Introduction
Globally, chickpea (*Cicer arietinum* L.) is the third most important food legume, grown in over 40 countries representing all the continents. Over 95% of the area, production and consumption is in developing countries. Chickpea is the most important pulse crop of India and occupies 7.1 million ha with a production of 5.7 million tons, accounting for 30.9% and 39.9% of total pulse area and production, respectively. The main chickpea producing areas are the upper basin Ganga and Yamuna viz. Punjab, Haryana, Uttar Pradesh and Bihar and the adjoining tracts of central India viz. Rajasthan, Madhya Pradesh and Maharashtra (Anonymous, 2006).

Chickpea is an important food legume that provides many dietary nutrients and phytochemicals, especially in Asian and Middle Eastern countries. Although, predominantly consumed for its protein content, chickpea seeds also contain various carotenoids that can serve as vitamin 'A' precursors, and/or as an antioxidant molecules. On an average chickpea seeds contain 23% protein, 64% total carbohydrates, 47% starch, 5% fat, 6% crude fiber, 6% soluble sugar and 3% ash. The mineral component is high in phosphorus (340mg/100g), calcium (190mg/100g), magnesium (140mg/100g), iron (7mg/100g) and zinc (3mg/100g). Chickpea protein digestibility is the highest among the dry edible legumes. The lipid fraction is high in unsaturated fatty acids, primarily linolic and oleic acids. Chickpea is mainly used for human consumption and only a small proportion is used as feed. Chickpea is also known for its use in herbal medicine and cosmetics. Chickpea meets 80% of its nitrogen requirements from symbiotic nitrogen fixation and can fix up to 140 kg N ha\(^{-1}\) from air. It also leaves substantial amount of residual nitrogen behind for subsequent crops and adds much needed organic matter to maintain and improve soil health, long term fertility and sustainability of the ecosystems (www.icrisat.org).
Chickpea suffers more than 50 diseases caused by fungi, bacteria, viruses and nematodes (Nene and Reddy, 1987), which lower the quality and quantity of the produce of this crop throughout the world.

Plant parasitic nematodes are one of the important limiting factors of plant growth and productivity, as they cause great destruction to plants singly or in collaboration with other pathogens and parasites. There is hardly any economic crop and for that matter any plant which is not being parasitized by one or more nematode species at a given time. The crop losses due to nematodes are not only in the form of reduced plant growth and yield but are also in the marketable quality of the produce. Plant parasitic nematodes cause US $ 125 billion of losses to world agriculture annually (Chitwood, 2003).

The reniform nematode (*Rotylenchulus reniformis*), a semi-endoparasite, is largely known to be a serious problem of chickpea in tropics, semi-tropics and warmer areas of temperate zone. As implied by common name, the mature females assume a reniform or kidney shape, then produce eggs in a gelatinous matrix, which usually occurs on the external surface of roots and are most frequently seen after a gentle wash of chickpea roots. Reniform nematode has been reported from chickpea plants grown in India, Syria, Tunisia, Ghana and Mediterranean countries (Lamberti, 1981; Oteifa, 1987; Ali, 1995). Reniform nematode is widely distributed in India and has wide host range. It has been reported on chickpea in Andhra Pradesh, Gujarat, Madhya Pradesh, Orissa, Uttar Pradesh and Bihar (Sharma and Sharma, 1998). In Uttar Pradesh the reniform nematode is wide spread in chickpea growing areas of Aligarh, Agra, Bulandshar, Ghaziabad, Kanpur and Mathura (Ali, 1995). Moreover, chickpea is also a victim of large number of fungal diseases occurring from pre-emergence to the maturity of crop. The various fungal diseases of chickpea in India are wilt disease (*Fusarium oxysporum* f. sp. ciceri (Padwick) Snyder & Hans.), dry root-rot *Rhizoctonia bataticola* (Taub.) Butler, wet root-rot (*R. solani* Kühn), collar-rot (*Sclerotium rolfsii* Sacc.), stem-rot (*Sclerotinia sclerotiorum* (Lib.) de Bary), foot-rot (*Operculella padwickii* Khesw.), black root-rot (*Fusarium solani* (Mart.) Sacc.) Ascochyta blight (*Ascochyta rabiei* (Pass.) Lab.), Alternaria blight (*Alternaria alternata* (Fr.) Keissler) and powdery mildews caused by *Leveillula taurica* (Lév.) Arnaud and *Erysiphe* Hedw. Ex Fr. (Anonymous, 1992; Ali, 1995; Bhargava et al., 1981).

Increased industrialization and human activities have impacted on the environment through the disposal of waste containing heavy metals. Mine drainage, metal industries, refining, electroplating, dye and leather
industries, domestic effluents, landfill leachate, agricultural runoff and acid rain contribute such a kind of waste (Aksu and Kutsal, 1990).

Heavy metals are defined as metals with a density higher than 5g cm\(^{-3}\). Fifty three of the 90 naturally occurring elements are heavy metals, but not all of them are of biological importance. Based on their solubility under physiological conditions, 17 heavy metals may be available for living cells and of importance for organisms and ecosystems (Weast, 1984). Among these metals, Fe, Mo and Mn are important as micronutrients; Zn, Ni, Cu, V, Co, W and Cr are toxic elements with high or low importance as trace elements; As, Hg, Ag, Sd, Cd, Pb and U have no known function as nutrients and seem to be more or less toxic to plants and microorganisms (Nies, 1999). The heavy metals released as toxic effluents from smelters are deposited into near by ecosystem (Arnesen et al., 1995) and migration of these contaminants into non-contaminated areas as dust or leachates through the soil and spreading of heavy metal containing sewage sludge are examples of events that contribute towards the contamination of our ecosystems (Atiemanav and Alok, 2004).

In recent years several studies have shown the harmful effects of metals on microbial diversity and activity in soil (McGrath, 1994). The heavy metal pollution has become a matter of concern in India over a last few decades. Industrialization in India gained a momentum with initiation of five-year development plan in the early 50's. The pollutants of concern include lead, chromium, mercury, uranium, selenium, gold, silver, copper and nickel. These toxic metals may be derived from mining operations, refining ores, sludge disposal, fly ash from incinerators, the processing of radioactive materials, metal plating or the manufacture of electrical equipments, paints, alloys, batteries, pesticides or preservatives. Heavy metals such as zinc, lead and chromium have a
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number of applications in basic engineering works, paper and pulp industries, leather tanning, organochemicals, petrochemicals, fertilizers, etc. Major lead pollution is through automobiles and battery manufacturers. For zinc and chromium, the major application is in fertilizer and leather tanning, respectively (Trivedi, 1989). As man continues to add pollutants to the environment, they continue to be widely dispersed. As a result, plants, plant pathogens and plant pathogenesis are all being affected. At present, very little is known on the effects of pollutants on pathogenic diseases of plants. The pollutants may affect the pathogenesis in different way: it may be increased or decreased through a direct effect of the pollutant-induced changes in the host plant or through changes in other aspects of the environment. With all pollutants, the threshold concentration required to injure plants is affected by the resultant of duration of exposure × concentration of pollutant and a multitude of interacting biological and meteorological variables (Parveen, 1995).

Among the abiotic cause of plant diseases, industrial and other chemical pollutants are important in relation to crop cultivation (Heagle, 1982). The use of waste water containing heavy metals for irrigation cause phytotoxicity and predispose plants to pathogenic damage (Cole et al., 1969). Moreover, several workers have investigated the effect of heavy metals on plant growth (Hagemeyer, 1999; Kukkola et al., 2000), and microorganisms including plant pathogens such as bacteria (Rajapaksha et al., 2004), fungi (Somashekar et al., 1983; Parveen and Alam, 1998) and nematodes (Hafkenscheid, 1971; Haight et al., 1982; Sturhan, 1986; Khan and Salam, 1990; Parveen and Alam, 1998; Khan et al., 2006).

In India, Aligarh is a major lock-manufacturing city for more than 70 years. During this period, large amount of heavy metals emitting
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from various lock manufacturing and electroplating industries has increased considerably during the last three decades. During a course of survey in various chickpea growing areas on both sides of Mathura Road, Aligarh district of Uttar Pradesh, more or less constant infections of reniform nematode, *Rotylenchulus reniformis* and root-rot fungus, *Fusarium solani* were observed on the roots of chickpea plants. Further investigation on the soil of these fields indicated the presence of high concentrations of heavy metals viz. chromium (94ppm) and nickel (118ppm). The association of either reniform nematode or root-rot fungus with heavy metals was invariably associated with the, stunting of plants, yellowing of leaves and ultimately death of certain plants. The source of irrigation in these fields is waste water coming from different industrial areas of Aligarh.

The information regarding the effect of heavy metals viz. Cr and Ni on reniform nematode, *R. reniformis* and root-rot fungus, *F. solani* infecting chickpea has not been furnished so far as indicated by the scanning of literature. So in order to furnish this information the present work was carried out to study the effect of chromium and nickel on pathogenic potential and management of *R. reniformis* and *F. solani* on chickpea var. Kranti with following objectives:

1. Identification of race of reniform nematode, *Rotylenchulus reniformis* associated with chickpea.

2. Studies on the effect of chromium and nickel on the hatching and mortality of *R. reniformis in vitro*.

3. Studies on the effect of chromium and nickel on the growth, sporulation and heavy metal uptake of *Fusarium solani in vitro*. 
4. Studies on potential pathogenic level of reniform nematode, _Rotylenchulus reniformis_ and root-rot fungus _Fusarium solani_ on chickpea.


6. Studies on the accumulation of chromium and nickel in chickpea plants infected with _R. reniformis_ and _F. solani_.

