# Studies on Integrated Management of Collar Rot of Chickpea

**THESIS**

*Submitted to*

**Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur**

**In partial fulfilment of the requirements**

**for the Degree of**

**MASTER OF SCIENCE**

*In*

**AGRICULTURE**

**(PLANT PATHOLOGY)**

*By*

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This is to certify that the thesis entitled, *"***Studies on integrated management of collar rot of chickpea***"* submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in Agriculture (Plant Pathology)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Priya Tiwari** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

All the assistance and help received during the course of the investigation has been acknowledged by her.

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The matter embodied in the thesis has not been submitted for the award of any degree/diploma. Due credit has been made to all the assistance and help.

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Place: Jabalpur
Date: **Priya Tiwari**

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# SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| @ | : at the rate of |
| °C | : Degrees Celsius |
| % | : Per cent |
| CD | : Critical difference |
| cm | : Centimeter |
| CRD | : Completely Randomized Design |
| *et al.* | : and other co-workers |
| Fig. | : Figure |
| g | : gram (s) |
| hr. | : hour |
| HCl | : Hydrochloric acid |
| *i.e.,* | : that is |
| Km | : kilo meter |
| Kg | : kilo gram |
| mg | : milli gram (s) |
| ml | : milli liter |
| Min | : minute |
| mm | : millimeter |
| N | : Normality |
| NaOH | : Sodium hydroxide |
| PDA | : Potato dextrose agar |
| PDI | : Per cent disease index |
| Ppm | : parts per million |
| Psi | : Pound per square inch |

# Chapter - I

# INTRODUCTION

# INTRODUCTION

Chickpea (*Cicer arietinum* L.) [2n=16, 738Mbp], commonly known as garbanzo beans is an important pulse crop that belongs to the family Leguminosae (Varshney *et al.,* 2013). It ranks third in most important food legume in the world after dry beans (*Phaseolus vulgaris* L.) and dry peas (*Pisum sativum* L.) (Dhar and Gurha, 1998). The origin of the chickpeas is thought to have been Levant and ancient Egypt (Davidson *et al*., 1999), which is logical since the plant prefers temperate and semiarid regions. India is the world's leading producer of chickpea. Major chickpea producing countries include India, Australia, Pakistan, Myanmar, Turkey, Ethiopia, Iran, Mexico, Canada and USA. Globally, a total of 14.26 million tons (mt) of chickpea were harvested from 13.72 million (m) ha of land, with a productivity of 1039 kg/ha. However, in India, 9.94 million tons of chickpea were harvested from an area of 9.55 million (m) ha of land, with a productivity of 1040 kg/ha (FAO STAT, 2019). In India the leading producing states include Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka and Andhra Pradesh together contributing to 90 per cent of the area and 91 per cent of the production in the country (DES, 2017-18). Among the different states of India, Madhya Pradesh is leading state in terms of area and production as it contributes 34% of the total chickpea area and 41% of the total chickpea production in the country. In Madhya Pradesh, it is grown in area of 36 lakh hactares with production of 46 lakh tones (Annual Report 2017-18, Directorate of Pulses Development)

Two main varieties of chickpeas exist: the light seeded Kabuli type and the smaller dark Desi type (Huntrods *et al*., 2013). The Desi (microsperma) types have pink flowers, anthocyanin pigmentation on stems, and a coloured and thick seed coat. The Kabuli (macrosperma) types have white flowers, lack anthocyanin pigmentation on stems, and have white or beige-coloured seeds with a ram's head shape, a thin seed coat and a smooth seed surface. Chickpea is valued for their nutritive seeds with high protein content 25.3 - 28.9% after dehulling (Hulse, 1991) carbohydrate 61.5%, fat 4.5% and vitamin 2.44%. The main proteins found in chickpea, similar to other legumes, are

albumins and globulins. Smaller amounts of glutelins and prolamines are also present (Saharan *et al*., 1994). Starch is the major carbohydrate fraction, representing about 83.9% of the total carbohydrates (Rinco´n *et al.,* 1998). It is also a good source of minerals such as Ca, P, Mg, Fe, K and β-carotene with higher content of manganese, zinc and phosphorous than other legumes. It is cholesterol free and is a good source of dietary fibre (DF), vitamins and minerals. Raw chickpea seeds (100 g) on an average provide about 5·0 mg of Fe, 4·1 mg of Zn, 138 mg of Mg and 160 mg of Ca.

Despite the high total production, yields of chickpea are low due to many biotic and abiotic constraints. Chickpea cultivation is subjected to significant losses due to insects and diseases ranging 5-10% in temperate and 50-100% in tropical regions (Van Emsen *et al.*, 1988). Among the biotic stresses, chickpea is attacked by 172 pathogens (67 fungi, 22 viruses, 3 bacteria, 80 nematodes and mycoplasma) from all over the world (Nene *et al.,* 1996).

Among the biotic constraints more than 50 diseases have so far been reported on chickpea. Among them soil borne diseases such as fusarium wilt (*Fusarium oxysporum f.sp. ciceris*), dry root rot (*Rhizocotonia bataticola*), collar rot (*Sclerotium rolfsii*) and black root rot (*Fusarium solani*) are the major limiting factor in chickpea production.

Collar rot caused by *Sclerotium rolfsii* is a serious threat to chickpea that may cause 55 to 95% mortality (Shrivastava *et al.*, 1984). It causes yield loss of up to 10–30% in India (Maurya *et al.,* 2008). It has an extensive host range; at least 500 species in 100 families are susceptible, the most common hosts are legumes, crucifers and cucurbits, and commonly occurs in the tropics, subtropics, and other warm temperate regions. The disease is favoured by high soil moisture, high soil temperature (25-30°C) and low organic matter in the soil (Mathur and Sinha, 1968). The disease appears in the early stages of the crop growth i.e., up to six weeks from sowing. The fungus can overwinter as mycelium in infected tissues or plant debris or as sclerotia near soil surface or buried in soil which serve as a major source of primary infection by germinating in response to alcohols and other volatile compounds released from decomposing plant material (Punja, 1985). Some

of the factors for severe outbreak of the disease include the presence of susceptible hosts, enough inoculum of virulent isolates of pathogen and climatic conditions favouring disease development over a period of time. *S. rolfsii* has wide host range with prolific growth and ability to produce persistent sclerotia to inflict the large economic losses associated with the pathogen (Mordue, 1974). The fungus can overwinter as mycelium in infected tissues or plant debris. Sclerotia serve as the principal over-wintering structure and primary inoculum for disease persistence near the soil surface. Sclerotia may exist free in soil or in association with plant debris. Those buried deep in the soil may survive for a year or less, whereas those at surface remain viable and may germinate in response to alcohols and other volatile compounds released from decomposing plant material (Punja, 1985). Sclerotia disseminate by cultural practices with infected soil and contaminated tools, infested transplanting seedlings, with water, wind and possibly seeds (Mahen *et al.*, 1995).

Therefore, looking to the importance of the crop and the economic losses imposed by collar rot disease in the chickpea growing areas of state, the present work entitled "**Studies on integrated management of collar rot of chickpea**" was undertaken to explore stable and durable management strategy for collar rot of chickpea with the following objectives:

1. To determine the distribution of collar rot of chickpea in Jabalpur.
2. To workout the approaches for the effective management of collar rot.

# Chapter - II

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Chickpea (*Cicer arietinum* L.) is a major food legume grown in many countries of the world including Indian subcontinent. The major chickpea growing countries include India, Australia, Pakistan, Myanmar, Turkey, Ethiopia, Iran, Mexico, Canada and USA (FAOSTAT, 2019). It is attacked by about 172 pathogens including 67 species of fungi, 3 bacteria, 22 viruses and mycoplasma and 80 species of nematodes (Nene et al. 1996; Singh and Sharma 1998).

## 2.1 Major diseases of chickpea

Some of the major diseases of chickpea in order of their global importance are Ascochyta blight (*Ascochyta rabie*), Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*), Botrytis grey mold (*Botrytis cineri*), Dry root rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*), Verticillium wilt, phytopthora root rot, rust and powdery mildew (Nene *et al.* 2012).

Collar rot of chickpea caused by *Sclerotium rolfsii* Sacc. is more prevalent in most tropics and warm countries. It is a multiphagous pathogen having wide host range and grows in prolific manner to produce persistent sclerotia which significantly augment the large economic losses in vicinity of other pathogens (Mehan *et al.,* 1995). The literature reviewed was mainly focussed on various aspects of *Sclerotium rolfsii* infecting chickpea; however, information on other crops is also included wherever the specific aspects were unavailable on chickpea.

## 2.2 The pathogen: History and taxonomy

In 1892, Peter Henry Rolfs, first published a description of a new disease on tomato, due to the infection of *Sclerotium rolfsii* in Florida (USA) imposing more than 70 per cent loss. The disease was acknowledged due to the presence of small, round sclerotia and the name *Sclerotium rolfsii* was assigned by Saccardo in 1911 who recognised the fungus as an imperfect form.

In India, Shaw and Ajrekar (1915) isolated an organism from rotted potatoes and it was identified as *Rhizoctonia destruens* Tassi. But, later Ramakrishnan's (1930) studies revealed that, the fungus involved was *S. rolfsii.*

Curzi (1931), however, changed it to *Corticium rolfsii* based on the studies of the perfect stage in pure culture.and this binomial was subsequently followed and accepted by several workers from various countries until in 1945 when West changed it to *Pellicularia rolfsii*. He characterized it by presence of aerolate hymenia, short celled, stout hyphae and right angled branching of mycelia.

Aycock (1966) reported that hyphae comprised of clamps in the form of forks and hooks or H like connections. Mundkar (1934) successfully isolated the perfect stage of *Sclerotium rolfsii.*

Subramanian (1971) stated typical characters of *S. rolfsii* Sacc. by presence of floccose mycelium with numerous sclerotia. Sclerotia produced, were pinkish buff to live brown to clove brown colour, globose, 0.8-2.5 mm in diameter. *S. rolfsii* formed hymenium aerolate, putty coloured, 30-40µ thick mycelium. Basidia ovoid, 7-9 x 4-5µ in size and each bear 2 or 4 parallel or divergent sterigmata, 2.5 x 4-6µ long. Basidiospores are elliptical to obvate, hyaline, smooth, rounded or apiculate at base, 6-7 x 3.5-5µ. However, according to Talbot (1973), the basidial stage of *Sclerotium rolfsii* is a species of *Athelia* in Corticiaceae family.

Gupta *et al.,* (2006) reported that fungus is facultative parasite, capable of living saphrophytically on dead organic tissues, particularly in many of its natural hosts, producing sclerotial bodies. It produces pycnidia when the atmospheric temperature is above $30^0$C and pycnidiospores remain viable for over year.

*Sclerotium rolfsii* control has met with very limited success because of the prolific growth, extensive host range of the pathogen and having the ability to produce large number of sclerotia that may persist in the soil for several years (Sennoi *et al.,* 2013).

Mahadevakumar *et al.* (2016) described the pathogen, *S. rolfsii* and stated that the fungus generally infects the lower stem near or at the soil surface.

Parvin *et al.* (2016) described *S. rolfsii,* a soil borne plant pathogen causing diseases on a wide range of agricultural and horticultural crops. It is

aggressive in terms of virulence and affects a wide variety of plants, including vegetables, cereals, legumes, flower and forage plants.

### 2.2.1 Classification

Teleomorphic stage of *Sclerotium rolfsii* is *Athelia rolfsii*. *Athelia rolfsii* (Curzi) C.C. Tu & Kimbr., the teleomorph of *S. rolfsii* is a basidiomycete fungus and classified as following:

*Athelia rolfsii* (Curzi) is a member of

| | | |
|---|---|---|
| Kingdom | : | Fungi |
| Phylum | : | Basidiomycota |
| Subphylum | : | Agaricomycotina |
| Class | : | Agaricomycetes |
| Subclass | : | Agaricomycetidae |
| Order | : | Atheliales |
| Family | : | Atheliaceae |
| Genus | : | *Athelia* |

*Sclerotium rolfsii* (Sacc.) is a member of

| | | |
|---|---|---|
| Kingdom | : | Mycota |
| Division | : | Eumycota |
| Sub division | : | Deuteromycotina |
| Class | : | Aganomycetes |
| Order | : | Aganomycetales |
| Family | : | Aganomycetaceae |
| Genus | : | *Sclerotium* |

### 2.2.2 Collar rot: Occurrence, distribution and economic losses

Collar rot of chickpea caused by *Sclerotium rolfsii* Sacc. (Teliomorph: *Corticium rolfsii* (Curzi) is prevalent in India. The disease is widespread in most tropics and warm countries including India, Bangladesh, Colombia,

Egypt, Ethiopia, Kenya, Mexico, Pakistan, Philippines, Sudan, Syria, Uganda and Zambia.

Weber *et al.* (1931) reported that *S. rolfsii* commonly occurs in the tropics, sub tropics and other warm temperate regions, especially the southern United States, Central and South America, West Indies, Southern European countries, Africa, India, Japan, Philippines and Hawaii. The pathogen rarely occurs where winter temperature falls below 0°C average (Punja, 1985). The collar rot causing pathogen *Sclerotium rolfsii*, is not important in the temperate region because the fungus *S. rolfsii*, can't hold out low temperature for long.

*S. rolfsii* is a destructive parasite of many plants and may cause yield losses of 10-25%. However, under severe conditions of collar rot, it can reach above 25% and upto 80-90 per cent (Rodriguez- Kabana *et al*. 1975; Grichar and Boswell, 1987). The mortality of seedlings ranged from 54.7-95.0% causing significant reduction in plant population in chickpea (Kotasthane *et al*. 1976).

*S. rolfsii* is a soil borne and survives in soil for many years together forming resistant structure sclerotia. (Allce, 1984; Das *et al.* 1997 and Kaushal *et al.* 2003).

Muthusamy and Marippan (1991) studied the collar rot caused by *S. rolfsii* is the important soil borne pathogen and reported 14-74% losses due to *S. rolfsii* in soybean.

Prasad (2005) reported that *S. rolfsii* causing collar rot is an important soil borne and fast spreading fungal pathogen and causes considerable damage to economically important crop in pulses like chickpea, bean, peas, lentil; legumes like soybean and groundnut; and many other crops like under field condition. The *S. rolfsii* has been reported to cause 30-60% reduction in yield of chickpea.

Maurya *et al.* (2008) reported that collar rot of chickpea is one of the devastating soil borne diseases of fungal origin due to which 10-30% yield losses are recorded annually depending upon the severity of disease.

Padole *et al.* (2009) reported 5-30% incidence of collar rot in 15 to 45 days old crop in a roving survey of 51 locations of Jabalpur and adjoin areas. Investigations on variations in 51 isolates of *Sclerotium rolfsii* showed considerable variations with regards to cultural, morphological characters and virulence of pathogen.

Singh *et al.* (2011) conducted an extensive roving survey in chickpea growing areas of different districts of Uttar Pradesh viz., Hamirpur, Jhansi, Lalitpur, Mahoba, Orai of Bundelkhand region during two consecutive years (2005-07) and 2006-07 and reported varying amount of disease incidence in different districts.

Ghosh *et al.* (2013) conducted a roving survey during Rabi season in 2010-2011 to obtain information on the distribution and incidence of chickpea diseases with respect to soil type, cultivar used, seed treatment in central and southern parts of India. Collar rot diseases were found at all of the sites and incidence ranged from 7.1–10.5 per cent irrespective of cultivar type and locations. The result indicated that collar rot is currently highly distributed in all surveyed chickpea growing areas of central and southern parts of India.

Warmer climate of high temperature coupled with high moisture favours the growth and development of *S. rolfsii* (Al-Askar *et al.* 2013).

Eslami *et al*. (2015) stated *S. rolfsii* as soil borne plant pathogenic fungi which is widespread and more prevalent in warm temperate and subtropical regions of the world.

### 2.2.3 Symptoms

The disease usually occurs at seedling stage predominantly in wet soil situations. The affected plants turn yellow and show sign of rotting at collar region, whitish mycelial strands can be seen on dried tap root. When the affected seedlings are uprooted from wet soil during earlier stages of infection, rapeseed like sclerotia (1 mm in diameter) can be observed. Habitually collar rot disease is usually seen in patches in the infected fields (Singh and Thapliyal, 1998). Wilson (1953) described the symptoms of stem rot of peanut and reported that mycelium swathe around the affected plants' stems near the soil surface. The production of copious white mycelium and

small brown spherical sclerotia on the infected parts are the characteristic symptoms of the disease.

During later stage of infection, affected plants/ branches turn yellow or droop while retaining their green colour, followed by drying and turning straw coloured. White mycelial strands come into sight at the collar region and above, covering the base of the branches. Whitish mycelia strands intermingled with brownish, small, irregular shaped sclerotia on branches have been reported. Wheeler (1969), Mordue (1974), Gupta and Sharma (2000), Rao *et al.* (2001) also described symptoms on infected plants in various crops.

Nene *et al*. (2012) reported the symptoms of collar rot of chickpea as drying plants whose foliage turns slightly yellow before death, scattered throughout the field is an indication of collar rot infection.

Reddi *et al.* (2014) reported the symptoms of collar rot *i.e.,* yellowing and wilting of branches, presence of white mycelial growth at collar region and production of mustard seed like sclerotia

Ramesh *et al.* (2014) discussed the soil borne diseases of chickpea and reported that collar rot causes seed rot and seedling mortality in the initial stages of crop growth up to 45 days.

### 2.2.4 Mycelium and sclerotia of fungus

Subramanian (1964), Barnett and Hunter (1972), Mahamood *et al.* (1976), Singh (1987), Mirza and Aslam (1993), Mohan *et al.* (2000) and Reddi *et al.* (2014) reported that fungus produces thick white to dirty white colony with profuse branching, fluffy fan shaped mycelial growth on artificial media. Initially sclerotium is white in colour and at later stage turns light brown to dark brown in colour. Further, these sclerotia are sub spherical in shape, with finely wrinkled or pitted, sometimes flattened surface, and commonly 0.5-1.5 mm in diameter. At maturity of culture, small mycelial knots are formed which later produce whitish sclerotial bodies turning to deep brown to tan coloured, shiny, hard and spherical mustard seed like structures at later stage.

*S. rolfsii* produces white fluffy, branched, septate mycelium with clamp connections only on the main hyphae, which spreads like a fan. Later

mycelium gives rise to smooth, hard and dark brown sclerotia. Sclerotia may be irregular or spherical in shape and resemble mustard seed like at maturity stage (Taubenhaus,1919; Barnett and Hunter,1972; Mahmood *et al*.1976; Boonthong and Sommart, 1985 and Mohan *et al*. 2000). The sclerotia are made up of three layers 1) inner medulla, 2) a middle cortex and 3) outer rind which was visualized using scanning electron microscopy by several workers. Further, the developmental and maturity stage of sclerotia was studied by Zarani and Christias (1997) and reported that size of sclerotia varied from 0.1 mm to 3.0 mm (Om Prakash and Singh, 1976; Ansari and Agnihotri, 2000 and Anahosur, 2001).

### 2.2.5 Host range

*S. rolfsii* has a wide host range and globally reported hosts include: alfalfa, amaryllis, artichoke, banana, bean, beet, brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, celery, chrysanthemum, coffee, cotton, cucumber, delphinium, endive, escarole, garlic, ginger, gourd, iris, lettuce, mango, muskmelon, mustard, narcissus, onion, parsley, southern pea, peanuts, pineapple, potato, pumpkin, radish, rhubarb, soybean, squash, tobacco, tulip, turf turnip, and yam (Aycock, 1966).

*Sclerotium rolfsii* has very wide host range; at least 5000 species in 100 families are susceptible. Among the different hosts, the most common hosts are the legumes, crucifers, and cucurbits (Punja, 2005).

Mullen (2001) reported that Southern blight caused by *Sclerotium rolfsii* is a serious disease of a wide variety of plants, including field, vegetable, fruit, ornamental crops and also turf.

### 2.2.6 Pathogen isolation, identification and maintenance

The isolation of fungus *S. rolfsii* has been reported from various parts of plant *viz.,* root (Harinath, 2000), stem (Kajal and Chitreswar, 2000), collar region (Rajalakshmi, 2002 and Narasimha *et al*. 2004), leaves and pods (Gupta and Sharma, 2004), diseased seeds and seedlings (Shivani *et al.* 2005).

*S. rolfsii* was also isolated by inoculating the sclerotia from infected plant parts in a Petri plate consisting of potato dextrose agar medium and

incubating the plates at 25 $^{0}$C for 7 to 10 days till formation of sclerotia. From each plate, single sclerotium was taken out and inoculated onto PDA slants to purify the isolates and were stored at 4 $^{0}$C for further use (Pandey and Pandey, 2005).

*S. rolfsii* was isolated by tissue isolation method from foot rot of finger millet (Kumar and Prasad, 2010); tissue segment method from crossandra plants (Arunasri *et al*. 2011).

Parvin *et al*. (2016) isolated *S. rolfsii* from eggplant, lentil, tomato and spinach showing symptoms on fruits, leaves, seeds and stems in Bangladesh.

Narain and Mishra (1979) reported that more number as well as size of sclerotia of ragi isolate of *S. rolfsii* produced on malt extract agar. *S. rolfsii* can also be maintained on potato sucrose agar medium (Ramarao and Usha, 1980).

PDA medium recorded as best medium to study the growth of *S. rolfsii* (Harinath, 2000; Dutta and Das, 2002; Gupta and Sharma, 2004; Gaur *et al.* 2005 and Raoof *et al.* 2006).

Ravindra *et al*. (2008) used ten different media (Asthana and Hawker's medium, Brown's medium, Chickpea extract medium, Conn's medium, Corn meal medium, Czapek-Dox medium, Kirchoff's medium, Malt extract medium, PDA and Richard's medium) to identify the maximum supporting media for growth and development of *S. rolfsii* and reported that PDA was maximum supporting mycelia growth and effective multiplication of the pathogen.

### 2.2.7 Test of virulence

The ability of an organism to cause the disease is considered as virulence. The pathogenic ability or virulence for *Sclerotium rolfsii* has been examined by several workers till date.

Roy (1977) reported that pathogenicity of *Sclerotium rolfsii* was tested on pea (*Pisum sativum* L.), cauliflower (*Brassica oleracea* var *capitata* L.) and Arum (*Colocassia* sp.). He reported more than 50 per cent rotting in 4 to 5 days of inoculation in all the cases, except *Colocassia* sp.

Sulladmath *et al*. (1975) reported that for testing pathogenicity, *Sclerotium rolfsii* was grown on corn-meal-sand medium for a week and mixed into the upper layer of sterilized soil filled in 6 inches earthern plots. Typical root rot symptoms were observed during 30-35 days after sowing. The organism was re-isolated from infected plants and identified as *S. rolfsii*.

Rao *et al*. (2002) also observed the stem rot or collar rot of flora beans (*Dolichos lablab*) during Kharif season 2001 and identified pathogen as *Sclerotium rolfsii* based on critical symptoms (appearance of initially small, oval, straw to brown lesions at the collar region followed by wilting of the lower leaves and gradual drying of the whole plant) of collar rot, morphological observations and pathogenicity test.

Haware and Nene (1978) recorded cent per cent germination in 42 inoculated chickpea checks where 50 percent of the seeds, in the inoculated treatment failed to germinate. The causal fungus initiated the rotting of the seeds and the seed surfaces were covered with white mycelial mat in soil. Germinated seeds were killed within seven days after emergence.

Siddaramaiah *et al.* (1978) reported that Niger (*Guyzotia abyssinica*), one of the important oil seed crop normally grown in all types of soil, can also be infected with collar rot pathogen and observed about one percent of niger plants were wilted. They identified collar rot causing pathogen as *Corticium rolfsii* in niger. The pathogenicity was proved by sowing 50 seeds, artificially inoculated with 20 days old *Corticium* sp. Culture and the same quantity of the seeds were sown in sterilized soil as control. Out of 50 seeds, 40 seeds germinated and 10 seeds were remained un-germinated. The fungus started infection after the third day of seed germination and all the 40 seedlings were infected within a week, causing post emergence death.

Khan and Javaid (2015) recorded 55-95% mortality due to the collar rot of chickpea during seedling stage of crop under favourable environmental conditions.

## 2.3 Management

Different cultural, chemical and biological management practices have been employed by several workers for the management of collar rot in various crops.

### 2.3.1 Effect of variety

Karat *et al.* (1985) evaluated a set of eight cultivars against collar rot under field conditions and identified that only one cultivar namely NP-3 remained free from infection of collar rot.

Sugha *et al*. (1991) evaluated a set of 210 chickpea cultivars from different sources. None of these were found resistant or even moderately resistant.

Hussain *et al.* (2005) screened 57 germplasm lines against collar rot of chickpea under pot culture and reported that out of 57 germplasm, only single genotype namely FLIP 97-174C was highly resistant to collar rot. Further, five genotypes were identified as resistant and 20 genotypes were found moderately resistant (tolerant). The remaining 31 genotypes were found in the category of susceptible to highly susceptible.

Rajan *et al.* (2012) screened 76 chickpea genotypes under field condition against *S. rolfsii* and reported that among these genotypes, eight were susceptible, 31 were moderately resistant, 26 were found resistant and 11 were grouped together into the category of tolerant against *S. rolfsii*.

Singh *et al.* (2012) evaluated 50 genotypes of chickpea against collar rot and reported four moderately resistant lines (KG-1226, KG-8, B-321, and B-311) only.

Shirsole *et al.* (2018) screened 185 chickpea entries under field condition against *S. rolfsii* and reported that out of 185 entries, five entries exhibited moderate resistance while, the remaining were grouped in different categories of susceptible to highly susceptible for collar rot of chickpea.

### 2.3.2 Influence of time of sowing

Singh *et al*. (2012) screened 50 germplasm of chickpea against collar rot caused by *S. rolfsii* and found that crop sown on October 1$^{st}$ had low disease incidence of 16% and increased with time passage. Hence, delayed sowing resulted into early stage crop damage by collar rot pathogen. However, “wilt and root rot complex” affected the crop prior to harvest.

Pal *et al.* (2018) studied the influence of 3 different dates of sowing on occurrence of chickpea collar rot in different varieties. The chickpea crop sown on 15 October using JG-62 variety showed maximum disease incidence and minimum in variety JAKI-9218 when sown on 1$^{st}$ November.

### 2.3.3 Influence of inoculum level on disease incidence

Inoculum potential is the energy required for the growth of a parasite available for infection of a host, at the surface of the organ to be infected. For development of root rot, certain number of fungal propagules should always survive in soil (Garret, 1956).

Kilpatrick and Merkle (1967) showed the effect of different inoculum levels of *S. rolfsii* on foot rot of wheat and reported that, 0.5 and 1.0 per cent inoculum was superior to 3, 5 and 10 per cent.

Nargund (1981) reported that significant amount of foot rot infection of wheat was recorded in 2% inoculum level, however,100% disease occurred at six per cent and above inoculum levels.

Sreenivas (1995) reported in their study that when pots were inoculated with 10% sclerotia of sunflower *S. rolfsii*, 57.52% pre-emergence mortality and 86.15% post-emergence mortality could be recorded respectively after one and three weeks after sowing.

Singh and Thapliyal (1998) observed that inoculum load of 2.5 to 10 g per kg soil considerably raise the pre-emergence soybean seedling rot from 36.7% to 90%. 92.50% pre-emergence stem rot at 2% inoculum level and 100% seedling mortality above 2% inoculum level observed in groundnut (Hanumanthegowda, 1999).

Prabhu (2003) reported that hundred per cent pre-emergence incidence took place at 4% and above inoculum load for soybean collar rot.

Bajantri (2005) reported 100% disease incidence at 4% and above inoculum levels. Hussain *et al.* (2006) reported that disease incidence increased upon increasing in the inoculum load. Further, young seedlings were more susceptible and susceptibility decreases with seedling age. 93.33% pre-emergence death of potato seedlings due to *Sclerotium* wilt at 3%

inoculum level and 100% infection at 4% and above inoculum load were reported (Kulkarni, 2007).

### 2.3.4 Chemical management

The effect of chemical fungicides against *Sclerotium rolfsii* has also been studied by several workers.

*Sclerotium rolfsii* causing southern blight of peanut with PCNB under, *in vitro* conditions employing poisoned food technique. Further different chemicals were evaluated under *in vitro* conditions and maximum inhibition was showed by calixin, vitavax, duter, ferbam, ceresan wet and brassicol which allowed no growth of fungus (Chauhan, 1978).

Harlapur *et al.* (1988) conducted experiment under *in vitro* condition and showed that the pathogen (*S*. *rolfsii*) was inhibited by Vitavax, Bayleton and Thiram in wheat crop.

The inhibitory effect of calixin, carboxin, copper oxychloride, mercury compounds, pentachloronitrobenzene has been studied by Chauhan (1978). Efficacy of carbendazim (as bavistin) has been reported by Randon et al. (1995). Complete inhibition in growth of the fungus, *Sclerotium rolfsii* was recorded by using captan, thiram, mancozeb, edifenophos, chlorothalonil, However, carbendazim did not show any inhibition Toorey *et al.* (2007).

Randon *et al.* (1995) reported that the carbendazim (Bavistin), Kasumin and Tecto used at five concentrations under *in vitro* conditions were most the most effective in inhibiting mycelial growth and sclerotia formation at low concentrations.

Alam *et al.* (2004) *in vitro* evaluated nine fungicides, viz., Bavistm (Carbendazim 50 per cent WP), Cupravit (Copperoxy chloride), Microthial (Sulphur 90 per cent WP), Thiovit (Wetable sulphur 80 per cent WP), Dithane M-45 (80 per cent WP), Rovral (iprodione 50 percent WP), Boron (100 per cent boric acid and 17 percent boron), Macuprex (Dodine 65% per cent WP) and Cumulims (80 percent manzeb and 20 per cent inerts including Zinc 80 per cent WP) each @ 0.35 g/100 ml against *Sclerotium rolfsii* (stem rot of betelvine) and reported that the highest (60 mm) and the lowest (2 mm) mycelial growth were recorded with Macuprex (Dodine 65 percent WP) and

Boran (100 per cent boric acid and 17 per cent boron), respectively. Mycelial growth was totally innhibited with Rovral (Iprodione 50 per cent WP).

Toorey *et al.* (2007) evaluated seven fungicides (each at 1000, 1500, 2000 ppm) against *Sclerotium rolfsii* under *in vitro* condition. Complete inhibition in growth of *Sclerotium rolfsii* was recorded by captan, thiram, mancozeb, hinosan (edifenphos) and antracol whereas chlorothalonil showed partial inhibition at low concentrations. *In vitro* evaluation of chickpea with the seven fungicides (captan, thiram, bavistin, mancozeb, entracol, kavach each @ 3 g kg seed and hinosan @ 1 g per kg seed) and two biological control agents (*Trichoderma harzianum* and *T. viride* each at 4 g / kg seed) against *Sclerotium rolfsii* showed that captan, kavach and thiram showed some reduction in pre-emergence mortality, while both the biological control did not show protection against pre-emergence mortality due to *Sclerotium rolfsii*.

Khan *et al.* (2015) studied commercial fungicides efficacy for collar rot under *in vitro* and *in vivo* conditions. *In vitro* bioassays using four fungicides namely Tegula (tebuconazole), Thiophanate Methyl, Ridomil Gold (metalaxyl + mancozeb) and Mancozeb at 50, 100, 250 ppm concentrations respectively, showed that all the concentrations of these fungicides significantly decreased radial growth of *S. rolfsii* over control. However, i*n vivo* studies in plastic pots using two chemical fungicides viz. Thiophanate methyl and Mancozeb revealed that there was 95% and 50% reduction in plant mortality due to Thiophanate methyl and Mancozeb respectively, over positive control, after 30 days of sowing.

Shirsole *et al.* (2019) tested the efficacy of 7 systemic, 4 non-systemic and 6 combo fungicides at different concentrations of 20, 50, 100, 200 and 500 ppm against *S. rolfsii* on PDA by poisoned food technique under *in vitro* conditions and seed treatment with fungicide under pot experiment. It was reported that systemic fungicides like, hexaconazole 5% EC, propiconazole 25% EC and combo products tebuconazole 50% + trifloxystrobin 25% WG, captan 70% + hexaconazole 5% WP, propiconazole 13% + difenoconazol and carboxin 37.5% + thiram 37.5% showed complete inhibition of the pathogen at all the evaluated concentrations. Whereas, the non-systemic fungicide mancozeb 75%WP, thiram 75% WS and propineb 70% WP was found

inhibitory only at higher concentrations (100 ppm) against *S. rolfsii* under *in vitro* condition.

### 2.3.5 Efficacy of bio agents

In nature several microorganisms have been identified producing secondary metabolites have shown the antimicrobial activities against plant pathogens. These microorganisms having antimicrobial principles are also known as bio agents and serve as bio pesticides.

Several microorganisms found in nature that produce secondary metabolites have antimicrobial properties against plant diseases. These antimicrobial microorganisms are also known as bio agents and are also used as biocontrol agents/ biopesticides (Kumar *et al.* 2009).

Efficacy of different biocontrol agents have been reported against *S. rolfsii*. However, major work of researchers focused on use of different species of *Trichoderma*. *Trichoderma harzianum* (Agrawal *et al.*1977; Matti and Sen, 1985; Mukhopadhyay *et al.* 1992; Biswas and Sen., 2000; Dutta and Das 2002), *Trichoderma viride* (Mukhopadhyay, 1987; Sugha *et al.* 1993; Mathur and Sarbhou, 1978), *Bacillus subtilis* (Patel and Anahosur, 2001; Kalappanavar *et al*. 2000; Abeysinghe 2009; Ahmad *et al.* 2019), *Pseudomonas fluorescens* (Manjula *et al.* 2004; Murugalakshmi *et al.* 2009; Ganeshan and kumar 2005), *Gluiocladium roseum* (Mukhopadhyay *et al.,* 1995) have been reported against various crops against *Sclerotium rolfsii.*

Dutta and Das (2002) revealed that soil application of *Trichoderma* spp. reduced the disease incidence collar rot and increased the yield. Thus *Trichoderma* spp. was antagonistic and effective in controlling the collar rot of tomato incited by *Sclerotium rolfsii* under *in vivo* conditions.

Biswas and Sen (2000) evaluated eleven isolates of *Trichoderma harzianum* against *S. rolfsii* in groundnut and potato under pot conditions and reported significant reduction in stem rot incidence when delivered as seed dressing (30 to 50%) or through direct soil application (72 to 83%) in the pot trails.

Shivani *et al.* (2005) reported *Pseudomonas fluorescence* resulted in increased seed germination, root length, shoot height, fresh and dry weight of

root and shoots and yield of sunflower. Seed treatment with two strains of *Pseudomonas fluorescens* reduced incidence of collar rot by 69.8 and 56.9% respectively.

Prabhu and Patil (2004) reported that biological control agents (@6.0 g *T. viride* per kg of seeds, 6.0 g *Trichoderma harzianum* per kg of seeds, and 10.0 g *Pseudomonas fluorescens* per kg of seeds) were effective in the reduction of collar rot caused by *Sclerotium rolfsii.*

Efficacy of biological agents to control the collar rot fungus *Sclerotium rolfsii* on soybean was studied by Ansari (2005). Seed treatment with *Trichoderma viride* @4g / kg*, Pseudomonas fluorescens* @ 10g / kg and untreated control was used as treatments. Seed germination was highest in *Pseudomonas fluorescens* treated seeds (51.11%), followed by *Trichoderma viride* treated seeds (47.82%) and germination was lowest in the control (37.50%). Both the biological control agents were effective in controlling collar rot incidence and also increased the emergence and decreased pre-emergence mortality.

Maurya *et al.* (2008) reported high efficacy of *Trichoderma harzianum* and plant growth promoting rhizobacteria (PGPR) against collar rot under *in vitro* as well as in the field. They used *T. harzianum* (@$10^4$, $10^6$ and $10^8$ spores/ml) and two PGPRs (*Pseudomonas fluorescens* strain 4 and *P. aeruginosa*) as foliar spray. Foliar application of *T. harzianum* ($10^8$ spore/ml) and *P. fluorescens* strain 4 ($10^8$ cfu/ml) showed maximum efficacy in reducing plant mortality as compared to the control.

# Chapter - III

# MATERIAL AND METHOD

# MATERIAL AND METHODS

The present study entitled **"Studies on integrated management of collar rot of chickpea"** was carried out in the field of Department of Agronomy, Seed Technology Research Centre, department of Plant Breeding and Genetics, JNKVV, Jabalpur. Laboratory experiments were conducted in the laboratory of department of Plant Pathology, Seed Technology Research Centre, JNKVV, Jabalpur. This chapter deals with the materials and methods used for conducting the survey for documentation of incidence of collar rot in Jabalpur and adjoining locations, evaluating the impact of seed treatments of chemicals, date of sowing, in different varieties on incidence of collar rot of chickpea. The details of materials used and procedures adopted in experimentation are described under the following headings.

## 3.1 Materials

### 3.1.1 Experimental site

All the laboratory experiments were conducted in the Post graduate laboratory of department of Plant Pathology, and also in seed health laboratory of Seed Technology Research Centre, College of Agriculture, Jabalpur. The field experiments related to impact of date of sowing and seed treatment in different varieties on incidence of collar rot was conducted in the field of department of Agronomy and impact of fungicidal seed treatment was conducted in the experimental field of Seed Technology Research, JNKVV, Jabalpur.

### 3.1.2 Glasswares

Different types of Borosil glassware were used throughout the investigations. The common glassware, *viz.,* test tubes Petri dishes, beakers, measuring cylinders, conical flasks, volumetric flasks, glass rods, funnel, pipettes, etc. were obtained from the Department of Plant Pathology, College of Agriculture, JNKVV Jabalpur.

### 3.1.3 Equipments

Compound microscope for observing the pathogen, hot air oven and autoclave for the sterilization of glasswares and media respectively, BOD Incubators for incubation of the test pathogen, laminar air flow cabinet for inoculation, refrigerator for storage of media and samples and electronic balance for weighing of chemicals were used. Other minor tools like inoculation needle, cork borer, spirit lamp, forceps, camel brush, inoculation loop and spreader etc. were also used during the investigation for various purposes.

### 3.1.4 Cleaning and sterilization of materials

All the glasswares were cleaned with detergent powder followed by thorough rinsing in tap water and distilled water. All the glasswares were sterilized in hot air oven at 180°C for 2 hrs. All the metallic instruments like inoculation needle, forceps etc. were sterilized by dipping them in alcohol and heating over flame till red hot. The medium and distilled water employed were sterilized in autoclave at 15 lbs p.s.i at 121.6°C for 15 minutes. Soil/sand sterilization was performed in autoclave at 15 lbs p.s.i at 121.6°C for 45 minutes.

## 3.2 Culture media

### 3.2.1 Potato Dextrose Agar

Required amount of peeled potato was cut into fine pieces. It was boiled in 500 ml of distilled water for 30 minutes and filtered through muslin cloth. Thereafter, 20 g of dextrose and 20 g of Agar-agar were dissolved in 500 ml boiling water. Potato extract was added in boiling mixture and mixed thoroughly by stirring with glass rod. After few minutes of boiling it was transferred to, about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton. The pH of the medium was adjusted to 7.0 ± 0.2 in the same way as mentioned above and autoclaved at 15 lbs p.s.i. at 121.6°C for 15 minutes.

Following media were used during laboratory studies.

**Table 3.1: Composition of Potato Dextrose Agar (PDA) media**

| Name of medium | Composition | Quantities |
|---|---|---|
| **Potato Dextrose Agar (PDA)** | Potato (peeled and sliced) | 200 g |
| | Dextrose | 20 g |
| | Agar-agar | 20 g |
| | Distilled water | 1000 ml |

### 3.3 Slant preparation and PDA plating

The melted potato dextrose agar (PDA) medium was transferred @ 5 ml per culture tube. While transferring care was taken that medium should not touch the inner wall of culture tubes. The culture tubes were sterilized at 15 lbs p.s.i. at 121.6°C for 15 minutes. After sterilization, it was allowed to solidify in slanting position and then stored in refrigerator for further use. Similarily, the sterilized and melted medium was poured aseptically in sterilized Petri plates @ 20 ml per Petri plate.

### 3.4 Field survey

A field survey was conducted in roving and fixed plot manner in Jabalpur and adjoining block to record the incidence of collar rot of chickpea.

#### 3.4.1 Roving Survey

A roving survey, was conducted covering five blocks of Jabalpur district during the months of October to November, 2020-21 to assess occurrence and distribution of collar rot of chickpea. Five villages were surveyed in each block and in each village minimum five fields were observed for recording the collar rot incidence. A Global positioning system (GPS) based survey questionnaire was prepared to collect information on collar rot incidence, soil type and adoption of seed treatment practice by the farmers. In each field, 10 quadrants of 1 x 1 m were randomly selected and number of infected plants were counted from each quadrant. Based on the number of infected and total number of collar rot infected plants, the disease incidence was calculated as per following formula. Disease incidence of individual fields was used for calculating the average incidence of collar rot in each village and further,

average of village incidence was used to calculate the mean incidence of each block.

$$PDI = \frac{\text{Number of infected plants}}{\text{Number of total plants}} \times 100$$

### 3.4.2 Fixed plot survey

The chickpea fields of department of Plant Breeding and Genetics, JNKVV, Jabalpur was regularly surveyed during Rabi 2020-21 to conduct the fixed plot survey where ten different varieties of chickpea were grown. All these ten different varieties of chickpea were regularly observed for occurrence of collar rot and incidence was recorded as described earlier. The different varieties observed for recording of collar rot of chickpea incidence are presented in Table 3.2.

**Table 3.2: List of varieties observed for recording disease incidence under fixed plot survey**

| S. No. | Variety | Type |
|---|---|---|
| **1.** | JAKI 9218 | Desi |
| **2.** | JG 36 | Desi |
| **3.** | JG 24 | Desi |
| **4.** | JG K5 | Kabuli |
| **5.** | JGK 6 | Kabuli |
| **6.** | JG 52 | Desi |
| **7.** | JG 14 | Desi |
| **8.** | JG 12 | Desi |
| **9.** | JG 63 | Desi |
| **10.** | JG 16 | Desi |

## 3.5 Collection of disease sample of collar rot of chickpea

Chickpea plants showing typical symptoms of collar rot, at seedling, stage were collected from experimental field of Seed Technology Research Field, JNKVV, Jabalpur. Samples were brought in the laboratory and symptoms were identified and confirmed for presence of collar rot infection in the samples.

## 3.6 isolation and purification of *Sclerotium rolfsii* causing collar rot of chickpea

The selected plant samples from the experimental field were used for the isolation of the *S. rolfsii*. The infected collar region of plant was cut into small pieces of about 0.5 cm using sterilized scalpel blade and were subjected to surface sterilization using 1% sodium hypochlorite solution for 30 seconds. The samples were then subjected to three subsequent washing with sterilized distilled water.

The surface sterilized small pieces were dried by keeping them on sterilized blotting paper so that excess water can be removed. The samples were then transferred onto Petri plates containing PDA medium and incubated at 23±1°C in BOD incubator. These plates were regularly monitored to note the growth of fungus around and on placed bits of samples. The fungal colony growth around bits were carefully transferred to another PDA plat and pathogen was identified on the basis of identification characteristics of *S. rolfsii* as described by Barnett and hunter, 1972. Pure cultures of *S. rolfsii* were obtained by hyphal tip method and maintained on PDA by storing at 4°C until use. The colony radial growth and colony characteristics were observed by placing the 5 mm mycelial disc of seven days old culture on fresh PDA plate. The colony radial growth was recorded each after 24 hrs of incubation until full Petri plate growth. The formation of sclerotia were observed after prolonged incubation of up to 21 days.

## 3.7 Disease management strategies

### 3.7.1 Impact of seed treatment on incidence of collar rot of chickpea

Considering the importance of collar rot of chickpea, an experiment was conducted to study the impact of seed treatment on incidence of collar rot of chickpea caused by *Sclerotium rolfsii*. In total four seed treatments with following details were applied in three varieties before sowing in natural field conditions with a known history of occurrence of collar rot. The incidence of collar rot was calculated as per method described earlier.

**Table 3.3 list of treatments used for the management of disease under fixed plot survey**

| Treatment No. | Treatment details | Dose |
|---|---|---|
| $T_1$ | Seed treatment with Vitavax power | 2 g/kg seed |
| $T_2$ | Seed treatment with *Rhizobium* + PSB | 10 ml/kg seed |
| $T_3$ | Seed treatment with Molybdenum | 1 g/kg seed |
| $T_4$ | Seed treatment with *Rhizobium* + PSB + Molybdenum | 10 ml/kg seed + 1 g/kg seed |
| $T_5$ | Control- No seed treatment | - |
| Varieties used | JG14, JG 36 and JGK 1 | |

### 3.7.2 Impact of date of sowing on incidence of collar rot of chickpea

An experiment was conducted under natural field conditions, to study the impact of date of sowing on incidence of collar rot of chickpea caused by *Sclerotium rolfsii*. In total three date of sowing were adopted i.e., first fortnight of November (09.11.2020), second fortnight of November (23.11.2020) and first fortnight of December (07.12.2020) in three varieties. The incidence of collar rot and Fusarium wilt were calculated as per method described earlier.

### 3.7.3 Impact of date of sowing and seed treatment on incidence of collar rot of chickpea

To identify the impact of seed treatment in combination with date of sowing on incidence of collar rot of chickpea caused by *Sclerotium rolfsii*, a field experiment was conducted under natural field conditions with following details. In total three date of sowing were adopted i.e., first fortnight of November (09.11.2020), second fortnight of November (23.11.2020) and first fortnight of December (07.12.2020). Four seed treatments comprising of vitavax power, *Rhizobium* + PSB, Molybdenum and *Rhizobium* + PSB + Molybdenum were applied before sowing during all three dates of sowing in three varieties. In this way 45 treatments were laid out in three replications under split plot design with following details. The incidence of collar rot was calculated as per method described earlier.

**Table 3.4 List of treatments along with different varieties and date of sowing**

| S. no. | Treatment No. | Treatment details | S. no. | Treatment No. | Treatment details |
|---|---|---|---|---|---|
| 1. | $T_1$ | $V_1T_1D_1$ | 24. | $T_{24}$ | $V_2T_4D_2$ |
| 2. | $T_2$ | $V_1T_2D_1$ | 25. | $T_{25}$ | Control-$V_2T_0D_2$ |
| 3. | $T_3$ | $V_1T_3D_1$ | 26. | $T_{26}$ | $V_2T_1D_3$ |
| 4. | $T_4$ | $V_1T_4D_1$ | 27. | $T_{27}$ | $V_2T_2D_3$ |
| 5. | $T_5$ | Control-$V_1T_0D_1$ | 28. | $T_{28}$ | $V_2T_3D_3$ |
| 6. | $T_6$ | $V_1T_1D_2$ | 29. | $T_{29}$ | $V_2T_4D_3$ |
| 7. | $T_7$ | $V_1T_2D_2$ | 30. | $T_{30}$ | Control-$V_2T_0D_3$ |
| 8. | $T_8$ | $V_1T_3D_2$ | 31. | $T_{31}$ | $V_3T_1D_1$ |
| 9. | $T_9$ | $V_1T_4D_2$ | 32. | $T_{32}$ | $V_3T_2D_1$ |
| 10. | $T_{10}$ | Control-$V_1T_0D_2$ | 33. | $T_{33}$ | $V_3T_3D_1$ |
| 11. | $T_{11}$ | $V_1T_1D_3$ | 34. | $T_{34}$ | $V_3T_4D_1$ |
| 12. | $T_{12}$ | $V_1T_2D_3$ | 35. | $T_{35}$ | Control-$V_3T_0D_1$ |
| 13. | $T_{13}$ | $V_1T_3D_3$ | 36. | $T_{36}$ | $V_3T_1D_2$ |
| 14. | $T_{14}$ | $V_1T_4D_3$ | 37. | $T_{37}$ | $V_3T_2D_2$ |
| 15. | $T_{15}$ | Control-$V_1T_0D_3$ | 38. | $T_{38}$ | $V_3T_3D_2$ |
| 16. | $T_{16}$ | $V_2T_1D_1$ | 39. | $T_{39}$ | $V_3T_4D_2$ |
| 17. | $T_{17}$ | $V_2T_2D_1$ | 40. | $T_{40}$ | Control-$V_3T_0D_2$ |
| 18. | $T_{18}$ | $V_2T_3D_1$ | 41. | $T_{41}$ | $V_3T_1D_3$ |
| 19. | $T_{19}$ | $V_2T_4D_1$ | 42. | $T_{42}$ | $V_3T_2D_3$ |
| 20. | $T_{20}$ | Control-$V_2T_0D_1$ | 43. | $T_{43}$ | $V_3T_3D_3$ |
| 21. | $T_{21}$ | $V_2T_1D_2$ | 44. | $T_{44}$ | $V_3T_4D_3$ |
| 22. | $T_{22}$ | $V_2T_2D_2$ | 45. | $T_{45}$ | Control-$V_3T_0D_3$ |
| 23. | $T_{23}$ | $V_2T_3D_2$ | | | |

$V_1$ = JG 14

$V_2$ = JG 36

$V_3$ = JGK 1

$T_1$ = Seed treatment with Vitavax power @ 2 g/kg seed

$T_2$ = Seed treatment with *Rhizobium* + PSB @10 ml/kg seed

$T_3$ = Seed treatment with Molybdenum @ 1 g/kg seed

$T_4$ = Seed treatment with *Rhizobium* + PSB + Molybdenum

$T_0$ = No seed treatment

$D_1$ = Date of sowing: 09.11.2020

$D_2$ = Date of sowing: 23.11.2020

$D_3$ = Date of sowing: 07.12.2020

### 3.7.4 Impact of fungicides seed treatment on incidence of collar rot of chickpea

Seeds of chickpea variety JG 14 were dressed with fungicides and sown in natural sick soil with known history of collar rot incidence.

**Treatment**

The commercial formulations of listed fungicides were procured from Seed Technology Research Centre, JNKVV, Jabalpur.

**Methodology**

The required amounts of seeds of JG 14 to be sown in 5x3 m were taken in a plastic bowl and the pre-measured fungicide was sprinkled over the pre-wetted seeds. Prior to this, 5 ml of water was sprinkled over the seeds to moisten the seed material. Uniform coating of fungicide over the pre-werred seeds was ensured by thorough mixing. Mixing was performed by gentle shaking.

Observations were recorded on seed emergence, mortality of seedlings due to *S. rolfsii*, upto 35 days after sowing.

**Table 3.5 List of fungicides used for the management of collar rot on chickpea**

| Chemical name | Trade name | Seed treatment@ per kg seed |
|---|---|---|
| Carbendazim | Bavistin | 1.5 g |
| Carboxim+Thiram | Vitavax Power | 1.5 g |
| Mancozeb | Diathane M-45 | 2.5 g |
| Tebuconazole | Folicur | 1.0 g |
| Thiram + Carbendazim | | 3.0 g |
| Copper oxychloride | Blue copper | 3.0 g |
| Chlorothalonil | Kavach | 1.0 g |
| Pyraclostrobin | Cabrio | 1.0 g |
| Azoxystribin | Amistar | 1.0 g |
| Control | | No seed treatment |

### 3.8 Statistical Analysis

The data were analyzed statistically using Completely Randomized Design (CRD) and Split Plot design as per the requirement.

Treatments were compared by mean of critical differences at 5% level of significance.

### 3.6 Skeleton of analysis of variance

| Source of variation | D.F. | S.S. | M.S.S. | T.cal. | F.tab. (5%) |
|---|---|---|---|---|---|
| Treatments | | | | | |
| Error | | | | | |
| Total | | | | | |

### 3.8.1 Test of significance

To test the significance difference among the treatment means following formula were used for calculating the critical differences.

$$S.Em\pm = \sqrt{\frac{MSE}{r}}$$

C.D. = S.Em × $\sqrt{2}$ × 't' at error d.f.

Where:

D.F. = Degree of Freedom

S.S. = Sum of square

M.S.S. = Mean sum of square

The significant different between mean was determined by using critical difference.

# Chapter – IV

# RESULTS

# RESULTS

Studies on chickpea collar rot caused by *Sclerotium rolfsii* (Sacc.) were undertaken during 2020-21 with the objective to identify the prevalence of collar rot in Jabalpur and adjoining locations and impact of date of sowing on incidence of collar rot. The experiments were conducted in the field of Department of Agronomy, and Seed Technology Research, JNKVV, Jabalpur. The lab experiments were conducted in the laboratory of Department of Plant Pathology, College of Agriculture, Jabalpur. The results obtained, are being presented under following section.

## 4.1 Occurrence and distribution of Collar rot of chickpea in different agro-conditions of Jabalpur

To identify the prevalence of collar rot of chickpea, a GPS based roving survey was conducted in five blocks of Jabalpur namely Jabalpur, Patan, Panagar, Sihora, and Sahpura during October to February, 2020. The survey was conducted during initial stage of crop growth i.e., within two-three weeks of sowing at seedling stage of chickpea. For recording the collar rot incidence, minimum five villages were surveyed in each block and in each village minimum five fields were randomly selected. In this way, a total of 125 chickpea fields were surveyed representing 25 villages from five blocks of Jabalpur. Additional data on seed treatment practices, soil type and GPS locations were also compiled for each village.

Collar rot of chickpea (*Sclerotium rolfsii*) was widely prevalent disease and caused considerable losses to plant stand under high soil moisture and approximately 30˚C temperature during sowing time in the form of pre-emergence mortality. Drying of plants took place and foliage turned slightly yellow before death. The diseased plants were scattered through the field indicated the collar rot infection. The disease generally appeared within two weeks of sowing during seedling stage of crop growth. During survey, it was observed that, young seedlings collapsed but if the collar rot pathogen *S. rolfsii* attacked older seedlings, it turned yellow and may dry without collapsing. The younger seedlings exhibited clear rotting at collar region of plant. The rotten portion and surrounding of soil in the infected plant was

mostly covered with white mycelial strands of the fungus in severe infection. The rapeseed like sclerotia could also be observed in the infected plant as attached structures to the white mycelial growth of *S. rolfsii* around the collar region and also in soil. The infected plants were collected from the field for isolation and purification of the causal fungus in the laboratory, followed by identification of the fungus. Under roving survey, the collar rot was identified based on these peculiar characteristics and disease incidence was recorded in each field. The village wise data for collar rot incidence was pooled and summarized as following:

It was observed that collar rot was prevalent in all the five surveyed blocks and villages near Jabalpur. However, the incidence of collar rot significantly varied from village to village and block to block. In Jabalpur block, the maximum collar rot incidence of 23.2 % was noticed in Tilhari village followed by 22.6 % incidence in fields of Bargi. However, minimum in incidence of 13.1% was recorded in Bhedaghat village of Jabalpur. In Patan block, highest collar rot incidence of 33.4% was recorded in Jamuwa village, followed by 31.6 % in Palari, and minimum of 13.6 % in Ghoghra village. In Panagar block, maximum collar rot incidence of 32.4% was recorded in Mudiya village, followed by 26.2 % in Bijauri and minimum of 12.1% in Liti village. In Sihora and Sahpura blocks maximum incidence of 30.4% and 24.8% was recorded in Jujhri and Jhojhi village respectively. However, minimum incidence of 12.9% and 9.7% was recorded in Gosalpur and Bhamki village of Sihora and Sahpura blocks respectively.

Among different surveyed blocks, minimum mean incidence of collar rot (9.7%) was recorded in Sahpura block. However, maximum mean incidence of 33.4 % was recorded in Patan block. The incidence of collar rot among different villages ranged from 9.7 to 33.4%. Among different villages, maximum incidence of collar rot was recorded in Jamuwa village (33.4%) of Patan block. However, minimum incidence of 9.7% was recorded in Bhamki village of Sahpura block. The detailed data of incidence of collar rot in different villages of different blocks along with their GPS locations, soil type and adoption of seed treatment practice by farmer are given in table 4.1. The graphical representation of occurrence of collar rot of chickpea in different villages/blocks is depicted in figure 1.

**Table 4.1: Incidence of Collar rot of chickpea in different blocks of Jabalpur**

| Block | Village | GPS | | Soil Type | Seed Treatment | PDI |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | | | |
| Jabalpur | Tilhari | 23.0723 | 79.5746 | Dark Black soil | No | 23.2 |
| | Bhedaghat | 23.0720 | 79.4802 | | Yes | 13.1 |
| | Mangeli | 23.0529 | 79.5605 | | Yes | 14.6 |
| | Bargi | 23.1052 | 79.3816 | | No | 22.6 |
| | Tewar | 23.0830 | 79.5054 | | Yes | 22.1 |
| | **Mean** | | | | | **19.12** |
| | **Range** | | | | | **13.1-23.2** |
| Patan | Palari | 23.3549 | 79.2521 | Black soil | No | 31.6 |
| | Mohgaon | 22.3601 | 79.2419 | | No | 29.3 |
| | Rahli | 22.3436 | 79.2709 | | No | 28.5 |
| | Jamuwa | 22.3410 | 79.2646 | | No | 33.4 |
| | Ghoghra | 22.4618 | 79.3038 | | Yes | 13.6 |
| | **Mean** | | | | | **27.28** |
| | **Range** | | | | | **13.6-33.4** |
| Panagar | Bijaura | 23.1631 | 79.5741 | Light to Deep Black soil | Yes | 14.8 |
| | Mudiya | 23.1802 | 79.5718 | | No | 32.4 |
| | Bamhnoda | 23.1703 | 79.5840 | | No | 25.3 |
| | Bijauri | 23.1649 | 79.5724 | | No | 26.2 |
| | Liti | 23.1824 | 79.5906 | | Yes | 12.1 |
| | **Mean** | | | | | **22.16** |
| | **Range** | | | | | **12.1-32.4** |
| Sihora | Jujhri | 23.2418 | 80.0412 | Medium Black soil | No | 23.5 |
| | Gosalpur | 23.2346 | 80.0347 | | Yes | 19.3 |
| | Rithauri | 23.2603 | 80.0556 | | No | 14.3 |
| | Kachhpura | 23.2400 | 80.0426 | | No | 22.6 |
| | Dhamki | 23.2134 | 80.0236 | | Yes | 26.4 |
| | **Mean** | | | | | **21.22** |
| | **Range** | | | | | **14.3-26.4** |
| Sahpura | Kisrod | 23.0912 | 79.4311 | Medium Black soil | No | 22.3 |
| | Jhojhi | 23.0720 | 79.3849 | | No | 15.6 |
| | Bhamki | 23.0825 | 79.4129 | | Yes | 25.7 |
| | Badkheda | 23.0847 | 79.4440 | | No | 22.9 |
| | Barauda | 23.1353 | 80.4134 | | No | 19.1 |
| | **Mean** | | | | | **21.12** |
| | **Range** | | | | | **15.6-25.7** |

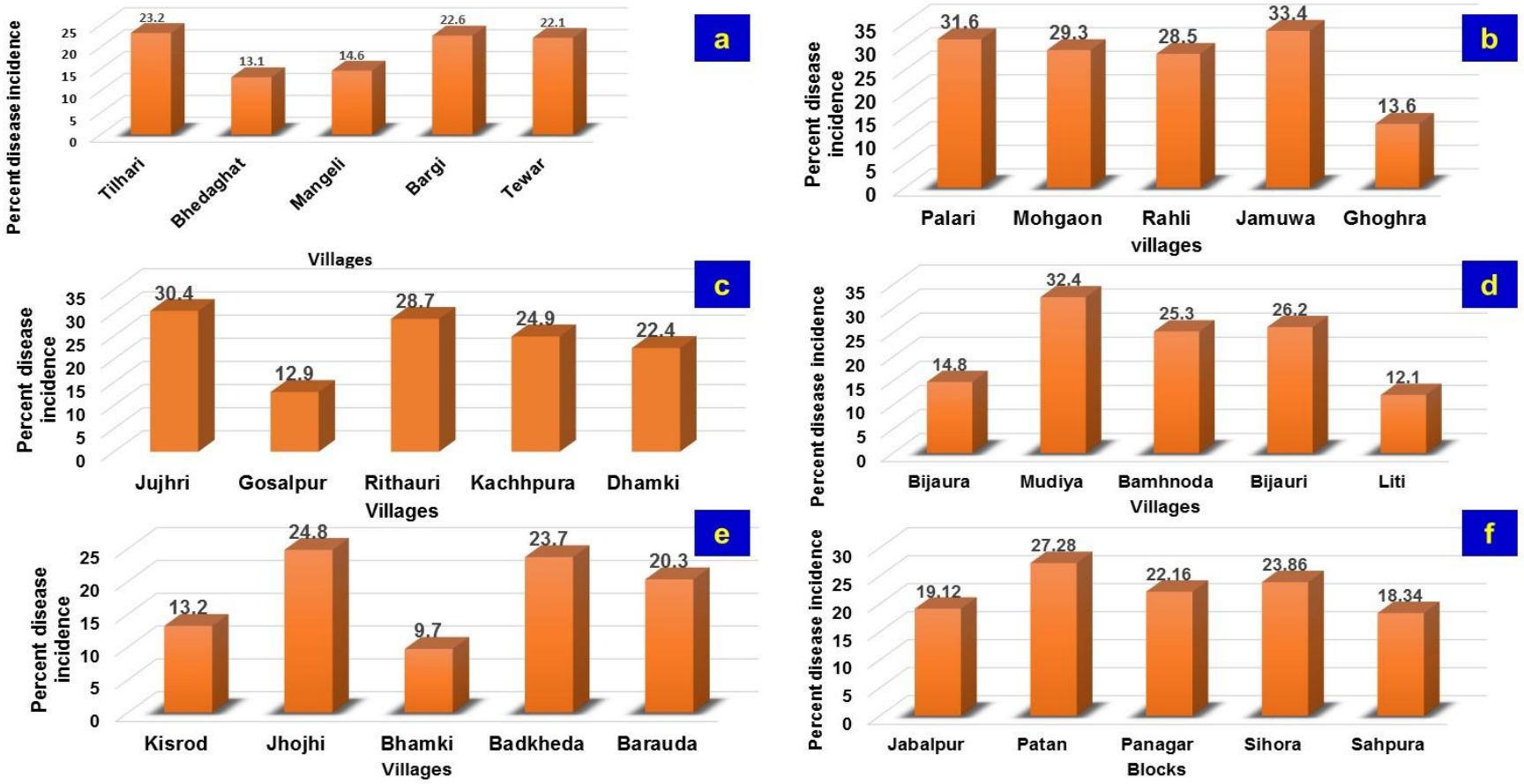


**Fig. 1: Incidence of collar rot of chickpea in different villages of a) Jabalpur b) Patan c) Sihora d) Panagar e) Shahpura f) Average incidence of collar rot of chickpea in different blocks of Jabalpur**


**Plate 1: Farmer's field showing the infection of collar rot in chickpea during roving survey in different blocks of Jabalpur**


**Plate 2: Farmer's field showing the infection of collar rot in chickpea during roving survey in different blocks of Jabalpur**

### 4.1.1 Impact of adoption of seed treatment practice on incidence of collar rot of chickpea at Farmers' field

During conduction of roving survey in farmers' field, adoption of seed treatment practice was enquired from respective farmer and it was observed that farmers were either not aware about the seed treatment practices or if they had adopted seed treatment practice, they were not known about the chemical or bioagent actually used. Local cultivars predominately prevailed in the surveyed area. The farmers from Jabalpur and Panagar block villages were more aware about adopting seed treatment of chickpea before sowing to mitigate the losses due to pathogens and farmers from three villages each from these blocks adopted seed treatment practice. Further, it was observed that fields sown with seed treatment application exhibited reduced incidence of collar rot in comparison to fields sown with treated chickpea seeds.

The average PDI of collar rot ranged from 9.7- 13.85% and 20.5-30.7% in fields without seed treatment and with seed treatment practice respectively. In fields, with seed treatment of chickpea before sowing, maximum incidence of collar rot (13.85%) was recorded in different villages of Jabalpur block. However minimum incidence of 9.7% was recorded in different villages of Sahpura block. In fields, where chickpea was sown without any seed treatment, maximum collar rot incidence of 30.7% was recorded in Patan block and minimum incidence of 20.5 % was recorded in Sahpura block. The average incidence of collar rot of 12.7% and 25.68% was recorded in chickpea fields sown with and without seed treatment respectively. The detailed data of incidence of collar rot in different villages/blocks with and without adoption of seed treatment practice are provided in table 4.2. The summarized data for each block for incidence of collar rot under adoption of seed treatment and without adoption of seed treatment are provided in table 4.3. The graphical representation of incidence of collar rot of chickpea in different blocks with and without adoption of seed treatment practice is depicted in figure 2.

**Table 4.2: Effect of Seed treatment on incidence of collar rot of chickpea at Farmers' field**

| Block | Village | PDI (No seed treatment) | Village | PDI (With seed treatment) |
|---|---|---|---|---|
| **Jabalpur** | Tilhari | 23.2 | Bhedaghat | 13.1 |
| | Bargi | 22.6 | Mangeli | 14.6 |
| | Tewar | 22.1 | - | - |
| | Mean | 22.63 | - | 13.85 |
| | Range | 22.10-23.20 | | 13.1-14.6 |
| **Patan** | Palari | 31.6 | Ghoghra | 13.6 |
| | Mohgaon | 29.3 | - | - |
| | Rahli | 28.5 | - | - |
| | Jamuwa | 33.4 | - | - |
| | Mean | 30.7 | | 13.6 |
| | Range | 28.50-33.40 | | - |
| **Panagar** | Mudiya | 32.4 | Bijaura | 14.8 |
| | Bamhnoda | 25.3 | Liti | 12.1 |
| | Bijauri | 26.2 | - | - |
| | Mean | 27.97 | | 13.45 |
| | Range | 25.30-32.40 | | 12.1-14.8 |

| Block | Village | PDI (No seed treatment) | Village | PDI (With seed treatment) |
|---|---|---|---|---|
| **Sihora** | Jujhri | 30.4 | Gosalpur | 12.9 |
| | Rithauri | 28.7 | - | - |
| | Kachhpura | 24.9 | - | - |
| | Dhamki | 22.4 | - | - |
| | Mean | 26.6 | | 12.9 |
| | Range | 22.4-30.4 | | - |
| **Sahpura** | Kisrod | 13.2 | Bhamki | 9.7 |
| | Jhojhi | 24.8 | - | - |
| | Badkheda | 23.7 | - | - |
| | Barauda | 20.3 | - | - |
| | Mean | 20.5 | | 9.7 |
| | Range | 13.2-24.8 | | - |
| | **Overall mean** | **25.68** | | **12.7** |
| | **Overall range** | **13.2-33.40** | | **9.7-28.7** |

**Table 4.3: Effect of Farmer's practice of seed treatment on incidence of collar rot of chickpea in different blocks of Jabalpur**

| Block | PDI | |
|---|---|---|
| | With Seed Treatment | Without seed treatment |
| Jabalpur | 13.85 | 22.63 |
| Patan | 13.6 | 30.7 |
| Panagar | 13.45 | 27.97 |
| Sihora | 12.9 | 26.6 |
| Sahpura | 9.7 | 20.5 |
| **Average** | **12.7** | **25.68** |
| **Range** | **9.7-13.85** | **20.5-30.7** |

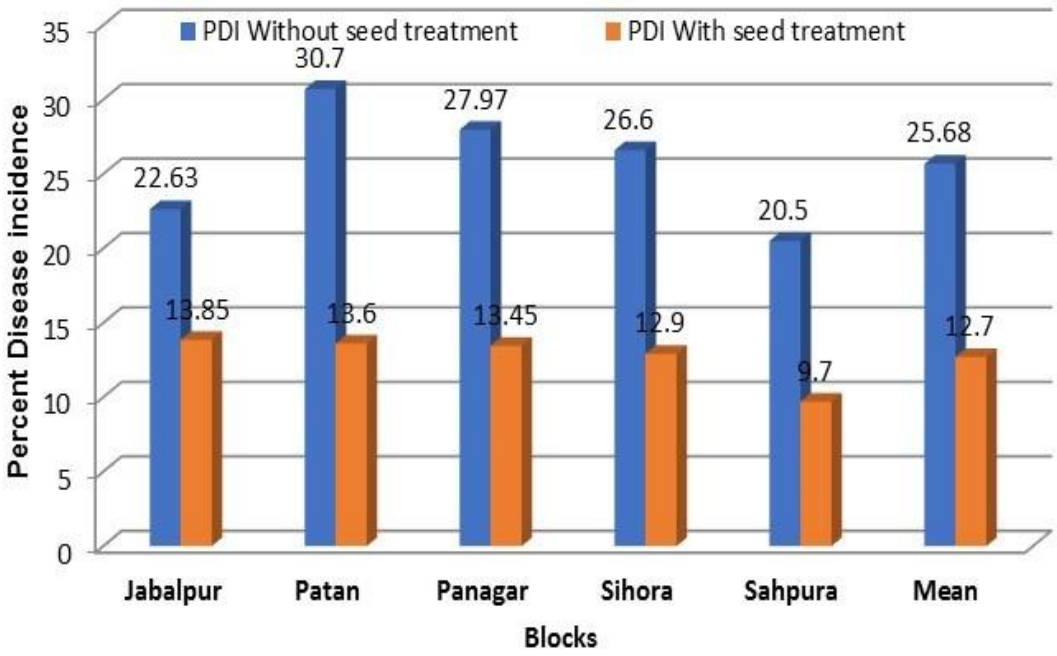


**Fig. 2: Graphical representation of effect of Farmers' practice of seed treatment on incidence of collar rot of chickpea in different blocks of Jabalpur**

### 4.2 Occurrence of collar rot in different varieties of chickpea

A fixed plot survey was conducted during Rabi 2020-21 in the chickpea field of department of Plant Breeding and Genetics, JNKVV, Jabalpur where ten different varieties of chickpea (JAKI 9218, JG 36, JG 24, JGK 5, JGK 6, JG 52, JG 14, JG 12, JG 63, and JG 16) were grown. The incidence of collar rot was recorded in all the ten varieties. It was observed that incidence of collar rot ranged from 16.66 per cent to 24.9 per cent. The maximum mean collar rot incidence of 24.9 % was recorded in JG 52 followed by 23.9 % in JG 63. However, minimum mean collar rot incidence of 16.66% was recorded in JG 24. The detailed data of collar rot incidence in different varieties are provided in table 4.4.


**Plate 3: Field view of impact of adoption of seed treatment practice on incidence of collar rot at Farmers' field showing the infection of collar rot in chickpea a) Without seed treatment b) With seed treatment**


**Plate 4: Proximate field view of impact of adoption of seed treatment practice on incidence of collar rot at Farmers' field showing the infection of collar rot in chickpea c) Without seed treatment d) With seed treatment**

**Table 4.4: Incidence of collar rot in different chickpea varieties**

| Variety | Per cent disease incidence |
|---|---|
| JAKI 9218 | 21.8 |
| JG 36 | 20.9 |
| JG 24 | 16.66 |
| JG K5 | 17.14 |
| JGK 6 | 20.2 |
| JG 52 | 24.9 |
| JG 14 | 22.6 |
| JG 12 | 21.5 |
| JG 63 | 23.9 |
| JG 16 | 21.07 |
| **Mean** | **21.067** |
| **Range** | **16.66-24.9** |

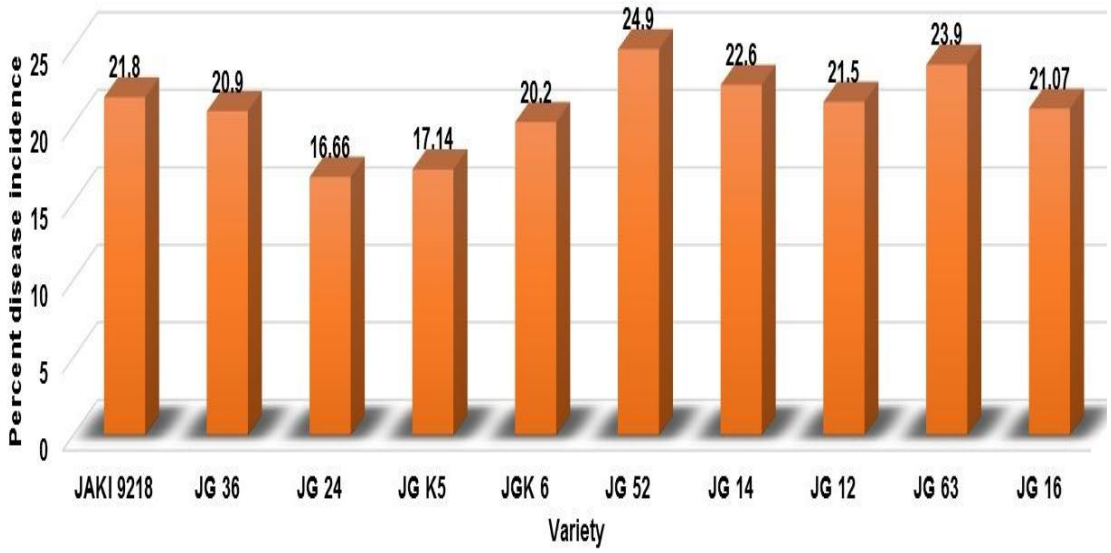


**Fig. 3: Incidence of collar rot of chickpea**



**Plate 5: Field view of variety-wise distribution of incidence of collar rot in chickpea a) JAKI 9218 b) JG 24**



**Plate 6: Field view of variety-wise distribution of incidence of collar rot in chickpea c) JG 14 d) JGK 6**

## 4.3 Isolation, purification and identification of *Sclerotium rolfsii* Sacc. from infected chickpea plants and its Symptomatology

### 4.3.1 Symptomatology

The symptoms of collar rot of chickpea caused by *Sclerotium rolfsii* were regularly observed during survey and also in experimental fields. Slightly yellow foliage with drying of plants before death in scattered pattern were observed. Presence of white mycelial growth in collar region of plants and brown colour sclerotia in soil could be observed in most of the collar rot infected chickpea seedlings. The infected plants were collected from the field for isolation and purification of the causal fungus in the laboratory, followed by identification of the fungus.

**Cultural characteristics**

The isolated *S. rolfsii* on potato dextrose agar medium exhibited snow-white coloured fluffy, compact mycelial growth with a silky lustre. The brown coloured, hard sclerotia formation started after 14 days of inoculation. Sclerotia were initially white in colour and became light brown to dark brown at maturity with size ranging from 0.5 to 1.5 mm in diameter. The mycelium of the pathogen was septate and hyaline with conspicuous branching at acute angles. The hyphae had clamps in the form of forks and hooks or H-like connections (Aycock, 1966).

The colony took five days to cover complete Petri plate growth of 90 mm. After 48 hrs, 20 mm, and after 96 hrs 35 mm colony radial growth was recorded. The data for colony radial growth after different incubation period is provided in table 4.5. The colony growth of *S. rolfsii* on PDA medium are depicted in figure 8.

**Table 4.5: Colony characteristics of *Sclerotium rolfsii* causing collar rot in chickpea**

| Colony radial growth of *S. rolfsii* on PDA after | | | | |
|---|---|---|---|---|
| 24 hrs | 48hrs | 72 hrs | 96 hrs | 120 hrs |
| 11 mm | 20 mm | 28 mm | 35 mm | 45 mm |
| Colony characteristics | Snow-white coloured, compact, fluffy mycelial growth with initially white coloured sclerotia turning into brown colour at later stage | | | |


**Plate 7: Symptoms of collar rot of chickpea a) individual infected plant in soil b) uprooted zoomed out individual plant showing white mycelial growth at collar region**

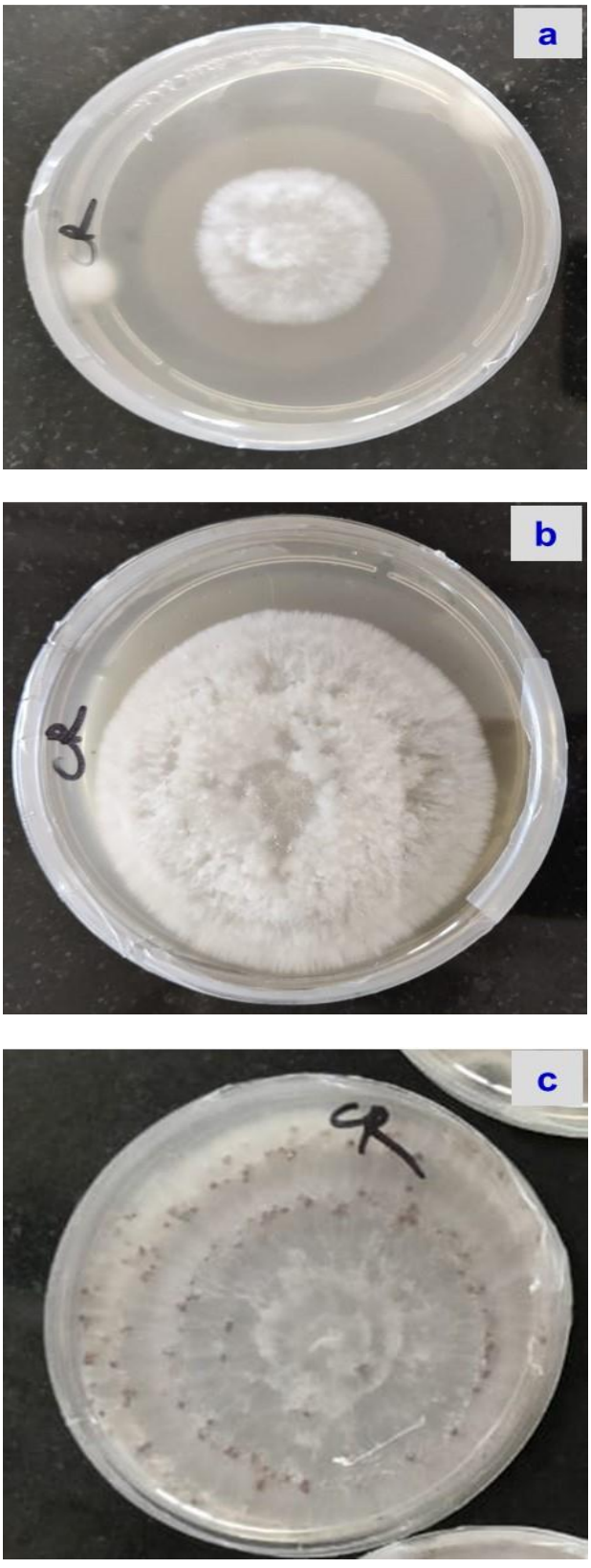


**Plate 8: Isolated pure culture of *Sclerotium rolfsii* causing collar rot of chickpea a) 3 days old b) 5 days old c) 15 days old culture showing sclerotia formation**

## 4.4 Impact of seed treatment on incidence of collar rot of chickpea

An experiment was conducted in natural field conditions to identify the effect of seed treatment on incidence of collar rot of chickpea. In total four seed treatment were applied (Vitavax power @ 2 g/kg seed, Rhizobium + PSB @ 10 ml/kg seed, Molybdenum @ 1 g/kg seed and Rhizobium + PSB + Molybdenum). The sowing of treated chickpea seed was performed on 23$^{rd}$ of November, 2020. Three varieties including JG 14, JG 36 and JGK 1 were taken during the experimentation. The overall incidence of collar rot among different treatments in all the three varieties ranged from 8.83% to 15.67% excluding control. In JG 14 variety, minimum incidence of collar rot of 9.96 % was recorded in seed treatment with Rhizobium + PSB @ 10 ml/kg seed followed by 10.12 % in seed treatment with Rhizobium + PSB + Molybdenum. The maximum incidence of 15.67 % was recorded in control plants. The similar trend in effectiveness of different treatment was recorded in JG 36 and JGK 1 with maximum effective treatment as seed treatment with Rhizobium + PSB @ 10 ml/kg seed. However, in control plots, maximum collar rot incidence of 14.11 % and 13.37 % was recorded in JG 36 and JGK 1 chickpea varieties respectively. The mean incidence was calculated across all the three varieties and it was observed that seed treatment with Rhizobium + PSB @ 10 ml/kg seed reduced the 36.86% incidence of collar rot in comparison to control. Seed treatment with Molybdenum @ 1.0 g per Kg seed didn't show significant reduction in incidence of collar rot and mean incidence of 14.03 % collar rot was recorded across all the three chickpea varieties. The detailed data of incidence of collar rot in different treatments in three chickpea varieties, with mean incidence and per cent disease control are provided in table 4.6. The graphical representation of incidence of collar rot of chickpea in different treatments with per cent disease control is depicted in figure 4.

**Table 4.6. Effect of different seed treatments on incidence of collar rot of chickpea (Sowing date: 23/11/2020)**

| Treatment No. | Treatment details | Percent incidence of Collar rot (25-30 DAS) | | | Mean incidence | Per cent disease control | | | Mean Per cent disease control |
|---|---|---|---|---|---|---|---|---|---|
| | | JG14 | JG36 | JGK1 | | JG14 | JG36 | JGK1 | |
| T1 | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 13.6 | 12.75 | 12.99 | 13.1 | 13.21 | 9.64 | 2.84 | 8.90 |
| T2 | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 9.96 | 8.46 | 8.83 | 9.08 | 36.44 | 40.04 | 33.96 | 36.86 |
| T3 | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 15.41 | 13.58 | 13.12 | 14.03 | 1.66 | 3.76 | 1.87 | 2.43 |
| T4 | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Molybdenum @ 1.0 g per Kg seed | 10.12 | 9.59 | 9.78 | 9.83 | 35.42 | 32.03 | 26.85 | 31.64 |
| Control | No seed treatment | 15.67 | 14.11 | 13.37 | 14.38 | 0.00 | 0.00 | 0.00 | 0.00 |
| C.D. | | NS | 2.641 | 3.524 | - | | | | |
| SE(m) | | 1.44 | 0.797 | 1.064 | - | | | | |

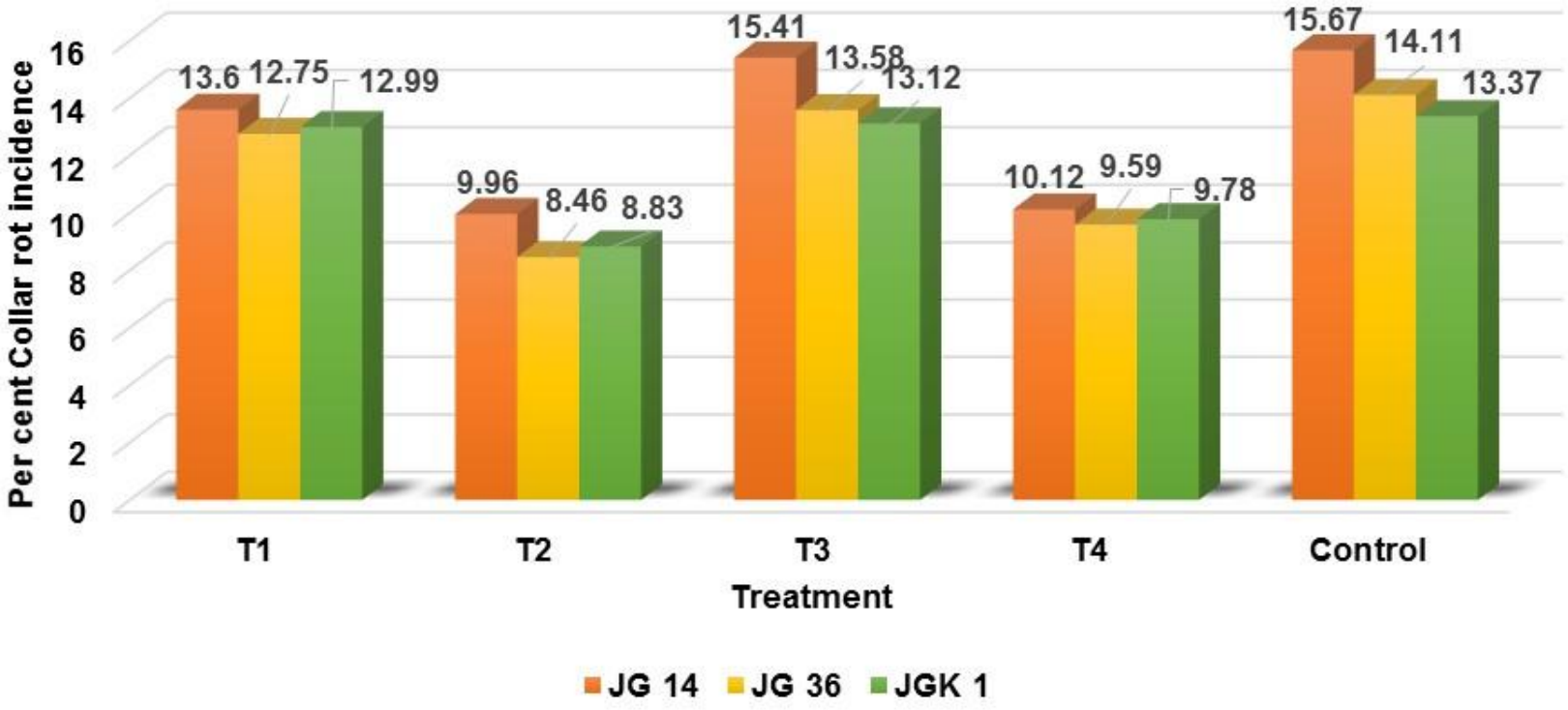


**Fig. 4: Graphical representation of effect of different seed treatment on incidence of collar rot in chickpea**

## 4.5 Impact of date of sowing on incidence of collar rot and Fusarium wilt of chickpea

Three varieties namely JG 14, JG 36 and JGK 1 were sown under natural field conditions on three dates i.e. First fortnight of November, 2020 (09.11.2020), second fortnight of November, 2020 (23.11.2020) and First fortnight of December, 2020 (07.12.2020). The incidence of collar rot and Fusarium wilt was recorded respectively 25-30 days and 45-50 days after sowing.

### Collar rot

The incidence of collar rot of chickpea was recorded highest during early sowing and it kept on decreasing by delaying the sowing. The maximum mean incidence of collar rot of 18.76 % was recorded in the treatment with sowing during the first fortnight of November. This was followed by sowing during second fortnight of November where 14.38% mean collar rot incidence was recorded. The minimum mean collar rot incidence of 8.77% was recorded under the sowing date during first fortnight of December. Among the different varieties, similar trend of collar rot incidence was recorded with respect to date of sowing. However, among different date of sowing and different varieties, maximum collar rot incidence of 21.18 % was recorded in JG 14. This was followed by JG 36 where 18.1% collar rot incidence was recorded. The minimum incidence of collar rot of 7.14 % was recorded in JGK 1 with sowing date of 07.12.2021 i.e., during first fortnight of December. This signified that late sowing conditions are unfavourable for development of collar rot in chickpea. The detailed data for collar rot incidence in all the three varieties during three different dates of sowing are presented in table 4.7. The graphical representation of collar rot incidence during three dates of sowing in three different varieties is presented in figure 5.

### Fusarium wilt

The incidence of Fusarium wilt of chickpea was recorded highest during sowing dates selected during second fortnight of November and it kept on decreasing during early or late sowing. The maximum mean incidence of wilt of 22.90 % was recorded in the treatment with sowing during the second

fortnight of November. This was followed by sowing during first fortnight of November where 20.47% mean wilt incidence was recorded. The minimum mean wilt incidence of 13.97 % was recorded in JG 14 under the sowing date during first fortnight of December. However, among different date of sowing and different varieties, maximum wilt incidence of 25.82 % was recorded in JG 36 and during the sowing in second fortnight of November. This was followed by 22.79 % in JG 36 variety when sowing was performed during first fortnight of November. The minimum incidence of wilt of 13.97 % was recorded in JG 14 during sowing in first fortnight of December. The data recorded revealed the minimum incidence of wilt of chickpea during the sowing in first fortnight of December. The detailed data for wilt incidence in all the three varieties during three different dates of sowing are presented in table 4.7. The graphical representation of wilt incidence during three dates of sowing in three different varieties is presented in figure 6.

**Table 4.7. Table showing the percent collar rot and fusarium wilt incidence on different sowing dates**

| Sowing date | Variety | Percent incidence | |
|---|---|---|---|
| | | Collar rot (25-30 DAS) | Fusarium wilt (45-50 DAS) |
| **First Fortnight of November 2020** | | | |
| **09-11-2020** | **JG 14** | **21.18** | **19.23** |
| **09-11-2020** | **JG 36** | **18.1** | **22.79** |
| **09-11-2020** | **JGK 1** | **17.01** | **19.41** |
| **Mean** | | **18.76** | **20.47** |
| **Second Fortnight of November 2020** | | | |
| **23-11-2020** | **JG 14** | **15.67** | **21.26** |
| **23-11-2020** | **JG 36** | **14.11** | **25.82** |
| **23-11-2020** | **JGK 1** | **13.37** | **21.64** |
| **Mean** | | **14.38** | **22.90** |
| **First Fortnight of December 2020** | | | |
| **07-12-2020** | **JG 14** | **11.21** | **13.97** |
| **07-12-2020** | **JG 36** | **7.97** | **16.31** |
| **07-12-2020** | **JGK 1** | **7.14** | **15.05** |
| **Mean** | | **8.77** | **15.11** |

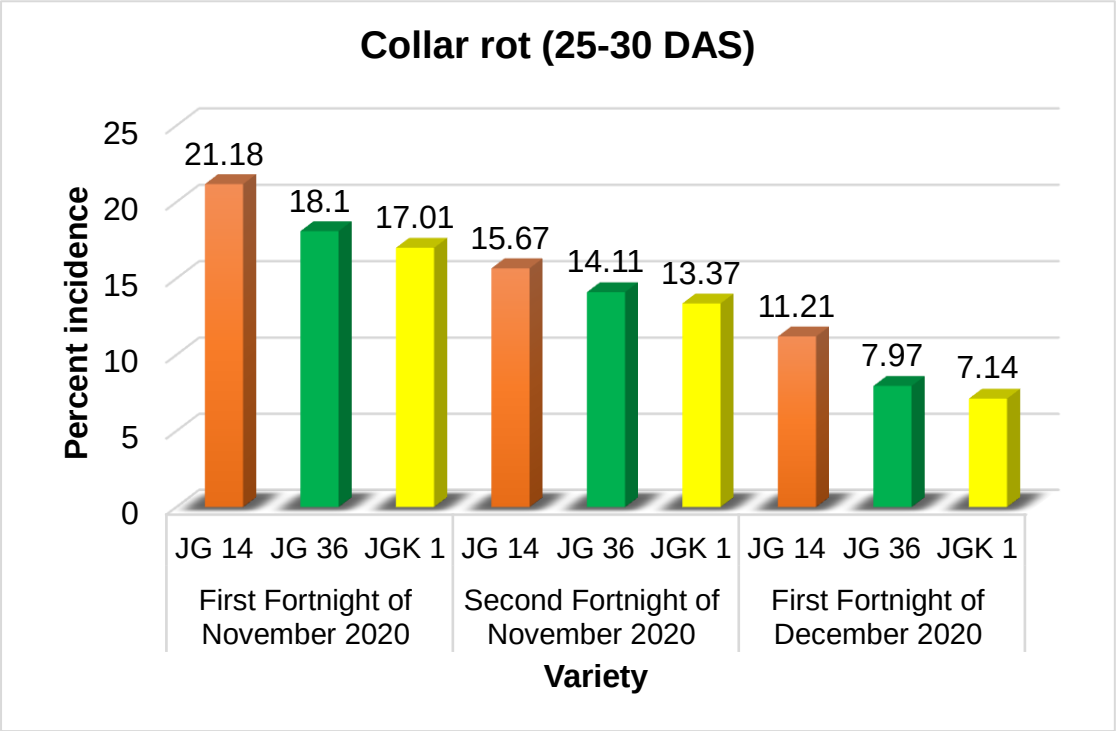


**Fig. 5: Graphical representation of mean collar rot incidence on different date of sowing in three different varieties of chickpea**

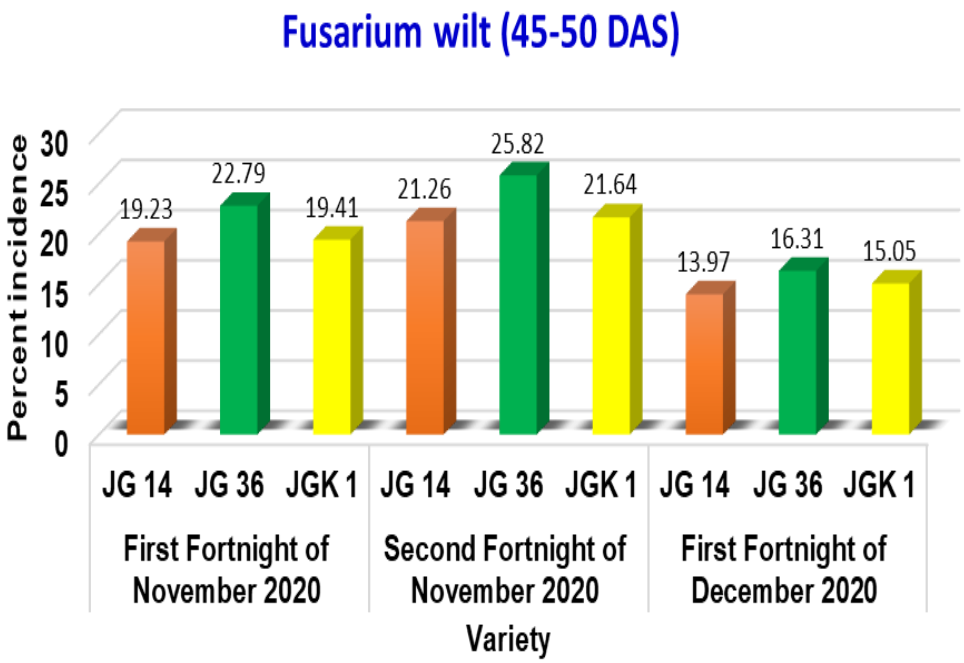


**Fig. 6: Graphical representation of mean Fusarium wilt incidence on different date of sowing in three different varieties of chickpea**

## 4.6 Impact of seed treatment and date of sowing on incidence of collar rot of chickpea

The field experiment was conducted to identify the role of seed treatment, date of sowing in three chickpea varieties namely JG 14, JG 36 and JGK 1. The experiment was laid out in split plot design. Three dates of sowing (First fortnight of November- 09.11.2020, second fortnight of November- 23.11.2020 and first fortnight of December- 07.12.2020) were performed after respective seed treatments of Vitavax power@ 2 g/kg seed, *Rhizobium* + PSB @ 10 ml/kg seed, Molybdenum @1 g/kg seed and *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g/kg seed. In control plots untreated seeds of respective chickpea varieties were sown on respective dates and in this way 45 treatments were implemented in natural field conditions in split plot design.

Significant effect of date of sowing along with impact of seed treatment were recorded in inhibiting the collar rot incidence. Among the different date of sowing and seed treatments, the collar rot incidence ranged from 6.73% to 19.35% in JG 14. However, the control exhibited 21.18%, 15.67% and 11.21% collar rot incidence during sowing in first, second fortnight of November and first fortnight of December respectively in JG 14. The maximum collar rot incidence was recorded during sowing in first fortnight of November. Among the different seed treatment practices, minimum collar rot incidence of 12.94%, 9.97% and 6.73% was recorded in seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed during sowing in first, second fortnight of November and first fortnight of December respectively in chickpea variety JG 14. This was followed by seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g/kg seed where 13.52%, 10.11% and 7.75 % collar rot incidence could be recorded during sowing in first, second fortnight of November and first fortnight of December respectively. Among the different seed treatment, across all the sowing dates, minimum impact of application of Molybdenum as seed treatment could be recorded and only 8.64%, 1.66% and 11.69% disease control was recorded during sowing in first, second fortnight of November and first fortnight of December respectively in JG 14 (table 4.8a).

In JG 36 variety, the incidence of collar rot was comparatively less than the JG 14 chickpea variety and among the different date of sowing and seed treatments, the collar rot incidence ranged from 6.42% to 16.90% excluding control of each date of sowing. However, the control exhibited 18.10%, 14.11% and 7.97% collar rot incidence during sowing in first, second fortnight of November and first fortnight of December respectively in JG 36. The minimum collar rot incidence was recorded during late sowing of chickpea first fortnight of December. Among the different seed treatment practices, maximum collar rot incidence of 16.90%, 13.58% and 7.64% was recorded in seed treatment with Molybdenum @ 1g/kg seed which was not significantly contributing in inhibition of collar rot incidence. However, maximum effect in collar rot control was revealed in seed treatment/application of *Rhizobium* + PSB @ 10 ml/kg seed during sowing in first, second fortnight of November and first fortnight of December and respectively 38.62%, 40.04% and 19.45% disease control was recorded in comparison to relative control in chickpea variety JG 36. This was followed by seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g/kg seed where 27.57%, 32.03% and 14.43 % collar rot control could be calculated over control during sowing in first, second fortnight of November and first fortnight of December respectively (table 4.8b).

While observing the collar rot incidence in JGK 1 with implementation of combination of different seed treatments and dates of sowing in analogous fashion as performed in JG 14 and JG 36, it was observed that least incidence of collar rot was present in all the treatments in comparison to JG 14 and JG 36, showing its more capacity to resist the collar rot incidence. However, the treatment wise efficacy in inhibition of collar rot was recorded in similar fashion of JG 14 and JG 36. In relation to, different seed treatments and date of sowing, the percent collar rot control ranged from 1.87% to 35.10% in JGK 1 in comparison to respective control. The maximum collar rot incidence was recorded in control with 17.01%, 13.37% and 7.14% incidence during sowing in first, second fortnight of November and first fortnight of December respectively in JGK 1. The maximum collar rot incidence was recorded in all the seed treatments and control in JGK 1 during sowing in first

fortnight of November as exhibited in JG 14 and JG 36. Among the different seed treatment practices, maximum collar rot incidence of 16.17%, 13.12% and 6.67% was recorded in seed treatment with Molybdenum @ 1g/kg seed during sowing in first, second fortnight of November and first fortnight of December respectively in chickpea variety JGK 1. This was followed by seed treatment with vitavax power @ 2 g/kg seed where 15.36%, 12.58% and 6.48 % collar rot incidence could be recorded during sowing in first, second fortnight of November and first fortnight of December respectively (table 4.8c).

Overall scenario across three varieties, three date of sowing and four seed treatments revealed that late sowing during first fort night of December in combination with seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed prior to sowing was recorded as best treatment for control of collar rot of chickpea irrespective of variety used. The detailed data of collar rot incidence and per cent disease control for each variety in the background of different seed treatments, date of sowing along with pooled analysis are presented in table 8a, 8b and 8c. The graphical representation of collar rot incidence and per cent disease control for different treatments of all the three varieties in three date of sowing is presented in figure 4.8 a,b,c.

**Table 4.8(a). Effect of different seed treatments and date of sowing on incidence of collar rot of chickpea (JG 14)**

| Variety | Date of sowing | Treatment No. | Treatment details | Per cent disease incidence | Per cent disease control |
|---|---|---|---|---|---|
| JG 14 | 09.11.20 | $T_1$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 17.41 | 17.80 |
| JG 14 | 09.11.20 | $T_2$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 12.94 | 38.90 |
| JG 14 | 09.11.20 | $T_3$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 19.35 | 8.64 |
| JG 14 | 09.11.20 | $T_4$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 13.52 | 36.17 |
| Control | 09.11.20 | $T_5$ | No seed treatment (Control) | 21.18 | - |
| JG 14 | 23.11.20 | $T_6$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 13.57 | 13.40 |
| JG 14 | 23.11.20 | $T_7$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 9.97 | 36.38 |
| JG 14 | 23.11.20 | $T_8$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 15.41 | 1.66 |
| JG 14 | 23.11.20 | $T_9$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 10.11 | 35.48 |
| Control | 23.11.20 | $T_{10}$ | No seed treatment (Control) | 15.67 | - |
| JG 14 | 07.12.20 | $T_{11}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 8.57 | 23.55 |
| JG 14 | 07.12.20 | $T_{12}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 6.73 | 39.96 |
| JG 14 | 07.12.20 | $T_{13}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 9.90 | 11.69 |
| JG 14 | 07.12.20 | $T_{14}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 7.75 | 30.87 |
| Control | 07.12.20 | $T_{15}$ | No seed treatment (Control) | 11.21 | - |
| CD A = 1.363, B = 1.212, A X B = 2.099, C = 0.939 | | | | | |
| SE(m) = A = 0.349, B = 0.431, A X B = 0.746, C = 0.334, AXC = 0.578, BXC = 0.746 | | | | | |

Factor A = Date of Sowing, B = Seed Treatment, C = Variety

**Table 4.8(b). Effect of different seed treatments and date of sowing on incidence of collar rot of chickpea (JG 36)**

| Variety | Date of sowing | Treatment No. | Treatment details | Per cent disease incidence | Per cent disease control |
|---|---|---|---|---|---|
| JG 36 | 09.11.20 | $T_{16}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 16.30 | 9.94 |
| JG 36 | 09.11.20 | $T_{17}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 11.11 | 38.62 |
| JG 36 | 09.11.20 | $T_{18}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 16.90 | 6.63 |
| JG 36 | 09.11.20 | $T_{19}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 13.11 | 27.57 |
| Control | 09.11.20 | $T_{20}$ | No seed treatment (Control) | 18.10 | - |
| JG 36 | 23.11.20 | $T_{21}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 12.75 | 9.64 |
| JG 36 | 23.11.20 | $T_{22}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 8.46 | 40.04 |
| JG 36 | 23.11.20 | $T_{23}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 13.58 | 3.76 |
| JG 36 | 23.11.20 | $T_{24}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 9.59 | 32.03 |
| Control | 23.11.20 | $T_{25}$ | No seed treatment (Control) | 14.11 | - |
| JG 36 | 07.12.20 | $T_{26}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 7.44 | 6.65 |
| JG 36 | 07.12.20 | $T_{27}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 6.42 | 19.45 |
| JG 36 | 07.12.20 | $T_{28}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 7.64 | 4.14 |
| JG 36 | 07.12.20 | $T_{29}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 6.82 | 14.43 |
| Control | 07.12.20 | $T_{30}$ | No seed treatment (Control) | 7.97 | - |
| CD A = 1.363, B = 1.212, A X B = 2.099, C = 0.939 | | | | | |
| SE(m) = A = 0.349, B = 0.431, A X B = 0.746, C = 0.334, AXC = 0.578, BXC = 0.746 | | | | | |

Factor A = Date of Sowing, B = Seed Treatment, C = Variety

**Table 4.8(c). Effect of different seed treatments and date of sowing on incidence of collar rot of chickpea (JGK 1)**

| Variety | Date of sowing | Treatment No. | Treatment details | Per cent disease incidence | Per cent disease control |
|---|---|---|---|---|---|
| JGK 1 | 09.11.20 | $T_{31}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 15.36 | 9.70 |
| JGK 1 | 09.11.20 | $T_{32}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 11.04 | 35.10 |
| JGK 1 | 09.11.20 | $T_{33}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 16.17 | 4.94 |
| JGK 1 | 09.11.20 | $T_{34}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 12.57 | 26.10 |
| Control | 09.11.20 | $T_{35}$ | No seed treatment (Control) | 17.01 | - |
| JGK 1 | 23.11.20 | $T_{36}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 12.58 | 5.91 |
| JGK 1 | 23.11.20 | $T_{37}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 8.36 | 37.47 |
| JGK 1 | 23.11.20 | $T_{38}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 13.12 | 1.87 |
| JGK 1 | 23.11.20 | $T_{39}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 9.44 | 29.39 |
| Control | 23.11.20 | $T_{40}$ | No seed treatment (Control) | 13.37 | - |
| JGK 1 | 07.12.20 | $T_{41}$ | Seed treatment with Vitavax power @ 2.0 g per Kg seed | 6.48 | 9.24 |
| JGK 1 | 07.12.20 | $T_{42}$ | Seed treatment with *Rhizobium* + PSB @ 10 ml per Kg seed | 5.46 | 23.53 |
| JGK 1 | 07.12.20 | $T_{43}$ | Seed treatment with Molybdenum @ 1.0 g per Kg seed | 6.67 | 6.58 |
| JGK 1 | 07.12.20 | $T_{44}$ | Seed treatment with *Rhizobium* @ 10 ml + PSB @ 10 ml + Mo @ 1.0 g per Kg seed | 6.17 | 13.59 |
| Control | 07.12.20 | $T_{45}$ | No seed treatment (Control) | 7.14 | - |
| CD A = 1.363, B = 1.212, A X B = 2.099, C = 0.939 | | | | | |
| SE(m) = A = 0.349, B = 0.431, A X B = 0.746, C = 0.334, AXC = 0.578, BXC = 0.746 | | | | | |

Factor A = Date of Sowing, B = Seed Treatment, C = Variety

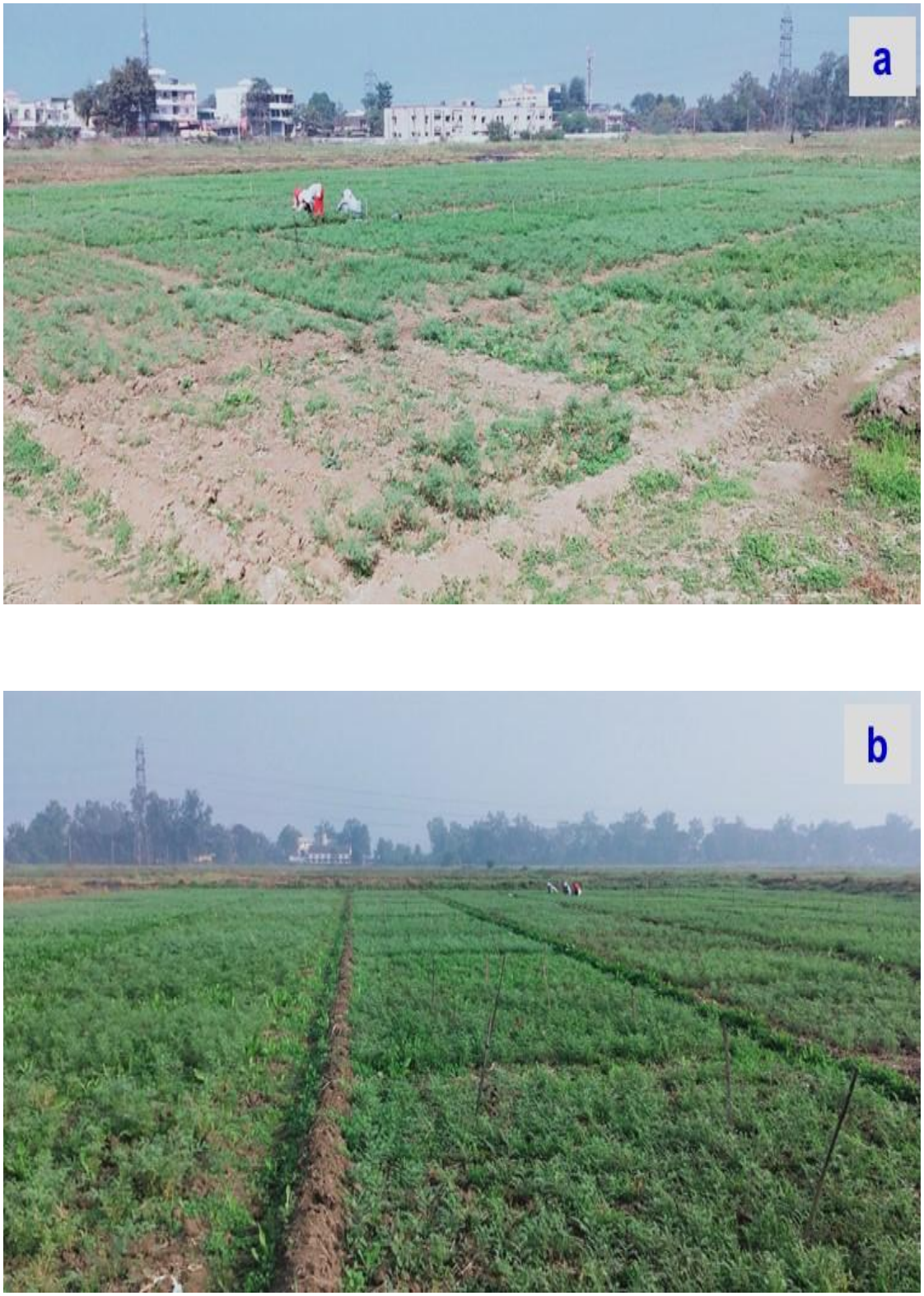


**Plate 9: Field view of experiment on impact of seed treatment and date of sowing on incidence of collar rot of chickpea early crop growth stage a) Early sown plots b) Late sown plots**



**Plate 10: Field view of experiment on impact of seed treatment and date of sowing on incidence of collar rot of chickpea showing collar rot infection in different plots (c & d)**

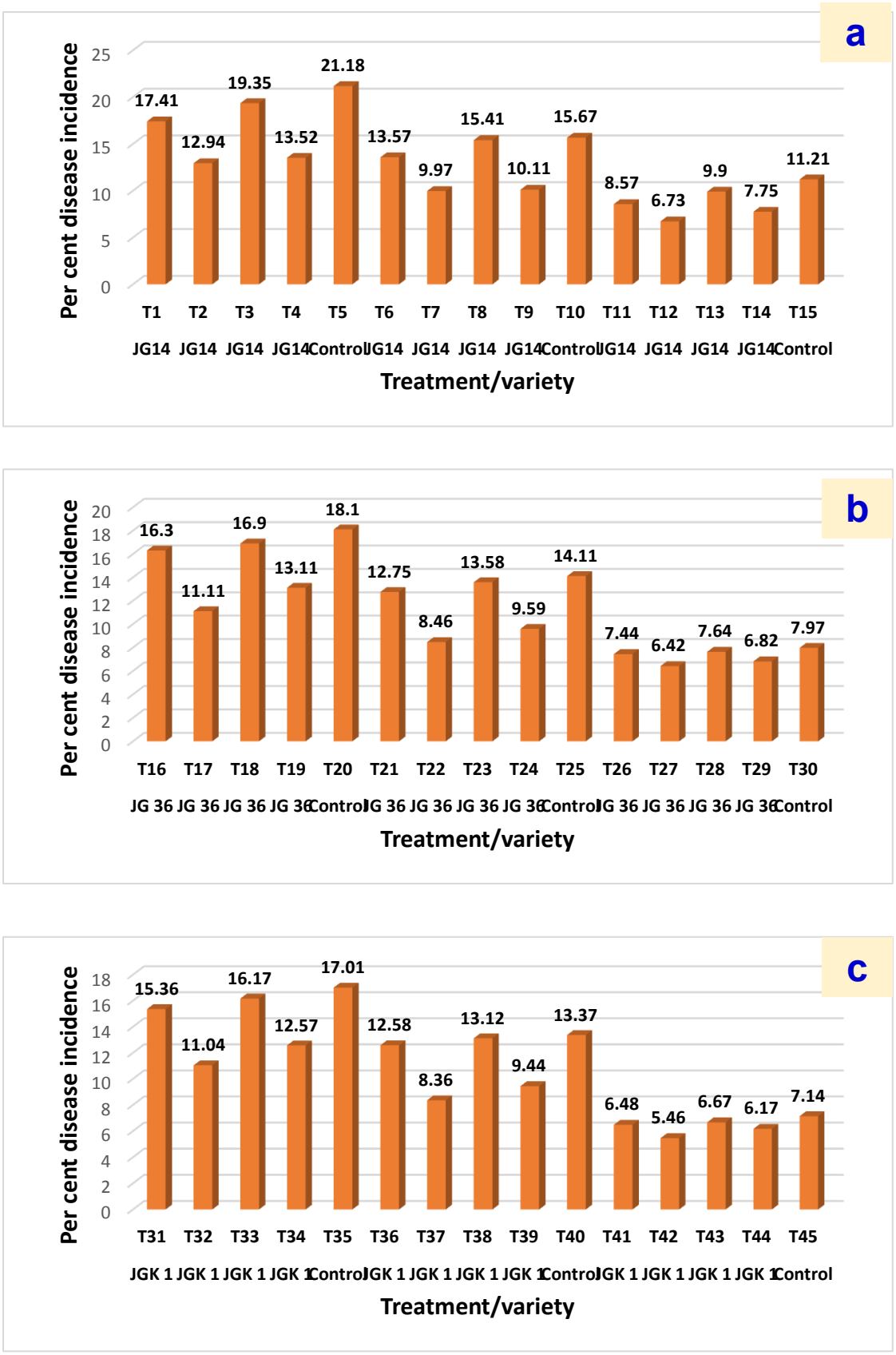


**Fig.7: Graphical representation of effect of different date of sowing and seed treatments on incidence of collar rot of chickpea in three different varieties of chickpea a) JG 14 b) JG 36 c) JGK 1**

## 4.7 Influence of fungicides seed treatment on incidence of collar rot

In total, nine fungicides were used to determine the effectiveness against collar rot pathogen. The seeds of chickpea variety JG 14 were dressed with respective fungicides in doses mentioned earlier prior to sowing. The experiment was conducted in naturally sick soil and with known history of collar rot prevalence.

### 4.7.1 Effect on seed germination

Seed treatment with fungicides resulted in enhanced seed emergence in comparison to control. In control plants, per cent seed emergence of 63.03% was recorded. However, in seeds treated with different fungicides, seed emergence ranged from 79.39% to 86.67&. Maximum seed emergence of 86.67% was recorded in seeds treated with 0.15% carboxin + Thiram. This was followed by seed application of Thiram + Carbendazim @ 0.3% and copper oxychloride @ 0.25% where respectively 86.06% and 85.45% seed emergence were recorded. The detailed data of seed emergence in different treatments of fungicidal seed treatment is presented in table 9. The graphical representation of per cent seed emergence for different treatments is depicted in figure 8.

### 4.7.2 Effect on collar rot incidence

Significant effect in control of collar rot incidence was represented by all the seed treatments. The collar rot incidence among different treatments ranged from 5.95% to 13.29% excluding control. However, in control plants, collar rot incidence of 23.05 % was recorded. The minimum collar rot incidence of 5.95% was recorded in seed treatment with carboxin + thiram (Vitavax power) @ 0.15%, followed by 6.30% collar rot incidence in seed treatment with thiram + carbendazim @0.3%. Among different seed treatments, the maximum collar rot incidence of 13.29% was recorded in seed treatment with tebuconazole @1.5%. The percent collar rot control was calculated over untreated check and it ranged from 43.69% to 72.67%. The detailed data of per cent disease incidence and per cent disease control in different treatments are presented in table 9. The graphical representation of per cent disease incidence and per cent disease control for different treatments is depicted in figure 10.


**Plate 11: Field view of experiment on impact of fungicidal seed treatment on incidence of collar rot of chickpea**

**Table 9: Effect of different fungicide seed treatments on emergence and incidence of collar rot and wilt of chickpea**

| Treatment No. | Fungicide chemical name | Trade name | Percent dose | Per cent seed emergence | Per cent disease incidence(25DAS) | Per cent disease control |
|---|---|---|---|---|---|---|
| $T_1$ | Carbendazim | Bavistin | 0.15 | 82.42 | 12.06 | 47.68 |
| $T_2$ | Carboxin+Thiram | Vitavax power | 0.15 | 86.67 | 5.95 | 74.19 |
| $T_3$ | Mancozeb | Diathane M-45 | 0.25 | 82.12 | 12.98 | 43.69 |
| $T_4$ | Tebuconazole | Folicur | 1.5 | 83.94 | 13.29 | 42.34 |
| $T_5$ | Thiram+Carbendazim | | 0.3 | 86.06 | 6.3 | 72.67 |
| $T_6$ | Copper oxychloride | Blue copper | 0.25 | 85.45 | 11.65 | 49.46 |
| $T_7$ | Chlorothalonil | Kavach | 0.15 | 79.39 | 10.25 | 55.53 |
| $T_8$ | Pyraclostrobin | Cabrio | 0.15 | 82.73 | 9.18 | 60.17 |
| $T_9$ | Azoxystrobin | Amistar | 0.1 | 84.24 | 7.56 | 67.20 |
| $T_{10}$ | Control | - | - | 63.03 | 23.05 | - |
| C.D. | | | | 6.754 | 4.181 | - |
| SE(m) | | | | 2.256 | 1.396 | - |
| C.V. | | | | 4.787 | 21.543 | - |

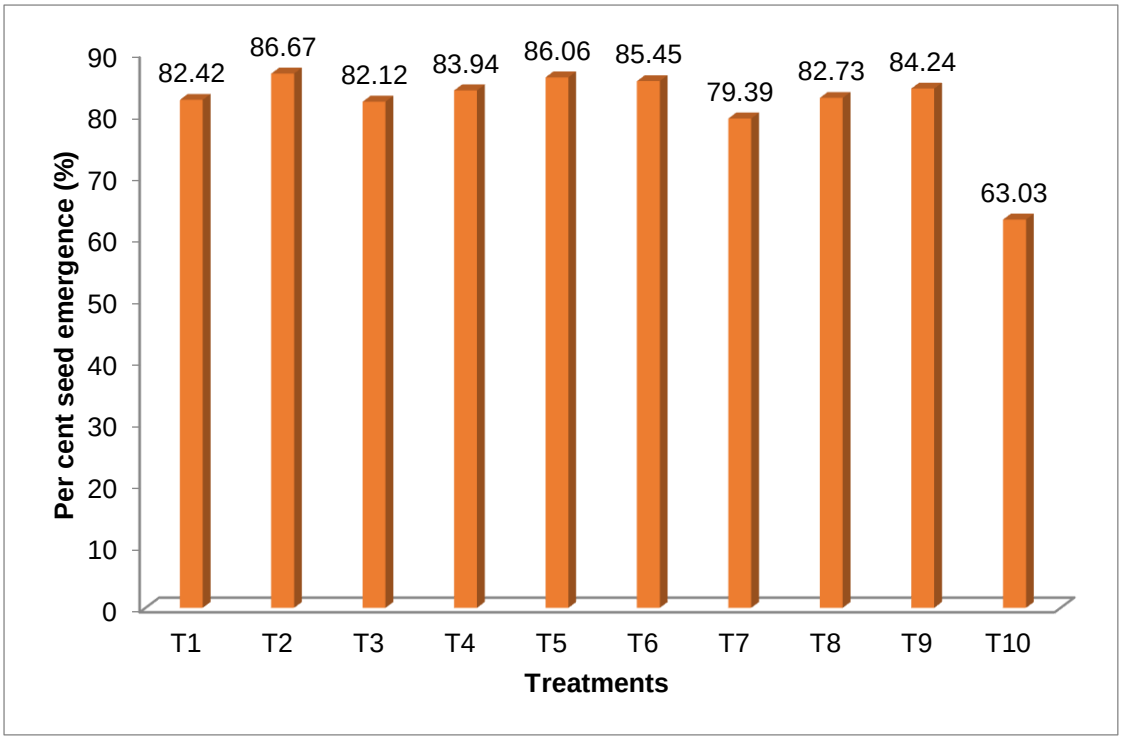


**Fig. 8: Graphical representation of effect of fungicidal seed treatment on per cent seed emergence**

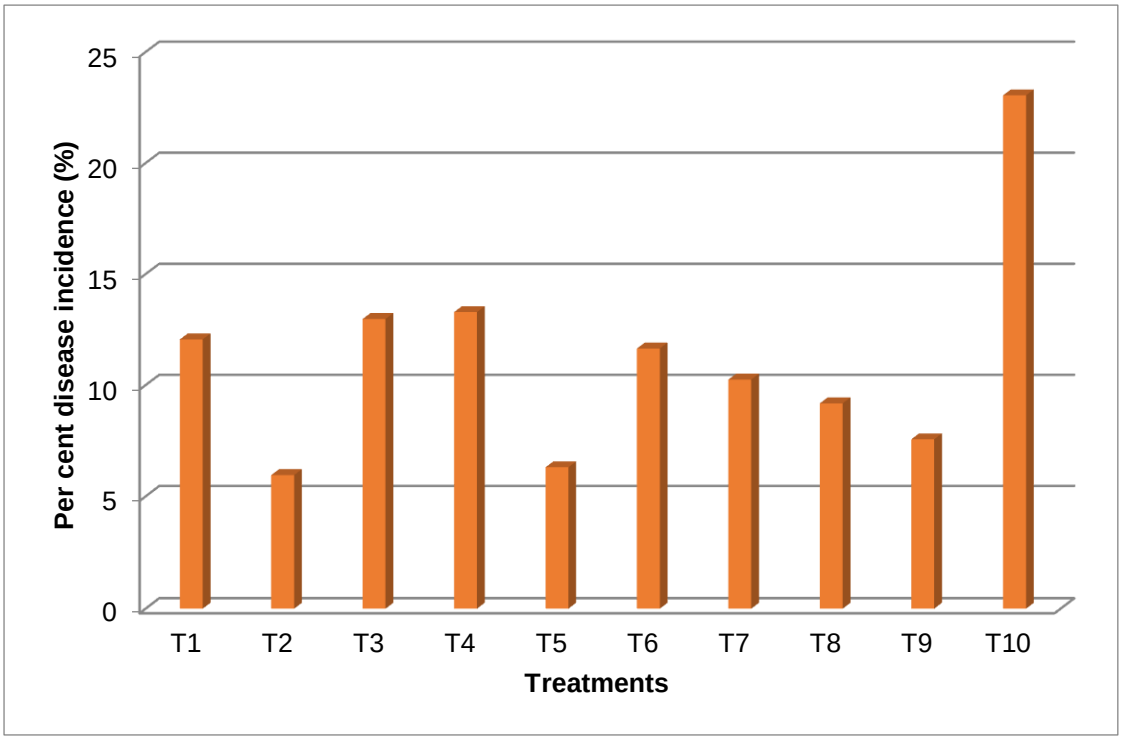


**Fig. 9: Graphical representation of effect of fungicidal seed treatment on collar rot incidence**

# Chapter - V

# DISCUSSION

# DISCUSSION

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in the world with high protein content of about 25.3– 28.9% in its nutritive seeds (Mafakheri *et al.,* 2011). Keeping the demanding population into consideration which has been estimated 9-10 billion people by 2050, with reducing arable agricultural lands due to urbanization and water resources, the global agricultural productivity must also complement to the growing world population (Sekhon, 2014; Godfray *et al.,* 2010, Massawe *et al.,* 2016). In the present scenario of cropping pattern,

Collar rot is an emerging chickpea disease of soil-borne nature that can cause 55–95 per cent mortality in seedlings when environmental conditions are favourable, such as heavy rainfall and high soil temperatures (25–30°C) (Sharma and Ghosh, 2017). Furthermore, collar rot control is difficult due to the pathogen's extensive host range, which includes at least 500 species belonging to 100 groups that are typically found in legumes, crucifers, and cucurbits (Aycock, 1966). *S. rolfsii* affects the collar region of chickpea plants and persists as mycelium in infected tissues and plant debris, as well as in the form of sclerotial structures in the soil or in conjunction with plant debris. In recent times, *S. rolfsii* has become more common in agricultural areas where high temperature coupled with abrupt rainfall increases soil moisture for prolonged periods owing to its high competitive saprophytic survival ability. With such a diverse spectrum of natural hosts, *S. rolfsii* potentially live in arid climates and stay in the soil for extended periods of time, even after multiple crop rotations. Controlling collar rot has been difficult due to a lack of knowledge about the components that influence its growth. Several fungicidal seed treatment has been suggested in past for control of collar rot in chickpea. However, combination of cultural practices, coupled with seed treatment may be a better alternative for management of collar rot pathogen in chickpea.

Keeping this in view, the aim of this study was to document the prevalence of collar rot of chickpea in Jabalpur and adjoining areas and secondly to investigate the combined effect of seed treatment and date of sowing on incidence of collar rot of chickpea.

A GPS based roving survey was conducted in five blocks of Jabalpur namely Jabalpur, Patan, Panagar, Sihora, and Sahpura during seedling stage (2-3 weeks of crop age) of crop growth in the period of October to February, 2020. It was observed that collar rot of chickpea was widely prevalent in the surveyed area and caused considerable losses to plant stand. Drying of plants took place and foliage turned slightly yellow before death. The diseased plants were scattered through the field indicated the collar rot infection. Further, it was observed that the younger seedlings showed clear rotting at collar region with presence of white mycelial growth of the fungus. Presence of rapeseed like brown coloured sclerotia could also be observed in the infected plant and adjoining soil.

The incidence of collar rot significantly varied from village to village and block to block and in this way, differential incidence of collar rot was observed in different fields of different villages/ blocks. Among different surveyed blocks, minimum mean incidence of collar rot (9.7%) was recorded in Sahpura block. However, maximum mean incidence of 33.4 % was recorded in Patan block. The incidence of collar rot among different villages ranged from 9.7 to 33.4%. Among different villages, maximum incidence of collar rot was recorded in Jamuwa village (33.4%) of Patan block. However, minimum incidence of 9.7% was recorded in Bhamki village of Sahpura block. The results obtained in roving survey revealed the hot spot area for occurrence of collar rot. The findings of present investigation are in agreement with several workers where they had reported the high incidence of collar rot in central India and caused significant reduction in the yield of chickpea (Prasad, 2005; Maurya *et al.* 2008). Padole *et al*. (2009) reported 5-30% incidence of collar rot in 15 to 45 days old crop in a roving survey of 51 locations of Jabalpur and adjoining areas. Singh *et al*. (2011) conducted an extensive roving survey in chickpea growing areas of different districts of Uttar Pradesh during 2005-07 and reported varying amount of disease incidence in different districts. Ghosh *et al*. (2013) in the roving survey 2010-2011 reported presence of collar region in all the surveyed areas of central India irrespective of cultivar type and locations. The findings of present investigations are in support to Ghosh *et al*.

(2013). The warmer climate of high temperature coupled with high moisture favours the growth and development of *S. rolfsii* in Madhya Pradesh as reported by Al-Askar *et al*. (2013); Eslami *et al*. (2015).

During conduction of roving survey in farmers' field, adoption of seed treatment practice was enquired from respective farmer and mostly unawareness of farmer's was recorded for adopting seed treatment before sowing. The farmers from Jabalpur and Panagar block villages were more aware about adopting seed treatment of chickpea before sowing to mitigate the losses due to pathogens and farmers from three villages each from these blocks adopted seed treatment practice. The fields sown with seed treatment application exhibited reduced incidence of collar rot in comparison to fields sown with treated chickpea seeds. In fields, where chickpea was sown without any seed treatment, maximum collar rot incidence of 30.7% was recorded in Patan block and minimum incidence of 20.5 % was recorded in Shapura block. The average incidence of collar rot of 12.7% and 25.68% was recorded in chickpea fields sown with and without seed treatment respectively. The significant effect of seed treatment with bioagents have been reported in reduction of the incidence of different diseases of chickpea and other crops (Kumar *et al.* 2010). Ghosh *et al*. (2013) also concluded variable distribution of collar rot of chickpea in respect to soil type, cultivar used, seed treatment practices in their study in central India. They reported that collar rot was highly distributed in central India which supports the findings of present investigations. During the fixed plot survey in the chickpea fields of department of Plant Breeding and Genetics, JNKVV, Jabalpur a set of ten different varieties were monitored for recording the incidence of collar rot. It was observed that maximum mean collar rot incidence of 24.9 % was recorded in JG 52 followed by 23.9 % in JG 63. However, minimum mean collar rot incidence of 16.66% was recorded in JG 24.

The isolated *S. rolfsii* on potato dextrose agar medium exhibited snow-white coloured fluffy, compact mycelial growth with a silky lustre and formation of brown coloured, hard sclerotia could be visualized in culture media after 14 days of inoculation. The similar type of characteristics of *S. rolfsii* have also been reported by Subramanian, (1971); Gupta *et al*. (2006).

An experiment was conducted in natural field conditions to identify the effect of seed treatment of Vitavax power, Rhizobium + PSB, Molybdenum and Rhizobium + PSB + Molybdenum under the background of three chickpea varieties namely JG 14, JG 36 and JGK 1. The overall incidence of collar rot among different treatments in all the three varieties ranged from 8.83% to 15.67% excluding control. In all the three tested varieties, minimum incidence of collar rot was recorded in seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed followed by *Rhizobium* + PSB + Molybdenum. The seed treatment with Rhizobium + PSB @ 10 ml/kg seed reduced the 36.86% mean incidence of collar rot in comparison to control. Among the different seed treatments, Molybdenum alone didn't show any significant reduction in incidence of collar across all the three evaluated varieties. The significant effect of seed application of *Rhizobium* and PSB has been reported in reducing the incidence of collar rot of chickpea by *Sclerotium rolfsii,* where they could record 24.74 % collar rot control by seed application of *Rhizobium* and PSB. Thus, findings of present study showing significant effect of *Rhizobium* and PSB in reduction of collar rot are supported by Singh *et al.* (2018).

To identify the impact of date of sowing on collar rot and Fusarium wilt, three varieties namely JG 14, JG 36 and JGK 1 were sown under natural field conditions on first fortnight of November, 2020 (09.11.2020), second fortnight of November, 2020 (23.11.2020) and first fortnight of December, 2020 (07.12.2020). The incidence of collar rot of chickpea was recorded highest during early sowing and it kept on decreasing by delaying the sowing. The maximum mean incidence of collar rot of 18.76 % was recorded in sowing during the first fortnight of November and subsequent delayed sowing reduced the incidence of collar rot. The minimum mean collar rot incidence of 8.77% was recorded in late sowing during first fortnight of December. This signified that late sowing conditions are favourable for development of collar rot in chickpea. It may be attributed because of low temperature weather span during the seedling stage of crop growth period. Similar observations has been recorded by Chandran *et al.* (2021) where in late sowing chickpea expression of collar rot was comparatively low in comparison to early sowing and thus supporting the present findings. Further, the incidence of Fusarium wilt of chickpea was recorded highest during second fortnight of November

and it kept on decreasing during early or late sowing. The maximum mean incidence of wilt of 22.90 % was recorded in the treatment with sowing during the second fortnight of November. This was followed by sowing during first fortnight of November where 20.47% mean wilt incidence was recorded. The results are in agreement with the findings of Usha Mina and Sunil Dubey, 2010 in which under controlled laboratory experiments the growth and sporulation of *F. oxysporum f. sp. ciceris* was observed at different temperatures. The 'Pusa 212' showed larger incubation period, less wilt incidence and higher yield in comparison 'BGD 1005'. Early sowing minimizes wilt incidence in both the cultivars. Lowest mean wilt incidence (22.6-25.5%) and maximum mean grain yield (13.5-14.3 tonnes/ha) were recorded in the crop sown on 10 and 20 november. Similar trend was observed in 'BGD 1005' whereas 20 November sown 'Pusa 212' crop showed lowest wilt incidence (15.3 and 20.1%) and highest grain yield (16.2 tonnes/ha) during both the years.

The cumulative effect of previously mentioned three date of sowing (09.11.2020, 23.11.2020 and 07.12.2020) and seed treatments of Vitavax power, *Rhizobium* + PSB, Molybdenum and *Rhizobium* + PSB + Mo revealed that minimum collar rot incidence was recorded in seed treatment with *Rhizobium* + PSB during sowing in first fortnight of December. This was followed by seed treatment with *Rhizobium* + PSB + Mo with same sowing dates. Among the different seed treatment, across all the sowing dates, minimum impact of application of Molybdenum could be recorded. In this way, overall scenario across three varieties, three date of sowing and four seed treatments revealed that late sowing during first fort night of December in combination with seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed prior to sowing was recorded as best treatment for control of collar rot of chickpea irrespective of variety used. Singh *et al.* (2018) worked with 5 treatments and found that the lowest disease incidence was recorded in Module 5 i.e., collar rot (1.77%), fusarium wilt (2.17%) and dry root rot (1.77%). Similarly, highest emergence per cent (88.13), number of healthy pod/plant (62), 100 seed weight (21.55g) and highest yield increase 53.10 per cent were found in also module 5.

The fungicidal seed treatment resulted in enhanced seed emergence in the range of 79.39% to 86.67% in comparison to control. In control plants, per cent seed emergence of 63.03% was recorded. Maximum seed emergence of 86.67% was recorded in seeds treated with 0.15% carboxin + Thiram. However, the collar rot incidence among different chemical treatments ranged from 5.95% to 13.29% excluding control. The minimum collar rot incidence of 5.95% was recorded in seed treatment with carboxin + thiram @ 0.15%, followed by 6.30% in thiram + carbendazim @0.3%. The percent collar rot control was calculated over untreated ranged from 43.69% to 72.67%. Wise *et al.* (2009) done an experiment in which asymptomatic and symptomatic seeds were treated with different fungicides to determine their effects on seedling emergence from soil and on Ascochyta blight development in seedlings grown in a growth chamber and in the field. The emergence of seedlings grown from asymptomatic seeds was significantly (P-< 0.05) greater than the emergence of seedlings grown from symptomatic seeds in the growth chamber and field trails. Fungicides were able to increase plant emergence from symptomatic seeds when compared with a control in the growth chamber trails.

# Chapter - VI

# SUMMARY CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

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# FOR FURTHER WORK

## SUMMARY

The present investigation entitled "**Studies on integrated management of Collar rot of chickpea**" was carried at Department of Plant Pathology, Jawaharlal Nehru Krishi Vishwavidyalya (J.N.K.V.V.), College of Agriculture, Jabalpur (M.P.) with the objective to record the status of collar rot of chickpea in adjoining areas of Jabalpur and to identify the effect of date of sowing, fungicidal seed application on incidence of collar rot of chickpea. Further efforts were also made to identify the varietal performance in different background of date of sowing and seed treatment for incidence of collar rot of chickpea caused by *Scerotium rolfsii*.

Seed treatment and cultural practices like sowing date alterations are age old practices to mitigate the biotic stress in different crops. The collar rot pathogen *S. rolfsii* is a soil borne fungus with multiple host range and propagates at a faster rate during seedling stage of crop growth under high temperature and heavy rainfall conditions. The changing climatic conditions are portraying serious threat in chickpea by delayed monsoon and intermittent rains during October in terms of enhanced infection of collar rot pathogen.

Keeping this in view a study was conducted to identify the incidence of collar rot of chickpea and impact of farmers' seed treatment practice on their occurrence, and further impact of seed treatment and date of sowing were evaluated on occurrence of collar rot in chickpea.

Major findings of the work are-

1. Collar rot was present in all the surveyed fields/villages/blocks unexceptionally. However, the incidence significantly varied from village to village and block to block in surveyed area. The minimum mean incidence of 9.7% of collar rot was recorded in Sahpura block. However, maximum mean incidence of 33.4 % was recorded in Patan block.

2. Reduced incidence of collar rot (12.7%) could be observed in farmers' field applying seed treatment in comparison to fields sown without seed treatment (25.68%). Among the varietal performance, maximum incidence of collar rot was recorded in JG 52 and minimum in JG 24.
3. The isolated *S. rolfsii* on PDA medium exhibited snow- white coloured fluffy, compact mycelial growth with a silky lustre and formation of brown coloured, hard sclerotia could be visualized in culture on prolonged incubation.
4. In all the three tested varieties, minimum incidence of collar rot was recorded in seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed followed by *Rhizobium* + PSB + Molybdenum. Among the different seed treatments, Molybdenum alone didn't show any significant reduction in incidence of collar.
5. The incidence of collar rot of chickpea was recorded highest during early sowing (09.11.2020) and it kept on decreasing by delaying the sowing (23.11.2020 and 07.12.2020).
6. The cumulative effect of three date of sowing and seed treatments revealed minimum collar rot incidence in seed treatment with *Rhizobium* + PSB @ 10 ml/kg seed prior to sowing during first fortnight of December across three evaluated varieties.
7. The fungicidal seed treatment resulted in enhanced seed emergence and reduced collar rot incidence. Maximum seed emergence of 86.67% and minimum collar rot incidence of 5.95% was recorded in seeds treated with 0.15% carboxin + Thiram which controlled 72.67% collar rot over control.

## Conclusion

Collar rot is one of the major soil borne fungal diseases prevailing in Jabalpur district of central India and significantly cause economic losses. The farmers aware about using seed treatment practice before sowing can reduce the incidence of these diseases and cope up with the economic losses caused by collar rot pathogen to a great extent. The delayed sowing during last week of November or first week of December coupled with seed treatment using *Rhizobium* + PSB @ 10 ml/kg seed prior to sowing can be used for management of collar rot of chickpea in hot spot pockets of collar rot. For chemical management, seeds treatment with 0.15% carboxin + Thiram provides good control of collar rot pathogen in chickpea and could be used as a potential alternative in unavailability of *Rhizobium* and PSB.

## Suggestions

Although study conducted in present investigation is an intial step towards identification of hot spot pockets of collar rot and its management. However, this needs to be further continued with following suggestions for future work:

1. The survey study needs to be completed on a large scale and all the diseases should be covered to prepare the digital disease map of chickpea from Madhya Pradesh in correlation with soil conditions, topography and other climatic conditions.
2. Soil solarisation, crop rotation, as cultural and foliar application, soil drenching of different bioagents, fungicides should be evaluated on a broader scale.
3. Pathogenic ability of isolates of *S. rolfsii* from hot spot pockets should be explored with identification of genetic factor for virulence using molecular markers like Single Nucleotide Polymorphisms (SNPs), Simple sequence repeats (SSRs), Sequence characterized amplified regions (SCAR) etc.
4. The application of nano-formulations of phyto-extracts as seed treatment and foliar application can be explored to establish their role in collar rot suppression.

# Chapter - VII

# BIBLIOGRAPHY

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# APPENDICES

# APPENDICES

**Analysis of variance table**

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 5.982 | | | |
| Treatment | 4 | 92.376 | 23.094 | 3.7 | 0.05452 |
| Error | 8 | 49.934 | 6.242 | | |
| Total | 14 | 148.292 | | | |

**Set no. 2**

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 33.936 | | | |
| Treatment | 4 | 76.282 | 19.071 | 9.996 | 0.00335 |
| Error | 8 | 15.263 | 1.908 | | |
| Total | 14 | 125.48 | | | |

**Set no. 3**

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 10.288 | | | |
| Treatment | 4 | 55.138 | 13.785 | 4.057 | 0.04373 |
| Error | 8 | 27.179 | 3.397 | | |
| Total | 14 | 92.605 | | | |

**Set no. 4**

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 34.303 | | | |
| Factor A | 2 | 1,440.82 | 720.412 | 131.334 | 0.00022 |
| Error(a) | 4 | 21.941 | 5.485 | | |
| factor B | 4 | 485.237 | 121.309 | 24.205 | 0.02352 |
| Int A X B | 8 | 95.136 | 11.892 | 2.373 | 0.00006 |
| Factor C | 2 | 110.695 | 55.348 | 11.043 | 0.93567 |
| Int A X C | 4 | 4.084 | 1.021 | 0.204 | 0.91243 |
| Int B X C | 8 | 16.402 | 2.05 | 0.409 | 0.99977 |
| Int A X B X C | 16 | 14.853 | 0.928 | 0.185 | |
| Error | 84 | 420.993 | 5.012 | | |
| Total | 134 | 2,644.47 | | | |

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 30.242 | | | |
| Treatment | 9 | 656.121 | 72.902 | 12.464 | 0 |
| Error | 18 | 105.283 | 5.849 | | |
| Total | 29 | 791.646 | | | |

| Source of variation | DF | Sum of squares | Mean squares | F-calculated | Significance |
|---|---|---|---|---|---|
| Replication | 2 | 70.158 | | | |
| Treatment | 9 | 1,274.44 | 141.605 | 9.277 | 0.00004 |
| Error | 18 | 274.743 | 15.263 | | |
| Total | 29 | 1,619.34 | | | |

# CURRICULUM VITAE

# CURRICULUM VITAE

The author of the thesis, **Priya Tiwari** D/o Late Surendra Tiwari and Smt. Urmila Tiwari was born on 17th October 1994 at Dist. Jabalpur MP. She passed her SSC with 8.0 CGPA in the year 2010 from Maharishi Vidya Mandir school, Dist. Jabalpur, Madhya Pradesh and higher secondary school with 62% in 2013 from Central Board of Secondary Education. Later, she took admission for B.Sc. (Ag) at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 2015. She has successfully completed her graduation with 7.6 OGPA out of 10 points scale in the year 2019. For further study, she took admission for M.Sc. (Ag.) with specialization in Plant Pathology in the College of Agriculture, JNKVV, Jabalpur (M.P), where she successfully completed all the course requirement for Master's degree with OGPA 7.46 out of 10 points scale (74.6) in the year 2021. For the partial fulfilment of the master's degree programme, she was allotted with a research work entitled "Studies on Integrated management of collar rot of chickpea", which is duly completed by her and presented in the form of thesis.