Introduction

CHAPTER 1 INTRODUCTION

Pulse crops occupy very important position in India as they contain nearly three times as much protein as in the cereals. They are, therefore, the main source of protein (Jeswani and Vanchaik, 1968; Chand and Srivastava, 1982) for the predominantly large vegetarian population of the country. Being rich source of protein, they provide about 20% (approx. 150 tonnes) of the world production of plant protein (Sharma and Varshney, 1999). The protein of pulses is nutritionally superior and important as the amino acid and lysine is found in larger quantity than in the cereal protein (Kharkwal, 1998d). Pulses are cultivated in almost all the states of India either alone or mixed with other crops. Legumes include pulses, vegetable and rich source of fodder for cattle (Kaul and Sekhan, 1974), and green manuring.

These crops are generally included in cropping system patterns as they help to keep the soil alive and productive because of their ability to fix atmospheric nitrogen with the help of nitrogen fixing bacteria. In India, legume crops are cultivated in 22.47 million hectares with an average production of 13.38 million tonnes (Ali *et al.*, 2006).

Chickpea (*Cicer arietinum* L.), a pulse crop belongs to the family Fabaceae, is believed to have originated in south Eastern Turkey and adjoining parts of Syria (Singh, 1997).

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops of India and the best legume for human consumption. It occupies about ¾ of wheat acreage of India and constitutes nearly 2/5 of the pulse crops of the country. Chickpea was grown over an area of 7.22 million hectare with a production of 6.01 million tonnes.

Chickpea is always cultivated as a winter (Rabi) crop throughout India, specially in the northern states like, Uttar Pradesh, Himachal Pradesh, Rajasthan and Haryana accounting for more than 6 million hectares (Ramanujan, 1997). It is grown alone or mixed with wheat, barley, linseed and mustard. Chickpea does not need very fine seed bed. Sowing is done in October and November. The crop matures within 90 to 150 days after sowing, depending upon the crop variety. Harvesting is usually done from middle of March to April.

Chickpea is a good source of protein (25.3-28.9%), fibre (3.0%), oil (4.8-5.5%), ash (3.0%), calcium (0.2%), phosphorus (0.3%). Digestibility of protein varies from 76-78% and its carbohydrate from 57-60% (Hulse, 1991; Huisman and Van der Poel, 1994). Raw whole seeds contain per 100 g: 357 calories, 4.5-15.69% moisture, 14.9-24.6 g protein, 0.8-6.4% fat, 2.1-11.7 g fibre, 2-4.8 g ash, 140-440 mg Ca, 190-382 mg P, 9.0 mg Fe, 0.0-225μg β-carotene equivalent, 0.21-1.1 mg thiamin, 0.12-0.33 mg riboflavin and 1.3-2.9 mg niacin (Duke, 1981; Huisman and Van der Poel, 1994). The amino acid composition of seeds with 19.5% protein, 5.50% oil is (per 16 g N): 7.2 g lysine, 1.4 g methionine, 8.8 g arginine, 4.0 g glycine, 2.3 g histidine, 4.4 g isoleusine, 7.6 g leusine, 6.6 g phenylalanine, 3.3 g tyrosine, 3.5 g threonine, 4.6 g valine, 4.1 g alanine, 11.7 g aspartic acid, 160 g glutamic acid, 4.3 g proline, and 5.2 g serine (Duke, 1981; Huisman and Van der Poel, 1994; and Williams *et al.*, 1994).

Chickpea seeds are eaten fresh as green vegetables, parched, fried, roasted, and boiled; as snack food, sweet and condiments; seeds are ground and the flour can be used as soup, dal, and to make bread. Dal is the split chickpea without its seed coat, dried and cooked into a thick soup or ground into flour for snacks and sweetmeats (Hulse, 1991). Sprouted seeds are eaten as a vegetable or added to salads. Young plants and green pods are eaten like spinach. Animal feed is another use of chickpea in many developing countries. Gram husks, and green or dried stems and leaves are used for stock feed, whole seeds may be used as meal directly for feed. Although most of the chickpea production and consumption is in India (>70%), the crop is also important in other countries of Asia, Europe and America (ICRISAT, 1986).

Agriculture is one of the major factor of the Indian economy, as 70% of population is dependent upon it for their livelihood and contributes over 40% of the gross production. Some most important crops are attacked by various kinds of pathogens viz. plant parasitic nematodes, fungi, viruses and bacteria either alone or in association with one another and causes serious damage to plants.

Plant-parasitic nematodes continue to threaten agricultural crops, throughout the world. Estimated over all average annual yield loss of the major crops due to damage caused by phytoparasitic nematodes is 12.3% while in chickpea alone it is 13.7% (Sasser, 1989). The national loss due to plant parasitic nematodes in 24 different crops in monetary terms has been worked out to the tune of 21068.73 million rupees. That the financial assistance given during Xth plan for nematode research under AICRP on Nematodes was 5.7 per cent of the monetary losses caused by phytonemtodes (Jain *et al.*, 2007)

Root-knot nematodes cause severe growth retardation of plants with fewer and smaller chlorotic leaves and produce root galls. On the roots due to hypertrophic and hyperplasia activities in the root tissues under the influence of endoparasitic sedentary nematodes.

Chickpea, like other food legume crops, are also affected by several soil borne fungal pathogens that infect and injure roots and lower stem tissues. Chickpea is frequently attacked by a wilt caused by *Fusarium oxysporum* f.sp. *ciceri* which is world wide in distribution (Woltz and Jones, 1981; Nene *et al.* 1981, 1989). The fungus causes severe yield losses in chickpea, in India it is 10-15%, which in years of severe epidemics may rise to 60-70% (Jalali and Chand, 1992). The disease is wide spread in the chickpea growing areas of the world and reported from at least 33 countries (Nene *et al.*, 1996). However, it was observed that early wilting causes 77-94% losses while late wilting causes 24-65% losses (Haware and Nene, 1980). The pathogen is both seed and soil borne; facultative saprophyte and can survive in soil up to six years in the absence of susceptible host (Haware *et al.*, 1986 b).

The *Rhizoctonia* fungus is also a soil inhabitant and causes serious disease on many hosts by affecting the roots, stem, tubers, corns and other plant parts. *Rhizoctonia* is known as sterile fungus. Its perfect stage is *Thanatophorus cucumaris*. The disease caused by *Rhizoctonia* determined throughout the world and causes losses on most annual plants including almost all vegetables and several field crops (Pascual *et al.*, 1988).

Among various pests and diseases, nematode fungus disease complex particularly of root-knot nematode, *Meloidogyne incognita* and wilt fungus *Fuarium oxysporum* poses a great problem to the cultivation of pulse crops by inflicting severe yield losses (Perveen *et al.*, 1999; De *et al.*, 2000; Mahapatra and Swain, 2001). There are large number of fungi inhabiting the rhizosphere, which might have influencing the disease complex situation involving nematodes and pathogenic fungi. Therefore, it becomes imperative to manage these pathogens on their respective hosts in order to have more economic value and better quality of crops. Since many of the most commonly used pesticides for disease management are expensive or being withdrawn from the market due to their harmful effects on humans, their persistence in the soil or their contamination of ground water. Using resistant varieties have been found to be susceptible after some years because of breakdown in their resistance and evolution of variability in the pathogen. Therefore, biological control and organic amendments are the only solution to maintain plant health. That's why investigators are concentrating their efforts on integrating biological control agents in plant disease management strategies (Jatala, 1986). The use of microorganisms that can grew in the rhizosphere are ideal for use as biological control agents. Rhizosphere provides the initial barrier against pathogen attack to the root (Weller, 1988). However, despite this wide interest, only a few biocontrol products are commercially available at present (Upadhyay and Rai, 1988). Of the various microorganisms present in the rhizosphere, *Rhizobium*, antagonistic fungus, *Trichoderma harzianum* and oil cakes with high nitrogen contents are noteworthy as biocontrol agents.

Rhizobia (Greek word Rhiza = Root and bios = Life) are soil bacteria that fix nitrogen after becoming established inside root nodules of legumes (Fabaceae) and produce toxic metabolites inhibitory to many plant pathogens (Haque and Ghaffar, 1993).

Roslycky (1967) reported production of an antibiotic bacteriocin while Chakroborty and Purkayastha (1984) reported greater production of phytoalexin from seeds having *Rhizobium*. Chickpea like other legumes are capable of fixing and utilizing atmospheric nitrogen through symbiotic relationship with *Rhizobium* bacteria. The crop thus improve soil fertility and economize crop production not only for themselves but also for the next cereals and non-legume crops grown in rotation and thereby minimizing the regular rate of nitrogen fertilizer. All this suggest that application of *Rhizobia* bacteria increases nitrogen and plant growth, which results in protecting plants from damage caused by pathogens. Legumes stimulate rhizobia much more than other rhizospheric microorganisms (Nutman, 1965).

Trichoderma is a cosmopolitan saprophytic fungus widely used as a biological control agent in the fight against plant diseases caused by economically important plant pathogens. *Trichoderma* are common in soil (especially water logged soil), dung and decaying plant materials. *Trichoderma* spp. are strongly antagonistic to nematodes and other fungi. *Trichoderma* spp. indeed have the ability to control plant diseases. It can colonize and protect the entire root system of the crop. Moreover, it is effective against a wide range of plant pathogenic fungi including *Pythium* spp., *Rhizoctonia solani, Fusarium* spp., *Botrytis cinerea, Macrophomina phaseolina, Sclerotium rolfsii,* and *Sclerotinia homoeocarpa* ((Elad *et al.*, 1971; Bell *et al.*, 1982; Wells *et al.*, 1972; Sivan *et al.*, 1987, 1993; Ghaffar, 1992; Inbar *et al.*, 1996; Naseby *et al.*, 2000, Bunker and Mathur, 2001; Khan *et al.*, 2004; Srobarova and Eged, 2005; Brewer and Larkin, 2005; Dubey *et al.*, 2006; Santamarina, 2006; Rojo, 2007 and Nikam, 2007).

Use of plant residues and organic amendments has been recognized as an effective way of achieving substantial population reduction of plant pathogenic life forms like nematodes, fungi etc. Organic amendments such as oil cakes and biocontrolling agents have been reported by several workers for the management of plant diseases (Anver, 2003; Ahmad *et al.*, 2004). Combined use of organic amendments (oil seed cakes) and microbes appears to be an interesting approach for the maintenance of soil productivity, as well as useful in management of root-knot, *Fusarium* wilt, root-rot diseases and improvement of plant growth. For a healthy environment there is a need to develop safe and effective methods for biocontrol to nematode and fungal diseases.

The aim of the present study is to focus attention on microbes which can be used for the management of root-knot nematode (*Meloidogyne incognita*) and fungi (*Fusarium oxysporum f. sp. ciceri* and *Rhizoctonia solani*) on chickpea. The present work is having following aspects –

1. Effect of different inoculum levels of root-knot nematode, *Meloidogyne incognita* on plant growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

2. Effect of different inoculum levels of wilt fungus, *Fusarium oxysporum* f. sp. *ciceri* on plant growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

3. Effect of different inoculum levels of root-rot fungus, *Rhizoctonia solani* on plant growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

4. Effect of individual and concomitant inoculations of variable inoculum levels of root-knot nematode, *Meloidogyne incognita* and wilt fungus, *Fusarium oxysporum* f. sp. *ciceri* on plant growth, nematode multiplication and wilt index in chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

5. Effect of individual and concomitant inoculations of variable inoculum levels of root-knot nematode, *Meloidogyne incognita* and root-rot fungus, *Rhizoctonia solani* on plant growth, nematode multiplication and root-rot index in chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

6. Effect of variable inoculum levels of biocontrol agent, *Trichoderma harzianum* with root-knot nematode, *Meloidogyne incognita*; wilt fungus, *Fusarium oxysporum* f. sp. *ciceri* and root-rot fungus, *Rhizoctonia solani* on plant growth, nematode multiplication, wilt and root-rot index in absence and present of *Rhizobium*.

7. Effect of individual and simultaneous inoculation of biocontrol agent *Trichoderma harzianum*, root-knot nematode, *Meloidogyne incognita* and wilt

fungus, *Fusarium oxysporum* f. sp. *ciceri* on nematode multiplication, wilt index and plant growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

8. Effect of individual and simultaneous inoculation of biocontrol agent, *Trichoderma harzianum*, root-knot nematode, *Meloidogyne incognita* and root-rot fungus, *Rhizoctonia solani* on nematode multiplication, root-rot index and plant growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

9. Effect of neem, castor, piludi and sunflower seed cakes and biocontrol agent, *Trichoderma harzianum* on the development of root-knot nematode, *Meloidogyne incognita* and wilt fungus, *Fusarium oxysporum* f. sp. *ciceri* and on the growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.

10. Effect of neem, castor, piludi and sunflower seed cakes and biocontrol agent, *Trichoderma harzianum* on the development of root-knot nematode, *Meloidogyne incognita* and root-rot fungus, *Rhizoctonia solani* and on the growth of chickpea (*Cicer arietinum*) var. Avrodhi in the absence and presence of *Rhizobium*.