CHAPTER IV

DISCUSSION

The rhizosphere is a unique habitat with a distinctive microbial complex which differs from that of the root-free soil. The community of rhizosphere is composed mainly of non-pathogenic microorganisms. But the very density and the increased microbial interactions harmful and beneficial - can be especially important for soil-borne pathogens because the disease-producing organism must penetrate the rhizosphere in order to initiate infection. Pigeon pea is an important legume. Wilt of pigeon pea caused by Fusarium udum Butler is a soil-borne disease. The disease take a heavy toll of the crop in most of the states of India. Fusarium udum is a soil-borne root-infecting pathogen. The information concerning the pigeon pea rhizosphere in relation to wilt disease is rather meagre. The aim of the present investigation has been to study the rhizosphere and rhizoplane mycoflora of pigeon pea plants uninoculated and inoculated with Fusarium udum, with a view to understand the ecology and control of F. udum, in relation to certain attributes that have recently been assigned to rhizosphere mycoflora.

Studies on rhizosphere and rhizoplane mycoflora of uninoculated and inoculated plants of pigeon pea with Fusarium udum at varying age reveal that there has been more fungal
population in the rhizosphere of both uninoculated and inoculated plants in comparison to non-rhizosphere (Fig. 1; Table 1). This is understandable as in the rhizosphere there are more secretions from roots which provide a better media for fungal activity. These findings are in agreement with many previous studies (Starkey, 1929 b, 1931 and 1958; Timonin, 1940 a,b; Lochhead, 1959; Halissenska and Moreau, 1959; Reddy, 1959; Ivarson and Katznelson, 1960; Rouatt and Katznelson, 1961; Zagallo and Pollen, 1962; Rangaswamy and Vasantharajan, 1962; Rovira, 1965; and Singh, 1971). Moreover, higher fungal population has been encountered in the rhizosphere of inoculated plants in comparison to their uninoculated counterparts. This may partly be attributed to the more root excretions in inoculated plants in comparison to uninoculated plants. More fungal population in infected plants has also been reported by the other workers (Agnihothrudu, 1957 a and 1959; Timonin, 1966; Mathur and Chauhan, 1972; Babushkina, 1973; and Rai and Upadhyay, 1980). Wood (1967) reported an increase in amino acids, carbohydrates etc. in the infected plants due to higher metabolic activity, which are probably leached out in the rhizosphere and cause higher rhizosphere effect in the inoculated plants. Collins and Scheffer (1953) and Wu and Scheffer (1967) also observed an increase in metabolic activity (respiratory rate) in the Fusarium infected tomato plants. Wheeler and Haney (1963) speculated that the cells which first come in
contact with a pathogenic agent generally leak due to loss of semipermeability of membrane. Changes in the biochemical nature of roots have also been noticed in the present studies. As a result higher concentrations of total free amino acids, phenols, o-dihydroxy phenols and sugars have been recorded in the roots of inoculated plants in comparison to uninoculated plants (Table 2). Upadhyay and Rai (1982), however, correlated the increase of fungal population in the wilted plants in comparison to healthy ones due to presence of large number of conidia and propagules of wilt pathogen *Fusarium oxysporum* in the rhizosphere. Agnihotru (1955) also found masses of conidia (both macro and micro) on the stem and also on the wilted branches. This along with higher root secretions may be operative in the present study also.

Age profoundly influences the rhizosphere population, RIS ratio and frequency of fungi in the rhizosphere and rhizoplane of both uninoculated and inoculated plants. In the rhizosphere of both uninoculated and inoculated plants the population of fungi increases with the increase in age of the plant upto 90 days then declines upto 180 days and increases again. Similarly, RIS ratio in the uninoculated plants increases upto 90 days, then declines upto 180 days and increases again. However, in the inoculated plants it increases upto 90 days and decreases upto 120 days, further
increases up to 150 days and then declines and increases again in the last. This indicates that in both uninoculated and inoculated plants the first peak of population has been during the highest vegetative growth of the plant and second peak during senescence, however, during the flowering and fruiting the population somewhat declines. Highest rhizosphere effect has been noticed during senescence i.e., 240 days old plants. These findings are in conformity with Starkey (1929), Parkinson (1957), Agnihotru (1957 b), Riviere (1959), Rouatt (1959), Katmelson (1961), Parkinson et al., (1963) and Ranga Rao (1971), where they have also reported that the rhizosphere effect increases with age of the plant and reaches a maximum coincident with its greatest vegetative development. However, a further increase during senescence was also reported by Gujrati (1969). At the stage of highest vegetative growth of the plant, the rhizosphere soil is biologically more active supporting larger microbial population than the corresponding non-rhizosphere soil. Increase in fungal population during senescence may partly be attributed to decaying roots of the plants and the substantial increase of the sloughed off root material in the rhizosphere. By and large, the frequency of most of the fungi increases in the rhizosphere and rhizoplane of uninoculated plants with the increase in age of the plant. However, in the inoculated plants, the frequency of most of
the parasitic forms increases with the age and saprophytic forms decreases (Tables 4 & 5). The frequency of saprophytic forms has been higher in the rhizosphere and rhizoplane of uninoculated plants in comparison to their inoculated counterparts. However, in the inoculated plants, the frequency of parasitic fungi has been higher in comparison to uninoculated plants. This indicates that in the rhizosphere and rhizoplane of uninoculated plants saprophytic fungi form the dominant flora; however, in the inoculated plants parasitic forms, particularly Fusarium udum. The frequency of Fusarium udum in the rhizosphere and rhizoplane increases with the age of the plant and slightly declines at senescence (Tables 4 & 5). The inoculation of Fusarium udum brings about the suppression of saprophytic forms. However, the parasitic forms have been encouraged. Upadhyay and Rai (1978 & 1982) and Rai and Upadhyay (1973) also demonstrated the ability of Fusarium udum to suppress other fungi in the rhizosphere and rhizoplane of pigeon pea. They also observed that Fusarium udum is a strong saprophytic colonizer of pigeon pea and has high competitive saprophytic colonization (CSC) ability.

The rhizosphere mycoflora of uninoculated plants and non-rhizosphere exhibit qualitative differences. Fungi viz., Circinella tenella, Aspergillus fumiculatus, A. sulfureus,
A. candida, A. terricola, Neocosmospora vasinfesta, Caphalosporium rosae-criaeum, Galacospora cerasia and black sterile mycelium have been reported from the rhizosphere of uninoculated plants and not from the non-rhizosphere; Mortierella alpina, Pyrenochaeta cajani, Monilia brunnea, Rhizoctonia solani and white sterile mycelium from the non-rhizosphere but not from the rhizosphere of uninoculated plants. It has been reported that root exudates have a distinct selective action on the rhizosphere microorganisms which results in the stimulation of certain groups and suppression of the others (Lochhead, 1940). Qualitative differences between the rhizosphere and non-rhizosphere mycoflora have also been reported by Chester and Parkinson (1959), Peterson (1953 & 1959), Catska et al., (1960), Papavizas and Davey (1961), Goos and Timonin (1962) and Singh (1971). Qualitative differences have also been observed in the rhizosphere mycoflora of uninoculated and inoculated plants. Circinella tanali, A. candida, Neocosmospora vasinfesta, Caphalosporium cortinum, G. amarea, Galacospora cerasia, Trichoderma viride, Fusidium viride, and black sterile mycelium have been reported only from uninoculated plants and Cunninghamella echinulate, Mortierella alpina, A. candida, Pyrenochaeta cajani, Monosporium olivaceum, Fusarium nuda, Rhizoctonia solani and yellow sterile
mycelium only from inoculated plants. In the beginning, infections by the pathogen induce changes in chemical composition of the host which might be advantageous to some fungi and disadvantageous to others. Higher concentrations of amino acids, phenols, o-dihydroxy phenols and sugars have been found in the inoculated plant roots in comparison to uninoculated counterparts (Table 2). However, no qualitative differences in amino acids have been noticed in both uninoculated and inoculated plants (Table 3). Changes in amino acid and sugar contents of healthy and diseased roots have been reported by Singh et al. (1973). Qualitative differences in the diseased and healthy plants of pigeon pea have also been reported by (Timonin, 1966; Rai and Vaidhyan, 1980). There have also been qualitative differences in the rhizosphere and rhizoplane mycoflora of uninoculated and inoculated plants at different ages. *Amarrillus fumicatus*, *A. flavus* and *Curvularia pellagens* in the rhizosphere and *A. fumicatus*, *A. flavus* and *A. niger* in the rhizoplane have been recorded from both uninoculated and inoculated plants at all age intervals. *Amarrillus sulphureus* in the rhizosphere and *Circinella tanella*, *A. sulphureus*, *Gibberula curtisii*, *C. roso-scriuum*, *Trichoderma viride* and *T. album* in the rhizoplane have been detected at all age intervals in uninoculated plants only. In the inoculated plants, on the
other hand, *Husor racemosus, Cunninghamella echinulata, Monosporium olivescum* and *Fusarium udum* in the rhizosphere and *H. racemosus, C. echinulata* and *F. udum* in the rhizoplane have been recorded at all age intervals. *Aspergilli* constitute the dominant flora of the rhizosphere and rhizoplane of uninoculated plants of pigeon pea. This is in agreement with Agnithothrudu (1953) who worked on the rhizosphere of sorghum, cotton, french bean and pigeon pea. However, in the inoculated plants of pigeon pea, *Fusarium udum* and other parasitic fungi constitute the dominant flora. This is in conformity with Rai and Upadhyay (1980). According to Scroth and Hildebrand (1964), Katsnelson (1965) and Revira (1965), rhizosphere microflora is affected by the age of the plant, probably due to the quantitative and qualitative changes in the root exudates. Quantitative changes in the concentrations of total free amino acids, phenols, o-dihydroxy phenols and sugars have been observed in the roots of both uninoculated and inoculated plants with the increase in age of the plant. Concentrations of total free amino acids, phenols, o-dihydroxy phenols and sugars increase up to 90 days old plant and decline up to 180 days old plants and further increase in case of free amino acids, phenols and o-dihydroxy phenols. There has not been any increase in sugars after 90 days in both uninoculated and inoculated plants. Inoculation of
Erysiphe pusmus increases the concentration of all the chemicals at all age intervals. Dimond (1970) also concluded that wilt pathogens brought about biochemical changes in the host plant which are pathogen as well as host origin.

The rhizosphere and rhizoplane mycoflora of different cultivars of pigeon pea uninoculated and inoculated with *Erysiphe pusmus* have similarities and also differences in quality and quantity. Certain forms like *Alternaria fimicola*, *A. clavus*, *A. niger*, *Phoma hibernica*, *Chaetomium magnus*, *Heterocera austriensis*, *Curvularia pallensena* and *Glomeromorium herbarum* have been recorded from all the cultivars in the rhizosphere and rhizoplane of both uninoculated and inoculated plants. However, certain forms have been restricted to certain cultivars in uninoculated and inoculated plants viz., *Rhizopus nigricans* ICPL-227 and ICPL-42; *A. arrichiana* Pant A-10; *Mortierella alpina* T-21 and No. 148; *Asperillus fimicola*us T-21 and ICPL-227; and *Chaetomium flavum* Pant A-10 and ICPL-42 in the rhizosphere; and *A. nigricans* ICPL-227, ICPL-42, MDA-1, and MDA-2; and *G. flavum* Pant A-10 and ICPL-42 in the rhizoplane. In the uninoculated plants *Asperillus terreus*, *Fusidium viride* and black sterile mycelium have been isolated from all the cultivars in the rhizosphere and *A. terreus* and black sterile mycelium in the rhizoplane. However, in the rhizosphere of uninoculated plants *Syncephalastrum racemosum* has been confined
to BDW-1 and BDW-2; *Aspergillus luchuensis* T-21, No. 148 and ICPL-227; *A. nidulans* T-21 and ICPL-227; *A. melleus* No. 148, Pant A-10, ICPL-227 and ICPL-42; *A. ochraceous* ICPL-227 and ICPL-42; *A. eumycetii* DL-73-2 and BDW-1; *Penicillium chrysogenum* BDW-1; *Necosomospora verniifica* T-21, Pant A-10 and DL-73-2; and *Trichoderma album* No. 148, BDW-1 and BDW-2; and in the rhizosphere *A. melleus* No. 148, Pant A-10, ICPL-227 and ICPL-42; and *N. verniifica* T-21, Pant A-10 and DL-73-2. In the inoculated plants *Cunninghamella ochimata,* *Fusarium oxysporum,* *Alternaria alternata,* *Helminthosporium sativum* and *Sclerotium rolfsii* have been detected from all the cultivars in the rhizosphere and rhizoplane. However, certain forms have been restricted to certain cultivars viz., *Bacillus cereus* T-21; *Cercospora cuniculata* ICPL-42 and DL-73-2; *Necosomospora ochimata* No. 148, Pant A-10, ICPL-42 and DL-73-2; *Fusarium oxysporum* ICPL-227, ICPL-42 and BDW-1, *Torula allii* No. 148, ICPL-227 and DL-73-2; *Rhizoctonia solani* T-21 and ICPL-227, ICPL-42 and BDW-1 in the rhizosphere; and *N. mucedo* ICPL-42, DL-73-2, BDW-1 and BDW-2; *N. cereus* T-21; and *R. solani* T-21, ICPL-227 and ICPL-42 in the rhizoplane.

Different pigeon pea cultivars differ in their rhizosphere fungal population. Highest fungal population has been recorded in the cultivar T-21 and lowest in BDW-1 in both uninoculated and inoculated plants. Higher fungal population
has been recorded in the rhizosphere of inoculated plants in comparison to uninoculated counterparts in all the cultivars (Table 6). Highest frequency has been recorded for *Amersillus fumigatus* in the rhizosphere and rhizoplane among all the cultivars in uninoculated plants. In inoculated plants, on the other hand, highest frequency has been noticed for *Fusarium udum* in the rhizosphere and rhizoplane among all the cultivars except BDN-1 and BDN-2, where it has been for *Amersillus fumigatus*. The frequency of saprophytic fungi has been higher in the rhizosphere and rhizoplane of uninoculated plants in comparison, to their inoculated counterparts (Tables 3 & 9). On the other hand, in the inoculated plants, the frequency of parasitic forms has been higher in comparison to uninoculated plants. In the uninoculated plants majority of the saprophytic fungi exhibit higher frequency in comparison to parasitic forms in all the cultivars. However, reverse has been true in the inoculated plants in all the cultivars except BDN-1 and BDN-2. The frequency of *Fusarium udum* has been highest in the rhizosphere and rhizoplane of T-21 followed by cultivars No.148, DL-78-2, ICPL-42, ICPL-227, Pant A-10, BDN-1 and BDN-2. In the rhizosphere and rhizoplane of uninoculated plants saprophytic fungi constitute the dominant flora among all the cultivars. Saprophytic fungi have been most dominant in cultivars BDN-1 and BDN-2 and least among T-21 and No. 148. This probably could be one of the reasons of high frequency of *Fusarium*
Fusarium udum has been able to establish in all the cultivars when inoculated around the roots. After inoculation, Fusarium udum has been able to alter the rhizosphere and rhizoplane mycoflora by suppressing saprophytic fungi and favouring parasitic forms; however, in the cultivars EDN-1 and EDN-2, the suppression of saprophytic forms has been least as a result the saprophytic forms dominated in comparison to parasitic forms. Quantitative estimations of roots of uninoculated and inoculated plants of all the cultivars reveal the higher concentrations of total free amino acids, phenols, o-dihydroxy phenols and sugars in inoculated plants of all the cultivars in comparison to their uninoculated counterparts. It has also been observed that cultivars which harbour higher number of fungi and have higher frequency of Fusarium udum in the rhizosphere and rhizoplane in comparison to other cultivars have low concentrations of total amino acids, phenols, o-dihydroxy phenols but higher concentration of sugars. On the other hand, cultivars which possess lower number of fungi and lower frequency of Fusarium udum in the rhizosphere and rhizoplane have higher concentrations of total free amino acids, phenols, o-dihydroxy phenols and lower concentrations of sugars in their roots. Matta et al. (1969) reported that tomato plants inoculated with Fusarium oxyssporum f. sp. lycomonii synthesise
increased amount of both total phenols and o-dihydroxy phenols. These compounds are produced more rapidly in resistant than susceptible plants. In the present studies also in the cultivars BDN-1 and BDN-2, which have low frequency of *Pseudomonas syringae*, increase in total and o-dihydroxy phenols has been much more in comparison to other cultivars (Table 7). Qualitative similarity in the mycoflora of different cultivars could possibly be attributed to the common characteristics of the different cultivars and the soil in question (Kusal and Singh, 1969). However, the differences in the qualitative nature of mycoflora may be in part due to preferential stimulation provided by different cultivars which might be dependent upon the nature and amount of their root exudates and sloughed off root materials (Parkinson, 1967; Gangvane, 1972) in addition to other factors.

Investigations on the rhizosphere and rhizoplane mycoflora of uninoculated and inoculated plants of cultivars T-21 and BDN-1 in relation to foliar sprays with growth regulators reveal that indole acetic acid, indole butyric acid, thio-indole butyric acid and gibberellic acid exhibit stimulatory effect on the population of fungi in the rhizosphere of both uninoculated and inoculated plants of both the cultivars; however, maleic hydraside shows inhibitory effect. Roy and Dwivedi (1967) also reported that foliar spray of some hormones like indole acetic acid and 3-yl-propionic acid resulted in increase in
rhizosphere population. Sullia (1968), Gujrat (1969) and Singh (1970) observed that rhizosphere fungal population of gram, leguminous weed and Arachis phaseolus increased as a result of foliar application of hormones. Gupta (1971) noticed that foliar application of gibberellic acid (50 to 200 ppm) significantly influenced the number of fungi per gram of soil in the rhizosphere of Vigna mungo and Ricinus communis. Dwivedi and Singh (1971) recorded that foliar spray of 50 ppm concentration of gibberellic acid increased the rhizosphere population; however, 100 and 200 ppm and all concentrations of maleic hydrazide showed inhibitory effect. Inhibitory effect of maleic hydrazide on the population of fungi in the rhizosphere has also been reported by Mishra (1968). On the other hand, Singh (1981) reported some stimulatory effect of maleic hydrazide. It seems that these chemicals applied to the leaves are translocated downward and are exuded out through roots in the same original form or their metabolic forms, thus altering the nature of root exudates which affect the rhizosphere population of fungi. Higher fungal population has been recorded in the rhizosphere of inoculated plants of both the cultivars in comparison to uninoculated plants. This may partly be attributed to increased root secretions in the inoculated plants. The frequency of majority of fungi increases in the rhizosphere and rhizoplane of uninoculated plants of both the cultivars with the sprays of indole acetic acid, indole butyric acid, thio-indole butyric acid and gibberellic acid and
decreases with maleic hydrazide. A similar observation has been made in the inoculated plants of both the cultivars; however, with indole acetic acid, indole butyric acid and thio-indole butyric acid, frequency of some of the saprophytic fungi decreases (Tables 11 to 20). The decrease may be attributed to the increase in the frequency of *Fusarium udum* along with other parasitic fungi. The frequency of *Fusarium udum* increases in the rhizosphere and rhizoplane mycoflora of both the cultivars with the spray of indole acetic acid, indole butyric acid, thio-indole butyric acid, gibberellic acid and decreases with maleic hydrazide (Tables 11 to 20). In the rhizosphere and rhizoplane of uninoculated plants of both the cultivars, the majority of saprophytic fungi have higher frequency in comparison to parasitic forms with all the foliar sprays. On the other hand, in the inoculated plants, the frequency of most of the parasitic forms has been higher in comparison to saprophytic forms in the rhizosphere and rhizoplane of T-21 and rhizoplane of BDH-1 in all the treatments except maleic hydrazide (Tables 11 to 20). However, in the rhizosphere of BDH-1 a reverse trend has been found except in indole acetic acid spray.

Foliar sprays with fertilizers reveal that by and large urea exhibits stimulatory effect on the rhizosphere population of uninoculated and inoculated plants of both the cultivars T-21
and BDN-1. On the other hand, spray with potash shows inhibitory effect in the rhizosphere of uninoculated and inoculated plants of cultivar T-21 and inoculated plants of cultivar BDN-1; however, a stimulatory effect in the rhizosphere of uninoculated plants of BDN-1 has been noticed. Ramachandra Reddy (1959 & 1968), Dubedi and Singh (1971), Rao and Raja (1978) reported a higher rhizosphere population with urea spray.

The frequency of majority of the fungi increases in the rhizosphere and rhizoplane of uninoculated and inoculated plants of both the cultivars with urea. On the other hand, with potash spray, the frequency of majority of saprophytic fungi increases while most of the parasitic forms decreases (Tables 21 to 24). Probably due to this fact, the population of fungi in the rhizosphere of uninoculated and inoculated plants of T-21 and inoculated plants of BDN-1 decreases because the parasitic forms constitute the dominant flora. However, the population of fungi in the rhizosphere of uninoculated plants increases because here the saprophytic fungi constitute the dominant flora. The frequency of Fusarium udum increases with urea; however, decreases with potash spray. Fusarium udum has been completely eliminated with potash spray in the rhizosphere and rhizoplane of BDN-1 after II and III spray. The changes in the rhizosphere population and frequency of fungi as a result
of spray of urea may partly be due to the fact that urea when sprayed is probably absorbed by the leaves and metabolised (Thorne, 1954; Boynton, 1954) resulting in more proteins and amino acid which on exudation might affect the rhizosphere mycoflora. Potash might also be absorbed by leaves and metabolised resulting in such substances which on exudation might influence the rhizosphere flora. In the rhizosphere and rhizoplane of uninoculated plants of both the cultivars, the frequency of most of the saprophytic forms has been higher in comparison to parasitic forms with urea and potash spray and only with potash spray in inoculated plants. However, a reverse trend has been observed with urea in the rhizosphere and rhizoplane of inoculated plants.

Studies on foliar sprays with pesticides reveal that by and large foliar spray of bavistin, vitavax, brassicol, benlate, fytolan, captan, wettable sulphur and 2,4-dichlorophenoxy acetic acid show inhibitory effect on the rhizosphere population of uninoculated and inoculated plants of both the cultivars. However, streptomycin spray shows stimulatory effect. Halleck and Cochran (1950), Sullia (1969), Srivastava and Mishra (1971), Balsubramanian and Rangaswami (1973) and Srivastava and Dayal (1981) also recorded inhibitory effect of different fungicides on the rhizosphere population. Gupta (1974) reported stimulatory effect on the rhizosphere fungal
population due to foliar spray of an antibiotic subamycin (a tetracycline compound). The frequency of majority of the fungi decreases with foliar spray of bavistin, vitavax, brassicol, benlate, fytolan, captan, wettable sulphur and 2,4-dichlorophenoxyacetic acid in the rhizosphere and rhizoplane of uninoculated plants of both the cultivars. However, with wettable sulphur, the frequency of some of the parasitic forms increases. With streptomycin most of the fungi exhibit an increase in the frequency. In the rhizosphere and rhizoplane of inoculated plants, the frequency of most of the saprophytic fungi increases while parasitic fungi decreases with bavistin, vitavax, brassicol, benlate and fytolan (Tables 25 to 34). A similar pattern has been observed in the rhizoplane of T-21 with captan and wettable sulphur. The increase in the frequency of saprophytic fungi may partly be due to the decrease in the frequency of *Fusarium oxysporum* and other parasitic forms. A different situation arises in the rhizosphere of T-21 with captan and wettable sulphur, where the frequency of majority of the saprophytic forms along with some parasitic forms increases while the remaining parasitic ones decreases. In the rhizosphere and rhizoplane of HDN-1 a reverse trend has been noticed. It is possible that captan and wettable sulphur might not be effective against those fungi exhibiting higher frequency along with other factors. The frequency of most of the fungi decreases with
2,4-dichlorophenoxy acetic acid in the rhizosphere and rhizoplane of inoculated plants of both the cultivars; however, with streptomycin the frequency of majority of the fungi increases (Table 39 to 42). The frequency of *Fusarium udum* decreases in all the sprays in the rhizosphere and rhizoplane of both the cultivars except with streptomycin where the frequency increases. *Fusarium udum* has been completely eliminated in the rhizosphere of BDN-1 with bavistin, 2,4-dichlorophenoxyacetic acid after III spray, in the rhizoplane of BDN-1 with bavistin after II spray and with vitavax after III spray (Table 25, 26, 28 & 39).

Balsubramanian and Rangaswami (1973) observed that application of fungicide reduced amino acid exudation, caused qualitative changes in sugars and considerably reduced the rhizosphere population. Same may be operative in the present study also. Increase in rhizosphere fungal population due to streptomycin spray may probably be assigned to the fact that the spray stimulates the plant to produce certain substances that are exuded from roots (Gupta, 1974) and thus alter the root exudation and fungal population (Vrany et al., 1962). In the rhizosphere and rhizoplane of uninoculated plants, majority of the saprophytic forms exhibit higher frequency in comparison to parasitic forms in all the treatments. A similar trend has been observed in the rhizosphere and rhizoplane of inoculated plants of both the cultivars with bavistin,
vitavax, brassicol, benlate and fytolan; with captan and wettable sulphur in cultivar T-21; with 2,4-dichlorophenoxyacetic acid and streptomycin in BDH-1. However, a reverse trend has been observed in the cultivar T-21 with 2,4-dichlorophenoxyacetic acid and streptomycin; in cultivar BDH-1 with captan and wettable sulphur.

Studies on non-rhizosphere, rhizosphere and rhizoplane in relation to different soil amendments indicate that in the rhizosphere and rhizoplane of both the cultivars T-21 and BDH-1 and in the non-rhizosphere amendments with urea, superphosphate, potash, neem cake, groundnut cake, castor cake and mustard cake show stimulatory effect; however, mahua cake, baevin, vitavax, brassicol, benlate, fytolan, captan and wettable sulphur show somewhat inhibitory. Stimulatory effect has also been noticed in the rhizosphere and rhizoplane of inoculated plants of both the cultivars with urea and superphosphate, however, rest of the treatments show inhibitory effect. The frequency of most of the saprophytic fungi in the rhizosphere and rhizoplane of uninoculated plants of both the cultivars and in the non-rhizosphere increases in treatments with urea, superphosphate, potash, neem cake, groundnut cake, mahua cake, castor cake, mustard cake and decreases in all the fungicidal treatments; however, most of the parasitic fungi increase with urea and superphosphate and decrease in
rest of the treatments. In the rhizosphere and rhizoplane of inoculated plants of cultivar T-21, the frequency of most of the saprophytic fungi increases in all the treatments; however, in case of BDN-1, the frequency increases in the treatments with urea, superphosphate, potash and oil cakes and either increases or decreases in the fungicidal treatments. On the other hand, the frequency of majority of parasitic fungi increases with urea and superphosphate and decreases in rest of the treatments in both the cultivars. In the rhizosphere and rhizoplane of T-21, Fusarium udum has been completely eliminated in treatments with neem cake, mahn cake, castor cake, bavistin, vitavax and benlate. In the rhizosphere and rhizoplane of BDN-1, Fusarium udum has been completely controlled in treatments with potash, neem cake, groundnut cake, mahua cake, castor cake, mustard cake, bavistin, vitavax, brassicol, benlate and fytolan (Tables 45 to 48). The saprophytic fungi exhibit higher frequency in comparison to parasitic forms in all the treatments in the rhizosphere and rhizoplane of un inoculated plants of T-21; however, in inoculated plants a reverse trend has been noticed in only urea and superphosphate. Similarly, in the rhizosphere and rhizoplane of un inoculated plants of cultivar BDN-1, the frequency of majority of saprophytic forms has been higher in comparison to parasitic forms; however, in inoculated plants
superphosphate has been exception where reverse trend has been observed. Mosolov et al. (1959) and Jalaluddin (1975) reported stimulatory effect of inorganic fertilisers on the non-rhizosphere and rhizosphere population. Inorganic fertilisers may induce fresh root formation and increase root exudation in the plants and thus may provide more substrate for rhizosphere and rhizoplane microorganisms resulting in more population and higher frequency of these organisms. In the inoculated plants Fusarium udum has been favoured by urea and superphosphate treatments. Although potash treatment has suppressed most of the parasitic forms resulting in stimulation of majority of the saprophytic forms in both uninoculated and inoculated plants. Papendick and Cook (1974) reported that Fusarium crown and foot rot was favoured by large amount of nitrogen. No Rae and Shaw (1933) observed that superphosphate increased pigeon pea wilt and also favoured the growth of pathogen in vitro. Rai and Upadhyay (1983) reported that competitive saprophytic colonization (CSC) of Fusarium udum was promoted by urea amendments. Lewis (1979) and Huber (1979) observed that high amount of potassium in soil was correlated with disease suppression or decline in population of several pathogens. Bruehl (1975) and Papavizas (1974) summarized many reports in which decrease in disease or pathogen survival was attributed to an increase in specific or general microbial activity. The increased
microbial activity may result in nutrient competition, myco-
parasitism or production of toxic materials (Marriman, 1976;
Papavizas, 1974).

Oil cakes, the product left after extraction of oils, contain sufficiently higher concentration of lignin, cellulose
and other carbohydrates, certain nitrogenous materials etc.
which are suitable for all types of colonizers, thus resulting
in the increase of fungal population, particularly saprobes.
Kiran (1977) has also reported that oil cakes during decompo-
sition in the soil are colonized by primary as well as secondary
and tertiary colonizers. The reduction in the frequency of
parasitic forms might probably be due to release of toxic
materials during decomposition which are fungistatic or fungi-
cidal. The possibility that oil cakes and other amendments
which are a source of nitrogen to crop plants, provide better
plant growth together with more root exudates and more host
surface for fungal activity can not be ruled out. Upadhyay and
Rai (1931) were of the opinion that soil amendments may leave
either detrimental effect on the pathogen or may change the
biological balance of soil in favour of antagonists, which
would ultimately suppress the pathogen. In the present studies
the frequency of Trichodermum virida and other saprophytic forms
substantially increases with oil cake amendments in the rhizo-
sphere and rhizoplane of both the cultivars. Therefore, the
part played by *Trichoderma viride* and other saprophytic forms as antagonists in suppressing the wilt pathogen *Eusarion udum* in the present investigation cannot be ruled out. *Evans* (1955) and *Saksema* (1960) also reported that high population of *Trichoderma* may suppress pathogen. The inhibitory effect of filtrates of certain saprophytic forms such as *Aspergillus terraeus*, *A. niger* and mixed filtrates of different soil fungi against *Eusarion udum* on solid media was shown by *Vasudeva* and *Roy* (1950) and *Vasudeva* and *Govindaswami* (1953). *Rai* and *Upadhyay* (1983) observed that colonisation of *Eusarion udum* on pigeon pea substrate was suppressed by saprophytic forms when present in inoculum mixture with *E. udum* or when substrate had already been colonised by them. Inhibitory effects on soil microorganisms as a result of application of nematicides, pesticides and herbicides have been reported by *Bollen et al.* (1954), *Bollen* (1961), *Lebed* (1964), *Tu* (1972 & 1973), *Singh* and *Prasad* (1973), *Mishra* and *Handwara* (1974), *Rodrigues-Kabana* and *Adams* (1975) and *Jain* and *Sehgal* (1980). *Vaartaja* and *Agnihotri* (1970) observed that with methyl bromide and captan the pathogenic fungi decreased and saprophytic forms increased in the rhizosphere of spruce. *Bertoldi et al.* (1977 & 1978) recorded inhibition of rhizosphere fungi with captan and benomyl.

(1978) and Upadhyay and Rai (1981) observed that application of many systemic fungicides in soil controlled the wilt disease of pigeon pea. Bavistin completely controlled the wilt disease. The decrease in frequency of parasitic forms with the amendments of fungicides may probably be attributed to decrease in competitive saprophytic colonisation (CSC) of these parasitic forms (Rai and Upadhyay, 1983).

In the present studies age and different cultivars have been found to influence the rhizosphere and rhizoplane mycoflora of both uninoculated and inoculated plants of pigeon pea. The frequency of *Fusarium udum* increases in the rhizosphere and rhizoplane with the age of the plant and slightly declines at senescence. Different cultivars exhibit different frequency of *Fusarium udum*. Foliar sprays with growth regulators, fertilizers, and pesticides and soil amendments with fertilizers, oil cakes and fungicides have brought about significant changes in the rhizosphere and rhizoplane mycoflora of both the cultivars T-21 and BDH-1. With the foliar spray of indole acetic acid, indole butyric acid, thio-indole butyric acid, gibberellic acid, urea and streptomycin, the frequency of *Fusarium udum* increases in the rhizosphere and rhizoplane of both the cultivars and decreases with sprays of maleic hydrazide, potash, bavistin, vitavax, brassicol, benlate, fytolan, captan, wettable sulphur and 2,4-dichlorophenoxyacetic acid. *Fusarium udum* has been
completely eliminated in the rhizosphere of BDH-1 with bavistin, 2,4-dichloroacetic acid after III spray; in the rhizoplane with bavistin after II and with vitavax after III spray. The frequency of *Fusarium udum* decreases with all the soil amendments except urea and superphosphate in the rhizosphere and rhizoplane of both the cultivars. *Fusarium udum* has been completely controlled in the rhizosphere and rhizoplane of T-21 with neem cake, mahua cake, castor cake, bavistin, vitavax, benlate and in the rhizosphere and rhizoplane of BDH-1 with potash, neem cake, ground nut cake, mahua cake, castor cake, mustard cake, bavistin, vitavax, brassicol, benlate and fytolan. The frequency of saprophytic forms has been found to increase with the decrease in the parasitic forms particularly *Fusarium udum* in all oil cake amendments. Moreover, the frequency of *Trichoderma viride* also substantially increases in oil cake amendments indicating the part played by antagonists in suppressing pathogens. The present studies would, therefore, go a long way in exploring and envisaging different possibilities where the rhizosphere microflora could be modified by foliar applications and soil amendments for control of root diseases. Brian (1957) also mentioned that successful control of root diseases probably lies in the development of satisfactory methods for influencing the rhizosphere microflora.