Review Paper

Important diseases in major pulses and their management

Abstract

Legume crops are very important group of plants that belong to Fabaceae or leguminaceae family and are rich in different essential amino acids. These legumes prove to be the cheapest and most easily accessible source of required proteins. Humans need proper amount of proteins and essential amino acids that are crucial for the proper functioning of the body. In developed countries a large number of diverse diets including meat, fish, protein drinks and food supplements are readily available but the developing countries having very small income per capita cannot afford all of these commodities. They fulfill their nutritional value by using legume crops. But in developing countries pulses face a number of biotic challenges. They have low production due to less improved varieties. Major damage to the pulse crops is due to the range of bacterial, fungal and viral diseases that drastically reduce the crop production per unit area. Major diseases of pulse crops include chickpea (Blight, Fusarium wilt, root rot), Green and Black gram (Leaf crinckle virus,Mung bean yellow mosaic virus, Mungbean phyllody disease, Cercospora leaf spot, Powdery Mildew), lentil (*Ascochyta* Blight, Stemphylium Blight, Anthracnose, Botrytis grey mold, Lentil Rust) and soya bean (Charcoal rot, White mold, Louisiana, Root rot, *Septoria glycines*, *Sclerotium rolfsii*, Black root rot). These diseases can be controlled by many physical as well as biological methods that have low cost of production and safe to environment. The detailed elaboration of major pulse diseases and their effective control methods have been summarized in this review paper.

Keywords: pulses, proteins, diseases, physical, biological, management.

1. Introduction

The role of food legumes in improving the health and nutrition of human [1], maintaining good stock of cattle [2], ameliorating the condition of soil [3], and in alleviating greenhouse gases [4]. No doubt legume crops have confronted a severe competition with important cereals (rice, wheat, maize) because of having huge market demands due to increasing population of mankind worldwide. In annual cropping patterns the main preferences are given to cereal crops as compared to the legume crops. Asia is the largest producer of the pulse crops. Legumes are used in diverse ways some are important as fodder or green manure, some as fermented fodders and some are used in extraction of vegetable oil particularly soybean and groundnut [5]. These legumes are used in each cropping pattern alternatively, either it is conventional or commercial production system [2]. A large increase in the area of cultivation is observed in the countries that are involved in Commercial production with large land holdings for example in Australia and North America [6].

Farmer is needed to be aware more about the implementation of modern agricultural technologies and should move towards organic agriculture. Farmer is needed to apply all the improved practices in the field so that all the research findings could be transformed into integrated crop management [2]. The legume family is on the number third in species in the whole plant kingdom carrying nearly 20000 species and second in importance as they are the potential source of proteins and have major role in nutritional value of human being and also in food security [7, 8, 9, 10]. All the legumes have built in ability of fixing nitrogen of atmosphere into the soil by the action of root borne bacteria or symbiosis and hence make them the part of the plant [11]. In the legume family abundant amount of proteins are present particularly pulses are rich in Lysine containing proteins and hence it supplements the diet with necessary amino acids which otherwise would be inadequate in lysine and tryptophan [12,13]. In addition to these legumes are also the source of many minerals, vitamins and metabolic intermediates as iso-flavinoids in the diet [7].

Protein shortage is one of the biggest issues in the world as nearly one billion people are facing the protein and multi nutrient deficiency and hence malnutrition [14]. Regarding to this, legumes are pivotal in dealing these malnutrition diseases because they are rich in proteins and micronutrients and cheaper sources of diet in poor and developing countries [12]. Globally 70.41 million tons of pulses are harvested from 77.5 million hectares. The yield of pulses on average is 907 kg/ha [15]. Major pulse crops, viz. common bean, chickpea, green gram, black gram, soybean, lentil, dry peas, cowpea, pigeon pea and faba bean approximately make 90% of pulses and first five are grown on wide scale in Pakistan. The legume crops can also be divided in two groups on the basis of temperature and area of adaptation and weather conditions. Hot climate legumes including common bean, pigeon pea and cowpea. b). Cool climate pulses including pea, chickpea, lentil, and faba bean [16]. Lentil and chickpea are considered to be the first crops that were ever domesticated by the prehistoric man 11,000 years ago, and these became the first step towards the modern agriculture [17]. Conventional breeding has played a great role in the improvement of quality and production of pulses by developing very high yielding cultivars and this was entirely the product of intensive research [18,19, 20, 21,22] and it raised the area under cultivation from 64 to 77.5 m ha in past 50 years [15].

The legume crops are severely damaged by a number of fungal viral and bacterial diseases. Pulses are mainly attacked by thirteen different type of viruses as reported in Australia [23]. Cool climate pulses are immensely damaged by Ascochyta blight as it is the most severe disease that attacks on leaves mainly attacking chickpea, lentil, faba bean and field pea and it may lead to total crop failure. The strains of these fungi are spread worldwide are host specific [24]. The pathogenic fungus starts sexual reproduction on the damaged residue that provides the space for accommodation of ascospores that are airborne and have potential to spread to longer distances. Then these fungi spread themselves within short range through splash borne asexual conidia. This disease damage all the aerial parts of the plant and symbolized by necrotic lesions and drop the yield to drastic limits. The quality of seed is damaged or poor seed development [24].

The cultivated area of chickpea in world is increased from 2.41 m ha to 10.68m ha from the last few decades [15]. The reason behind low productivity of cowpea is considered to be due to diseases as bacterial blight, rust, leafspot and some scabs along with some insect pests as legume flower thrips, pod borer and storage weevil [21]. In addition to these issues parasitism of some weeds causes a yield loss of 85-100% have been observed in cowpea [25]. Similarly, lentil is also damaged by many fungal disorders that greatly decline its yield. They include Aschochyta blight, Fusarium wilt, anthracnose, blight, rust, collar rot, root rot, dry root rot, and white mold [19, 26, 27]. Lentil is very susceptible to abiotic stresses along many biotic factors as temperature severities, cold and heat stress and water and mineral shortage and salinity [27].

Green and black gram are damaged by leaf spot, powdery mildew, and mung bean yellow mosaic virus (YMMV) and these diseases cause major decline in production and quality deterioration as well [28]. Viral diseases are transmitted by some foreign vectors such as whitefly. The condition gets intensified in damp and humid environment as it supports the fungal and pathogenic growth. The diseases can be controlled by the practices like changing the cropping pattern and date of sowing, through plant extracts, Bio fumigation and biological control. Soybean is also the favorite crop for the pathogens and they attack it with full of their might and bigger issue is small resistance in soybean against diverse type of pathogens. The most damaging diseases of soybean are caused by viruses, Sclerotium blight, anthracnose, rust and charcoal rot. Chemical method of controlling these diseases is widely used globally and biological methods are under consideration [29]. The following study is conducted to summarize major diseases and world as well along with their effective remedies and possible solutions in controlling these diseases.

2. Chickpea

Chickpea (*Cicer arietinum* L.) (diploid, 2n=16) is most important crop of modern agriculture [30]. Chickpea is at ranks third in the world in legume crops [31,32, 33]. In some developing countries, legume crops are big source of nutritional protein for many people that are vegetarians moreover by millions of people who are vegetarians either by optional or by beliefs [34]. Chickpea plant belong to the Papilionoid subfamily of leguminosae [30]. In Pakistan area for cultivation is 931 thousand hectares and production are 359 thousand tons (Agriculture Economic Survey 2016-2017). Largest producer is India and mostly production is the desi types (Janzen 2006). Moreover, cultivation of chickpea acting a major part in agriculture schemes to fulfill space crop rotations and production play role in food and nitrogen fixing ability reduce the N fertilizer in the soil. There are two types of chickpea; Desi or black category is generally yellow to black testa, having rough surface and small size. Major black chickpea growing countries are Asians countries, Mexico South, Ethiopia and Iran. Second category is white or Kabuli chickpea having, tender surface and having light creamy colour, Grown in Mediterranean countries, Australia, North America West, Asia and North Africa [35]. Chickpea production is now low and condition is more serious due the presence of blight, wilt and root rot diseases [36] and caused by *Ascochyta rabiei, Fusarium oxysporum* and *Macrophomina phaseolina* [32]. In maintainable agriculture, diseases legumes crops should be control and manage by integrated disease management (IDM) approaches that can be success fully controlled by biological and physiological methods that are favorable for human to take in diet [37].

2.1 Gram Blight:

Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labrousse and major biotic factor to decrease yield of chickpea worldwide. Major growing country of chickpea have the blight disease [38]. Gram blight has been stated from different countries; India, Spain, Romania, Tanzania, Syria, Turkey, America, Australia, Bulgaria, Bangladesh, Lebanon, Cyprus, Pakistan, Ethiopia, Canada, France, Tunisia, Greece, Iran, Algeria, Israel, Iraq, Jordan, Italy, the USSR, Morocco, and Mexico. The disease is extra commonly detected in Cyprus, Bulgaria, Algeria, Iraq, Israel, Greece, Lebanon, Romania, Jordan, Pakistan, Morocco, Spain, Tunisia, Syria, the USSR and Turkey [39]. The disease looks frequently in epidemic ways and in both the Barani and irrigated zones of Pakistan [31].

All aerial chickpea parts come under stress of gram blight. Emerging seedlings of chickpea appeared brown lesions in the base that occurs because of infected seeds. Gradually, lesions start increasing in size as a result cover and surround the stem finally loss of the plants. Leaflets having uneven circular to extended shaped brown lesions display dark red and dark brown margins. Generally round lesions increase in number and start darker appearance on the green pods having more and circularly organized pycnidia. Plant completely involve in serious infections, the lesions reach to the seeds and shrive it [40]. Pakistan have field which completely failure the crop. Disease causes 20-25% crop loss per year but the conditions favorable for the disease growth and lead to complete crop failure [41].

2.1.1 Management:

The host plant resistance is indicator for the resistant genotypes against the disease but completely resistance is not present in genotypes [42]. Such as chickpea crop is mostly cultivated in rain fed zones with little input applications, seed treatments by fungicides are expensive and poor farmer cannot afford it [32, 43]. The occurrence and harshness of disease on plant is measure by the active interaction of a susceptible host, a causal pathogen, and encouraging environmental conditions for disease. In plant disease triangle, genotype resistant is a most important part for disease management. Sometime according to environment condition the moderately resistant chickpea genotypes accomplish well and in favorable environment the low level of resistant genotypes performs badly or poorly and yield decrease. Inappropriately, our germplasm has not completed resistance against gram blight and not present in our present cultivar. we should search the genotypes and use in our breeding program [44]. Those zones like colder or drier regions where mostly crop cultivated and crop residues present long time, there is of crop rotation with longer cycle. Consecutive chickpea crops can cause for the initial epidemic disease growth [42]. In Canada rotation study was shown, Gossen and Miller reported that the cruelty of gram blight in a susceptible genotype was 81% after one interval crop at flowering stage but after three intervening crops less 5% disease. After the initial chickpea crop, the pathogen was silently occurring in the field 4 years, after the first two intervening crops the inoculum pressure decrease significantly [45]. When sown deep (50–200 mm), Chickpea has ability to produce a long hypocotyl [46]. The long hypocotyls help the plant in protection many diseases and facilitate a buffering area for falling transmission of *A. rabiei* from diseased seed to evolving seedling. Chickpea is mostly sown in the interval when soil temperature and moisture are promising for both fungal development and seed germination [47]. Chickpea intercropping with different non-host crop approach can decrease the dispersion of gram blight in chickpea. The non-host plants play role as physical barrier to the dispersion of the gram blight. Chickpea is intercropped, in replacement rows, with barley, mustard, or wheat in India, [47, 48]. Well-adjusted and acceptable deliveries of nutrients increase the tendency of crop to bear abiotic and biotic stresses by increase physiological resistance. Chickpea has tendency to fixing atmospheric nitrogen [49].

2.2. Fusarium wilt:

Fusarium wilt is a dangerous and common fungal disease of chickpea produced by *Fusarium oxysporum*. It is a vascular, seed borne and soil borne pathogen. In favorable conditions high temperature with drought, wilting can look within 3–4 weeks after sowing. In susceptible genotypes plant death rate goes up to 80% at flowering and pod formation stage due to disease [50]. The Fusarium wilt was reported from many countries including India, Burma, Bangladesh, Ethiopia, Pakistan, Tunisia, Chile, Syria, Mexico, Iran, Sudan, Peru, Nepal, Malawi, USSR, Spain, the United States, Turkey and Italy. But, badly effected chickpea cultivated countries are India, Nepal, Pakistan, Iran, Myanmar, Tunisia and Spain [51].

Greatly susceptible genotypes appear symptoms in 25 days after sowing is called as early wilt, as well as softness of individual leaves with discoloration in dull-green, dryness and downfall of the entire plant. But, symptoms are frequently very visible at flowering 6-8 weeks after sowing and look at podding stage also known as late wilt. Late wilted plants show drooping of the rachis, petioles and leaflets with yellowing and necrosis of foliage. firstly, upper part of the plant drops but, in few days, dropping take place on the entire plant. Sometime wilt affects only a few branches is known as partial wilt. Roots of infected shoot appear no outside root discoloration when uprooted it affected and dry. Plant roots and stem shows dark-brown yellowing of xylem tissues in cross section area of shoot. In older bends occur in the vascular tissues of roots and stems at the end cavity formation between xylem and phloem, medulla and xylem, cortical parenchyma and phloem. Formation thick gels and blockings in xylem vessel but not in tyloses, cause barrier in movement of water and nutrients however shows the morphological symptoms [30].

2.2.1. Management:

Pathogen resistance is the practical and cost proficient disease control measure for management of Fusarium wilt. Furthermore, resistant cultivars could be used to increase the efficiency of integrated management strategy [30]. Operational quarantine and certified pathogen-free seed are used for the management of Fusarium wilt in chickpea growing zones to free from *F. oxysporum* [52]. Burning is conflicting to old preservation rule and measured a destructive practice. Thermo-sanitation with smaller environmental influence can be attained by glowing the crop debris with propane or oil-fueled flamers [53]. Sowing date can be used as a disease control strategy for management of Fusarium wilt of chickpeas. Biological control is more beneficial for environment to chosen sowing dates is best method for the disease management [37]. Fusarium wilt can be decreased by the action with various bacterial or fungal biocontrol agents (e.g., *Trichoderma harzianum*, nonpathogenic *F. oxysporum, Bacillus* spp., *Pseudomonas* spp. However, disease appearance by these microscopic means have been shown to be affect by:

i) Inoculum concentration of the pathogen.
ii) Race, strain or isolate of the pathogen.
iii) Environmental conditions more important for biocontrol dispersion or action [30].

F. oxysporum inoculum in soil can be decreased by cleanliness i.e. organic amendments and soil solarization [30].

2.3 Root rot:

Root rot (*M. phaseolina*) soil borne fungal chickpea disease and it is reported to cause losses reaching between 10 and 15% worldwide. In risky condition, the disease can reach up to 100% crop loss [54]. *M. phaseolina* has been exposed to be capable to infect over 400 plant species [36]. which is widespread throughout the temperate and tropical zone of the world and severe in chickpea growing countries of India affecting a 10-25% crop loss [55]. Root rot Symptoms are different and liable on the year time that the plant is diseased. Root rot usually disperse later in the season and infection of seedling can happen anytime throughout the growing period. Infected seedlings display a brown discoloration at the soil line spreading up the stem that may change dark brown to black colour. Infected seedlings foliage can look off-color or start to dry out and change into brown. Infected young plants may survive under cool, wet situations but transmit a dormant infection that will show symptoms later in the season when the weather is hot and dry. But, the addition of seed treatment and soil application with bio-control means can form their populations in the crop locality during the early stage of crop growth and deliver protection at later stage against the soil borne pathogen [36].

But, the studies attentive on laboratory and greenhouse-based evaluations of inhibition capacity and manufacture of antibiotics and conquest of sclerotial germination [56]. Two bio-control agents described to be operative against pathogens [57] in decreasing growth of *M. phaseolina* in laboratory conditions. Then, their effectiveness in field conditions was also assessed.

2.3.1 Management:

Previously reports reveal that bio-control agents like *Pseudomonas fluorescens* efficiently occupied and decreased the growth of sclerotia of *M. phaseolina*. It was assumed that may perform as a latent bio-control agent for root rot [58]. New agents including *Bacillus* subtilis, *Trichoderma harzianum, Trichoderma viride*and botanist have also been searched to be active for chickpea pathogen [59]. Crop replacement and ridge and furrow sowing are suggested to control rot root disease by cultural controlling methods [60]. One more effective, cost-effective, and ecologically method to control rot root disease complex depend on the use of resistant chickpea varieties. The soil types occur in field may or may not affected crop to more disease occurrences. Certainly, we detected a relationship between soil type and disease occurrence, fields having dark black soil also suffering the highest occurrence and severity of rot root. Dark soil holds more moisture than other soils, accordingly supporting rot root pathogens [61]. Rhizosphere organisms offer a primary fence for pathogens attack the root. Microorganisms grow in the rhizosphere are perfect for utilize as biocontrol agents. Phosphate-solubilizing microorganisms as they alter insoluble phosphatic compounds into soluble to increasing the development and yield [62]. The crop is cultivated too late, farmers have threat crop yield loss because of terminal drought in which moisture is exhausted. The occurrence and harshness of rot root disease were the maximum in northern and northwestern Ethiopia where the crop is early cultivated in late August, moist condition favor the disease dispersion. Late sowing date decrease rot root occurrence and harshness and maximize the chickpea yield in Spain and India [63].

3. Greengram and Blackgram

Legume crops constitute an important part of dietary proteins of the vegetarians. Pulses, the food legumes, have been grown by farmers since millennia providing nutritionally balanced food to the people of India [64] many other countries in the world. The importance of pulses as an excellent source of protein, vitamins, and minerals is well established. Greengram and blackgram are important legume crops extensively cultivated in Asia. The crops are used in different ways, where seeds, sprouts, and young pods can be eaten up as sources of protein, amino acids, vitamins, and minerals, while other plant parts are used as animal feed and green manure. Greengram protein is easily digested without flatulence. Greengram is an important source of protein for people in cereal-based society. Both greengram and blackgram adapt well to different cropping systems and can fix atmospheric nitrogen (N2) in symbiosis with soil bacteria of *Rhizobium* spp., rapid growth, and early maturity. Trends on the demand and production of the crops are increasing [21,65]. The annual world production area of mungbean is about 5.5 million ha [66] of which about 90% is in Asia. India is the biggest producer of mungbean where about 2.99 million ha are cultivated. Although world blackgram production is difficult to approximate, the crop may be produced slightly lower amount than greengram. In India alone, blackgram occupies about 3.15 million ha. Blackgram (*Vigna mungo* L.) is one of the important pulses of Phaseolus group that have an important position after chickpea in India [67]. Black gram is an important source of highly digestible high-quality protein for vegans and sick persons. The protein content of various pulses ranges from 17-24 percent which is about 2-3 times more than cereals. Black gram contains approximately 25-26 percent protein and 61 percent carbohydrates while green gram contains 20.8-33.1 percent protein and 62-64 percent carbohydrates [68]. Black gram is a staple in Chinese cuisine where they use the whole bean or its sprouts. In Europe mungbean is referred to as greengram [69].

Among biotic stresses, leaf spot, powdery mildew, and mungbean yellow mosaic virus (YMMV) are major diseases and have been found to appear in the epidemic form thereby causing a huge loss in farmers' field of Telangana State [28]. It becomes severe in the wet season causing 0.0 % to 100.0 percent yield loss [70].

3.1 Viral diseases

Two whitefly (*Bemisia tabaci*) transmitted begomoviruses, Mungbean yellow mosaic India virus (MYMIV) and Mungbean yellow mosaic virus (MYMV) causing yellow mosaic disease (YMD) are major factors for severe crop losses of mungbean in Indian subcontinent [71, 72]. Recently, a thrip (*Thrip tabaci*) transmitted Tospovirus, Groundnut bud necrosis virus (GBNV) appeared to be a serious concern causing bud necrosis disease (BND) in pulse crops in India [73, 74]. Urdbean (black gram) leaf crinkle disease complex (ULCD) in pulse crops, still unknown of its etiology, reported from Delhi in 1968, became widely spread nowadays all over in India and causes huge yield losses of pulses [75,76]. Multiple infections with more viruses causing severe damages in many crops have been reported time to time [72, 77]. Black gram (*V. mungo*) infected by mixed infection with YMD, BND and ULCD in Delhi condition is reported [72].

3.1.1 Leaf crinckle virus

Bean is vulnerable to the attack of many diseases. Among them leaf crinkle disease caused by urdbean (blackgram) leaf crinkle virus (ULCV) is important [72]. Under field conditions ULCV is more serious in blackgram than greengram and other pulses [67, 72]. It is naturally transmitted through whitefly (*Bemisia tabaci*) [78]. This may result in 100% yield loss during the epidemic years [76]. On an average, the virus has been reported to decrease grain yield by 35-81%. It is reported that losses from leaf crinkle disease ranged between 2.12-93.98% in *Vigna radiata* versa and 2.82-95.17% *in Vigna mungo*. The direct relation existed between the stage of plant growth at which infection occurred and yield loss. The reduction in tryptophan, increase in IAA and higher sugar content have been reported in black gram leaves infected by leaf crinkle virus [67]. The disease is characterized by crinkling, curling, puckering, rugosity of leaves, enlargement of leaf lamina, stunting of plants and malformation of floral organs [76]. Seed borne nature of the virus is well established and the disease has attained serious proportions [79]. Numerous attempts have been made for the identification of resistant sources against these diseases [80,81] of greengram and blackgram. Urdbean (Black gram) leaf crinkle virus (ULCV) is a crucial, common and most corrosive disease in Pakistan and other countries growing food legumes in summer. High disease occurrence is finding out every year, which are evaluated to the combination of different factors such as occurrence of inoculums potential, suitable ecological/environmental conditions and high white fly population. Evaluation of disease resistance genotypes are regarded as durable and an efficient solution of minimizing urdbean crinkle virus (ULCV). Therefore, screening of urdbean genotypes against ULCV under natural conditions was performed [82].

3.1.2 Mung bean yellow mosaic virus

Mung bean yellow mosaic disease caused by mung bean yellow mosaic begomovirus (MYMV) is the most erosive viral disease of green gram and black gram not only in Pakistan but also in India, Bangladesh, Srilanka and adjacent area of Southeast Asia. This virus has a broad host range and is transmitted by whitefly (*Bemisia tabaci* Genn.) and not through seed, sap and soil. In severe cases, the leaves and other plant parts become completely yellow and the losses may be as high as 100% [83]. Depending upon crop variety and location, disease occurrence of Mung bean yellow mosaic virus (MYMV) was from 4% to 40% in Pakistan [82]. In several cases, leaves and other plant parts become completely yellow and the losses may be as high as 100% [28, 84]. It is reported incident ranging from 0% to 58.5 % among various varieties during their evaluation program for resistance against MYMV from Uttar Pradesh [28]. MYMV disease leads to severe yield reduction not only in India, but also in Pakistan, Bangladesh and areas of South East Asia in Black gram [77].

3.2 Bacterial disease

3.2.1 Mungbean phyllody disease

During spring 2008, mungbean plants in Faisalabad, Pakistan, showed severe symptoms of phyllody like transformation of floral parts into green and leaf-like structures. A 16Sr II-D phytoplasma was found to be causative for causing the symptoms [85]. Phytoplasmas are a class of plant pathogenic wall-less, phloem-inhabiting bacteria (class Mollicutes) that leads intense damage to plants in terms of reduction in biomass and quality of plant products. They are known to infect and cause damage to approximately 1000 plant species worldwide including fruits, vegetables, cereals, trees and legumes [85, 86]. Phytoplasmas are by nature transmitted by phloem feeding insects, often leafhoppers [87], but they are also transmitted through grafting and vegetative propagation (cuttings, storage tubers, rhizomes or bulbs). Diseased plants commonly show symptoms that include phyllody, virescence (green pigmentation in tissues that are not normally green), yellowing, reduction in leaf size, stunted growth, witches-broom (a wild, erratic, broom-like growth at the ends of shoots, stems or branches), leaf-curl, bunchy appearance of growth at the ends of the stems, floral gigantism, and a generalized decline like, stunting, die-back of twigs and unseasonal yellowing or reddening of leaves) [86, 88].

3.3 Fungal diseases

Abiotic and biotic stresses caused remarkable decline in legume yield in South Asia and South East Asia. Among biotic stresses, fungal diseases are causative for reducing yield up to 40– 60% in green gram [89]. Fungal pathogens can infect mungbean plants at different stages, such as during emergence, seedling, vegetative and reproductive stages and cause substantial damage leading to yield loss or complete failure of production. Species of the genera *Fusarium* (wilt), *Rhizoctonia* (wet root rot), and *Macrophomina* (dry root rot) infect green gram plants during seed/seedlings stages (seed-borne or soil borne), while species of the genera *Colletotrichum* (anthracnose), *Alternaria* and *Cercospora* (leaf spot), *Erysiphe/Podospheara* (Sphaerotheca) (powdery mildew) affect plants during vegetative and reproductive stages. Powdery mildew occurs across India and Southeast Asian countries and becomes severe in dry season causing 9.0 % to 50.0 per cent yield loss [70, 81]. The powdery mildew occurs round the year under plausive conditions and it is more intense in late sown Kharif crop.

3.3.1 Cercospora leaf spot

Cercospora leaf spot actuated by *Cercospora cruenta* and *C. canescens* determines severe leaf spotting and defoliation at the time of flowering and pod formation. Involvement of different species in causing *Cercospora* leaf spot complicates characterization of species. *Cercospora* leaf spot was first known to occur in Delhi, India (and is prevalent in all parts of the humid tropical areas of India, Bangladesh, Indonesia, Malaysia, Philippines, Taiwan as well as Thailand [70]. *Cercospora canescens* savage the crop and the symptoms come across on leaves as water-soaked spot with greyish borders. Severity of disease causes death of the tissues of infected leaves. The pathogen also affects the petioles, stems and pods. Under favorable condition the spots increase in size and during flowering and pod formation lead to defoliation. In case of intense attack of *Cercospora* premature defoliation is also observed. Often, the leaves may become unshaped and wrinkled. Poor pod formation, late maturity and immature seed formation are also possible. *Cercospora* spp. produce a perylenequinone toxin called cercosporin that is non-selective affecting bacteria, plants, fungi and animals unless these produce protective antioxidants such as carotenoids [90].

3.3.2 Powdery Mildew

Powdery mildew caused by *Erysiphe polygoni* DC, is a problem in cool dry weather. Pathogen is obligate parasite and has wide host range. Limited information is available on the etiology and biology of *E. polygoni* on *Vigna mungo* and *Vigna radiata* [70]. Infected plants could be identified by white powdery spots on the leaves and stems. The lower leaves are the most affected but the mildew can also appear on any above-ground part of the plant. As the disease progresses, the spots get larger and denser.

3.4 Management of diseases of greengram and blackgram

Several viruses infecting pulses have been reported from time to time causing considerable crop loses in mungbean. Changes in cropping pattern, introduction of new genotypes, changed insect vector dynamics and appearance of new strains are major causes for virus incidence [72]. The lack of resistance in mung bean is the major concern to ramp up adequate viral inoculum pressure. Therefore, much attention is needed in searching pathogen derived resistance in exploiting genetic engineering approach, a change path for development of resistant cultivars. Furthermore, it is essential to determine the environmental factors and retool crops/weeds those play major roles for the disease development and then to design proper management strategy of the viral diseases based on these factors. To control Cercospora leaf spot of Mungbean different techniques and methodologies including use of chemical fungicides spray of different botanicals and use of resistant variety are being practiced. Evaluation of some systemic fungicides against *Cercospora canescens* was reported by Khunti in 2005, in Gujrat, India. For the evaluation, a field trial was organized and different fungicides namely hexaconazole, penconazole, tridemorph, Sulphur, triadimephon, propiconazole, dinocap, thiophanate methyl, carbendazim and mancozeb against Cercospora leaf spot caused by *Cercospora canescens* in Mungbean. Big research has been conducted to detect resistance source by different researchers [91, 92, 93,94) which identified either no resistance source [91,92] or relatively resistant source [93,94] against MYMV. No highly resistant mungbean variety is available in Pakistan. So, there is a need of a durable resistance against this disease. Many resistant sources are available against powdery mildew. Also, its incidence can be lessened by adjusting the date of sowing with wider spacing [70].

3.4.1 Control through plant extracts

Uddin in 2013 evaluation of some botanical extracts to control leaf spot disease of Mung bean. Different concentrations of plant extracts were evaluated for disease control. Six domestic plant species; Neem leaves extract, Garlic cloves extract, Biskatali leaves extract, Alamanda leaves extract, Arjun leaves extract and Debdaru leaves extract were used for the experiment. Currently, there are no proper measures for directly controlling phytoplasma-caused disease. Whereas, the disease could potentially be control indirectly by spraying systemic insecticides to kill the leafhopper vector, the use of resistant germplasm is the best option [86]. The fungicidal effect of aqueous extracts of four plant species viz; *Azadaracta indica* A. Juss., *Datura metel* L. var. *quinquecuspida* Torr., *Ocimum sanctum* L. and *Parthenium hysterophorus* L. was observed in vitro study. Leaf extract of *Azadirachta indica* at 100% concentration completely retard germination of pathogen spores.

3.4.2 Biofumigation

Brassicaceae crop residues have been reported to reduce proliferation of soilborne pathogens and result in a subsequent decrease in the incidence of plant diseases caused by them [95]. During the decomposition of crucifer residues, glucosinolates (GSLs) break down to produce sulphides, isothiocyanates (ITCs), thiocyanates and nitrile compounds, which have either fungistatic or antifungal properties. Soil rectification with crucifer residue occluded with solarization produce a huge variety of toxic volatile substances and improve the effectiveness of solarization in decreasing pathogen population and thereby disease incidence [96,97].

3.4.3 Biological control

Most economical and durable approach is biological control of soil borne pathogens. Potential antagonists, especially *Pseudomonas fluorescens* and *Bacillus subtilis* are likely candidates as bio-protectants [98]. The application of a single antagonist is not likely to be better in all environmental conditions where it is applied. Application of *T. viride, T. harzianum, P. fluorescens* and *B. Subtilis* along with neem cake and compost enhanced the survivability of bioagents and suppression of soil borne diseases [99,100]. These biocontrol agents suppress plant pathogens through a variety of mechanisms especially mycoparasitism, competition, induced resistance, antibiosis etc.

4. Lentil

The Fabaceae constitute a large botanical family, consisting of more than 450 genera and 12,000species [101]. Pulses are a good source of protein, carbohydrates, dietary fiber, minerals, vitamins, and phytochemicals required for human health [89, 102, 103, 104,]. Consumption of pulses may have potential health benefits in humans, such as reduced risk of coronary heart disease, colon cancer, diabetes mellitus, osteoporosis, hypertension, gastrointestinal disorders and reduction of LDL cholesterol [105, 106]. Lentil (Lens culinaris) is the most ancient cultivated crops among the legumes. It is indigenous to South Western Asia and the Mediterranean region. The important lentil-growing countries of the world are India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria [107]. The total cultivated area in the world as about 4.6 million hectares producing 4.2 million tons of seeds with an average production of 1095 kg/ha [6]. Lentil flour is mixed with cereals to make breads, cakes, noodles and infant formula [108, 109, 110]. Lentil is well-known for its ability to induce short-term satiety and a low glycaemic response and helps to maintain body weight, especially due to the presence of β-glucans [111]. Lentil also contains phytochemicals including phenolic acids, flavanols, saponins, phytic acid and condensed tannins and presents a good antioxidant property [112]. It also contains notable quantities of both soluble and insoluble fibres and minerals [113]. It provides health benefits including reduced risk of cardiovascular disease, cancer, diabetes, osteoporosis, hypertension, gastrointestinal disorders, adrenal disease and reduction of low-density lipoprotein (LDL) cholesterol [102, 106, 114]. Per capita consumption of lentil as a whole grain or in its processed form has been increased that has resulted into five-fold increase in its global production during the last five decades. The increase in the sown area is reported to be 155% and average yield has been doubled from 528 to 1068 kg ha–1 [15].

4.1 Fungal diseases

Biotic stresses caused by pathogenic fungi include Fusarium wilt (*Fusarium oxysporum*), Ascochyta blight (Ascochyta lentis), Anthracnose (Colletotrichum truncatum), Stemphylium blight (Stemphylium botryosum), Rust (Uromyces viciae-fabae), Collar rot (Sclerotiun rolfsii), Root rot (Rhizoctonia solani), and Botrytis gray mold (Botrytis cinerea). it is also susceptible to several species of Orobanche and Phelipanche prevalent in the Mediterranean region [115,116].

4.1.1 Fusarium wilt:

Wilt caused by *Fusarium oxysporum* is a devastating disease [117] and is important in India, Pakistan, Iran and Syria. The disease appeared in severe form in 1949 with the incidence as high as 67%. A survey of 116 districts of nine lentil growing states of India revealed a range of 0.7–9.3% plant mortality at reproductive [118]. Out of 28 locations belonging to 9 districts in Pakistan, 21 locations showed 100% disease incidence [119]. *Fusarium oxysporum* infects its host by entering through the root and grows in the plant xylem. It blocks the vascular system and prevents transport of water and nutrients to the plant that causes wilting, discoloration, and eventually death of the plant. Recently, pathotypes have been reported from Spain [120]. In lentil, the extent of the damage due to the disease ranges from 20-24% annually [121, 122].

Researcher observed significant reduction in disease incidence and maximum grain yield in field trials using 'Pant L-639' a popular cultivar against lentil wilt with T. harzianum + Pseudomonas fluorescence [123]. Similarly, in another report suggest that the disease severity was reduced with increased plant height with the combination of T. harzianum + S. vermifera. *Fusarium oxysporum* persists in the soil through chlamydospores and remains viable for several seasons, as a result of which the management is very difficult although some attempts have been made through chemicals [124, 125, 126] as well as biological control [123]. The most effective method for the management of lentil wilt disease is host plant resistance [127]. The cultural control generally depends on date and depth of sowing and manipulation of agronomic practices. Delayed sowing usually lowers the wilt incidence whereas compared with early sowing (end of July) reduce the yield [128] analyzed the presence and involvement of antifungal compounds in wilt resistance. Phenolic have an important role in imparting resistance against wilt disease because only wilt-resistant lines produced this compound.

4.2 Bacterial diseases

4.2.1 *Ascochyta* Blight

Ascochyta blight is one of the most widespread, being of economic concern in the majority of lentil-producing regions, especially under the mild, wet winter conditions of Mediterranean and maritime climates [127,129]. Disease is caused by Ascochyta lentis which can infect cultivated and wild species of lentil including *L. culinaris subsp. orientalis, L. ervoides, L. lamottei, L. nigricans, and L. tomentosa* [130]. However, the pathogen appears to be host-specific to the Lens genus, being unable to cause disease symptoms on other legume crops including chickpea, faba bean, field pea, or hairy vetch [131]. The symptoms of the disease include irregularly shaped lesions on leaves, petioles and stem are tan and darker brown on pods and seeds. Black pycnidia are visible in the Centre of mature/older lesions. Heavily infected seeds are shriveled and discolored with whitish mycelium and pycnidia.

4.2.2 *Stemphylium* Blight

Stemphylium blight caused by Stemphylium spp. is another common disease of lentil, which causes significant yield losses in Australia [132]. In Saskatchewan, it is suspected that stemphylium blight has not been correctly identified in the field, as the lesions closely resemble those of ascochyta blight [133]. Lentil are most susceptible to the disease in the last third of the growing season and epidemics are favoured by warm temperatures between 25 and 30 °C and wet conditions of more than 85% humidity for 48h [134]. The prevalence of moderate to warm temperatures below 25°C and wetness duration longer than 24 h favor the appearance, development, and spread of Stemphylium blight. Plant debris as well as infected seed are important sources of S. botryosum inoculum [135]. Infected seed causes transmission of the disease from region to region and also serves as a source of initial inoculum in the season.

The use of fungicides has been effective in reducing the economic losses due to Stemphylium spp in a range of crops. Several fungicides (chlorothalonil, mancozeb, tebuconazole, procymidone and iprodione) have been found to provide effective control of diseases caused by Stemphylium spp. in various host species. Under severe disease pressure, fungicide application at 7-day regular intervals increased the stand as compared to applications every 10 or 14 days. Stemphylium spp. has been successfully controlled using chiorothalonil. Cultural control methods which have been employed to combat Stemphylium spp. in other hosts include crop rotation, residue incorporation, choosing the best planting and harvesting dates; and the use of resistant varieties [127].

4.2.3 Anthracnose:

Anthracnose is an important disease of lentil, caused by *Colletotrichum truncatum* has been reported from Bangladesh, Canada, Ethiopia, Morocco, Syria and Canada [136]. Later pathogen was renamed C. lentis in 2014 [137]. Annual disease surveys in Saskatchewan between 2012 and 2015 showed that anthracnose was present in 60–83% of lentil fields [138]. pathogen forms microsclerotia on infected stems and leaflets during the growing season [139]. Irregularly shaped, light brown necrotic lesions start to develop on lower stems and gradually increase in number and size until they coalesce and give the stems a blackish brown appearance. Lesions on leaves are circular with few acervuli in the middle of each lesion and premature leaf drop begins at early flowering. The fungus penetrates the vascular tissue, which results in plant wilting, and large brown patches of dying plants become evident in the field after flowering. The disease is favored by high humidity and temperatures of 25-30°C, and is seed borne but has not been shown to be transmitted from seed to seedling [140].

The current disease management practices are based primarily on application of foliar fungicides such as chlorothalonil or benomyl [141]. Seed treatment with fungicides provides complete control of the seed-borne fungus. Zero-tillage can be used to take advantage of the quicker break down of anthracnose inoculum on the soil surface compared to infected plants buried in the soil. A shorter rotation, combined with removal of straw is considered adequate in the drier regions. Plant breeders and pathologists in Canada have identified primitive lentil lines with excellent resistance to anthracnose and are developing new cultivars with resistance to the disease. In collaboration with the Canadian lentil breeders, Australian plant breeders are also developing anthracnose resistant cultivars [141].

4.2.4 *Botrytis* grey mold

Botrytis grey mold is caused by the fungal pathogen *Botrytis fabae* and *B. cinerea.* In 1987, Knights first time reported the disease in Australia and since then the disease has caused considerable damage to commercial lentil crops grown throughout Victoria and South Australia [142]. Depending on the location of the crop, symptoms may initially appear either on flowers and pods or lower in the crop canopy. The most damaging symptoms become apparent after the crop has reached canopy closure and a humid microclimate is produced under the crop canopy. Death of plants can often occur before the onset of flowering and pod fill. Infection will continue to spread resulting in patches of dead plants within crops. When the weather turns dry and the infected plants are disturbed, clouds of spores are released into the air. Flowers can show symptoms of infection with typically grey mouldy growth present on petals, causing flower death. Pods which become infected will be covered in the grey mouldy growth, rot, and turn brown when dried out. Seeds within these pods will fail to fill properly [24].

Practices that delay or avoid the formation of a dense canopy include the adjustment of sowing dates and rates, use of wider row spacing to increase air flow, weed control and optimum fertilizer use, particularly avoiding high nitrogen levels. potential alternate host plants can he controlled to reduce the early buildup of disease inoculum. Lentils should also not be grown adjacent to faba bean and chickpea stubble. Seed treatments with fungicides such as benomyl, carboxin. chlorothalonil or thiabendazole can reduce seed-borne inoculum levels. Resistant lentil germplasm has been identified in Australia, and Canada. The lentil variety 'Nipper' was released in 2006 from the Australian lentil breeding program with resistance to both botrytis grey mold and ascochyta blight [142].

4.2.5 Lentil Rust

Lentil rust is a serious fungal disease caused by the pathogen Uromyces viciae- fabae. Lentil rust is particularly important in Bangladesh, Ethiopia, India, Morocco, Nepal, Pakistan and Turkey. In India a crop loss of 100% has been reported. In 2000, Bejiga also emphasized its importance in Africa. Seed yield loss in lentils attributable to rust has been estimated at 25% in Ethiopia. In 1997, however, a lentil rust outbreak throughout Ethiopia caused yield losses of up to 100% [143]. About 2500 ha of lentil being completely wiped out by rust in the Gimbichu district of Ethiopia. It occurs in the form of yellowish brown, small pustules surrounded by halo zone, present mainly on the leaves. When the disease develops, spores of rust spread to the other parts of plants, other plants and even to the other fields. This disease can also occur on the stems and pods and the rust pustules are similar but larger in size than the leaves. In severe infections leaves are shed and plants dry prematurely, the affected plant dries without forming any seeds in pods or with small shriveled seeds. in severe cases of infection plants become stunted and showed burnt appearance. Seed size in severely infected crop was reduced appreciably. Winter season is favorable for occurrence of diseases when temperature is increased up to 20-25 °C at a growing stage of plants [144]. The presence of humidity in the environment is a very important factor for fungal as well as bacterial infections of commercial crops [145].

In 2006 Lal studied the effect of fungicides both as seed treatment and as foliar spray against rust of lentil under field conditions and reported that seed treatment with propiconazole at the rate 1.0 ml/kg seed) showed minimum disease severity. A substantial reduction in rust severity could be achieved through the use of row spacing wider than 15 cm.

4.3 Viruses:

Lentil plants can be infected by a range of viruses but generally the effect on yield is not as great as that caused by fungal pathogens and diseases. Worldwide, lentils are susceptible to at least 30 different virus species representing 16 genera from nine families [135, 146] Most important viruses that infect lentil are Bean leafroll virus (BLRV), Bean yellow mosaic virus (BYMV), Beet western yellows virus (BWYV), Cucumber mosaic virus (CMV). BLRV was first reported in Australia in 1999 [23]. A yield reduction of 91% has been reported when plants were infected with BLRV at the pre-flowering stage, while at the flowering stage infection may result in only 50% yield loss. In Washington, USA, up to 80% disease incidence was noted in some fields during an epidemic year. BWYV was reported in Iran [146]. The causal viruses are transmitted in a persistent manner by aphids, but not by seed. Epidemic spread of this disease is always associated with high aphid vector populations. The initial symptoms on leaves of virus infected lentil plants show interveinal chlorosis, which intensifies with time until the whole leaf becomes yellow. Other symptoms include leaf rolling, reduction in leaf size and significant reduction in pod setting.

4.4. Management:

Various practices such as planting date, high seeding rate and narrow row spacing, use of early maturing cultivars, and using border plantings that are a non-host of the virus have proved effective in reducing virus incidence in lentil crops. Manipulation of planting date to avoid exposure of plants to peak vector populations at the most vulnerable early growth stages is a standard virus control measure widely recommended for use in legume crops. Six lentil genotypes were identified with combined resistance to different viruses [146].

5. Soybean

In 1992 Backman and Jacobsen observed the soybean germplasm derived from cool temperate region of China. When this germplasm is exported to warm areas the greater number of diseases start occurring. Soybean is more preferred for Cool temperate or mild but less favorable for warm as the disease attack becomes difficult to manage. The biological method to control the attack is burial of crop residue but this is not always helpful as this method only reduce the spread of disease. Hartman discussed that in tropical areas the spread of diseases can be reduced by different cultural practices, crop rotation and by using seed of good quality diseased free and by using resistant varieties [147]. About 35 diseases in soybean has been discovered in India which causes a significant reduction in yield. The most damaging diseases of soybean are caused by viruses, Sclerotium blight, anthracnose, rust and charcoal rot [29].

5.1 Charcoal rot

Charcoal rot disease is causing a major loss of production in Soybean yield. The pathogen suppresses the yield of Soybean and have the ability to survive is harsh environmental conditions. The use of fungicides was not much effective against this pathogen so fungal isolates of Trichoderma spp were used as a biological control. Two of the strains of this species were identified as an efficient biological agent against charcoal rot. The result of the use of this biological agent was reduction in the disease attack and in the result the crop production was improved [148]. A bacteria Rhizobium japonicum significantly reduces the attack of charcoal rot caused by Macrophomina phaseolina. The rhizobium bacteria inhibit the growth of charcoal root and ultimately results in the reduction of the attack of this disease [149].

5.2 White mold

White mold of soybean in the recent years proved to be the second most destructive disease of soybean in US. This disease causes severe yield reduction. In addition to yield loses this pathogen also reduces the seed quality. Studies were conducted to check the effectiveness of Sporidesmium sclerotivorum as a biological agent against White mold (Sclerotinia stem rot of soybean). Hence was concluded that to get a control over this disease it is necessary to provide a sufficient inoculum of this biological agents which in result will enhance the production by decreasing the attack of the disease [150]. The fungus is an aggressive colonizer and produces new macro conidia rapidly and this uniqueness allows it to remain active for few years after a single infestation [151]. *Sporidesmium sclerotivorum* has the ability to completely destroy the pathogen in the soil. A fungus Coniothyrium minitans is the most widely available biological agent to control stem rot. Researches have shown that this fungus gives best results if applied 3 months before the stem rot is likely to be developed [152].

5.3 Louisiana

Louisiana is called the heaven for diseases in soybean. Diseases which proves to be less damaging in other states can cause severe reduction in production in Louisiana. A fungus Simplicillium lanosoniveum is identified as an effective biological agent against *Phakopsora pachyrhizi*, a pathogen that causes soybean rust. With the inculoum of this fungus the disease was greatly minimized [153]. Experiment with 133 bacterial isolates that were collected from soybean rhizosphere. Their biological traits were studied. Some of the isolates were found to be effective and were selected. These isolates showed highest effect on reducing the soybean damping-off. To inhibit the growth of Phytophthora sojae these isolates releases volatile metabolites [154].

5.4 Root rot

Root rot of soybean is caused by *phytophthora megasperma*. It causes both emergence and post emergence damping-off. In less susceptible cultivars the symptoms restrained to roots only while in susceptible cultivars it causes leaf wilting, yellowing of leaves and leaf flagging. This causes the death of the plant. In Michigan fungal and actinomycete parasites are used as a biological agent to control phytophthora megasperma attack [155].

5.5 *Septoria glycines*

Septoria glycines is the major disease that affects the crops of Argentina. The disease appears shortly after planting and becomes severe at maturity. The disease causes brown spots on the leaves and result in yield loses. To control this disease biological fungicides *Bacillus subtilis* and *B. pumilus* were formulated. The chemical fungicides were also used to compare both results. The biological fungicides and chemical fungicides showed same results. B. subtilis show better results as compared to *B. pumilus.* The chemical and biological fungicides show best results when used at higher level. These fungicides showed a complete control over the disease and were found very effective in treating the disease [156].

5.6 *Sclerotium rolfsii*

Sclerotium rolfsii a disease caused in common bean, soybean and in other 72 important crops were studied. The rhizobium strains were used to control the disease. The strains show high efficiency in controlling the disease. In pot condition SEMIA 439 and 4088 showed a complete control over the disease. In field conditions also, both of these strains showed good control over the disease [157].

5.7 Black root rot

Thielaviopsis basicola causes black root rot in soybean. No resistant cultivar is present for this disease. Only biological and chemical methods are used to treat this [158], this is the soil-borne pathogen that attacks the roots of the plant. Research was conducted to control it biologically using organic amendments which increases the soil microbial population and ultimately suppresses the growth of this pathogen. In this research the population of pathogens was reduced by using the lysis of germ tubes after germination. This appears to be the primary mechanism of biological control [159].

5.8 Management

Soybean subject to variety of diseases and proves a good host of fungal and bacterial pathogens. Several chemicals are used to treat the infection caused by several pathogens. The use of chemicals is an expensive method and impractical. The method that can reduce the occurrence of diseases which reduces the yield losses is crop rotation and burial of crop residue. These methods are economically and environmentally favorable. Corn-Soybean crop rotations economically beneficial. The problems caused by root knot and cyst nematode can be reduced by crop rotation. These methods are not always economically feasible hence resistant varieties can be used [160].

Conclusion:

Pulses are very important group of plants that have significant role in nutrition. They provide essential amino acids in a less expensive way. The yield of the pulse crop is declining day by day because of various factors. These crops are prone to damage by the biotic as well as a-biotic factors and confront severe challenges. The present study concluded that important diseases of major pulse crops can be overcome to some extent by some physical and biological practices. According to the climate changes, these stress increase day by day. A detailed elaboration of different diseases of important pulses are explained. In addition to these, the strategies to control these diseases is explained in detail. This review helps in the identification of diseases and also with the biological and physical methods to manage the major diseases of pluses.

References

[1] Tharanathan RN, Mahadevamma S. Grain legumes: a boon to human nutrition. Trends Food Sci. Technol. 2003;14(5):07–18.

[2] Siddique KHM, Johansen C, Turner NC, Jeuffroy MH, Hashem A, Sakar D, Gan Y, Alghamdi SS. Innovations in agronomy for food legumes. A review. Agron. Sustain. Dev. 2012; 32:45–64.

[3] Biederbeck VO, Zentner RP, Campbell CA. Soil microbial populations and activities as influenced by legume green fallowing in a semiarid loam. Soil Biol Biochem. 2005; 37:1775–1784.

[4] Lemke RL, Zhong Z, Campbell CA, Zentner R P. Can pulse crops play a role in mitigating greenhouse gases from North American agriculture? Agron. J. 2007; 99:1719–1725.

[5] Ofua ZM, Akhidue V. The Role of Pulses in Human Nutrition: A Review. J. Appl. Sci. Environ. Mgt. 2005; 9(3):99 – 104.

[6] FAO (Food and Agriculture Organization of the United Nations). FAOSTAT. Statistical database of FAO, Rome. 2010. Available at http://faostat.fao.org/default.aspx. Accessed 26 Jan 2010

[7] Cannon SB, May GD, Jackson SA. Three sequenced legume genomes and many crop species: rich opportunities for translational genomics. Plant Physiol. 2009; 151:970–977.

[8] Gepts P, Beavis WD, Brummer C, Shoemake RC, Stalker HT, weeden NF, Young ND. Legumes as a model plant family: genomics for food and feed report of the cross-legume advances through genomics conference. Plant Physiol. 2005; 137:1228–1235.

[9] Weeden NF. Genetic changes accompanying the domestication of *Pisum sativum*: is there a common genetic basis to the 'domestication syndrome' for legumes? Ann Bot. 2007; 100:1017–1025.

[10] Young ND, Mudge J, Noel ellis TH. Legume genomes: more than peas in a pod. Curr Opin Plant Biol. 2003; 6:199–204.

[11] Zhu H, Choi HK, Cook DR, Shoemaker RC. Bridging model and crop legumes through comparative genomics. Plant Physiol. 2005; 137:1189–1196.

[12] Broughton J, Hernandez G, Blair M, Beebe, Gepts P, vanderleyden J. Beans (Phaseolus spp.): model food legumes. Plant Soil. 2003; 252:55–128.

[13] Ufaz S, Galili G. Improving the content of essential amino acids in crop plants: goals and opportunities. Plant Physiol. 2008; 147:954–961.

[14] Godfray HC, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson, Thomas SM, Toulmin C. Food security: the challenge of feeding 9 billion people. Science. 2010; 327:812–818.

[15] FAO. Food and Agricultural Organization of the United Nation, FAO Statistical Database. 2012. (http://faostat.fao.org)

[16] Bohra MK, Pandey UC, Jha B, Singh IP, Singh D, Datta SK, Chaturvedi N, Nadarajan, Varshney RK. Genomics‐assisted breeding in four major pulse crops of developing countries: present status and prospects. Theor Appl Genet. 2014; 127:1263–1291.

[17] Zohary D, Hopf M. Domestication of plants in the old world, 3rd edn. Clarendon Press, Oxford. 2000.

[18] Gaur PM, Jukanti AK, varshney RK. Impact of genomic technologies on chickpea breeding strategies. Agronomy. 2012; 2:199–221.

[19] Pérez de la vega M, Fratini RM, Muehlbauer FJ. Lentil. In: Genetics, genomics and breeding of cool season grain legumes (genetics, genomics and breeding in crop plants). Science Pubs, New Hampshire, 2011:98–150

[20] Saxena KB. Genetic improvement of pigeonpea: a review. Tropical Plant Biol. 2008; 1:159–178.Abraham AD, Menzel W, Lesemann DE, Varrelmann M, Vetten HJ. Chickpea chlorotic stunt virus: a new Polerovirus infecting cool-season food legumes in Ethiopia. Phytopathology, 2006; 96:437–446.

[21] Singh DP, Ahlawat IPS. Greengram (*Vigna radiata*) and blackgram (*V. mungo*) improvement in India: Past, present and future prospects Indian J Agric Sci.; 2005;7755 (75): 243–50.

[22] Torres AM, Avila CM, Stoddard FL, Cubero JI. Faba bean in: Genetics, genomics and breeding of cool season grain legumes (genetics, genomics and breeding in crop plants). Science Pubs, New Hampshire, 2011:50–97.

[23] Freeman AJ, Aftab M. Effective management of viruses in pulse crops in south eastern Australia should include management of weeds Australasian Plant Pathol. 2011; 40:430–441.

[24] Davidson JA, Kimber RBE. Integrated disease management of *Ascochyta blight* in pulse crops. Eur J Plant Pathol. 2007; 119:99–110.

[25] Kamara AY, Ajeigbe HA, Omoigui LO, Chikoye D. Intensive cereal–legume–livestock systems in west African dry Savannas. In: Proceedings of issues in tropical agriculture eco-efficiency: from vision to reality. CIAT. 2012:1–17.

[26] Ford R, Rubeena, Redden RJ, Materne M, Taylor PWJ. Lentil. In: Kole C (ed) Genome mapping and molecular breeding in plants: pulses, sugar and tuber crops. Springer, Berlin. 2007; 91–104.

[27] Muehlbauer FJ, Cho S, Sarker A, McPhee K, Coyne CJ, Rajesh PN, Ford R. Application of biotechnology in breeding lentil for resistance to biotic and abiotic stress. Euphytica. 2006; 147:149–165.

[28] Vijaya BA. Genotypes against Major Diseases in Green Gram and Black Gram under Natural Field Conditions. Int. J. Curr. Microbiol. App. Sci. 2017; 6(6):832-843.

[29] Deshpande A, A Review on Pre-Harvesting Soybean Crop Pests and Detecting Techniques, International Journal of Advance Research in Computer Science and Management Studies. 2014; (2): 404-411.

[30] Jimenez-Díaz RN, Castillo P, Jimenez-Gasco MM, Landa BB, Navas-Cortes JA. *Fusarium* wilt of chickpeas: Biology, ecology and management. Crop production. 2015; 73:16-27.

[31] Bokhari A, Ashraf M, Rehman A, Ahmad A, Iqbal M. Screening of chickpea germplasm against Ascochyta blight. Pak. J. Phytopathol. 2011; 23:5-8.

[32] Sarwar N, Akhtar KP, Shah TM, Atta BM. Evaluation of chickpea advance genotypes against blight and wilt diseases under field conditions. Int. J. Agric. Biol. 2012; 14:993-996.

[33] Hirich A, El Omari H, Jacobsen S, Lamaddallena N, Hamady A, Ragab R, Jelloul A, Choukr Allah R. Chickpea (Cicer arietinum L.) physiological, chemical and growth responses to irrigation with saline water. Aust. J. Crop Sci. 2014; 8:646-654.

[34] Choudhary AK, Kumar S, Patil BS, Bhat JS, Sharma M, Kema S, Ontagodi TP, Datta S, Patil P, Chaturvedi SK, Sultana R, Hegde VS, Choudhary S, Kamannavar PY, Vijayakumar AG. Narrowing yield gaps through genetic improvement for *Fusarium* wilt resistance in three pulse crops of the semi-arid tropics, SABRAO J. Breed. Genet. 2013; 45:341–370.

[35] Ahmad S, Khan MA, Sahi ST, Ahmad R. Evaluation of chickpea germplasm against *Ascochyta rabiei* (pass) lab. J. Anim. Plant Sci. 2013;23(2): 440-443.

[36] Manjunatha SV, Naik MK, Khan MFR, Goswami RS. Evaluation of bio-control agents for management of dry root rot of chickpea caused by *Macrophomina phaseolina.* Crop Protection. 2013; 45:147-150.

[37] Landa BB, Navas-Cortes JA, Jimenez-Díaz RM. Integrated management of Fusarium wilt of chickpea combining the use of choice of sowing date, host resistance, and biological control. Phytopathology, 2004b; 94:946-960.

[38] Chongo G, Buchwaldt L, Gossen BD, Lafond GP, May WE, Johnson N, Hogg T. Foliar fungicides to manage ascochyta blight (*Ascochyta rabiei*) of chickpea in Canada. Can. J. Plant Pathol. 2003b; 25:135–142.

[39] Shahid A. A, Husnain T, Riazuddin S. Ascochyta blight of chickpea: Production of phytotoxins and disease management. Biotechnology Advances. 2008; 26:511–515.

[40] Islam W, Qasim M, Noman, Idrees, Wang L. Genetic resistance in chickpea against ascochyta blight: historical efforts and recent accomplishments. The J. Anim. Plant Sci. 2017; 27(6):1941-1957.

[41] Jabbar A, Khan SA, Iqbal MA, Javed N, Shahbaz MU, Iqbal M. Determination of resistance in chickpea germplasm against *Ascochyta rabiei* (pass l.) and its chemical management. Pak. J. Phytopathol. 2014: 26(01):73-81.

[42] Khan MI, Arshad W, Zeeshan M, Ali S, Nawaz A, Batool A, Fayyaz M. Screening of chickpea kabuli (*Cicer arietinum* L.) germplasm against *Ascochyta* blight (*Ascochyta rabiei*). Journal of Biodiversity and Environmental Sciences. 2018; 12(2):128-132.

[43] Chaudhry MA, Muhamma F, Afzal M. Screening of chickpea germplasm against Fusrium wilt. J. Agric. Res. 2006; 44:307-312.

[44] Pande S, Siddique KHM, Kishore GK, Baya B, Gaur PM, Gowda CLL, Bretag T, Crouch JH. *Ascochyta* blight of chickpea: biology, pathogenicity, and disease management. Aust. J. Agricult. Res. 2005; 56: 317–332.

[45] Gossen BD, Miller PR. Survival of *Ascochyta rabiei* in chickpea residue on the Canadian prairies. Can. J. Plant Pathol. 2004; 26:142–147.

[46] Gan YT, Miller PR, McDonald CL. Response of kabuli chickpea to seed size and planting depth. Can. J. Plant Sci. 2003b; 83:39–46.

[47] Gan YT, Siddique KHM, MacLeod WJ, Jayakumar P. Management options for minimizing the damage by *ascochyta* blight (*Ascochyta rabiei*) in chickpea (*Cicer arietinum* L.). Field Crops Resear. 2006;97: 121–134.

[48] Jamil FFM, Sarwa M, Sarwar N, Khan JA, Zahid MH, Yousaf S, Arshad HMI, Haq I. Genotyping with RAPD markers resolves pathotype diversity in the *Ascochyta* blight and *Fusarium* wilt pathogens of chickpea in Pakistan. Pakistan J. Bot. 2010; 42:1369-1378.

[49] Gan YT, Selles F, Hanson KG, Zentner RP, McConkey BG, McDonald CL. Effect of formulation and placement of Mesorhizobium inoculants for chickpea in the semiarid Canadian Prairies. Can. J. Plant Sci. 2005; 85:555–560.

[50] Kaura P, Duhana JS, Thakurb R. Comparative pot studies of chitosan and chitosan-metal nanocomposites as nano-agrochemicals against fusarium wilt of chickpea (*Cicer arietinum* L.). Biocatalysis and Agricultural Biotechnology. 2018; 14:466-471.

[51] Chand H, Khirbat SK. Chickpea wilt and its management - a review. Agric. Rev. 2009;30 (1):1 – 12.

[52] Pande S, Rao JN, Sharma M. Establishment of the chickpea wilt pathogen *Fusarium oxysporum* f. sp. ciceris in the soil through seed transmission. Plant Pathol. J. 2007; 23:3-6.

[53] Powelson ML, Rowe RC. Managing diseases caused by seedborne and soilborne fungi and fungus-like pathogens. In: Johnson, D.A. (Ed.), Potato Health Management, second ed. APS Press, St. Paul, MN, 2008:183-195.

[54] Damtea T, Ojiewo CO. Current status of wilt/root rot diseases in major chickpea growing areas of Ethiopia. Archives of Phytopathology and Plant Protection. 2016; 49:222-238.

[55] Ali M, Kumar S. Productivity levels of pulses in major producing states in India. In: Survey of Indian Agriculture. The Hindu Year Book, Chennai, 2008: 44-45.

[56] Anand M, Naik MK, Ramegowda G, Devikarani GS. Bio-control and PGPR of Pseudomonas fluorescens isolates. J. Mycopathol. Res. 2010; 46:135-139.

[57] Rini CR, Sulochana KK. Usefulness of Trichoderma and Pseudomonas against *Rhizoctonia solani* and *Fusarium oxysporum* infecting tomato. J. Trop. Agric. 2007; 45:21-28.

[58] Srivastava AK, Singh T, Jana TK, Arora DK, Singh T. Induced resistance and control of charcoal rot in Cicer arietinum by *Pseudomonas fluorescens*. Can. J. Bot. 2001; 79:787-795.

[59] Naik MK, Madhukar HM, Devika Rani GS. Evaluation of biocontrol efficacy of Trichoderma isolates and methods of its applications against wilt of chilli caused by *Fusarium solani*. J. Biol. Control 2009;23: 31-36.

[60] Tebke D, Ojiewo CO. Current statuses of wilt/root rot diseases in major chickpea growing areas of Ethiopia. Arch. Phytopathol. Plant Protect. 2016; 49:222–238.

[61] Yimer S. M, Ahmed S., Fininsa C, Tadesse N, Hamwieh A, Cook DR. Distribution and factors influencing chickpea wilt and root rot epidemics in Ethiopia. Crop Protection. 2013; 106:150-155.

[62] Siddiqui ZA, Akhtar MS. Biocontrol of a chickpea root-rot disease complex with phosphate-solubilizing microorganisms. Jour. of Plant Pathology. 2007; 89 (1):67-77.

[63] Deepika T, Meena VD. Effects of sowing dates and weed management on Growth and yield of chickpea in Indo-Gangetic Plains. Proc. Natl. Acad. Sci. India Sect. B Biol. Sci. 2014; 86:33–38.

[64] Nene YL. Indian pulses through the millennia. Asian Agri-history. 2006;10: 179-202.

[65] Tomooka N, Vaughan DA, Kaga A. Mungbean [*Vigna radiata* (L.) Wilczek]. In: Genetic Resources, Chromosome Engineering, and Crop Improvement: Grain Legumes, Volume I. (Edited by Singh RJ and Jauhar PP), CRC Press, Florida, USA, 2005:325–45.

[66] Somta P, Srinives P. Genome Research in Mungbean [*Vigna radiata* (L.) Wilczek] and Blackgram [*V. mungo* (L.) Hepper], ScienceAsia. 2007; 33:69-74. DOI: 10.2306/scienceasia1513-1874.

[67] Sharma P, Sharma A, Singh M. Effect of leaf crinkle disease on yield and quality of urdbean (*Vigna mungo* L. Hepper) in Himachal Pradesh. H.J.A.R. 2015; 41(1):80-82.

[68] Ashfaq M, Khan MA, Mukhtar T, Sahi ST. Role of mineral metabolism and some physiological factors in resistance against urdbean leaf crinkle virus in blackgram genotypes. International Journal of Agriculture and Biology. 2014; 16:189–194.

[69] Chavan SO, Patil YR. Ancient and modern review of nutritional value and therapeutical benefits of Mugha (Green gram). J.Biol Sci Opin. 2013;1(2):101-104.

[70] Pandey S, Sharma M, Kumar S, Gaur PM, Chen, W, Kaur L, Macleod W, Basandrai AK, Basandrai D, Bakr A, Sandhu JS, Tripathi HS, Gowda CLL. Integrated foliar diseases management of legumes. In: Grain Legumes: Genetic improvement, Management and Trade, Eds. By Masood Ali *et al.,* 2009:143-161. Indian Society of Pulses Research and Development, Indian Institute of Pulses Research, Kanpur, India.

[71] Biswas KK, Malathi VG, Varma A. Diagnosis of symptomless yellow mosaic begomovirus infection in pigeonpea by using cloned Mungbean yellow mosaic India virus as Probe. JPBB. 2008; 17:9-14.

[72] Varma A, Biswas KK. Viral diseases of pulses: emerging concerns. In: Souvenir of International conference on grain legumes: quality improvement, value addition and trade. IIPR. 2009:63-69.

[73] Sarita RK, Jain RK. Nucleotide sequence of S and M RNA segments of a Groundnut bud necrosis virus isolate from Vigna radiata in India. Arch Virol. 2007; 152:1195-1200.

[74] Biswas KK, Tarafdar A, Kumar A, Dikshit HK, Malathi VG. Multiple infection in urdbean (*Vigna mungo*) in natural condition by begomovirus, tospovirus and urdbean leaf crinkle virus complex. Indian Phytopath. 2009; 62:975-982.

[75] Sharma RB, Prasad SM, Kudada N. Leaf crinkle virus disease in urdbean (*Vigna mungo* Linn.). J Res.Birsa Agric Univ. 2007; 19:73-79.

[76] Kanimozhi S, Ganapathy T, Rajinimala N. Seed transmission of ULCV in Mungbean and Urdbean plants infected with both MYMV and ULCV. Arch. Phytopathology Plant Protec. 2009; 42:401–408.

[77] Biswas KK, Biswas K, Tarafdar A. Multiple and mixed infections with yellow mosaic, leaf crinkle and bud necrosis disease complex in mungbean: A threat to cultivation of mungbean in India. Legume Reesearch. 2015; 38(3):382-388.

[78] Khaleeq-ur-Rehman, Iftikhar Y, Ali Y, Yasin O, Arshad U, Khan WA, Hafeez A, Jafir M, Ali S. Screening of Urdbean (*Vigna mungo* (L) Hepper) Genotypes against ULCV in Relation to Epidemiological Factors. Advances in Zoology and Botany. 2018; 6(1):41-46. DOI: 10.13189/azb.2018.060105.

[79] Sharma PN, Sharma A, Sharma OP, Sharma SK, Garg ID. Association of an unusual filamentous virus with leaf crinkle disease of urdbean in Himachal Pradesh. J. Mycol. Plant Pathol. 2014; 44: 257-263.

[80] Basandrai D, Basandra AK, Sharma V, Devlash R, Gautam NK. Evaluation for multiple resistances to yellow mosaic, anthracnose, Cercospora leaf spot and powdery mildew in urdbean germplasm. Plant Dis. Res. 2011; 26(2): 166.

[81] Reddy KS, Dhanasekar P, Dhole VJ. A review on powdery mildew disease resistance in mungbean. J. Food Legumes. 2008;21(3):151-155.

[82] Bashir M, Ahmad MZ, Mansoor S. Occurrence and distribution of viral diseases of mungbean and mashbean in Punjab. Pakistan. Pakistan Journal of Botany. 2006;38(4):1341-13.

[83] Munawwar MH, Ali A, Malik SR. Identification of resistance in mungbean and mashbean germplasm against mungbean yellow mosaic virus. Pakistan J. Agric. Res. 2014;27(2).

[84] Bashir M, Jamali AR, Ahmed Z. Genetic resistance in mungbean and mashbean germplasm against mungbean yellow mosaic begomovirus. Mycopath. 2006;4(2): 1-4.

[85] Akhtar KP, Dickinson M, Hodgetts J, Abbas G, Asghar MJ, Shah TM, Atta B, Ahmad M, Haq MA. The phytoplasma disease 'mung bean phyllody' is now present in Pakistan. Plant Pathol. 2010; 59:399.

[86] Akhtar KP, Sarwar G, Abbas G, Asghar MJ, Sarwar N, Hamed M, Mungbean phyllody disease in Pakistan: symptomatology, transmission, varietal response and effects on yield characteristics, International Journal of Pest Management. 2012;58(2):139-145.

[87] Weintraub PG, Beanland L. Insect vectors of phytoplasmas. Annu Rev Entomol. 2006; 51:91–111.

[88] Bertaccini A, Franova J, Botti S, Tabanelli D. Molecular characterization of phytoplasmas in lilies with fasciation in the Czech Republic. FEMS Microbiol Lett. 2005; 249:79–85.

[89] Kaur M, Singh N. Characterization of protein isolates from different Indian chickpea (*Cicer arietinum* L.) cultivars. Food Chem. 2007; 102:366–74.

[90] Maryam Shahzady H, Ahmad T, Moosa A, Khan WA, Naeem I, Nasir M, Aslam Khan M, Abbas A. A General Review of Cercospora Leaf Spot Disease of Mungbean and its Management. Int. j. sci. footpr. 2017; 5(2): 81-84.

[91] Akbar W, Aslam, Atif RM, Nawaz-ul-Rehma S. Exploration of Durable Resistance in Mungbean against Mungbean Yellow Mosaic Disease. Pak. J. Agri. Sci. 2017;54(2): 415-422.

[92] Shad N, Mughal SM, Farooq K, Bashir. Evaluation of mungbeen germplasm for resistance against mungbean yellow mosaic begomovirus. Pak. J. Bot. 2006; 38:449-457.

[93] Sudha M, Karthikeyan A, Anusuya P, Ganesh NM, Pandiyan M, Senthil N, Raveendran M, Nagarajan P, Angappan K. Inheritance of resistance to mungbean yellow mosaic virus (MYMV) in inter and intra specific crosses of mungbean (*Vigna radiata*). Am. J. PlantSci. 2013; 4:1924-1927.

[94] Mohan S, Sheeba A, Murugan E, Ibrahim SM. Screening of mungbean germplasm for resistance to mungbean yellow mosaic virus under natural condition. Ind. J. Sci. Technol. 2014; 7: 891-896.

[95] Sinha P, Rizvi G, Parashar R. Management of Wilt Disease of Pulses: A Review. Int. J. Pure App. Biosci. 2014; 6(4): 696-708. doi: 10.18782/2320-7051.6726

[96] Prasad P, Kumar J. Management of Fusarium wilt of chickpea using brassicas as biofumigants. Legume Research. 2017; 40 (1):178-182.

[97] Prasad P, Pandey S, Kumar J. High performance liquid chromatography protocol for glucosinolate profiling in Brassica L. species. Indian J. Nat. Prod. Resour. 2015; 6:221-226.

[98] Parthasarathy S, Thiribhuvanamala G, Subramanian KS, Prabakar K. Bacterial antagonists and hexanal-induced systemic resistance of mango fruits against *Lasiodiplodia theobromae* causing stemend rot. Journal of Plant Interactions. 2016;11(1): 158-166.

[99] Narayanan P, Vanitha S, Rajalakshmi J, Parthasarathy S, Arunkumar K, Nagendran K, Karthikeyan G, Efficacy of biocontrol agents and fungicides in management of mulberry wilt caused by *Fusarium solani*. J. Biol. Cont. 2015;29(2): 107-114.

[100] Shanmugapackiam S, Parthasarathy S, Jebaraj D, Christopher DJ. Exploitation of compost amended biological agents for the management of vascular wilt *Fusarium oxysporum* f. sp. lycopersici in tomato. Advances in Life Sciences. 2016; 5(7):29332941.

[101] Rubatzky VE, Yamaguchi M. World Vegetables: Principles, Production, and Nutritive Values. New York: Chapman & Hall. 2012.

[102] Boye J, Zare F, Pletc A. Pulse proteins: processing, characterization, functional properties and applications in food and feed. Food Res. Int. 2010a; 43:414–31.

[103] Costa GED, Queiroz-Monici KDS, Reis SMPM, de Oliveira AC. Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes. Food Chem. 2006; 94:327–30.

[104] Iqbal A, Khalil IA, Ateeq N, Khan MS. Nutritional quality of important food legumes. Food Chem. 2006; 97:331–35.

[105] Bazzano LA, Thompso AM, Tees MT, Nguyen H, Winham DM. Non-soy legume consumption lowers cholesterol levels: a meta-analysis of randomized controlled trials. Nutr. Metab. Cardiovasc. Dis. 2011; 21:94–103.

[106] Hu FB. Plant-based foods and prevention of cardiovascular disease: an overview. Am. J. Clin. Nutr. 2003; 78(5):44–51.

[107] Ahlawat IPS. Agronomy – rabi crops, Lentil. Division of Agronomy Indian Agricultural Research Institute, New Delhi – 110 012 Agronomy. 2012.

[108] Farooq Z, Boye JI. Novel food and industrial applications of pulse flours and fractions. In: Tiwari B K, Gowen A, McKenna B, eds., Pulse Foods: Processing, Quality and Nutraceutical Applications. Academic Press London, UK. 2011:283–324.

[109] Rathod RP, Annapure US. Physicochemical properties, protein and starch digestibility of lentil-based noodle prepared by using extrusion processing. LWT-Food Science and Technology, 2017; 80:121–130.

[110] Turfani V, Narducci V, Durazzo A, Galli V, Carcea M. Technological, nutritional and functional properties of wheat bread enriched with lentil or carob flours. LWT-Food Science and Technology, 2017; 78:361–366.

[111] Kim H, Behall KM, Conway JM. Short-term satiety and glycemic response after consumption of whole grains varying in the amount of β-glucan in overweight adults. In: North American Association for the Study of Obesity 2005 Annual Meeting. Obesity Research, 2005:13.

[112] Durazzo A, Turfani V, Azzini E, Maiani G, Carcea M. Phenols, lignans and antioxidant properties of legume and sweet chestnut flours. Food Chemistry. 2013: 140:666–671.

[113] Kumar SK, Barpete S, Kumar J, Gupta P, Sarker A. Global lentil production: Constraints and strategies. SATSA Mukhapatra - Annual Technical Issue, 2013; 17:1–13.

[114] Jacobs DR, Gallaher DD. Whole grain intake and cardiovascular disease: A review. Current Atherosclerosis Reports, 2004; 6:415–423.

[115] Kumar S, Kumar J, Singh S, Ahmed S, Chaudhary G, Sarker A. Vascular wilt disease of lentil: a review. Journal of Lentil Research. 2010; 4:1-14.

[116] Sharpe AG, Ramsay L, Sanderson LA, Fedoruk MJ, Clarke WE, Rong L, Kagale S, Vijayan P, Vandenberg A, Bett KE. Ancient orphan crop joins modern era: Gene-based SNP discovery and mapping in lentil. BMC Genomics. 2013; 14.

[117] Taheri N, Fallahati RM, Jafarpour B, Bagheri AR, Jahanbaghsh V. Pathogenic and genetic characterization of *Fusarium oxysporum* f. sp. lentis by RAPD and IGS analysis in Khorasan province. World Appl. Sci. J. 2010; 9:239–244.

[118] Chaudhary RG, Saxena DR, Dhar V, Singh RK, Namdev JK. Prevalence of wilt-root rot and their associated pathogens at reproductive phase in lentil. Arch. Phytopathol. Plant Protect. 2010; 43:996–1000.

[119] Rubab A, Chaudhary RA, Farah N, Ghulam S. Surveillance and morphological characterization of Fusarium isolates associated with lentil wilt. Pakistan J. Phytopathol. 2014; 26:85–88.

[120] Pouralibaba HR, Rubiales D, Fondevilla S. Identification of pathotypes in *Fusarium oxysporum* f. sp. lentis. Eur. J. Plant Pathol. 2016; 144:539–549.

[121] Ali M. Augmentation of Pulses Production. Mission.: IIPR Kanpur24: 2007; pp: 16-21.

[122] Jaruhar HB, Prasad A. Effect of different pH levels on the growth and sporulation of *Fusarium oxysporum* schlecht. F. Sp. Lentis vasudeva and srinivasan the causal organism of wilt disease of lentil. The Bioscan. 2011; 6(1):289291.

[123] Garkoti A, Kumar V, Tripathi HS. Control of wilt disease of lentil through biocontrol agents and organic amendments in Tarai region of Uttarakhand. Indian J. Environ. Bio. 2014; 35:1067–1070.

[124] Maheshwari SK, Bhat A, Masoodi SD, Beig MA. Chemical control of lentil wilt caused by *Fusarium oxysporum* f. sp. lentis. Ann. Plant Protect. Sci. 2008; 16:419–421.

[125] Singh VK, Naresh P, Biswas SK, Singh GP. Efficacy of fungicides for management of wilt disease of lentil caused by *Fusarium oxysporum* f. sp. lentis. Ann. Plant Protect. Sci. 2010; 18:411–414.

[126] Sinha RKP, Sinha BBP. Efficacy of potash, botanicals and fungicides against wilt disease complex in lentil. Ann. Plant Protect. Sci. 2004; 12:454–455.

[127] Ye G, McNeil DL, Hill GD. Breeding for resistance to lentil ascochyta blight. Plant Breed. 2002;121: 185–191.

[128] Iftikhar A, Khan S, Sarwar A, Haq A, Jabbar A. Biochemistry of resistance in chickpea against wilt disease caused by *Fusarium oxysporum* f. sp. ciceris. Pakistan Journal of Botany. 2005; 37:97-104.

[129] Ford R, Inder P, Taylor PWJ, Lindbeck K. Ascochyta blight of lentil, in Compendium of Chickpea and Lentil Diseases and Pests, eds W. Chen, H. C. Sharma, and F. J. Muehlbauer (St. Paul, MI: APS Press), 2011:40–42.

[130] Tullu A, Banniza S, Tar'an B, Warkentin T, Vandenberg A. Sources of resistance to ascochyta blight in wild species of lentil (*Lens culinaris* Medik.). Genet. Resour. Crop Evol. 2010; 57:1053–1063.

[131] Peever TL, Barve MP, Stone LJ, Kaiser WJ. Evolutionary relationships among Ascochyta species infecting wild and cultivated hosts in the legume tribes Cicereae and Vicieae. Mycologia. 2007; 99:59–77.

[132] Murray MG, Brennan JP, The current and potential costs from diseases of pulse in Australia, 2012th edn. Grains Reseaserch and Development Corporation, Kingston, ACT, Australia. 2012.

[133] Morrall RAA. Diseases of Lentil. In: Diseases of Field Crops in Canada (3rd ed) (KL Bailey, BD Gossen, RK Gugel and RAA Morrall eds), The Canadian Phytopathological Society. 2003:191-200.

[134] Mwakutuya E, Banniza S. Influence of temperature and wetness periods on the development of stemphylium blight on lentil. Plant Dis. 2010; 94:1219–1224

[135] Taylor PWJ, Ford R. Biology of ascochyta blight of cool season food and feed legumes. European Journal of Plant Pathology (In press). 2007.

[136] Anderson KL, Buchwaldt L, Chongo, Gossen BD, Morrall RAA, Pears PG. Diseases of lentil in Saskatchewan 1999. Canadian Plant Disease Survey. 2000; 80:96-98.

[137] Damm U, O'Connell RJ, Groenewald JZ, Crous PW. The Colletotrichum destructivum species complex—Hemitrophic pathogens of forage and field crops. Stud Mycol. 2014; 79:49–84.

[138] Dokken-Bouchard FL, Bassendowski K, Chant S, Friesen S, Ippolito J, Miller S, Stephens DT. Survey of lentil diseases in Saskatchewan, 2012-2015. Can Plant Dis Surv. 2016; 95:182–185.

[139] Buchwaldt L, Lentil anthracnose. In: Muehlbauer F, Chen W, editors. Compendium of lentil and chickpea diseases. The American Phytopathological Society. APS Press; St. Paul Minnesota USA. 2011:31–34.

[140] Mahmood Y, Khan MA, Iqbal M. Evaluation of various fungicides against powdery mildew disease on peas. Pakistan J. Phytopathol. 2008; 20(2):270-271.

[141] Chongo G, Gossen BD, Bernier CC. Infection by Colletotrichum truncatum in resistant and susceptible lentil genotypes. Canadian Journal of Plant Pathology. 2002; 24:81-85.

[142] Lindbeck KD, Bretag TW, Materne MA. Breeding for resistance to Botrvtis fabae in Australian lentils. In: Proceedings of 8th International Congress of Plant Pathology, Christchurch, New Zealand, 2003:29l.

[143] Negussie T, Pretorius ZA. Yield loss of lentil caused by *Uromyces viciae fabae*. S.A. J. Plant Soil 2008; 25:32-41.

[144] Taylor P, Lindbeck K, Chen W, Ford R. Lentil diseases. In: Yadav, S.S., McNeil, D.L. and Stevenson, P.C. (eds) Lentil: An Ancient Crop for Modern Times. Springer, Dordrecht, The Netherlands, 2007:291–313.

[145] Swan LD, Backhouse D, Burguess LW. Surface soil moisture and stubble management practice effects on the progress of infection of wheat by *Fusarium pseudograminearum*. Aust. J. Exp. Agr. 2000; 40:693-698.

[146] Makkouk KM, Attar N. Seed transmission of cucumber mosaic virus and alfalfa mosaic virus in lentil seeds. Arab Journal of Plant Protection 2003; 21:49–52.

[147] Hartman GL, Sinclair JB. Soybean Disease Management: Chemical and Biological Control in Tropical Regions. 1992:164-173.

[148] Barari H, Foroutan A. Biocontrol of Soybean Charcoal Root Rot Disease by Using Trichoderma spp. Cercetari Agronomice in Moldova, 2016;49(2): 41-51.

[149] Chakraborty U, Purkayastha RP. Role of rhizobitoxine in protecting soybean roots from *Macrophomina phaseolina* infection, Canadian Journal of Microbiology, 1984; 30(3):285-289.

[150] Del Rio L, Martinson C, Yang X. Biological Control of Sclerotinia Stem Rot of Soybean with *Sporidesmium sclerotivorum*, Plant Disease, 2002; 86(9):999-1004.

[151] Peltier A, Bradley C, Chilvers M, Malvick D, Mueller D, Wise K, Esker P. Biology, Yield loss and Control of Sclerotinia Stem Rot of Soybean. Journal of Integrated Pest Management, 2012; 13(2):1-7.

[152] Adams P, Ayers W. *Sporidesmium sclerotivorum*: distribution and function in natural biological control of sclerotial fungi. AGRIS: International Information System for the Agricultural Science and Technology.1980.

[153] Carver R, Schneider, Raymond W. Biology Control and Risk Management of Soybean Diseases in Louisiana, LSU AgCenter, 2011.

[154] Tehrani AS, Zebarjad A, Hedjaroud GA, Mohammadi M. Biological control of soybean damping-off by antagonistic rhizobacteria, Meded Rijksuniv Gent Fak Landbouwkd Toegep Biol Wet, 2002; 67(2): 377-80.

[155] Schmitthenner A. Problems and Progress in Control of Phytophthora Root Rot of Soybean, Plant Disease, 1985; 69(4):362.

[156] Mantecón J. Efficacy of chemical and biological strategies for controlling the soybean brown spot (*Septoria glycines*). Ciencia e investigación agraria, 2008; 35(2).

[157] Volpiano CG, Lisboa BB, São José JFB, Oliveira AMRD, Beneduzi A, Passagli LMP. Rhizobium strains in the biological control of the phytopathogenic fungi Sclerotium (Athelia) rolfsii on the common bean, Plant Soil. 2018; 432:229-243.

[158] Sneh B, Holdaway B, Hooper G. Lockwood J. Germination–lysis as a mechanism for biological control of *Thielaviopsis basicola* pathogenic on soybean. Canadian Journal of Botany, 1976; 54(13):1499-1508.

[159] Maduewesi J, Lockwood J. Test Tube Method of Bioassay for *Thielaviopsis basicola* Root Rot of Soybean. Phytopathology, 1976; 66(6):811.

[160] Weaver D, Rodriguez-Kabana R. Disease Management in Soybean: Use of Cultural Techniques and Genetic Resistance, Pest Management in Soybean, 1992: 214-223.