REVIEW

PEST AND DISEASE OF CHICKPEA (*CICER ARIETIUNUM* L.) AND THEIR MANAGEMENT: A REVIEW

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***Key words**: chickpea, disease, pest, pathogens, damage*

INTRODUCTION

Chickpea (*Cicer arietinum* L.) known as gram or garbanzo bean is an valuable annual herbaceous legume belonging to the family *Leguminosae* (also known as *Fabaceae* or *Papilionaceae*), subfamily Papilionoideae (*Faboideae*) and the monogeneric tribe *Cicereae* Alef. Chickpea is a diploid (2n = 16), self-pollinating, grown primarily for human utilization (Vanderpuye, 2010). Chickpea is an essential legume crop and has become an integral part of a sustainable production system (Shukla et al. 2014).

After dry bean and peas, chickpea is the third most important and useful pulse crop grown in the world (Acevedo et al. 2021). Chickpea cultivation increase biological nitrogen fixation in the soil, due to its symbiotic relationship with rhizobia. Therefore, chickpea cultivation plays a “vital duty” in innovative sustainable models of agro-ecosystems inserted in crop rotation in arid and semi-arid environments for the reduction of chemical inputs and soil improvement (Leonetti et al. 2018; Hiremath et al. 2011).

It is a good and valuable source of carbohydrates and protein. The protein quality is considered to be better than other pulses and is estimated at 24% and ranges from 15 to 30% depending on variety and environmental conditions (Nleya et al. 2000). Chickpea has considerable amounts of all the essential amino acids except sulphur-containing amino acids, which can be supplemented by adding cereals to the diet (Jukanti et al. 2012; Bampidis et. Christodoulou, 2011).

Chickpea underwent a severe loss of genetic diversity as a consequence of a series of bottlenecks unique to this crop, reluctant cross-compatibility with wild species, winter-spring annual phenology and difficulty in domestication. Consequently, *C. arietinum* showing a lack of adaptive diversity for a range of biotic and abiotic stress. Sensitivity to environmental stress, susceptibility to viruses, pathogens and pests, and poor cross-pollination are the main cause for the limited diffusion and modest production of chickpea (Leonetti et al. 2018).

Despite growing demand and high-yield potential, chickpea productivity is insufficient. Several biotic such as *Ascochyta blight*, *Verticillium*, *Fusarium* wilt and pod borer, and abiotic such as drought, low temperature and salinity constraints are major factors for lower chickpea production (Garg et al. 2011).

Damage by insect, pests and disease are considered the major factors leading to low yield in chickpea (Kaur et al. 2018). Due to the high concentration of protein, chickpea plant is susceptible to a number of insect pests, which attack on roots, foliage and pods. Gram pod borer (*Helicoverpa armigera* Hubner) constitutes a worldwide pest of great economic importance on this crop (Sarwar et al. 2009).

MATERIALS AND METHODS

We have compiled data from specialized studies from last years, studies that address to chickpea pests and disease. We searched the databases in Google Academic, Springer, ScienceDirect, Food Science and Food Safety, Journal of Chemical Technology & Biotechnology, using the following keywords ” disease of chickpea ”; ”pests of chickpea”; ” chickpea diseases and insect-pest management” and ” integrated pest management for chickpea”.

RESULTS AND DISCUSSIONS

Chickpea is susceptible to a relatively huge number of insect, pests and disease (figure 1). Among these pathogens, *Fusarium, Verticillium* and *Ascochyta rabiei* are predominant (Shukla et al. 2014).

Fusarium wilt (*F. oxysporum f.sp ciceris*) is one of the major and significant yield limiting factors of chickpea (figure 2).

Figure 1. Pest and disease of chickpea

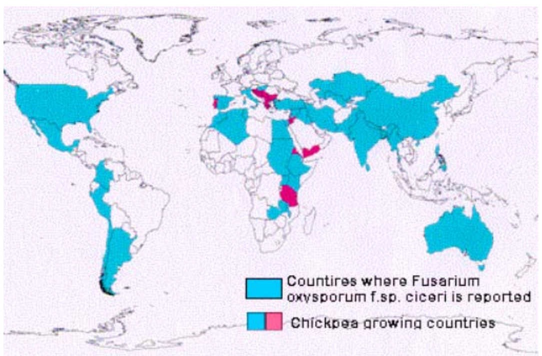

Figure 2. *F. oxysporum f.sp ciceris* worldwide *dispersal (*https://www.icrisat.org/)

Fusarium is a dangerous soil-borne fungus which survives through chlamydospores in seeds and dead plant debris. The fungus infects through roots and penetrates into the vascular system, causing wilt and considerably reducing yields. It is a vascular disease that causes blackening and browning of xylem. Affected plants first show drooping of the leaves, then collapse. The roots can look healthy but when split vertically the vascular tissues show brown or black discoloration (ICRISAT, 2010).

Since *Fusarium* can survive successfully in soil for several years, the use of fungicide to control the disease is impractical. Moreover, abuse in pesticide utilization has favoured the development of resistant pathogens (Shukla et al. 2014).

It is problematic to manage the disease either through crop rotation or application of chemicals because of soil nature persistence and its ability to survive for long time, even in the absence of host (Haji-Allahverdipoor et al. 2011).

The use of wilt resistance chickpea cultivars is the most effective, successful and eco-friendly method of managing the disease (Haji-Allahverdipoor et al. 2011).

Application of AgNPs in agriculture has been examined by many scientists. AgNPs is useful for controlling Fusarium wilt disease of chickpea. AgNPs biosynthesized by *Pseudomonas* sp., *Cephalosporium* sp., *Achromobacter* sp., and *Trichoderma* sp., demonstrate antifungal activity (Kaur et al. 2018).

Silver nanoparticles have the ability to show antimicrobial activity against many bacteria and fungi *Alternaria alternate, Alternaria solani*, *Botrytis cinerea*, *Sclerotinia homoeocarpa*, *Thanatephorus cucumeris* and *Botryodiplodia theobromae* (Kaur et al. 2018).

Various microorganisms viz., fungi, bacteria, mycorrhizae etc. have been tested for their capability to suppress plant diseases. Most of the studies, have used strains of *Trichoderma* species. *Bacillus subtilis* and *Pseudomonas fluorescens* have also been widely analysed for suppression of plant pathogens (Mohiddin et Khan, 2018).

Arbuscular mycorrhizal fungi have formidable potential for use as bioprotectant. The inoculation of mycorrhizal fungi increased P uptake and growth which makes plant more resistant against pathogenic effect of *Fusarium*. Inoculation of mycorrhizal fungi must be done prior to the transplantation of crop seedlings (Shukla et al. 2014; Pellegrino, Bedini, 2014; Fitter et al. 2011).

Plant growth promoting rhizobacteria (PGPR) are group of bacteria that actively colonize plant roots and enhance plant growth and yield. The mechanism by which PGPR promote plant growth are not entirely understood, but are thought to involve the ability to produce phytohormones, asymbiotic N2 fixation against phytopathogenic microorganisms by production of siderophores, the synthesis of enzymes, antibiotics and fungicidal compounds (Meenakshi et al. 2010).

Application of bacterial strains in combination with 20 kg N ha−1 were more suitable than the application of the strains alone as well as their respective controls in terms of promoting plant growth and improving soil health (Joshi et al. 2019).

Ascochyta blight (*Didymella rabiei*) is a dangerous disease of chickpea that causes about 20% to 100% yield loss annually and may produce total failure to the crop under epidemic conditions. Ascochyta blight develops quickly when plants are wet for several hours. The pathogen infects the aerial parts of plants: leaves, stems, flowers and pods. The pathogen fungus, causes necrotic lesions. Lesions on pods and leaves are circular and elongate on petioles and stems. When the lesions surround stems and petioles, they usually break (Duzdemir et al. 2014).

Dry root rot (*Rhizoctonia bataticola*) it is a serious disease under moisture stress conditions and when the crop is vulnerable and exposed to temperature above 30°C (figure 3).

The disease appears especially around flowering and podding stage. The whole plant dries up and turns straw-colored. Roots become brittle and black and have only a few lateral roots or none at all (ICRISAT, 2010).

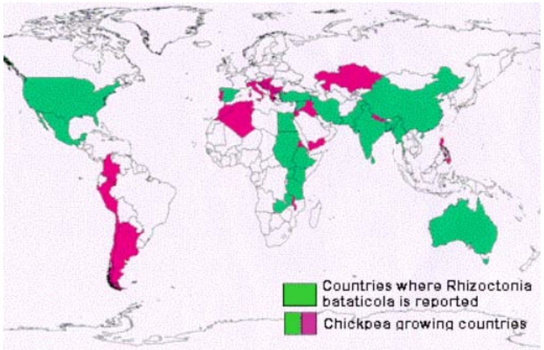

Figure 3. *Rhizoctonia bataticola* worldwide *dispersal* (https://www.icrisat.org/)

Botrytis grey mold (*Botrytis cinerea*) it is an important disease in some regions of Asia. Leaves become yellow followed by defoliation. Rotting of terminal buds and water soaked lesions are the main foliage symptoms. The disease can produce flower drop resulting in poor pod setting and extension of the crop duration (ICRISAT, 2010).

The disease is generally seen at flowering time when the crop canopy is fully developed. Extreme vegetative growth due to too much irrigation or rain, varieties that have a spreading habit and close spacing favor disease development. Temperatures between 20 and 25°C and exaggerated humidity around flowering and podding time favor disease development. As temperatures favorable to botrytis grey mold are a bit higher than those for ascochyta blight, these diseases may occur one after the other with ascochyta blight appearing first (Nene et al. 2012).

The most relevant viruses reported to infect and induce disease in chickpea are: Alfalfa mosaic virus (AMV, *Alfamovirus*, *Bromoviridae*), Bean leafroll virus (BLRV), Cucumber mosaic virus (CMV, *Cucumovirus, Bromoviridae*), Beet western yellows virus (BWYV) (both *Luteovirus, Luteoviridae*), Pea enation mosaic virus complex (PEMV-1, *Enamovirus, Luteoviridae*), Chickpea stunt disease-associated virus (CpSDaV, genus unassigned, *Luteoviridae*), and a number of geminiviruses of the genus *Mastrevirus*, the most important being Chickpea chlorotic dwarf virus (CpCDV) (Leonetti et al. 2018).

In the most characteristic diseases generated by soil-borne families, root-lesion nematodes (*Pratylenchus spp*.), cyst-forming nematodes (CNs) (*Heterodera spp*.), reniform nematodes (*Rotylenchus reniformis*), and root-knot nematodes (RKNs) (*Meloidogyne spp*.) have been found pathogenic for chickpea (Leonetti et al. 2018).

Root-knot nematode (*Meloidogyne incognita* and M. *javanica) produces damage* to chickpea. Particularly *M. arenaria, M. incognita*, and *M. javanica* cause huge galls in chickpea roots, whereas *M. artiellia* gives rise to very small galls surrounding the feeding sites or no galls in the infected roots (Leonetti et al. 2018).

Treatments with *B. subtilis* eliminated the galls, egg masses and soil population of *M. incognita* but it was less than *Pochonia chlamydosporia*.

Pochonia chlamydosporia is a serious important parasite of root-knot nematodes (Mohiddin et Khan, 2018). The fungus is also known for the capacity to produce some exoenzymes that help in disintegration of egg shell. Strains of *P. chlamydosporia* and *T. harzianum* have been found to parasitize massive the eggs of *G. rostochiensis*, *G. pallida* and *Panagrellus redivivus* leading to considerable decline in the respective soil populations (Mohiddin et Khan, 2018).

B. subtilis is not a parasite of plant nematodes, but the bacterium may have capacity to suppressed nematode infection through other mode of action. The control of nematode infection may result through production of antibiotics such as bacillomycin, iturin, and siderophores which may affect egg hatch (Mohiddin et Khan, 2018).

B. subtilis was found to be an successful plant growth promoter. Its application resulted to considerably greater dry matter and yield of chickpea. *Bacillus subtilis* has the ability to produces phytohormones, solubilizes minerals and produces siderophores that can solubilize and sequester iron from the soil and provide it to plants cells. *P. fluorescens* and *Trichoderma* spp. are also mentioned to solubilize phosphorus and produce antibiotics (Mohiddin et Khan, 2018).

Helicoverpa armigera, the pod borer is a serious constraint to global chickpea production (Khatodia et al. 2017). It is the most problematic pest of chickpea in all the chickpea growing areas. In case of severe damage it compromises almost all the pods (table 1).

Larvae can be green, yellow, brown, or pink, but are generally striped, irrespective of their color (ICRISAT, 2010).

Table 1. Control measures for *Helicoverpa armigera*.

Control measures	Authors
Early sowing;	(ICRISAT, 2010)
Bird perches can be installed in the fi eld to attract predatory birds;	(ICRISAT, 2010)
Intercropping coriander with chickpea;	(ICRISAT, 2010)
Bio-rational pesticides such as *Bacillus thuringiensis* (Bt), Nuclear Polyhedrosis Virus (NPV), entomopathogenic fungi (*Metarhizium anisopliae*), etc;	(ICRISAT, 2010; Cherry et al. 2000; Allahyari et al. 2019)
Application of chemical sprays and bio-pesticides;	(Waqas et al. 2009; Khalique et al. 2012)
Hand picking+indoxacarb, weeding + indoxacarb;	(Waqas et al. 2009)
Neem oil;	(Bhushan et al. 2011)
Pheromone traps;	(Ahmed and Khalique 2002)

The pod borer is widely distributed throughout the world and has facultative diapauses, which enables them to survive adverse weather conditions. The larvae feed directly on the pod, causing seed abortion and damage, thereby having the ability to produce major crop losses (Khatodia et al. 2017).

Sitona macularius is also a problematic pest for chickpea. The larvae feed predominantly on roots and nodules of legumes. Severe attacks lead to stunted, yellow plants. The adults prefer upon leaves, cutting typical U-shaped notches from the edge of the leaflets. This weevil prefers lentil and seldom, if ever, damages more than 5% of chickpea plants or nodules in any field. Consequently, the prejudice to chickpea does not merit specific control measures (Reed et al. 1989).

Liriomyza cicerina is common pest and produces damage in the chickpea. However, current work has shown that many of the leaf mines occurring early in the season are caused by an unidentified species of Agromyza. Liriomyza sp. has been reported to cause significant damage in Mexico (Reed et al. 1989).

Agrotis ipsilon is generally a pest of unimportant, but may reduce plant stand in case of serious infestation. Gray-black larvae live beneath the soil surface during the day, and become active at night. They cut and destroy the seedlings at or below ground level (ICRISAT, 2010).

Aphis craccivora and *Acyrthosiphon pisum)* produces damage to chickpea. Both these species are vastly distributed and found on a wide range of legumes in all regions where chickpeas are cultivated. The aphids prefer stems, leaflets and pods. The plants wilt when large colonies build up on them. However, stunt disease cause the most damage in chickpea. This is produced by bean leaf-roll virus which is transmitted by these aphids. Stunt disease reduces plant growth and leaflets are smaller with a reddish brown color (yellow in kabuli types). Scraping the lower part of the stem reveals brown phloem which is specific of this disease (Reed et al. 1989).

Usually, insect pests damage the crop either as vectors of various bacterial and fungal diseases or as destroyers of seedlings, flowering, foliage and fruiting bodies (Ramesh, Rao, 2017).

Invariably, pulses are infested with beetle and weevil in fields as well as at storage time. Due to infestation, seeds undergo biochemical alterations which outcomes in the loss of different constituents of the seeds. *C. maculatus* is one of the significant pests of pulses and chickpea seeds suffer from quantitative and qualitative losses due to severe attack of this bruchid (Saxena 2011).

Callosobruchus sp. attacked chickpea are considerably affected not only in terms of quantitative and qualitative, but also these grains lose their germinating capacity completely as well (Haile, 2015).

In general, the kabuli plants and seeds are much more vulnerable to insect attack than the desi type (Reed et al. 1989).

Prior to planting, treatment of chickpea seed are recommended to be conducted with fungicide seed dressing in order to protect them against seed-borne ascochyta blight, botrytis grey mould and damping off (*Pythium* spp.). Moreover, *Phytophthora* and *Fusarium* root rot diseases might be managed with seed treatments (Office of the Gene Technology Regulator, 2019).

Periodic sun drying over several months would eliminate the adult bruchids. The pulses seeds would be rendered free from viable infestation if heated for 10 minutes to 58°C which represents the thermal death point of *Callosobruchus chinensis*,. Mixing of smaller seeds such as ragi, mustard, or some inert particles such as sand or wood ash with food grains is practiced in large number regions for small scale storage of pulses.

The Sadabahar leaves and custard apple powder have been demonstrated to protect legume seeds from bruchids. Treatments with vegetable oils such as lemon oil (*Citrus limon*), peanut oil, garlic oil (*Allium sativum*), *Acorus calamus* oil, mustard (*Brassica* sp.), castor (*Ricinus communis*), sunflower (*Helianthus annuus*) and safflower oils, and neem oil have been shown to be efficient in managing *C. chinensis*, *Tribolium castenum*, and *C. maculatus*. However, the efficiency of such traditional treatments on commercial scale requires to be further investigated. Regulation of storage temperature below a limit at which insect development is stopped is efficient in controlling infestation (Chavan et al. 1987).

Ash represents an inert dust that affects the respiratory system of the insect and may kill them by suffocation. Khaire (1992) mentioned that mixing ash with grain makes the entry of insects in grain a challenging task and cause physical and physiological injuries to the insects. Beside, ash is chemically inactive but with insecticidal property.

The ash dusts that decrease the relative humidity of the storage condition could also dry the grain surface to cause less damage by the pest. Larval development and egg laying of the beetles could be disrupted because ash dusts cover the grain seeds. It might also affect the insect movement for mating (Haile, 2015).

Intercropping system decrease the risk from epidemic of insect-pest and disease, and overcome the effect of adverse environmental conditions along with better utilization of solar radiation and inputs like fertilizer and water compared to crops in sole system (Das et al. 2016).

Chickpea can be cultivated as a sole crop or intercropped with sorghum (*Sorghum bicolor*), linseed (*Linum usitatissimum*), repeseed (*Brassica napus* L.) and other crops (Poddar et al. 2013). It can also be grown in some rotation with teff (*Eragrostis* tef), pearl millet (*Pennisetum glaucum*), wheat (*Triticum vulgare*) or other crops.

Integration of chickpea in crop rotations provides a means of disease and pest cycle break. Chickpea is also deeprooted compared to other legumes and hence has the potential to tap soil moisture from greater depths which may not be available to shallow-rooted crops (Vanderpuye, 2010).

CONCLUSIONS

Chickpea is vulnerable to a considerable number of pathogens. Arbuscular mycorrhizal fungi have formidable potential for use as bioprotectant. The inoculation of mycorrhizal fungi improved growth and P uptake which makes plant more resistant against pathogenic effect of *Fusarium*.

A break of at least three years between chickpea crops is recommended to diminish the risk of ascochyta blight disease. Chickpea must also be sown in fields that are at least 500 m from previous year's chickpea crops. It is useful to know the paddock history, as chickpea is susceptible to damage from residual herbicides, such as sulfonylureas, that are used to manage weeds in previous crops or fallows.

ABSTRACT

This paper is a review of the literature in recent years that focuses on the the most relevant pest and disease of chickpea (*Cicer arietinum*). Chickpea is a remarkable legume crop and has become an integral part of a sustainable production system**.** Chickpea cultivation plays a pivotal role in innovative sustainable models of agro-ecosystems inserted in crop rotation for soil improvement and the reduction of chemical inputs. Damage by insect pests and disease-causing pathogens are considered as the most significant factors leading to low yield in chickpea. Being rich in protein, chickpea plant is vulnerable to a number of insect pests, which attack on roots, foliage and pods.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Ministry of Agriculture and Rural Development, trough the ADER 2020 Program, developed by VRDS Bacau.

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