



CHAPTER-III OBSERVATIONS

OBSERVATIONS



The experimental findings have been presented in tables in the following order :

1. Physico-chemical properties of effluent and tube well water samples (Tables : 1 – 4).
2. Physico-chemical properties of soil samples collected from control as well as treated field (irrigated with effluent) (Tables : 5 – 8).
3. Per cent occurrence of mycoflora isolated from soil samples of control and treated fields (Table : 9 – 10).
4. Number of microorganisms g^{-1} dry soil in control and treated soil samples (Table : 11).
5. Per cent incidence of wilting of tomato in the selected fields (Tables : 12).
6. Population dynamics of *Fusarium oxysporum* f. sp. *lycopersici* in relation to other microorganisms (Tables : 13).
7. Colony interaction between the test pathogen and some dominant micro-flora (Table : 14).

8. Effect of volatile metabolites of some microorganisms on mean radial growth of the test pathogen (Table : 15).
9. Effect of non-volatile metabolites of microorganisms on hyphal dry weight and mean radial growth of the test pathogen (Table : 16 – 17).
10. Effect of some pesticide on growth of the test pathogen (Table : 18 – 19).
11. Effect of effluent on mean radial growth of the test pathogen and some dominant microflora (Table : 20).
12. Effect of some heavy metals on mean radial growth of the test pathogen and some dominant microflora (Tables : 21 – 25).

Table – 1 : Seasonal Variation in Colour, Odour, Temperature, pH and Electrical Conductivity of Effluent and Tube-well Water (2003 – 2004)

| Properties | Samples | Seasons | | |
|-------------------------------------|-----------------|----------------|----------------|------------------------|
| | | Rainy | Winter | Summer |
| Colour | Effluent | Brown | Dark Brown | Dark Brown |
| | Tube-well Water | Colourless | Colourless | Colourless |
| Odour | Effluent | Stinking Smell | Stinking Smell | Pungent Stinking Smell |
| | Tube-well Water | Odourless | Odourless | Odourless |
| Temperature (°C) | Effluent | 34.90 | 28.30 | 36.10 |
| | Tube-well Water | 28.60 | 25.40 | 30.75 |
| pH | Effluent | 8.30 | 8.40 | 8.70 |
| | Tube-well Water | 7.16 | 7.10 | 7.20 |
| Electrical Conductivity (m mhos/cm) | Effluent | 8.45 | 9.50 | 10.50 |
| | Tube-well Water | 0.44 | 0.46 | 0.49 |
| Total Solids (ppm) | Effluent | 1688.75 | 1726.65 | 1785.24 |
| | Tube-well Water | 89.20 | 92.40 | 93.11 |

Table – 2 : Seasonal Variation in Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand and Total Alkalinity of Effluent and Tube-well Water (2003 – 2004)

| Properties | Samples | Seasons | | |
|--------------------------------|-----------------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Dissolved Oxygen (ppm) | Effluent | 0.0 | 0.0 | 0.0 |
| | Tube-well Water | 6.25 | 6.0 | 6.50 |
| Biological Oxygen Demand (ppm) | Effluent | 250 | 280 | 265 |
| | Tube-well Water | 0.0 | 0.0 | 0.0 |
| Chemical Oxygen Demand (ppm) | Effluent | 320 | 348 | 340 |
| | Tube-well Water | 0.0 | 0.0 | 0.0 |
| Total Alkalinity (ppm) | Effluent | 336.8 | 338.2 | 340.6 |
| | Tube-well Water | 41.0 | 40.0 | 42.0 |

Table – 3 : Seasonal Variation in Carbonate, Chloride, Phosphate, Sulphate, Nitrate-Nitrogen, Ammonium-Nitrogen and Total Nitrogen of Effluent and Tube-well Water (2003 – 2004)

| Properties | Samples | Seasons | | |
|-------------------------|-----------------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Carbonate (ppm) | Effluent | 47.46 | 60.08 | 54.25 |
| | Tube-well Water | 3.21 | 3.40 | 3.35 |
| Chloride (ppm) | Effluent | 208.25 | 239.45 | 250.55 |
| | Tube-well Water | 11.95 | 12.30 | 12.42 |
| Phosphate (ppm) | Effluent | 0.38 | 0.43 | 0.45 |
| | Tube-well Water | 0.03 | 0.04 | 0.05 |
| Sulphate (ppm) | Effluent | 240.85 | 225.61 | 256.56 |
| | Tube-well Water | 19.96 | 18.92 | 22.50 |
| Nitrate-Nitrogen (ppm) | Effluent | 0.81 | 0.85 | 0.79 |
| | Tube-well Water | 0.27 | 0.29 | 0.28 |
| Ammonium-Nitrogen (ppm) | Effluent | 74.20 | 79.05 | 77.25 |
| | Tube-well Water | 0.08 | 0.12 | 0.09 |
| Total Nitrogen (ppm) | Effluent | 75.81 | 82.88 | 78.75 |
| | Tube-well Water | 0.89 | 0.95 | 0.92 |

Table – 4 : Seasonal Variation in Sodium, Potassium, Calcium, Magnesium, Chromium (VI) and Dye of Effluent and Tube-well Water (2003 – 2004)

| Properties | Samples | Seasons | | |
|---------------------|-----------------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Sodium (ppm) | Effluent | 198.95 | 241.12 | 185.26 |
| | Tube-well Water | 6.40 | 7.15 | 6.40 |
| Potassium (ppm) | Effluent | 42.53 | 48.56 | 50.25 |
| | Tube-well Water | 16.95 | 17.10 | 17.35 |
| Calcium (ppm) | Effluent | 47.35 | 56.35 | 58.25 |
| | Tube-well Water | 9.30 | 9.45 | 9.72 |
| Magnesium (ppm) | Effluent | 13.26 | 16.75 | 15.35 |
| | Tube-well Water | 13.80 | 13.98 | 13.93 |
| Chromium (VI) (ppm) | Effluent | 46.35 | 51.25 | 57.25 |
| | Tube-well Water | – | – | – |
| Dye (ppm) | Effluent | 69.10 | 76.25 | 77.35 |
| | Tube-well Water | – | – | – |

Table – 5 : Seasonal Variation in Texture, Water Holding Capacity, pH and Electrical Conductivity of Soil Irrigated with Effluent and Control (2003 – 2004)

| Properties | Samples | Seasons | | |
|-------------------------------------|------------------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Mechanical Composition (Texture) | Treated Sand (%) | 52.40 | 52.50 | 53.30 |
| | Control Sand (%) | 56.70 | 57.50 | 57.80 |
| | Treated Silt (%) | 29.20 | 29.50 | 29.00 |
| | Control Silt (%) | 28.60 | 28.50 | 28.30 |
| | Treated Clay (%) | 18.40 | 18.0 | 17.70 |
| | Control Clay (%) | 14.70 | 14.0 | 13.90 |
| Water Holding Capacity (%) | Treated | 44.80 | 45.30 | 43.70 |
| | Control | 46.70 | 48.80 | 46.60 |
| pH | Treated | 8.20 | 8.40 | 8.70 |
| | Control | 7.20 | 7.30 | 7.40 |
| Electrical Conductivity (m mhos/cm) | Treated | 10.25 | 11.89 | 12.50 |
| | Control | 2.20 | 2.35 | 2.52 |

Table – 6 : Seasonal Variation in Per Cent Organic Matter, Bulk Density, Porosity and Moisture of Soil Irrigated with Effluent and Control (2003 – 2004)

| Soil Properties | Samples | Seasons | | |
|--------------------|---------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Depth in 0 – 30 cm | | | | |
| Organic Matter (%) | Treated | 0.416 | 0.505 | 0.454 |
| | Control | 0.320 | 0.361 | 0.347 |
| Bulk Density (%) | Treated | 1.57 | 1.60 | 1.55 |
| | Control | 1.46 | 1.50 | 1.44 |
| Porosity (%) | Treated | 42.98 | 42.90 | 43.10 |
| | Control | 45.89 | 45.80 | 45.95 |
| Moisture (%) | Treated | 25.0 | 22.50 | 16.25 |
| | Control | 20.50 | 18.65 | 10.55 |

Table – 7: Seasonal Variation in Chromium VI and Exchangeable Cation (Sodium, Potassium, Calcium and Magnesium) of Soil Irrigated with Effluent and Control (2003 – 2004)

| Soil Properties | Samples | Seasons | | |
|-----------------------------------|---------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Chromium (VI) (ppm) | Treated | 13.35 | 15.62 | 16.10 |
| | Control | – | – | – |
| Exchangeable Sodium (me/100 g) | Treated | 5.90 | 6.55 | 6.20 |
| | Control | 0.35 | 0.45 | 0.42 |
| Exchangeable Potassium (me/100 g) | Treated | 4.10 | 4.30 | 4.82 |
| | Control | 4.70 | 4.85 | 5.03 |
| Exchangeable Calcium (me/100 g) | Treated | 3.15 | 3.50 | 3.81 |
| | Control | 4.90 | 5.10 | 5.17 |
| Exchangeable Magnesium (me/100 g) | Treated | 3.15 | 3.72 | 3.42 |
| | Control | 3.36 | 3.90 | 3.65 |

Table – 8 : Seasonal Variation in Chloride, Sulphate, Carbonate, Phosphorus, Nitrate-Nitrogen, Ammonium-Nitrogen and Total Nitrogen of Soil Irrigated with Effluent and Control (2003 – 2004)

| Soil Properties | Samples | Seasons | | |
|--------------------------|---------|---------|--------|--------|
| | | Rainy | Winter | Summer |
| Chloride Content (ppm) | Treated | 37.50 | 39.52 | 42.80 |
| | Control | 24.55 | 25.50 | 27.41 |
| Sulphate Content (ppm) | Treated | 210.70 | 203.60 | 216.50 |
| | Control | 32.50 | 31.45 | 34.40 |
| Carbonate (ppm) | Treated | 71.54 | 78.60 | 75.45 |
| | Control | 58.39 | 64.59 | 61.55 |
| Phosphorus Content (ppm) | Treated | 37.55 | 39.75 | 41.90 |
| | Control | 47.60 | 50.55 | 53.49 |
| Nitrate Nitrogen (ppm) | Treated | 19.90 | 24.55 | 22.30 |
| | Control | 27.65 | 32.50 | 30.50 |
| Ammonium Nitrogen (ppm) | Treated | 74.59 | 80.50 | 77.65 |
| | Control | 15.75 | 19.55 | 18.60 |
| Total Nitrogen (ppm) | Treated | 185.45 | 190.75 | 188.35 |
| | Control | 189.86 | 198.73 | 194.50 |

Table - 9 : Per Cent Occurrence of Mycoflora Isolated from Soil Irrigated with Effluent (2003 - 2004)

| Name of Species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr. | May | Jun |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <i>Acrophialophora fusicapora</i> | 15.78 | 11.62 | - | - | - | - | - | 6.25 | - | - | 9.09 | 5.26 |
| <i>Alternaria alternata</i> | - | - | - | - | 10.71 | 7.40 | - | 6.25 | 6.81 | 10.81 | 3.03 | - |
| <i>Aspergillus flavus</i> | 2.63 | - | 7.69 | 6.89 | - | 3.70 | 3.84 | - | - | - | - | 5.26 |
| <i>A. Inchiuensis</i> | 2.63 | 4.65 | 2.56 | 3.44 | - | - | - | - | - | 2.70 | - | - |
| <i>A. nidulans</i> | - | - | - | 6.89 | 7.14 | - | - | - | - | 13.51 | - | - |
| <i>A. niger</i> | 13.15 | - | - | 13.79 | - | - | - | - | - | 24.32 | 18.18 | 10.52 |
| <i>A. sulphureus</i> | - | - | - | 6.89 | 7.14 | - | - | - | - | 2.70 | - | - |
| <i>A. terreus</i> | 26.31 | 23.25 | 17.94 | 6.89 | 17.85 | 25.90 | 26.92 | 31.25 | 9.09 | 24.32 | 30.30 | 47.36 |
| Black sterile mycelium | 7.89 | - | - | - | 7.14 | - | - | - | 13.63 | - | 9.09 | - |
| <i>Cephalosporium roseo-griseum</i> | - | 4.65 | 10.25 | - | - | 3.70 | 3.84 | 6.25 | - | - | - | - |
| <i>Chaetomium</i> sp. | - | 4.65 | 5.12 | - | - | - | - | - | - | - | - | - |
| <i>Cladosporium cladosporioides</i> | 2.63 | 2.32 | 2.56 | 3.44 | 3.57 | 3.70 | - | 6.25 | 9.09 | - | 3.03 | - |
| <i>Curvularia lunata</i> | 5.26 | 4.65 | - | - | 3.57 | 3.70 | - | 6.25 | 9.09 | 2.70 | 3.03 | - |
| <i>Fusarium oxysporum</i> f. sp. <i>lini</i> | - | 4.65 | 5.12 | 6.89 | 7.14 | 7.40 | 15.38 | 9.37 | 13.63 | - | - | - |
| <i>F. oxysporum</i> f. sp. <i>lycopersici</i> | - | 4.65 | 5.12 | 6.89 | 7.14 | 7.40 | 11.53 | 9.37 | 9.09 | 2.70 | - | - |
| <i>Penicillium chrysogenum</i> | - | 4.65 | 5.12 | 3.44 | - | - | - | - | - | - | - | - |
| <i>Penicillium citrinum</i> | 2.63 | 6.96 | 7.69 | - | 10.71 | 7.40 | 3.84 | 3.12 | 4.54 | - | - | - |
| <i>P. frequentans</i> | - | - | - | - | 3.57 | 7.40 | 3.84 | - | 4.54 | 2.70 | - | 10.52 |
| <i>P. granulatum</i> | 2.63 | 2.32 | - | 3.44 | - | - | - | - | - | - | - | - |
| <i>P. rugulosum</i> | - | 4.65 | 7.69 | - | - | - | - | - | - | - | - | - |
| <i>Trichoderma harzianum</i> | 7.89 | - | 7.69 | - | - | - | 7.69 | 9.37 | 2.27 | 2.70 | 9.09 | 5.26 |
| <i>T. viride</i> | - | 4.65 | 5.12 | 3.44 | 3.57 | - | 7.69 | - | 4.54 | 2.70 | 3.03 | 5.26 |
| White Sterile mycelium | 10.52 | 11.62 | 10.25 | 27.58 | 10.71 | 18.50 | 15.38 | 9.37 | 13.63 | 8.10 | 12.12 | 10.52 |
| Total Number of Species | 12 | 15 | 14 | 13 | 13 | 11 | 10 | 11 | 12 | 12 | 10 | 8 |

Table - 10 : Per Cent Occurrence of Mycoflora Isolated from Control Soil (2003 - 2004)

| Name of Species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <i>Acrophialophora fuispora</i> | 10.20 | 13.33 | 9.30 | - | - | - | - | - | 5.26 | - | 6.81 | 20.00 |
| <i>Alternaria alternata</i> | 2.04 | 2.22 | - | - | - | - | - | 8.57 | 2.63 | 15.90 | 2.27 | 6.66 |
| <i>Aspergillus flavus</i> | - | 2.22 | 18.60 | 2.77 | 3.12 | - | - | - | - | 13.63 | - | - |
| <i>A. fumigates</i> | 2.04 | - | - | - | - | - | - | - | - | - | - | - |
| <i>A. luchuensis</i> | 4.08 | 2.22 | 2.32 | 2.77 | - | 10.34 | - | - | - | - | 6.81 | 13.33 |
| <i>A. nidulans</i> | - | - | - | - | - | 10.34 | - | - | - | 13.63 | - | - |
| <i>A. niger</i> | - | 17.77 | 16.27 | 13.88 | 3.12 | 10.34 | 3.33 | 8.57 | 7.89 | 25.00 | 22.72 | - |
| <i>A. sulphureus</i> | - | - | - | - | - | - | - | - | 5.26 | 4.54 | 13.63 | - |
| <i>A. terreus</i> | 46.93 | 22.22 | 6.97 | 2.77 | 3.12 | 6.89 | 10.00 | 20.00 | 5.26 | 9.09 | 34.09 | 20.00 |
| Black sterile mycelium | - | 2.22 | - | - | 21.87 | - | 10.00 | - | 21.05 | 2.27 | 2.27 | 6.66 |
| <i>Cladosporium cladosporoides</i> | 2.04 | 2.22 | 6.97 | - | 12.50 | - | 3.33 | 2.85 | 5.26 | - | - | 13.33 |
| <i>Cream sterile mycelium</i> | - | - | - | - | - | - | - | 2.85 | - | - | - | - |
| <i>Curvularia lunata</i> | - | - | - | - | - | 10.34 | - | - | 5.26 | - | - | - |
| <i>Fusarium oxysporum</i> f. sp. <i>limi</i> | - | - | - | 5.55 | 6.25 | 6.89 | 10.00 | 5.71 | 5.26 | - | - | - |
| <i>F. oxysporum</i> f. sp. <i>lycopersici</i> | - | 2.22 | 4.65 | 8.33 | 12.50 | 10.34 | 16.66 | 8.57 | 5.26 | 2.27 | 2.27 | - |
| <i>Penicillium chrysogenum</i> | 2.04 | 6.66 | 9.30 | 16.66 | - | - | - | 2.85 | 2.63 | 2.27 | - | - |
| <i>Penicillium citrinum</i> | 6.12 | 4.44 | 9.30 | 2.77 | - | - | - | - | 2.63 | - | - | - |
| <i>P. frequentans</i> | 4.08 | 2.22 | 9.30 | 5.55 | - | 10.34 | - | 5.71 | - | - | - | - |
| <i>P. granulatum</i> | 2.04 | - | - | 5.55 | - | - | - | - | - | - | - | - |
| <i>P. rugulosum</i> | - | - | - | 11.11 | 12.50 | - | - | - | - | - | - | - |
| <i>Trichoderma harzianum</i> | 4.08 | 2.22 | 2.32 | - | 6.25 | - | 3.33 | 2.85 | 2.63 | 4.54 | - | - |
| <i>T. viride</i> | 2.04 | 2.22 | 2.32 | 5.55 | 3.12 | - | 3.33 | - | 2.63 | 2.27 | - | - |
| White Sterile mycelium | 12.24 | 15.55 | 2.32 | 16.66 | 15.62 | 10.34 | 44.00 | 28.57 | 21.05 | 4.54 | 6.81 | 20.00 |
| Yellow Sterile mycelium | - | - | - | - | - | - | - | 2.85 | - | - | - | - |
| Total Number of Species | 13 | 15 | 13 | 13 | 11 | 9 | 9 | 12 | 15 | 12 | 9 | 7 |

Table – 11 : Average Number of Microorganisms (g^{-1} dry soil), Isolated from Soil Samples of Control Soil and Soil Irrigated with Effluent (2003 – 2004)

| Months | Control Soil | | | Soil Irrigated with Effluent | | |
|-----------|----------------------------|-------------------------------|------------------------------------|------------------------------|-------------------------------|------------------------------------|
| | Fungi ($\times 10^3$) | Bacteria ($\times 10^6$) | Actinomycetes ($\times 10^5$) | Fungi ($\times 10^3$) | Bacteria ($\times 10^6$) | Actinomycetes ($\times 10^5$) |
| July | 35.25 | 9.34 | 7.30 | 30.45 | 11.85 | 6.15 |
| August | 38.15 | 10.98 | 7.45 | 32.60 | 12.58 | 4.75 |
| September | 30.10 | 14.10 | 9.95 | 20.50 | 20.57 | 8.45 |
| October | 17.20 | 14.00 | 8.57 | 19.90 | 11.45 | 4.90 |
| November | 24.45 | 9.79 | 6.93 | 15.85 | 11.01 | 3.85 |
| December | 23.10 | 9.53 | 4.37 | 25.40 | 7.55 | 2.65 |
| January | 20.15 | 6.75 | 4.85 | 16.15 | 8.75 | 3.40 |
| February | 23.10 | 9.85 | 7.39 | 20.05 | 12.70 | 6.31 |
| March | 19.35 | 7.85 | 5.40 | 17.83 | 11.45 | 5.10 |
| April | 24.30 | 6.79 | 3.25 | 27.63 | 8.25 | 5.65 |
| May | 12.85 | 10.85 | 5.27 | 12.65 | 15.25 | 3.50 |
| June | 8.60 | 8.92 | 3.25 | 10.60 | 11.85 | 3.15 |

Table – 12 : Per Cent Incidence of Wilting of Tomato in the Control and Irrigated Field with Effluent

| Cropping Seasons | Soil Samples | November | December | January | February | March |
|------------------|--------------|----------|----------|---------|----------|-------|
| 2003 – 2004 | Control | 11.25 | 18.78 | 25.00 | 33.68 | 39.25 |
| | Irrigated | 10.25 | 14.73 | 22.75 | 28.36 | 32.62 |
| 2004 – 2005 | Control | 18.95 | 26.25 | 30.38 | 38.67 | 46.78 |
| | Irrigated | 15.37 | 19.85 | 26.65 | 32.15 | 36.55 |
| 2005 – 2006 | Control | 24.75 | 30.67 | 36.15 | 44.85 | 52.78 |
| | Irrigated | 18.38 | 25.25 | 31.67 | 36.28 | 42.35 |

Table - 13 : Population Dynamics of General Mycoflora Including Pathogen *Fusarium oxysporum* f. *sp. lycopersici* in the Selected Fields in Term of Per Cent Frequency and Per Cent Occurrence in Non-Rhizosphere, Rhizosphere and Rhizoplane of Healthy and Wilted Plants of Tomato

| Soil Samples | Name of Species | November | | | | | December | | | | | January | | | | | February | | | | | March | | | | |
|------------------------------|---|----------|-----|------|-----|------|----------|------|------|-----|------|---------|------|------|------|------|----------|------|------|------|------|-------|------|------|------|------|
| | | NR* | HR† | HRP‡ | WR† | WRP‡ | NR* | HR† | HRP‡ | WR† | WRP‡ | NR* | HR† | HRP‡ | WR† | WRP‡ | NR* | HR† | HRP‡ | WR† | WRP‡ | NR* | HR† | HRP‡ | WR† | WRP‡ |
| Control Soil | <i>Fusarium oxysporum</i> f. <i>sp. lycopersici</i> | 6.0 | 8.0 | 25 | 65 | 85 | 8 | 10 | 35 | 80 | 90 | 9.4 | 15 | 40 | 82.5 | 100 | 10.5 | 18.0 | 45 | 84.5 | 100 | 12 | 21.2 | 50 | 86.5 | 100 |
| | Other Species | 94 | 92 | - | 35 | | 92 | 90 | 20 | | 91.6 | 85 | 17.5 | | 89.5 | 82.0 | - | 15.5 | - | | | 88 | 78.8 | | 13.5 | |
| Soil Irrigated with effluent | <i>Fusarium oxysporum</i> f. <i>sp. lycopersici</i> | 8.5 | 7.0 | 15 | 62 | 80 | 10.5 | 9.5 | 25 | 78 | 85 | 12 | 13.5 | 35 | 80 | 90 | 12.5 | 16.5 | 40 | 82.5 | 100 | 13.0 | 20 | 40 | 86 | 100 |
| | Other Species | 91.5 | 93 | | 38 | | 89.5 | 91.5 | 22 | | 88 | 86.5 | 20 | | 87.5 | 83.5 | | 17.5 | | | | 87 | 80 | | 14 | |

* = percent occurrence, ** = percent frequency, NR = non-rhizosphere, HR = Rhizosphere of healthy plants, WR = rhizosphere of wilted plants, HRP = Rhizoplane of healthy plants, WRP = rhizoplane of wilted plants

Table – 14 : Colony Interaction between *Fusarium oxysporum* f. sp. *lycopersici* and Some Dominant Microflora Isolated from Soil Irrigated with Effluent and Control Soil

| Test Microorganisms | Type | % Inhibition of Colony of Test Pathogen | % Inhibition of Colony of Test |
|------------------------------------|-----------------|---|--------------------------------|
| <i>Alternaria alternata</i> | B ₁₁ | 33.33 | 34.78 |
| <i>Aspergillus flavus</i> | B ₁ | 42.85 | 35.00 |
| <i>A. luchuensis</i> | B ₁ | 60.00 | 40.00 |
| <i>A. niger</i> | B ₁ | 56.66 | 16.00 |
| <i>A. terreus</i> | B ₁ | 38.70 | 26.66 |
| <i>Cladosporium cladosporoides</i> | A | 20.00 | 26.66 |
| <i>Penicillium citrinum</i> | B ₁ | 40.00 | 25.00 |
| <i>P. frequentans</i> | B ₁ | 48.57 | 32.00 |
| <i>Trichoderma harzianum</i> | B ₁ | 66.66 | 25.00 |
| <i>T. viride</i> | B ₁ | 53.33 | 25.15 |
| Colourless Bacteria | D | 46.65 | 30.50 |
| Yellow Colour Bacteria | C | 32.36 | 29.15 |
| <i>Streptomyces rimosus</i> | D | 45.18 | 10.95 |
| <i>S. rochi</i> (SR _I) | D | 56.15 | 24.87 |

A = Mutually intermingling growth where both fungi grew into one another without any sign of interaction.

B₁ = Intermingling growth where the fungi being observed is growing into the opposed fungus either above or below its colony.

B₁₁ = Intermingling growth where the fungus under observation has ceased growth and is being over grown by another colony.

C = Slight inhibition with narrow demarcation line.

D = Mutual inhibition at a distance of > 2 mm.

Table – 15 : Effect of Volatile Substances of the Test Microorganisms on Per Cent Inhibition of Radial Growth of *Fusarium oxysporum* f. sp. *lycopersici* at Different Intervals

| Test Microorganisms | Incubation Periods | | | | | Mean |
|------------------------------------|--------------------|-------|-------|--------|--------|-------|
| | 48 hr | 72 hr | 96 hr | 120 hr | 144 hr | |
| <i>Alternaria alternata</i> | 6.17 | 5.85 | 5.36 | 4.48 | 4.23 | 5.21 |
| <i>Aspergillus flavus</i> | 9.14 | 7.72 | 7.0 | 6.49 | 5.55 | 7.18 |
| <i>A. luchuensis</i> | 11.13 | 9.95 | 8.15 | 7.85 | 7.13 | 8.84 |
| <i>A. niger</i> | 16.14 | 13.35 | 10.05 | 8.44 | 7.28 | 11.05 |
| <i>A. terreus</i> | 15.40 | 12.31 | 11.10 | 10.53 | 7.77 | 11.42 |
| <i>Cladosporium cladosporoides</i> | 6.0 | 6.42 | 6.28 | 4.45 | 4.10 | 5.45 |
| <i>Penicillium citrinum</i> | 14.98 | 12.65 | 9.47 | 8.45 | 7.54 | 10.61 |
| <i>P. frequentans</i> | 18.46 | 15.73 | 12.94 | 10.59 | 9.39 | 13.42 |
| <i>Trichoderma harzianum</i> | 20.82 | 16.72 | 14.53 | 13.34 | 10.32 | 15.14 |
| <i>T. viride</i> | 16.21 | 14.31 | 12.25 | 10.83 | 8.42 | 12.40 |
| Colourless Bacteria | 6.85 | 6.72 | 6.75 | 5.16 | 5.22 | 6.14 |
| Yellow Colour Bacteria | 8.75 | 7.25 | 6.65 | 6.30 | 6.10 | 7.01 |
| <i>Streptomyces rimosus</i> | 20.25 | 18.35 | 16.75 | 13.35 | 11.28 | 15.99 |
| <i>S. rochi</i> (SR ₁) | 18.33 | 15.32 | 13.95 | 12.27 | 11.31 | 14.23 |

Table – 16 : Effect of Culture Filtrates (non-volatile metabolites) of the Test Microorganisms on Per Cent Inhibition in Hyphal Dry Weight of *Fusarium oxysporum* f. sp. *lycopersici*

| Test Microorganisms | Per Cent Inhibition |
|------------------------------------|---------------------|
| <i>Alternaria alternata</i> | 39.04 |
| <i>Aspergillus flavus</i> | 54.50 |
| <i>A. luchuensis</i> | 91.75 |
| <i>A. niger</i> | 87.63 |
| <i>A. terreus</i> | 61.38 |
| <i>Cladosporium cladosporoides</i> | 48.80 |
| <i>Penicillium citrinum</i> | 51.19 |
| <i>P. frequentans</i> | 47.72 |
| <i>Trichoderma harzianum</i> | 53.79 |
| <i>T. viride</i> | 45.80 |
| Colourless Bacteria | 29.54 |
| Yellow Colour Bacteria | 27.25 |
| <i>Streptomyces rimosus</i> | 75.35 |
| <i>S. rochi</i> (SR ₁) | 69.79 |

Table – 17: Effect of Culture Filtrates (non-volatile metabolites) of the Test Microorganisms on Per Cent Inhibition in Radial Growth of *Fusarium oxysporum* f. sp. *lycopersici*

| Test Microorganisms | % Concentration | | | |
|------------------------------------|-----------------|-------|-------|-------|
| | 5 | 10 | 15 | 20 |
| <i>Alternaria alternata</i> | 6.66 | 13.33 | 20.00 | 24.00 |
| <i>Aspergillus flavus</i> | 4.00 | 14.66 | 20.00 | 22.66 |
| <i>A. luchuensis</i> | 58.66 | 69.33 | 89.33 | 93.33 |
| <i>A. niger</i> | 46.66 | 61.33 | 70.66 | 84.00 |
| <i>A. terreus</i> | 44.00 | 49.33 | 57.33 | 61.33 |
| <i>Cladosporium cladosporoides</i> | 6.66 | 10.66 | 13.33 | 16.00 |
| <i>Penicillium citrinum</i> | 6.66 | 20.00 | 29.33 | 32.00 |
| <i>P. frequentans</i> | 4.00 | 6.66 | 14.66 | 17.33 |
| <i>Trichoderma harzianum</i> | 6.66 | 13.33 | 17.33 | 36.00 |
| <i>T. viride</i> | 9.33 | 13.33 | 40.00 | 66.00 |
| Colourless Bacteria | 6.95 | 15.25 | 24.18 | 30.15 |
| Yellow Colour Bacteria | 6.45 | 13.15 | 22.32 | 26.75 |
| <i>Streptomyces rimosus</i> | 20.26 | 40.33 | 52.32 | 72.12 |
| <i>S. rochi</i> (SR _I) | 19.66 | 38.45 | 51.47 | 68.95 |

**Table – 18 : Effect of Fungicides on Per Cent Growth
Inhibition of *Fusarium oxysporum* f. sp.
*lycopersici***

| Fungicides | Concentrations (ppm) | | | | | |
|----------------|----------------------|--------|--------|--------|--------|--------|
| | 50 | 100 | 200 | 300 | 400 | 500 |
| Bavistin | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Benlate | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Blue Copper | 50.85 | 65.15 | 67.75 | 68.25 | 69.25 | 71.50 |
| Brassicol | 44.00 | 46.10 | 49.15 | 51.35 | 53.24 | 55.45 |
| Dithane M – 45 | 33.16 | 35.18 | 42.37 | 45.58 | 48.37 | 51.92 |
| Folfat | 73.10 | 74.15 | 75.10 | 76.12 | 76.82 | 77.25 |
| Mancozeb | 31.15 | 48.10 | 53.35 | 57.72 | 62.36 | 69.10 |
| MEMC | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Thiram | 68.18 | 70.16 | 72.25 | 74.18 | 76.36 | 78.75 |

Table – 19 : Effect of Insecticides on Per Cent Growth Inhibition of *Fusarium oxysporum* f. sp. *lycopersici*

| Insecticides | Concentrations (ppm) | | | | |
|--------------|----------------------|-------|-------|-------|-------|
| | 100 | 250 | 500 | 750 | 1000 |
| B. H. C. | 22.10 | 51.35 | 78.27 | 85.35 | 91.75 |
| Ekalux | 46.57 | 59.33 | 64.15 | 69.25 | 73.15 |
| Monocil | 6.47 | 17.16 | 27.45 | 40.25 | 53.85 |
| Thiodone | 31.45 | 41.12 | 50.33 | 56.82 | 61.65 |

Table – 20 : Effect of Effluent on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

| Test Microorganisms | % Concentrations | | | |
|---|------------------|-------|-------|-------|
| | 5 | 10 | 15 | 20 |
| <i>Alternaria alternata</i> | 3.33 | 10.00 | 15.00 | 17.66 |
| <i>Aspergillus flavus</i> | 6.25 | 10.00 | 13.50 | 18.00 |
| <i>A. luchuensis</i> | 11.30 | 18.25 | 22.15 | 30.64 |
| <i>A. niger</i> | 8.88 | 13.33 | 17.77 | 22.22 |
| <i>A. terreus</i> | 14.28 | 17.85 | 21.42 | 28.57 |
| <i>Cladosporium cladosporoides</i> | 3.33 | 6.66 | 8.90 | 12.45 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 5.55 | 11.11 | 13.33 | 16.50 |
| <i>Penicillium citrinum</i> | 10.80 | 20.25 | 25.00 | 27.50 |
| <i>P. frequentans</i> | 18.25 | 20.00 | 22.50 | 30.00 |
| <i>Trichoderma harzianum</i> | 3.33 | 3.50 | 3.70 | 3.90 |
| <i>T. viride</i> | 3.33 | 3.40 | 3.60 | 4.10 |
| Colourless Bacteria | 3.35 | 6.65 | 8.95 | 11.45 |
| Yellow Colour Bacteria | 5.65 | 10.25 | 12.33 | 15.95 |
| <i>Streptomyces rimosus</i> | 10.00 | 20.95 | 22.65 | 28.25 |
| <i>S. rochi</i> (SR ₁) | 8.85 | 12.45 | 17.50 | 22.25 |

Table – 21 : Effect of Cadmium on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

| Test Microorganisms | Concentrations (ppm) Cd | | | |
|---|-------------------------|-------|-------|-------|
| | 25 | 50 | 100 | 200 |
| <i>Alternaria alternata</i> | 27.56 | 33.55 | 42.25 | 62.35 |
| <i>Aspergillus flavus</i> | 15.10 | 43.85 | 65.60 | 84.35 |
| <i>A. luchuensis</i> | 29.25 | 54.85 | 69.60 | 83.75 |
| <i>A. niger</i> | 18.25 | 34.15 | 39.95 | 62.60 |
| <i>A. terreus</i> | 25.75 | 49.90 | 68.70 | 83.95 |
| <i>Cladosporium cladosporoides</i> | 30.25 | 48.10 | 56.35 | 65.25 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 24.50 | 49.59 | 67.35 | 80.50 |
| <i>Penicillium citrinum</i> | 34.55 | 44.00 | 55.20 | 78.80 |
| <i>P. frequentans</i> | 24.35 | 41.70 | 56.22 | 67.52 |
| <i>Trichoderma harzianum</i> | 4.25 | 7.55 | 21.15 | 49.30 |
| <i>T. viride</i> | 3.85 | 7.15 | 20.95 | 48.95 |
| Colourless Bacteria | 9.50 | 13.52 | 33.15 | 45.75 |
| Yellow Colour Bacteria | 23.95 | 27.57 | 42.65 | 67.65 |
| <i>Streptomyces rimosus</i> | 39.15 | 54.10 | 67.45 | 69.39 |
| <i>S. rochi</i> (SR ₁) | 33.35 | 45.72 | 62.78 | 73.10 |

Cadmium (Cd) was added in the culture medium in chloride form

Table – 22 : Effect of Chromium on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

| Test Microorganisms | Concentrations (ppm) Cr | | | |
|---|-------------------------|-------|-------|-------|
| | 25 | 50 | 100 | 200 |
| <i>Alternaria alternata</i> | 20.15 | 22.95 | 30.15 | 44.85 |
| <i>Aspergillus flavus</i> | 12.65 | 36.35 | 53.85 | 63.45 |
| <i>A. luchuensis</i> | 20.25 | 39.15 | 57.50 | 64.85 |
| <i>A. niger</i> | 12.75 | 29.65 | 40.90 | 60.35 |
| <i>A. terreus</i> | 14.25 | 34.50 | 40.67 | 53.20 |
| <i>Cladosporium cladosporoides</i> | 22.35 | 40.75 | 49.55 | 60.70 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 14.35 | 18.65 | 26.40 | 42.75 |
| <i>Penicillium citrinum</i> | 22.15 | 31.10 | 34.52 | 46.60 |
| <i>P. frequentans</i> | 12.15 | 14.35 | 25.71 | 42.90 |
| <i>Trichoderma harzianum</i> | 27.75 | 33.25 | 42.10 | 48.45 |
| <i>T. viride</i> | 26.35 | 30.15 | 41.55 | 47.95 |
| Colourless Bacteria | 20.25 | 33.65 | 49.95 | 54.95 |
| Yellow Colour Bacteria | 13.32 | 21.15 | 30.78 | 43.54 |
| <i>Streptomyces rimosus</i> | 19.52 | 22.91 | 31.03 | 40.75 |
| <i>S. rochi</i> (SR ₁) | 30.74 | 39.25 | 44.93 | 56.15 |

Chromium (Cr) was added in the culture medium in chloride form

Table – 23 : Effect of Lead on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

| Test Microorganisms | Concentrations (ppm) Pb | | | |
|---|-------------------------|-------|-------|-------|
| | 25 | 50 | 100 | 200 |
| <i>Alternaria alternata</i> | 12.35 | 23.25 | 34.10 | 41.47 |
| <i>Aspergillus flavus</i> | 9.50 | 14.41 | 26.70 | 35.59 |
| <i>A. luchuensis</i> | 10.15 | 22.20 | 31.31 | 42.15 |
| <i>A. niger</i> | 11.35 | 17.15 | 24.20 | 37.80 |
| <i>A. terreus</i> | 10.10 | 18.49 | 27.70 | 46.65 |
| <i>Cladosporium cladosporoides</i> | 7.55 | 17.30 | 23.52 | 28.50 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 12.95 | 16.75 | 21.15 | 33.23 |
| <i>Penicillium citrinum</i> | 16.50 | 27.50 | 39.40 | 49.80 |
| <i>P. frequentans</i> | 10.15 | 23.85 | 38.15 | 47.65 |
| <i>Trichoderma harzianum</i> | 2.50 | 7.82 | 16.72 | 21.15 |
| <i>T. viride</i> | 2.85 | 8.15 | 17.35 | 21.95 |
| Colourless Bacteria | 7.21 | 20.42 | 29.59 | 42.62 |
| Yellow Colour Bacteria | 17.11 | 27.69 | 44.25 | 56.58 |
| <i>Streptomyces rimosus</i> | 9.52 | 30.45 | 43.65 | 56.72 |
| <i>S. rochi</i> (SR ₁) | 18.36 | 33.50 | 47.69 | 56.10 |

Lead (Pb) was added in the culture medium in nitrate form

Table – 24 : Effect of Nickel on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

| Test Microorganisms | Concentrations (ppm) Ni | | | |
|---|-------------------------|-------|-------|-------|
| | 25 | 50 | 100 | 200 |
| <i>Alternaria alternata</i> | 12.45 | 29.15 | 43.85 | 67.55 |
| <i>Aspergillus flavus</i> | 16.75 | 29.75 | 41.35 | 55.10 |
| <i>A. luchuensis</i> | 12.35 | 23.85 | 37.55 | 50.15 |
| <i>A. niger</i> | 15.95 | 34.95 | 53.90 | 61.25 |
| <i>A. terreus</i> | 18.90 | 30.55 | 42.95 | 55.15 |
| <i>Cladosporium cladosporoides</i> | 15.85 | 30.15 | 49.25 | 66.50 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 9.90 | 18.35 | 30.15 | 41.45 |
| <i>Penicillium citrinum</i> | 8.55 | 14.00 | 28.15 | 44.50 |
| <i>P. frequentans</i> | 17.15 | 33.50 | 28.10 | 44.25 |
| <i>Trichoderma harzianum</i> | 13.25 | 26.85 | 38.25 | 46.95 |
| <i>T. viride</i> | 12.75 | 27.35 | 37.10 | 47.15 |
| Colourless Bacteria | 15.25 | 27.65 | 35.29 | 47.00 |
| Yellow Colour Bacteria | 12.75 | 20.85 | 25.10 | 33.52 |
| <i>Streptomyces rimosus</i> | 19.32 | 32.25 | 45.85 | 54.28 |
| <i>S. rochi</i> (SR ₁) | 11.42 | 17.47 | 34.82 | 43.54 |

Nickel (Ni) was added in the culture medium in chloride form

Table – 25 : Effect of Zinc on Per Cent Growth Inhibition of Some Dominant Microflora and the Test Pathogen

| Test Microorganisms | Concentrations (ppm) Zn | | | |
|---|-------------------------|-------|-------|-------|
| | 200 | 400 | 600 | 800 |
| <i>Alternaria alternata</i> | 22.25 | 36.25 | 40.25 | 50.15 |
| <i>Aspergillus flavus</i> | 14.75 | 32.50 | 38.25 | 46.95 |
| <i>A. luchuensis</i> | 15.65 | 31.52 | 38.35 | 47.10 |
| <i>A. niger</i> | 21.95 | 39.70 | 37.55 | 46.75 |
| <i>A. terreus</i> | 23.15 | 30.75 | 35.25 | 41.10 |
| <i>Cladosporium cladosporoides</i> | 11.25 | 31.80 | 41.10 | 53.35 |
| <i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i> | 9.10 | 14.20 | 23.25 | 29.15 |
| <i>Penicillium citrinum</i> | 23.35 | 40.10 | 49.75 | 51.95 |
| <i>P. frequentans</i> | 19.85 | 33.15 | 41.65 | 49.95 |
| <i>Trichoderma harzianum</i> | 11.20 | 29.15 | 35.15 | 40.90 |
| <i>T. viride</i> | 12.35 | 30.25 | 35.70 | 42.55 |
| Colourless Bacteria | 19.39 | 32.35 | 43.90 | 57.52 |
| Yellow Colour Bacteria | 13.35 | 23.42 | 37.54 | 67.10 |
| <i>Streptomyces rimosus</i> | 20.10 | 38.52 | 41.45 | 60.15 |
| <i>S. rochi</i> (SR ₁) | 24.12 | 40.80 | 51.95 | 64.15 |

Zinc (Zn) was added in the culture medium in sulphate form