaf spot	<i>Cercospora canescens</i> and <i>Pseudocercospora cruenta</i>
Dry root-rot	<i>Rhizoctonia bataticola</i> (Pycnidial stage - <i>Macrophomina phaseolina</i>)
Bacterial blight	<i>Xanthomonas campestris</i> pv <i>phaseoli</i>
Rot-knot nematodes	<i>Meloidogyne</i> spp.
Yellow Mosaic	Mungbean yellow mosaic virus (Geminivirus)
Bean common mosaic virus	Virus

COMMON DISEASES IN PULSE CROPS AND THEIR MANAGEMENT

1. Rust

Rust pathogen is an obligate biotrophic parasite.¹⁹ Disease caused by *Uromyces fabae* (*U. vicia-fabae*) and wide-spread disease, attacks several crop species such as broad bean (*Vicia faba*), pea (*Pisum sativum*), and lentil (*Lens culinaris*), as well as more than 50 other *Vicia* species, and about 20 *Lathyrus* species.²⁰ It is a major disease in the Middle East, North Africa, Europe and China, where moderate to considerable yield losses. *Uromyces fabae* is autoecious, macrocyclic rust all spore forms and produced on a single host.²¹ Telio and pycnio spores do not infect plant, basidio, aecio and uredio spores can infect. Teliospores represent the final spore form of rust fungi.²² Telia form on stems and leave late in the season, remaining in crop debris after harvest, the fungus over-wintering as teliospores. In spring teliospores germinate to form a metabasium

that produces basidiospores, germinate to form monokaryotic infection structures. The infection mainly occurs uredospores, with aeciospores spreading the fungus throughout the canopy and between plants. Urediospores are single-celled, hydrophobic, and have spines on their surface.²³

Uromyces ciceris-arietini Jacz is an economically important disease that causes rust on *Cicer arietinum* L. (chickpea), infected leaves dry up and falls down causing 80 to 90 percent yield loss. *Uromyces ciceris-arietini* Jacz. infection appears as small oval, brown, powdery lesions on both surfaces, especially on lower surface of leaf. The uredospores, cover the entire leaf surface. Uredospores are spherical, brownish yellow in colour, and loosely echinulated with 4-8 germ pores. Late in the season dark teliospores appear on the leaves. The fungus survives in the legume weed *Trigonella polycerata* as uredospores during summer months and serves as the

primary source of infection spread through wind-borne uredospores. The rust pustules may appear on petioles, stems and pods. The pycnial and aecial stages are unknown. This rust can be identified based on morphology of teliospores and uredinio-spores.²⁴ During hot period pathogen survival in fields of *C. arietinum* at lower altitudes.²⁵ In India, *U. ciceris-arietini* over summers on *Medicago polyceratia* (L.) Trautv. is the only reported host of *U. ciceris-arietini*.²⁵

Uromyces phaseoli-typica is autoecious, long cycle rust and all the spore stages occur on the same host. The disease is mostly seen on leaves, rarely on petioles, stem and pods. The fungus produces small, round, reddish brown uredosori mostly on lower surface. Uredospores serve as inoculum for secondary spread of the disease. In the late season, teliosori appear on the leaves which are linear and dark brown in colour. Yellow coloured pycnia appear on the upper surface of leaves. Orange coloured cupulate aecia develop later on the lower surface of leaves. *Uromyces phaseoli-typica* survives in the soil through teliospores and as uredospores in crop debris, primary infection through sporidia as developed by teliospores. Secondary spread is by wind-borne uredospores. *Uromyces phaseoli-typica* disease is distributed worldwide causes major problems in humid tropical and subtropical areas and epidemics in humid temperate regions.²⁶ The life cycle of the fungus is divided into five spore stages: spermatia, aeciospores, uredospores, teliospores, and basidiospores.²⁴ The teliospore germinates to produce a basidium in which meiosis occurs and on which haploid basidiospores develop to infect the host.²⁷ The basidiospores are windblown to susceptible plants where they germinate and penetrate the upper leaf surface through stomata. A layer of free water is necessary for germination and penetration to occur. On a susceptible bean cultivar, an appressorium is formed, penetration is direct and intercellular and intracellular hyphae are developed.²⁸ The entire infection cycle occurs within approximately 12-15 days.²⁹

The bean rust control crop rotation, soil incorporation of bean debris, planting within recommended dates, growing resistant cultivars, and timely spraying of fungicides.³⁰ Cultural controls include crop rotation and removal of old plant debris which may bear viable uredospores and teliospores.³¹ The

disease has been controlled by dusting plants every 7-10 days with sulfur at a rate of 25-30 kg/ha after pustules first appears. Spray Mancozeb 2 kg or Carbendazim 500 g or Propiconazole 1L/ha, immediately on the set of disease. The effective chemicals still in use by some countries are bitertanol, triadimefon, propiconazole, triphenylphosphite, and oxycarboxin.²⁹ New fungicides like the strobilurins and new triazoles are also recommended. *B. subtilis* was sprayed on field-grown beans three times per week it caused 75% reduction in rust severity.³² *Verticillium lecanii* (Zimm.) Viegas penetrates, invades, and kills uredospores and teliospores of and colonizes pustules.³³

2. Powdery mildew

Powdery mildew is one of the economically important diseases which reduce the yield up to 21 percent.³⁴ Yield reduction by the reduction in photosynthetic and physiological changes (20-40 per cent) depending on the stage and time disease appears.³⁵ Yield losses ranging from 9 to 50 per cent have been reported from Taiwan³⁶ and grain yield losses up to 21%.³⁴ Powdery mildew is one of the widespread diseases of several legumes crop. The fungus is an obligate (biotroph) parasite that requires living hosts to complete their life cycle. The fungus survives as cleistothecia in the infected plant debris.

Powdery mildew caused by *Erysiphe polygoni* is an air-borne disease and worldwide distribution, with warm dry days and cool nights.³⁷ *E. polygoni* is an obligate parasite and survives as cleistothecia in the infected plant debris. The symptoms usually observed on 35-40 days old crop³⁸, during flowering and pod formation stage.³⁹ Powdery mildew of pea (*Pisum sativum*), caused by *Erysiphe pisi* DC, is an important disease in pea crops worldwide.⁴⁰ This disease causes up to 50% yield losses and reduces plant height, node number, pod number per plant, seeds per pod, pod quality and seeds weight.⁴¹ The infection begins through the conidia dispersed by wind; conidia land and germinate on a suitable host, forming a single germ tube that elongates before differentiating into an appressorium.³⁷ Secondary appressoria are formed in secondary hyphae, the secondary haustoria allowing successful establishment of colonies that sporulate to complete the infection cycle. The disease first appears on the leaves; in its advanced stage, stems and pods

become infected, the superficial growth of the fungus, thread-like stands (hyphae) over the plant surface and the production of chains of spores (conidia), when the infection is severe, both the surfaces of the leaves are completely covered by whitish powdery growth and affected parts get shriveled and distorted. Conidiophores arise vertically from the leaf surface, bearing conidia in short chains, in later season; cleistothecia appear as minute, black, globose structures with myceloid appendages. Cleistothecium contains 4-8 asci and each ascus contains 3-8 ascospores which are elliptical single celled and hyaline. Primary infection is usually from ascospores from perennating cleistothecia. The secondary spread is carried out by the air-borne conidia.

Disease resistance varieties are an important strategy for controlling plant pathogens, and cost effective and environmentally more acceptable than reliance on pesticides.⁴² Spray Carbendazim 500 gm/ Wettable sulphur 1.5 kg/ Tridemorph 500 ml/ha at the initiation of disease and at 15 days interval. Spraying twice at 15 days interval starting from the initial appearance of the disease by Karathane (Dinocap) @ 0.1% and Sulfex 0.2% effective in reducing the intensity.

3. Phytophthora blight

Phytophthora blight is an emerging threat to pigeonpea production area. Diseases cause 100% yield losses under favorable environment. Climate variability, frequent rainfall with warm temperature is responsible for the emergence of phytophthora blight.⁴³ *Phytophthora cajani*, was first isolated from India¹³ from infected pigeonpea plants with stem canker symptoms. Phytophthora blight symptoms at seedling stage water-soaked lesions and become necrotic in the trifoliate leaves that causes seedling die suddenly. The leaflet lesions are circular to irregular and up to 1 cm in diameter. The whole foliage show blighted appearance under high humidity (>80%) conditions. On stems, brown to dark brown lesions from the healthy green portion near the ground level. Lesions on the stem and branches increase rapidly, on above plant.

The fungicides very effective way to minimizing the impact of plant diseases. Phenylamides (acylanilides) group metalaxyl widely used against the *Phytophthora* spp.⁴⁴ Mefenoxam and metalaxyl used to protectant

the *Phytophthora* spp.⁴⁵ The fungicides mixtures with different biochemical effective in management of fungicide resistance.⁴⁶ The fungicide mixtures increase the effectiveness of disease management.⁴⁷ The biological control an eco-friendly and best alternative overcome the problems of pesticide residue and pathogens resistance.⁴⁸ The *Trichoderma* spp importance bio-control agent, use against a variety of pathogens and growth enhancing action.⁴⁹

4. Anthracnose

Anthracnose of bean causing serious crop loss and widely distributed throughout the world. Anthracnose was first described in Germany in 1875.⁵⁰ Yield loss is due to early leaf senescence and plant death and shrunken seeds and lesions on its coat.⁵¹ Anthracnose of bean is a seed-borne disease caused by the fungus *Colletotrichum lindemuthianum*. The infected seeds are the most important means of dissemination of this pathogen.⁵² It has wide host range on many legume species including vegetables and grain. *Colletotrichum lindemuthianum* (Sacc. and Magnus) Lams-Scrib. is economically important seed borne disease. Disease causes dark brown necrotic lesions and decrease leaf photosynthesis activity.⁵³ *Colletotrichum lindemuthianum* produces cell wall degrading enzymes and low molecular weight phytotoxins that may killing cells in advance and contribute to the necrotrophic growth of this pathogen.⁵⁵

Leaves, stems and pods of bean plants are susceptible to anthracnose. The characteristic symptom of the disease is black-red sunken spots develop on infected pods, spots become older, the edges develop a black ring with a red outer border, pink ooze in the center contains spores of the fungus. A characteristic symptom underside of infected leaves, veins turn brick-red to purple and eventually black. Infected seeding has dark brown to black sunken lesions on the cotyledons and stems. Severely infected cotyledons cause stunted growth, girdles the stem and kill the seedling. Infected pods may shrivel, seeds have brown to black blemishes and sunken lesions and seeds carry the inoculums.

The primary inoculums sources of bean anthracnose in the field are infected seeds.⁵² Seeds play an important role in the long distance distribution of the pathogen.⁵³

Moisture is required for development, spread, and germination of the spores for infection. The spores can spread from infected to healthy plants by rain splash, wind-blown rain and through the movement of insects, animals and man, especially when the foliage is moist.⁵⁴ The fungus has races that vary from, country, region, location, and variety, to another.⁵⁵ In Brazil more than 25 different *C. lindemuthianum* races have been identified⁵⁶ *C. lindemuthianum* spores are produced inside acervulus and immerse in water soluble-formed mucilage.⁵⁷ The conidiophores rupture through the host cuticle and form acervuli on the plant surface.⁵⁵

Diseases management can archived by reduce the pathogen inoculums in the field.⁵⁸ Use of disease-free seed is the best for management of diseases. Crop rotations of 2 to 3 years and seed treatment /soil application of bi-agents *Trichoderma viride*, *Trichoderma harzianum* and *Gliocladium virens* caused significant inhibition of mycelial growth of *C. lindemuthianum*, thereby effectively controlled the seed borne infection.⁵⁹ Application of spore suspension of *Trichoderma viride* as seed dip and soil drench was effective against seed borne infection of *C. lindemuthianum*.⁶⁰ Neem (*Azadirachta indica*) seed extract effectively inhibited both germination of conidia and mycelial growth of *C. lindemuthianum*.⁶¹ Seed treatment and field spray through the extracts of *Lawsonia inermis* improved seedling emergence and reduced incidence of bean anthracnose.⁶² Mancozeb seed treatment at a rate of 3 g/kg seeds and Carbendazim foliar spray at a rate of 0.5 kg/ha were found to be effective in reducing bean anthracnose epidemics.⁶³

5. Cercospora Leaf spot

Cercospora leaf spot disease of green gram caused by *Cercospora canescens*. The disease was first time reported in Delhi, India.⁶⁴ *Cercospora canescens* infected leaves show small, brown, water-soaked, circular spots surrounded by a yellowish halo, the petioles, stems and pods also affected by the pathogen. Disease appeared 30-40 days after planting, which spreads rapidly in susceptible varieties causing premature defoliation.⁶⁵ Spots appear on leaves first brown, later turned grey to dirty grey with narrow reddish brown margin, sub circular to irregular and 5-10 mm wide.⁶⁶ The fungus produces clusters of dark brown septate conidiophores, conidia are linear, hyaline, thin-walled and 5-6 septate, serve as primary inoculums in disease incidence. Rain

splashes also play as a major role in dispersal of conidia.⁶⁷ *Cercospora* leaf spot is considered as an important pathogen and widespread many commercial crops.⁶⁸ Warm wet conditions are favorable for *Cercospora* leaf diseases.⁶⁹ The fungus survives on diseased plant debris and on seeds. The secondary spread is by air-borne conidia. High humidity favors disease development.

Disease can manage through cultivate resistant varieties and disease free seed, intercrop the moong with tall cereals and millets, clean cultivation, low crop density and wide row planting. Some botanical extracts to control leaf spot disease of green gram.⁷⁰ *Cercospora* leaf spot of green gram manage through the use of chemical fungicides.⁷¹ Some systemic fungicides evaluated against *Cercospora canescens* as reported in Gujrat, India.⁷² Two sprays of carbendazim were found effective against leaf spot of green gram, followed by tridemorph and mancozeb.⁷³ Chlorothalonil was found effective in control of leaf spot of greengram.⁷⁴ Minimum diseases intensity and higher yield was recorded in the application of hexaconazole (0.1%) followed by penconazole (0.1%).⁷⁵ Hexaconazole was found to be highly effective in management of leaf spot of mungbean.⁷² Carbendazim and Benomyl found highly effective in reduction of disease severity.⁷⁶

6. Fusarium wilt

Fusarium oxysporum is commonly found on many economically important crops, it is a soil borne pathogen. *F. oxysporum* survive in a dormant stage in the soil for several years and spread in water. Infects host through the root and grows in xylem, blocks the vascular system and prevents water and nutrients to the plant. Wilted plants can be easily recognized in the field with wilt patches. Wilt occurs at the seedling stage of plants but is mainly seen at flowering and podding stages.

Pigeon pea wilt prevalent throughout the growing regions of the world. The disease was first recorded by Butler⁷⁷ in Bihar, India, and subsequently reported from other growing countries.⁷⁸ Pathogen caused significant yield losses in many susceptible cultivars of pigeonpea.⁷⁹ *F. udum* is host specific and is pathogenic to only pigeonpea.⁸⁰ *Fusarium udum* Butler, is the major constraint to pigeonpea production worldwide.⁸ Wilt disease can cause 30-100% loss in grain yield.⁸¹

The incidence of disease has been reported from 30 to 60% at flowering and crop maturity stages.⁸² Disease can cause yield losses up to 100% in susceptible cultivars.⁸³ Fusarium wilt (*Fusarium udum* Butler), an important soil-borne disease of pigeonpea [*Cajanus cajan* (L.)], causes significant yield losses yield.⁸⁴ Fusarium wilt incidence is increasing in the major pigeonpea production regions of India.⁸⁵ *Fusarium udum* (perfect stage-Gibberella indica) is economically damaging crop, seedling and adult plants show the symptoms of with yellowing and drying of leaves followed by whole plant wilting. Infection starts from seedling stage but expression of the disease is prominent at flowering and podding stage.⁸¹ The disease occurs sporadically in the fields, infection starts at the seedling stage. Infected plants gradually wilting from bottom to top, as a result of plugging of xylem vessels and show vascular browning, plants wilts and dies. The fungus produces macroconidia, microconidia and chlamydospores. *F. udum* isolates shown high degree of pathogenic variations same or different geographical origin.⁸⁶ The high diversity and virulence due to the influence of environment factors and soil inhabitant nature.⁸⁷

Crop rotation, seed treatment with fungicides and biocontrol agents and use resistant cultivars are common practices for management of Fusarium wilt.⁸⁸ Disease is monocyclic and survive in infected debris is soils as a saprophyte for up to 3 years. Pathogen enters through finer roots and cause primary infection. Seed treatment in combination with carbendazim @ 2 g/kg of seeds + *Trichoderma viride* @ 2.5 kg/ha and farm yard manure @ 50 kg/ha.⁸⁹ Seed dressing by *Pantoea dispersa* reduces wilt incidence by 47%.⁹⁰

7. Ascochyta blight

Ascochyta blight is fungal disease in cool-season of legumes and cause yield loss globally. *Ascochyta rabiei* causing disease of chickpea, lentil, and faba bean in a host-specific manner.⁹¹ The disease spreads during cool, wet weather from infected plants by rain splash of spores. *Ascochyta rabiei* (teleomorph - *Didymella rabiei*) infects all aerial parts of the plant, which results in yield loss ranging from 10% to 100%.^{92,93} The fungus can penetrate the pod and infect the seed. The infected seeds are sown; the emerging seedlings will develop

dark brown lesions at the base of the stem. Affected seedlings may collapse and die.

First symptoms appear water soaked lesions on the leaves and stems, which turn brown or dark brown. At later stages lesions girdle the stem and above the girdle falls off. In lesions with concentric rings form due to asexual structures called pycnidia, appear on leaves, stems, and pods. The infected pod results in shrivelled and infected seeds. Infected seeds appear discolored and shriveled and often harbor lesions bearing dark pycnidia.⁹⁴ Disease is more prevalent during the flowering and podding stages of the plant, but appear any time after plant emergence. Spores of the fungus produced on crop residues are carried into new crops by wind. Symptoms become visible in 4–5 days and pycnidia develop in 7–10 days. *A. rabiei* exhibits both teleomorphic (sexual) and anamorphic (asexual) stages in its life cycle, sexual fruiting body called a pseudothecium. It can survive as mycelia/conidia or for extended periods as sclerotia in crop debris. Contaminated seeds and ascospores serve as a major source of primary inoculums.⁹⁵ *A. rabiei* can survives up to 8 months on infected chickpea debris within a 10–35°C temperature range,⁹⁶ and 20 months on infected stems.⁹⁷ Pseudothecia formed on chickpea-infected debris harbor ascospores that are carried over long distances by wind and can infect plants, as spreading the disease to new regions.⁹⁴ During the growing season, conidia from pycnidia are dispersed by rain splashing locally and serve as secondary inoculums.¹⁸ The disease spread mainly through the movement of seeds, dissemination of spores via wind and water, and infected chickpea debris.

The integrated disease management to keep the disease below the economic threshold.⁹⁸ Use of healthy seeds, seeds treatments with fungicides, and destruction of diseased debris. Seed treatment with systemic fungicides such as strobilurins enhances plant resistance of young seedlings. Seed treatments with the fungicide thiabendazole or in combination with other chemicals prevent disease spread through seeds.⁹⁹

8. Grey mold

Grey mould is caused by *Botrytis cinerea* is an airborne plant pathogen attacking over 200 crop hosts worldwide. Fungus cause soft rot due to cell-wall-degrading enzymes, toxins

and low-molecular-weight compounds such as oxalic acid. The aerial plant parts, decay of plant tissues by growth of fuzzy grey-brown mould, many fungicides have failed due to genetic flexibility. Most legumes suffer attack by *Botrytis cinerea*, field bean (*Vicia faba*) damaged by chocolate spot caused by *Botrytis fabae*.

Botrytis cinerea and *Botrytis fabae* have a broad host range (faba bean, field pea chickpea and lentil) including cause botrytis grey mould, and survive on infected seed, debris and sclerotia in the soil leading to direct infection of plants and production of airborne spores. Mycelium survives within infected dead host tissues left as crop debris. The melanized rind and β -glucans encasing the internal mycelium protect sclerotia from UV radiation and microbial attack.¹⁰⁰ Sclerotia begin growth in early spring in temperate to produce conidiophores and multinucleate conidia serving as a primary source of inoculums. Spores can blown several kilometers and deposited on host plants.

Grey mould is difficult to control because it has several hosts as inoculums sources, the chemicals used for control of *B. cinerea* have recently been reviewed.¹⁰¹ Fungicides are namely affecting respiration, microtubule assembly, osmoregulation, sterol biosynthesis inhibitors and toxicity is reversed by amino acids¹⁰² Bio-control agents' such as *Trichoderma harzianum*, *Clonostachys rosea* (*Gliocladium roseum*), yeast *Candida oleophila*, and bacteria *Streptomyces griseoviridis*, *Bacillus subtilis* and *Pseudomonas syringae* use in management.

9. Dry root-rot

Dry root-rot is caused by *Rhizoctonia bataticola*, threat to leguminous crops in India. The disease occurs both in young seedlings and grown up plants, the disease generally appears during reproductive phase of the crop. Affected plants are usually straw colored, lower leaves show yellowing, drooping and premature defoliation, infected roots of plants brittle and dry, brown dots can be seen on the stem portion represents the pycnidial stage of the fungus. Minute dark sclerotia are seen in the shredded bark and root tissues in the pith. The disease generally appears when temperature is more than 30°C. Dry rot is soil borne fungus causing disease in most of agricultural crops including pigeon pea.¹⁰³ Dry root rot of chickpea is caused by *Rhizoctonia*

bataticola (Taubenhaus) E. J. Butler, and their pycnidial stage is *Macrophomina phaseolina* (Tassi) Goid]. Sclerotia are jet black, smooth, hard, minute, globose and 110-130 μ m in diameter. Conidiophores (phialides) are hyaline, short, obpyriform develop inner walls of the pycnidium. The conidia (Pycnidiospores) are hyaline, single celled and ellipsoid to ovoid. The primary spread of the disease is by seed and soil, secondary spread is by air-borne conidia. The pathogen survives as sclerotia in the soil as facultative parasite.

Diseases can manage through summer deep ploughing, grow resistant cultivars, drought should be avoided, young seedlings should be saved from high temperatures. Crop rotation with with sorghum. Seed treatment with bioagents like *Trichoderma harzianum* or *Trichoderma viridae*, @ 6g/kg, *P. fluorescens* @ 10g/ kg of seed and Carbendazim/Thiram 2g/kg of seeds, apply Neemcake at 150 kg/ha.

10. Collar rot

Diseases occur where high temperature prevailed during the rainy season. The disease is severe when soil moisture is high and temperature is about 30 C. *Sclerotium rolfsii* is an important soil borne and fast spreading, produces densely floccose, white, septate mycelium, causes damage to the plants. Numerous olive brown hard fungal bodies' sclerotia measuring 0.8 to 2 mm are produced on host tissues and in culture. Losses caused by collar rot due to death of the seedling in early crop stage. *S. rolfsii* has been reported to cause 22 to 50 per cent reduction in yield of chickpea. Seedling mortality in chickpea has been reported from 54.7 to 95.00 per cent.¹⁰⁴ Pathogen infects more than 500 species of plants in about 100 families. The fungus can overwinter as mycelium in infected plant debris and sclerotia in soil which serve as a major source of primary infection, germinating in response to alcohols and volatile compounds released from decomposing plant material.¹⁰⁵ The pathogen being soil-borne, polyphagous in nature and persistence in soil, which control with chemicals to be ineffective and uneconomical.

Management of pathogen is difficult as its wide host range and soil borne in nature. Seed treatment with fungicide (thiram) reduces the disease incidence. The combination of bio-control agent (*Trichoderma harzianum*)

with fungicides as seed treatment is very effective against collar rot. *T. viride* and *T. harzianum* were highly sensitive to Bavistin, it completely inhibited the growth at 100 ppm as reported.¹⁰⁶ The two fungicides Carbendazim and Thiophanate methyl at 1 ppm and 5 ppm on mycelial growth of *Trichoderma* isolates evaluated.¹⁰⁷

11. Bacterial blight

Bacterial blights or common bacterial blight of beans is caused by *Xanthomonas axonopodis* pv. *phaseoli*, halo blight (*Pseudomonas syringae* pv. *phaseolicola*), and bacterial brown spot (*Pseudomonas syringae* pv. *syringae*). Common bacterial blight one of the most economically important disease worldwide.¹⁰⁸ Diseases cause significant losses in common beans in tropical and subtropical climates. The most common diseases are halo blight and common blight. Both diseases are carried on the seed and can be spread from plant to plant by rain, hail, irrigation and wind. Halo blight occurs primarily when temperatures are cool. Light greenish-yellow circles that look like halos form around a brown spot on the plant. Common blight affected leaves turn brown and drop quickly from the plant and pods do not yellow halo around the infected spot. Pod lesions may appear as small, brown, scabby spots. Common blight occurs worldwide mostly during warm weather. Pod symptoms of common and halo blight are very similar; therefore, these diseases should be identified by leaf symptoms. Leaf symptoms of halo blight may be confused with those of brown spot.

Common bacterial blight is a seed borne disease of common bean, caused by *Xanthomonas axonopodis* pv. *phaseoli* and variant *Xanthomonas fuscans* subsp. *Fuscans*.¹⁰⁹ During warm and humid weather, disease highly destructive causes losses in both yield and seed quality of bean in Ethiopia.^{110,111} Common bacterial blight bean initially symptoms appear as water-soaked spots that become necrotic, light brown lesions of irregular shape with distinct, bright yellow margins which serves as a diagnostic symptom of common bacterial blight. These lesions enlarge to 10 mm and similar water-soaked spots form on the pods and seeds inside small and malformed. In humid weather yellow slimy ooze of bacterial present on the pod lesions. Pathogen survives on or in the seed, primary

source of this pathogen. Pod symptoms of common and halo blight diseases are virtually indistinguishable. Bean plant residues can also be a source of the bacterium. Secondary spread can occur by wind-blown rain, overhead irrigation, contaminated equipment, or people and animals.

Halo blight is the second of the major bacterial bean disease. symptoms are similar to those of common blight and begin as small necrotic water-soaked lesions that become surrounded by prominent light green 'halos' which are diagnostic on the leaves. Toxin produced by the halo blight bacterium when the temperatures are less than 21°C. In hot weather, halo blight will resemble bacterial brown spot. Pods show water-soaked spots that are difficult to distinguish from symptoms of common blight. Infected bean seed is the most important source of the halo blight bacterium; pathogen can survive more than 4 years in bean seed. The pathogen can survive in bean residues from previous seasons.

The bacterial brown spot caused by *Pseudomonas syringae* pv. *syringae* on several kinds of plants. The initial symptom of bacterial brown spot is small water-soaked spots that develop into distinctive necrotic brown spots about 3-8mm in diameter, often with a narrow, diffuse yellow margin on leaves, sunken brown spots can form on the pods. Weeds are over-wintering sources of the pathogen and infected plant debris source of inoculums. Contaminated seed is the major means of dispersal, plant to plant contact, and water splash from rain. Bacteria enter plants through wounds caused insects, machinery or climate, or through natural openings. The disease develops in warm, humid weather, in temperatures of 28°C to 32°C.

Seeds are the primary source of inoculum of *X. axonopodis* pv. *phaseoli*.¹¹² Effective diseases management strategy is use of pathogen free seed.¹¹³ Infested debris is also primary source of inoculums, disposal of debris through burning an effective management strategy.¹¹⁴ Use disease-free seed, resistant cultivars, use two to three-year crop rotation, eliminate alternate hosts such and weeds. Copper based fungicides applied early in the season and repeatedly to slow down the spread of halo blight. Seed treatment with the antibiotic streptomycin can help reduce contamination

of the surface of the seed coat. The easiest and most effective way to prevent its spread is to avoid coming into contact with plants, control pests, like beetles and whiteflies.

12. Yellow Mosaic Disease (YMD)

Yellow mosaic disease (YMD) is deadly disease and biggest challenge that is caused by yellow mosaic viruses (YMV). Disease spread to the mungbean crop through whitefly (*Bemisia tabaci*).¹¹⁵ Disease reported throughout the world but its heavy incidence reported from India, Bangladesh, and Pakistan.¹¹⁶ In India, MYMV was first reported from the mungbean fields of Indian Agricultural Research Institute (IARI), New Delhi during 1950s.¹¹⁷ Yellow mosaic disease is caused by four distinct begomoviruses viz., MYMV, MYMIV, dolichos yellow mosaic virus and horsegram yellow mosaic virus; collectively known as yellow mosaic viruses (YMV).^{118,119} Legumoviruses has been used to refer the legume infecting bipartite begomoviruses.¹²⁰ MYMV particles were first observed and purified in the leaf cells of mungbean.¹²¹ The genome of Thailand isolates of MYMV,¹²² and the isolate from North India.¹²³ The DNA-A and DNA-B of bipartite begomoviruses were supposed to be unique and diversification due to the component exchange during evolution.¹²⁰

Whitefly (*Bemisia tabaci*) a polyphagous pest causes severe damage of crops not only sucking the plant sap but also as a vector of several viral diseases.¹²⁴ The virus moves in a persistent circulative manner but do not replicate in the whitefly,¹²⁵ in next feeding healthy plant the virus injected with salivary secretion. The virus circulates from the foregut, midgut, hindgut, hemolymph, and finally to the salivary glands of the whitefly before their release into the plants.¹²⁶ The minimum latent period is 8 h between acquisition and inoculation, for successful transmission of viruses.¹²⁷ The virus enters the phloem cells through the whitefly proboscis, viral aggregates appear in the host cell nuclei two days before the symptom appearance.¹²¹ Symptoms appear as scattered yellow-color spots on the young leaves, later turns into a yellow mosaic pattern and ultimately results in complete yellowing. The pods become smaller in size, yellowing of the leaves and decrease the photosynthetic efficiency.¹¹⁸ Systemic infections lead to symptom expression.¹²⁸

Eradication of primary hosts such as perennial weeds and summer whiteflies as facilitate YMD.¹¹⁸ Manage through the development and use of resistant varieties. Application of systemic insecticides as considered at the early growth stage effective for whitefly management development of insecticide resistance in vectors.^{129,130} Field sanitation, plucking of infested leaves, water-sprays, avoiding an excess of nitrogen fertilizer.¹³⁰ The excessive use of chemicals resulted in harmful impacts on environment and human health.¹³¹

13. Sterility Mosaic Disease (SMD)

Sterility mosaic disease (SMD) is endemic in most of the pigeonpea-growing regions of India. Yield losses estimated more than 90% annual loss in India. The SMD was first described in 1931. The genus Emaravirus is the causal agent of sterility mosaic disease (SMD) of pigeonpea [*Cajanus cajan* (L.) Millsp.]. This disease is often referred to as the 'green plague' as the infected plants are pale green with excessive vegetative growth. The yield losses depend on the genotype and stage of infection; infection before flowering (<45 days after planting) can lead to a yield loss from 95% to 100%.⁸ Sterility mosaic disease is characterized by stunted and bushy plants, leaves of reduced size with chlorotic rings and partial or complete cessation of flower production (sterility). The virus genome contains five segments of single-stranded RNA that encode proteins in negative, transmitted in a semi-persistent manner by an eriophyid mite (*Aceria cajani*).^{132,133} Infected perennial and volunteer plants serve as a source for the virus and play an important role in the disease cycle. The disease is mainly controlled by resistant cultivars. Genetic engineering through RNA-interference (RNAi). Insecticides and acaricides are commonly used for the chemical management of vectors transmitting viral diseases.^{134,135,136}

14. Diseases caused by Nematodes

Plant-parasitic nematodes have hollow and protrusible spear (stylet) that inject host tissues and withdraw nutrients.¹³⁷ Typical symptoms are stunted growth, wilting, leaf discoloration and deformation of the roots, nutrient and water deficiencies. Nematode life cycle consists of an egg, 4 juveniles' stages and an

adult, life cycle depending on the species and the temperature. The root-knot nematodes and cyst nematodes (*Heterodera* spp.) are sedentary endoparasites of plant roots, causing damage leguminous crops.¹³⁸ *Meloidogyne* species are economic importance worldwide.¹³⁹ The four major species are root-knot nematode i.e. *M. incognita* and *M. javanica*, *M. arenaria* and the temperate *M. hapla*.¹⁴⁰ Mature females lay eggs in a protective gelatinous matrix which forms an egg mass found on the root surface and can contain up to 1000 eggs. Root-knot nematodes have unbalanced sex ratios, from amphimixis to obligatory mitotic parthenogenesis.¹⁴¹ Cell wall breakdown by cellulolytic and pectolytic enzymes. Disease complexes with *Fusarium* wilt, *Rhizoctonia solani* and *Thielaviopsis basicola*, have also been reported.¹⁴² Second-stage juvenile (J2) that hatches from the egg in soil and penetrates the root directly behind the tip at the zone of elongation.¹³⁷ The parasitic J2 of cyst nematodes migrate through root cortical cells in intracellularly, while the J2 of root-knot nematodes migrate between root cortical cells in intercellularly to reach the root vascular cylinder. The esophageal gland cells of both nematodes actively synthesize and secretions from the stylet during migration within tissues and subsequent formation of feeding cells.¹⁴³ The root-knot nematodes induce the formation of three to six multinucleate giant cells in root xylem parenchyma. Giant cells form nuclear division without cellular division. In pericycle and cortical root cells stimulated to divide form hyperplasia and giving rise the galls. The J2 of cyst nematodes select a single root pericycle cell to induce an initial syncytial cell. Cyst nematodes, J2s migrate to the root tip and make a U-turn when they reach the apical meristematic region. They move upwards in the vascular cylinder towards the zone of differentiation. Enzymes of dissolution of cell walls to initial syncytia, give rise multinucleate feeding site called a syncytium.¹⁴⁴ The syncytium, a large multinucleate feeding structure formed by partial cell wall dissolution. The nematode begins to feed and swells sedentary state to become a reproductive adult. Cyst nematodes to survive for prolonged periods in the soil in the absence of a host.¹⁴⁵ The life cycle host-specific species, hatching occurs in response to host-derived chemical present in root diffusates.¹⁴⁶ The J2 then locates its host, invades and migrates destructively and intracellularly

through the root.¹⁴⁷ DNA synthesis is induced and metabolism increases, providing a rich food source for the nematode.¹⁴⁸

Root lesion nematodes (*Pratylenchus* spp.) are distributed worldwide. *Pratylenchus* species have rank third to root-knot and cyst nematodes, impact on crops worldwide.¹⁴⁹ *Pratylenchus* spp. are polyphagous, migratory, intercellular root endoparasites, complete their life cycle lasts 3–8 weeks. Lesion nematodes have six life stages - egg, four juvenile stages, and the adult stage. Longer term survival under adverse conditions through anhydrobiosis, more than a year. Root damage cause slows plant growth, water stress, stunting and yellowing, infected roots are usually discoloured and stubby, infection damage to the epidermis, cortex and root endodermis. Lesion nematodes produce characteristic necrotic lesions on the root surface. The lesions turn from reddish-brown to black initially on the root surface. As the nematodes continue to migrate and feed within the roots, the lesions can coalesce to become large necrotic areas of tissue and girdle the root. They migrate intracellularly and feed cells within the root formed cavities.

The health and environmental risks, use of nematicides and alternative control strategies. Resistant cultivars can be used to reduce nematode populations. The resistance involves a gene which acts by destroying the giant cells produced by the developing nematode. Cultivars such as forage sorghum show good resistance to most species and races. Crop rotations to non-host crops also offer limited opportunities to manage lesion nematode field populations. *Pratylenchus* species have wide host ranges including both dicots and monocots.

CONCLUSION

Pulses are an important component of humane diet and major source of proteins, minerals and vitamins. The legumes crops are agricultural important for enriching the soil fertility through biological nitrogen fixation in soil. The major pulses are grown such as chickpea, pigeon pea, mung bean, urd bean, field pea, lentil and beans. Leguminous crops are suffering from biotic and biotic

stress because economic losses. Some fungal, bacterial and viral diseases are very severe causes economic losses to the pulse crops. The management strategies adapted such as cultural, physical, chemical and biological in diseases management. The integrated disease management method uses for all types of disease to keep pressure below the economic threshold level.

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