Abstract

Cultivation of leguminous crops is worldwide from ancient times because of their economic utility being next to cereals only (Allen and Allen, 1958). In India, legumes are cultivated in almost all the states either alone or mixed with other crops. Legumes include pulse, vegetable, fodder and green manuring crops. Since pulses contain nearly three times as much proteins as in the cereals and because proteins from pulses are cheaper they occupy a significant place in the Indian diet as one of the main sources of protein. (Jeswani and Vanchaik, 1968; Chand and Shrivastava, 1982). A mixed diet consisting of pulses and cereals is almost as rich in proteins as obtained from the animal products (Panikkar, 1968). Moreover, a significantly large population of India being vegetarian, pulses play a key role in the daily diet of Indian people. They constitute a rich source of fodder for cattle also (Kaul and Sekhon, 1974), and are generally used for green manuring.

Pulse crops also play a significant role in maintaining soil fertility as they have a unique mechanism for using the inert nitrogen gas directly from the soil atmosphere (Chowdhary, 1968). It is estimated that about 14 to 53 metric tonnes of nitrogen is fixed annually by the symbiotic association between nitrogen fixing bacteria and the legumes (Quispel, 1974). The forage legumes fix approximately 125-300 kg nitrogen/hectare/year and pulse legumes fix about 50 to 60 kg nitrogen/hectare/year (Mishustin and Shilnikova, 1971). The total production of pulses in our country was 13.07 million tonnes (MT) in the year 1999-2000 and the crop grown over 22.85 million hectares, yielded 57 kg per hectare till now.

Lentil is one of the principal pulses crop in common use in India. The
unripe pods are used as a green vegetables and dry leaves, stalks, husk and broken grain as cattle feed. It is cultivated in all parts of India especially Bengal, Madras, M.P. and U.P. (Watt, 1890). It is sown in all kinds of soil. In the Kashmir valley, it is grown for green manuring paddy. Generally it is a winter crop, Randhawa (1958), is of the opinion that it is also grown as kharif crop in some parts of the country. It contains (25.1%) protein next to Soyabean (43.2%).

In spite of some significant achievements, pulses research and development still face many challenges. According to World Health Organisation (WHO) and Food and Agricultural Organisation (FAO), the per head pulse requirement for a day is 80 gms. But, unfortunately the production of pulse crop is far below the approved per capita. It is reported that the availability of pulses per capita declined sharply from 64 gms in 1951-56 to less than 40 gms in 1985-86. The government has set up the 27 mission mode projects operationalized under the National Agricultural Technology Project (NATP), for focused research on issues of critical importance. The basic object of NATP is region specific and economically safe Integrated Pest Management (IPM) models developed for cotton, rice, pulses, vegetables and oil seeds.

In the tropical substance agriculture, the yield of pulses are often far below the World standards. One of the causes could be loss due to poor plant protection measures, various pathogens such as bacteria, fungi, viruses and nematodes, cause serious damage to pulse crops either alone or in association with one another.
Though, the plant parasitic nematodes often cause severe damage to cultivated crops, their role as a limiting factor in Agricultural production has not been generally appreciated. These microscopic organisms, sometimes also called thread worms, eelworms, round worms, etc. mostly inhabit the soil in association with the roots of plants. A few species feed on the aerial parts of plants too, such as stems, leaves, earheads, grains etc. Unlike insects and other disease-causing agents like bacteria, fungi and viruses, nematode populations increase rather slowly, and the diseases caused by them are, generally, not of sudden epidemic type resulting in obvious destruction of the crop over vast areas in a matter of days, but cause slow decline in yields spreading over years.

Plant parasitic nematodes by themselves are capable of causing severe disease symptoms but in the presence of other soil micro-organisms, the damage at times, becomes devastating. In fact under field conditions there is probably no soil borne plant diseases which can be said to have monopathogenic origin. Thus most of the soil borne plant diseases are of the result of interaction of two or more pathogens of the same or different groups causing complex diseases. Several such associations involving fungi, bacteria and nematodes have been investigated. During the last 4-5 decades considerable attention has been paid to the complex diseases caused by the interaction of nematodes and fungi (Powell, 1971a, b; Nath et al., 1984; Kumar and Sivakumar, 1981; Edward et al., 1984; Tiwari, 1998; Abdel-Momen and Starr, 1998; Kumar and Sivagami, 1999).

Occurrence of *Rotylenchulus reniformis* (Linford and Oliveira, 1940 and a fungus, *Rhizoctonia solani* Kühn was observed in lentil growing areas of Aligarh District of Uttar Pradesh, India. It was observed that there were patches
in the field, where the lentil plants were badly damaged as compared to nearby plants in the same field. Isolation of nematode from the roots and soil and fungus from roots of such plants indicated heavy infestation of \textit{R. solani} and \textit{R. reniformis}. However, in other neighbouring areas where these pathogens were present singly, the damage was comparatively lesser.

Keeping in view the importance of the crop and the association of nematode and the fungus observed in the field, it was considered desirable to study whether this aggravated damage was causal or due to the result of interaction between nematode and fungus on lentil crop. With this aim in view the following aspects have been studied.

\textbf{Varietal reaction of lentil to the test nematode and fungi :}

Twenty varieties of lentil (DPL-25, DPL-26, DPL-28, DPL-33, DPL-35, DPL-36, DPL-38, DPL-39, DPL-40, DPL-42, DPL-43, DPL-44, LH-88-8, DPL-47, LH-90-54, LH-90-57, LH-90-85, LH-90-103, LH-90-84 and LH-90-87) were screened for their reaction to the reniform nematode, \textit{Rotylenchulus reniformis} and also to host specific fungi such as root-rot fungus, \textit{Rhizoctonia solani} on lentil, using different inoculum levels. The resistance/susceptibility reaction was assessed not only on the basis of multiplication rate in case of \textit{R. reniformis} and root-rot index in case of \textit{R. solani}, but also on the basis of reduction in different plant growth parameters. In presence of \textit{Rhizobium}, lentil varieties DPL-43, LH-90-57, DPL-44 and LH-90-85 were found resistant to \textit{R. reniformis} where as LH-90-85 to \textit{R. solani}.

In case of lentil, the root-rot fungus was found to be most damaging while the reniform nematode the least. The inoculum level
of the pathogens was found directly correlated to the extent of plant damage in terms of length, fresh and dry weight of plants, pod-numbers, chlorophyll content and root-nodulation. Reproduction factor of nematode was found high at low inoculum level but reduction in growth parameters was less at low inoculum level. However, at the higher inoculum level, the reproduction factor decline sharply but plant growth was affected adversely. Nematode multiplication was increased as the inoculum level increased (Tables-1a, 2a).

The reaction of different varieties of lentil to the test pathogens was also studied in absence of Rhizobium. It was revealed that all the test pathogens brought about greater damage to various growth parameters. Moreover, the cultivars found resistant in presence of Rhizobium, showed susceptibility in absence of Rhizobium to varying extent (Tables-1b, 2b).

**Influence of antagonistic fungi against nematode and fungi on lentil:**

In a pot study, influence of some antagonistic fungi (P. lilacinus, T. viride, A. niger, V. chlamydosporium, A. oligospora) were assessed against R. reniformis singly or in combination with R. solani on lentil. Among all the antagonistic fungi, P. lilacinus was found to be highly effective followed by T. viride, A. niger, V. chlamydosporium and A. oligospora in limiting the detrimental effects of the pathogens. The different treatments were found to be more effective to R. reniformis than R. solani. As a consequence, plant growth parameters such as plant length, fresh weight, dry weight, pod number, chlorophyll content and root-nodulation improvement was observed (Tables-3a, 4a, 5a, 6a
and 7a). A similar experiment was also done in the absence of *Rhizobium* (unbacterized seeds), here in this case the overall growth of plants was less, both in pathogen inoculated as well as uninoculated plants (Tables- 3b, 4b, 5b, 6b and 7b).

**Effect of oil-seed cakes in combination with *P. lilacinus* against nematode and fungi on lentil:**

In a pot study, efficacy of different oil-seed cakes (neem, castor, mahua, mustard, sesame, soybean, groundnut, linseed, karanj, duan) were also evaluated against *R. reniformis* and soil-inhibiting fungi, *R. solani* on lentil. Among all oil-seed cakes, neem-seed cake was found to be highly efficacious followed by castor, mahua, mustard, sesame, soybean, groundnut, linseed, karanj, duan in limiting the detrimental effects of the pathogens.

Highest inhibition in population of *R. reniformis* was noted in beds treated with neem-seed cake and *P. lilacinus* followed by castor, mahua, mustard, sesame, soybean, groundnut, linseed, karanj, duan. Moreover, less similar pattern was also noted in the reduction of frequency of pathogenic fungi. Frequency of saprophytic fungi increased in beds treated with oil-seed cakes and *P. lilacinus* where neem-seed cake with *P. lilacinus* gave the best results followed by castor, mahua, mustard, sesame, soybean, groundnut, linseed, karanj, duan-seed cake (Tables-8a, 9a, 10a, 11a, 12a, 13a, 14a, 15a, 16a, 17a).

As a consequence of reduction in the population of *R. reniformis* and frequency of *R. solani*, the plant growth (length, fresh
weight, dry weight, pod number, chlorophyll content and root-
nodulation) of lentil improved. Moreover, there was positive
correlation between the improvement in plant growth and reduction
in pathogenic nematode and fungi (Tables-8a, 9a, 10a, 11a, 12a, 13a,
14a, 15a, 16a, 17a).

A similar experiment was also done in the absence of *Rhizobium*
(unbacterized seeds), here in this case the overall growth of plants was
less, both in pathogen inoculated as well as uninoculated plants (Tables-
8b, 9b, 10b, 11b, 12b, 13b, 14b, 15b, 16b, 17b).

The effect of different treatments also persisted even after a
lapse of 12 months in the next growing season when lentil was
grown. The population of *R. reniformis* as well as frequency of *R.
solani* could not increase as freely as in case of untreated beds,
consequently improving plant growth characters. In this crop, the
multiplication of nematode was below the initial population of the
preceding crop in all the treatments.