***Review Article***

# Integrated disease management of chickpea *Fusarium* wilt


## Abstract

Chickpea (*Cicer arietinum*) is one of the world's major legume crops and suffers substantial damage from wilt disease caused by *Fusarium oxysporum* f. sp. *ciceri* (Padwick) with yield loss over 60 per cent. It is an important soil borne plant pathogen and is difficult to manage by application of chemical pesticides. Moreover, the chemical control is costly and leads to residual effect. A plethora of reports indictes the efforts made to reduce environmental effects and rationalize the use of pesticides and manage the pathogen more effectively through Integration of Disease Management (IDM). Application of soil amendments and specific bio-control agents also incorporated in IDM which has potential to suppress soil-borne pathogens through manipulation of the physicochemical and microbiological environment. Therefore, IDM approach for controlling chickpea *Fusarium* wilt might be a cost effective and eco friendly approach.



**Keywords:** Chickpea (*Cicer arietinum*), *Fusarium* wilt, Integration of Disease Management (IDM)




## Introduction:

Chickpea (*Cicer arietinum* L.) is one of the important legume crop (Sunkad et al., 2019) grown in the Mediterranean basin and World-wide (Saxena, 1990). It is third pulse crop in the World after dry bean (*Phaseolous vulgaris* L.) and dry pea (*Pisum sativum* L.) (Nikam *et al*., 2007). Chickpea is a member of sub-family Papilionaceae (*leguminaceae* family) and originated from Middle East and subsequently spread over 45 countries with arid, semi-arid and sub-tropical environment. It is a *Rabi* season crop. India accounts for approximately 75 % of global chickpea production. Chickpea contributes about 67 % to *Rabi* pulse production and 46 % of total production of India. India is a major chickpea producing country, highest production has been received from Madhya Pradesh (39 %) followed by Maharashtra (14 %), Rajasthan (14 %), Andhra Pradesh (10 %), Uttar Pradesh (7 %), Karnataka (6 %) and remaining state contribute about 10 per cent. In Bihar, the chickpea crop mostly grown in Rohtas, Bhojpur, Aurangabad, Gaya, Nawadah, Munger, Patna, Begusarai, Purnea etc. covering an area of 0.06 **million hectares (**m ha) with annual production of 0.73

million tons and productivity of 983 kg/ha (Agricultural statistics at a glance, 2016). Other important chickpea producing countries are Pakistan, Australia, Turkey, Iran, Myanmar, Ethiopia, Mexico, etc. (Merga and Haji 2019).

Chickpea valued for its nutritive seed composition which is high in protein content and used increasingly as a substitute for animal protein (Hossain *et al.*, 2010). It has ability for nitrogen fixation which accumulates nitrogen in soil(Hulse, 1991). Chickpea is also a good source of minerals such as Ca, P, Mg, Fe, K and β-carotene (Wallace et al., 2016; Abbo et al., 2005) . Chickpea has a higher content of manganese, zinc and phosphorous than other legumes (Wang *et al.,* 2010).

Chickpea is mainly consumed as 'Dal' (split cotyledons) and chhole. Many attractive dishes *viz*. sweets, snacks and namkeen are also prepared from its floor called besan and also eaten as whole fried or boiled and salted. Fresh green leaves (sag) are used as vegetables and green grains as hare chhole or chholia. Straw of gram is an excellent fodder while both husk and bits of 'Dal' are valuable cattle feed. Sprouted seeds are eaten as a vegetable or added to salads. Young plants and green pods are eaten like spinach. Animal feed is another use of chickpea in many developing countries.

**Chickpea *Fusarium* wilt**

Many factors contributed towards chickpea low yield but the pathological constraints are the most important. Chickpea wilt caused by *F. oxysporum* Schlechtend Fr. f. sp. *ciceris* (Padwick) Matuo & K. Sato is the most important soil-borne disease of chickpea throughout the world and particularly in the Indian Sub-continent, the Mediterranean Basin and California (Haware, 1990; Jalali and Chand, 1992; Nene & Reddy, 1987). *Fusarium oxysporum* f.sp. *ciceri* may survive in soil and on crop residues as chlamydospores for up to six years in the absence of host plant and spread by means of both soil and infected seeds (Haware et al., 1996). Attacks of the *Fusarium* wilt pathogen can destroy the crop completely or cause a significant annual yield loss especially in low rainfall regions which is a permanent threat to the chickpea causing wilt syndrome. *F. oxysporum* f.sp. *ciceri* produces mycotoxins. *Fusarium* wilt of chickpea is prevalent in almost all chickpea-growing areas of the world and its incidence varied from 14 to 32 % in the different states of India (Dubey *et al.*, 2010). This disease causes yield losses up to 100 % under favorable conditions (Landa *et al.*, 2004).

Characteristic symptoms of this disease develop at any stage of plant growth and affected plants may be grouped in patches or appear spread across the field (Haware, 1990;

Nene and Reddy, 1987; Trapero-Casas and Jim_enez-Díaz, 1985). Highly susceptible cultivars can show symptoms within 25 days after sowing (designated 'early wilt'), including flaccidity of individual leaves followed by a dull-green discoloration, desiccation and collapse of the entire plant. However, symptoms are usually more conspicuous at the onset of flowering, 6 to 8 weeks after sowing, and can also appear up to poding stage ('late wilt'). Late wilted plants exhibit drooping of the petioles, rachis and leaflets, followed by yellowing and necrosis of foliage. Initially, drooping is observed in the upper part of the plant but within few days it occurs on the entire plant. Symptoms may affect only a few branches of a plant resulting in partial wilt. Roots of affected seedlings and plants show no external root discoloration if they are uprooted before being severely affected or dried (Nene et al., 1991) . However, the roots and stem of plant develop a dark-brown discoloration of xylem tissues that can be seen when they are split vertically or cross-sectioned. Histological distortions occur in the vascular tissues of affected roots and stems as a result of cavity formation between phloem and xylem, xylem and medulla, phloem and cortical parenchyma as well as anomalous cellular proliferation in the vascular cambium. This, together with formation of optically dense gels and occlusions in xylem vessel (but not of tyloses), probably contributes to retarded vascular flow of water and nutrients as well as development of morphological symptoms (Jim_enez-Díaz *et al.,* 1989).

## Integrated disease management (IDM)

Management of this pathogen is not possible by adopting a single approach like cultural practices, fungicides, host plant resistance or bio-agents and thus shows the necessity to integrate management packages for controlling this devastating disease (Landa et al., 2004). Although fungicides have shown promising results in controlling the pathogen ((Maitlo et al., 2014; Golakiya et al., 2018), phytotoxicity and fungicidal residues along with environmental contamination and human health hazards prevents their large-scale use. Therefore, replacement of fungicides with use of bio-agents and/or products has become a focus of considerable interest in the context of sustainable, economical and profitable agriculture (Sahni and Prasad 2020). Some non-conventional chemicals like salicylic acid (SA) triggered Systemic Acquired Resistance (SAR) which enhanced innate immunity in plant (Dihazi et al., 2011; Spoel SH 2019). Research indicates the application of various non-conventional chemicals enhanced host resistance against pathogens (Lazarovits, 1988; Sinha, 1995; Bhatacharya and Roy, 1998; Sharma *et al.*, 2007). In recent years, efforts were made to reduce environmental effects and rationalize the use of pesticides and manage the pathogen more

effectively through Integration of Disease Management (IDM) practices by a combination of appropriate techniques. Soil amendements with organic matter and/or use of bioagents become quite benifical for controlling wilt disease in several crops including chickpea (Lamichhane et al., 2017; Sahni and Prasad 2020). It has also been shown that vermicompost produced from cattle manure can suppress some soil-borne pathogenic fungi. Reports indicated that the vermicompost added to container media significantly reduced the infection of tomato plants by *Phytophthora nicotianae* var. *nicotianae* and *Fusarium oxysporum* f. sp. *lycopersici* (Szczech and Brezeski 1994; Szczech 1995 & 1999). Plant growth-promoting rhizobacteria (PGPR) were also shown to inhibit wilt pathogen (Shobha and Kumudini 2012). Elicitation of plant's defence by plant growth-promoting rhizobacteria (PGPRs) has received increasing attention in recent years. *Pseudomonas* spp. known as PGPR have been shown to trigger systemic resistance in plants, often referred to as induced systemic resistance (ISR) (Van Loon *et al*. 1998; Pieterse *et al.* 2000, 2014). The ISR improves the plant's defence mechanisms, however it is not specific and can protect plants against a broad spectrum of pathogens (Moradi et al., 2012; Pieterse *et al.* 2000, 2014). ISR is based on the recognition between specific elicitors of rhizobacteria and receptors (Van Loon *et al.* 2008). Elicitors of induced resistance can be either components of the bacterial cell surface or metabolites excreted by PGPRs (Van der Ent et al., 2009). The ISR reduces the sensitivity of plants towards pathogens and is phenotypically similar to systemic acquired resistance (SAR) (Van Loon *et al.* 1998; Van Wees *et al.* 1999). Simultaneous activation of SAR and ISR provides enhanced defensive capacity compared to each single resistance (Choudhary et al., 2007). Mode of action studies reveal that biological control by PGPR involves production of bacterial metabolites, which reduce the population or activities of pathogens or deleterious rhizosphere micro flora (Gopalakrishnan et al., 2016; Sahni and Prasad 2020). These metabolites may include siderophor that bind Fe making it less available to harmful micro flora (Kloepper *et al*., 1987; Subba Rao, 1993; Shobha and Kumudini 2012). Several studies have demonstrated that production of antibiotics (e.g. pyrrolnitrin, phycocyanin, 2, 4- diacetylphloroglucinol) by microbial inocula can cause suppression of pathogens (Pierson and Thomashow, 1992). Other mechanisms for biological control of disease may include: competition for infection sites and nutrients parasitism on pathogens i.e. destruction of fungal pathogen by action of lytic enzymes (e.g. chitinase and β-1,3-glucanase) and HCN that degrade fungal cell wall and uncharacterized antifungal factors (Velazhahahan *et al*., 1999; Kandoliya et al., 2017; Kumar et al., 2018). Recent work on the broad spectrum of PGPR-mediated induced systemic resistance against different pathogens in different crops has gained importance. Seed treatment

with *Pseudomonas fluorescens* was effective not only against the fungal root pathogen, *Fusarium oxysporum* f. sp. *raphani*, but also against the bacterial leaf pathogen, *Pseudomonas syringae* pv. tomato and fungal leaf pathogen, *Fusarium oxysporum*. Similarly, *Pseudomonas fluorescens* strain Pf1 induces resistance against different pathogens in different crops, viz. *Rhizoctonia solani* (Nanada Kumar, 1998) and *Colletotrichum falcatum* in sugar (Viswanathan and Samiyappan, 1999). Foliar application of plant growth-promoting rhizobacteria (PGPR) can reduce disease incidence intensity of powdery mildew of pea caused by *Erysiphepisi* (Singh *et al*. 2000). Therefore, a combinational effort must be adopted to fight against fusarium wilt resistance in chickpea.

**Conclusion:**

Wilt disease caused by *Fusarium oxysporum* f. sp. *ciceri* (Padwick) is one of the major notorious fungal diseases in Chickpea. Sustainable and ecofriendly management of wilt disease in chickpea agisnt wilt disease requires inclusion of various components. The inclusion of organic matter, application of non conventional chemicals and bioagents having PGPR activities must be involved in intregrated disease management of chickpea wilt disease.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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