6. SUMMARY AND CONCLUSION

During the investigation *Trichoderma* species are widely isolated and found in variety of different soil types, other substrates of planted materials, or heavily infested humus material, or in cultivated as well as from baren or non cultivated soils from different locations of Delhi, Haryana and Uttar Pradesh having a variety of vegetation during the temperature range of 15.5 to 42°C and normal humidity of 50 - 65 % and with normal pH level. About 600 soil samples from various substrata and locations were collected. Mostly eight species namely *Trichoderma citrinoviride*, *T. flavofuscatum*, *T. hamatum*, *T. harzianum*, *T. koningii*, *T. virens*, *T. viride* and *T. longibrachiatum* were identified and brought into axenic cultures on the basis of conidiophores, conidiogenous cell and conidia.

The effect of seasonal variation showed that the best growth of *Trichoderma citrinoviride* was recorded during November to January when the temperature ranged in between 12.7-19.3°C with 63-67 % humidity level and the rainfall recorded to the extent of 32.2 mm. *Trichoderma flavofuscum* was recorded during November at 10.5-28.1°C thus more prevalent at lower range of temperature. *Trichoderma hamatum* recorded best during August and September at 22.6-31.1°C with humidity ranged in between 60-70 %. *Trichoderma harzianum* recorded best during November and December at temperature ranged in between 12.7-19.3°C, with humidity recorded in between 63-67 %. *Trichoderma koningii* recorded best during November to February when temperature ranged at 12.7 to 19.3°C at 63-67 % humidity level. *Trichoderma virens* recorded best during May and June when temperature recorded in between 31.2-33.7°C with 46-51 % humidity. *Trichoderma viride* recorded best during November to February when temperature ranged in between 15.5-19.3°C. *Trichoderma longibrachiatum* recorded best during December to February when temperature recorded in between 2.7-15.5°C with 67-72% humidity level and rainfall recorded 2.2-32.2 mm.
Trichoderma citrinoviride grew best in PDA and CAM in linear growth of 85 mm followed by SNA, MEA and OMA (50-65 mm diam growth) and least in TSM (25 mm diam growth). Trichoderma flavofuscum grew best in PDA, (80 mm) followed by MEA, OMA (40-55 mm diam growth) and least in SNA, CAM and TSM (20-30 mm diam growth) in linear growth. Trichoderma hamatum grew best in MEA, PDA, and SNA (60-75 mm diam growth) and poorly in CAM, OMA and TSM (20-40 mm diam growth) in linear growth. Trichoderma koningii grew best in PDA and CAM (80-85 mm) followed by SNA (60 mm diam growth), and OMA MEA (30-40 mm diam growth) and least in TSM (20 mm diam growth) of linear growth. Trichoderma virens grew best in SNA, PDA and MEA (70-85 mm diam growth) than in CAM (60 mm diam growth) followed to OMA (45 mm diam growth) and least in TSM (35 mm diam growth) in linear growth. Trichoderma harzianum grew best in PDA (85 mm) followed by OMA, CAM and SNA (70-80 mm diam growth) and least in TSM and MEA (50-55 mm diam growth) in linear growth. Trichoderma viride grew best in PDA, CAM, (75-85 mm diam growth) than in Oatmeal Agar (65 mm diam growth), and least in TSM and MEA (30-40 mm diam growth) in linear growth. The Trichoderma longibrachiatum grew best in PDA (60 mm diam growth) followed by SNA, MEA and OMA (40-50 mm diam growth) and least in TSM and CAM (30 mm diam growth) each in linear growth. PDA and CAM have proved to be the best media for the growth of all Trichoderma species (30-85 mm diam growth) followed by SNA, MEA, OMA (40-65 mm diam growth) and least in TSM (25-50 mm diam growth) in their linear growth.

Most favorable temperature for the eight Trichoderma species was found in between 25-30°C where, the growth average recorded in between (53-90 mm diam growth), second best temperature was recorded at 20°C where growth average varies in between (34-60 mm diam growth) and least at 15°C where growth rate was in between 18-32 mm diam growth. However none of the Trichoderma species grew at 40°C.

pH had a significant influence on the growth and sporulation of Trichoderma species. Trichoderma citrinoviride grew best at pH-5 followed

None of the isolate of eight different *Trichoderma* species grew at water potential maintained at -6.0 Mpa. While all the eight grew well (linear growth 52-90 mm) at -0.9 Mpa and -2.3 Mpa, followed by -3.7 (linear growth 42-71 mm) and least at -4.6 Mpa (linear diameter 21-58 mm) across the colonies of *Trichoderma* species. The best growth (linear growth 90 mm) was recorded when the water potential was adjusted at -0.9 Mpa to -2.3 Mpa for *Trichoderma koningii* and *Trichoderma longibrachiatum* followed by *Trichoderma flavofuscum* (linear growth 78 mm at -0.9 Mpa and 57 mm at -2.3 Mpa), *Trichoderma viride* (linear growth 75 mm at -0.9 Mpa and 66 mm at -2.3 Mpa), *Trichoderma virens* (linear growth 73 mm at -0.9 Mpa and 70 mm at -2.3 Mpa) and least in *Trichoderma hamatum* (linear growth 53 mm at -0.9 Mpa and 52 mm at -2.3 Mpa). The water potential adjusted at -3.7 Mpa adjudged third best. Among this group *Trichoderma longibrachiatum* and *Trichoderma koningii* grew well followed by *Trichoderma viride, Trichoderma flavofuscum, Trichoderma harzianum, Trichoderma hamatum* and *Trichoderma virens.*

All the eight *Trichoderma* species grew poorly (linear growth 31 to 58 mm at water potential - 4.6 Mpa. Therefore it is concluded that when water potential is increased the *Trichoderma* grew well and when it is decreased the growth of *Trichoderma* species starts declining.
Growth of *Trichoderma viride* has been modified for temperature and pH. For temperature, parameter values for $T_{\text{min}}$, $T_{\text{opt}}$, and $T_{\text{max}}$ 5, 28 and 40°C could explain the growth phenomenon using the selected Rosso type model. Therefore, growth of the fungus could be predicted in prevailing environmental condition. It was seen that effect of temperature is independent of the effect of pH. However, the model for pH to growth rate was of poor fit.

Spatial distribution of *T. viride* was uniform and random throughout the year. *Trichoderma viride* population estimated in bamboo root zone soil found to exist consistently throughout the year with seasonal variation. However, population in soil samples other then bamboo root zone was minimum throughout the year.

*Trichoderma* is an important biocontrol agent specially against plant pathogens. Several diseases have been reported to be controlled by *Trichoderma* spp. mainly *T. viride* and *T. harzianum*. Several *Trichoderma* formulation (products) for soil and seed borne pathogens are reported but *Trichoderma* growth in soil has not been determined. If this information is available then the scope of *Trichoderma* application in soil will be facilitated and the use of fungicides will be reduced to check soil and water pollution.

Growth of *Trichoderma* is dependent on temperature, pH and water potential. Therefore, its activity is highly influenced by the environmental conditions especially due to temperature, pH and moisture status. For commercial production, it is necessary to find out the response of important growth parameters or influential factors. Moreover, it is also necessary to predict the biocontrol capability in an environment. Therefore, development of quantitative relationships or models to explain the growth pattern in response to temperature, pH and water potential is very urgently needed. Moreover, due to lack of knowledge of the ecology, biocontrol potential of the species, has not been exploited so far. There has been lot of works demonstrating biocontrol effect of *Trichoderma* on many plant pathogens. But most the studies are only in controlled or laboratory conditions. Many authors claimed biocontrol effect of *Trichoderma* under field conditions.
But the methodology or techniques followed hardly could impress upon the claims. No studies have taken care of the environmental considerations for this agent.

Quantification of fungal activity or growth in terms of temperature, pH and water potential would enable predictions of their ability to grow and survive in soil and seasonal distributions would further add to the knowledge on survival and activity of *Trichoderma*. In vitro growth studies in relation to temperature, pH and water potential would help to develop quantitative relationships. Keeping in view of the above facts the present research problem has been selected which will help in exploring the useful aspects of *Trichoderma*. 