GENERAL SUMMARY AND CONCLUSIONS
World wide uses of fungicides along with other pesticides and chemical fertilizers have become more popular these days. Undoubtedly with the help of these chemicals we have saved and increased our crops and their products to a great extent. However their side effects what ever they may be cannot be neglected any more.

More often than not indiscriminate uses of various fungicides and chemical fertilizers cause adverse effects on some useful micro-organisms and crop plants as well. Ultimately these adverse effects may cause reduction in fertility of the soil. As such in order to regulate their usage continuous microbial monitoring of agricultural lands is called for. On this background present study was undertaken in which the effects of five commonly used fungicides and three chemical fertilizers on the soil microflora of some agricultural lands were investigated.

As evident from the results of present study, all the five test fungicides were found to cause more or less adverse effects on fungal and bacterial population of the soil. And their adverse effects on both were found more deleterious and long lasting in their higher concentrations. With the increase of time microbial population was found to recover gradually which sometimes even surpassed the original level at certain lower concentrations.
A number of plant pathogenic and saprophytic fungal species like Aspergillus niger, A. fumigatus, A. flavus, Alternaria alternata, Curvularia lunata, C. pallescens, Drechlera spicifera, Fusarium culmorum, F. equiseti, Penicillium frequentans, P. nigriceps, Trichoderma viride, Cephalosporium roseo-griseum, Verticillium terrestre and Monodictys sp. were found comparatively more resistant to most of the fungicides in soil and when affected their reappearance was seen much earlier than other soil fungi. Whereas certain mucoraceous forms including Absidia butleri, Absidia sp., Cunninghamamella verticillata, Rhizopus nigriceps; some species of Aspergillus and Penicillium like A. versicolor, A. niveus, A. sydowi, A. ornatus, A. candidus, Aspergillus sp., P. lilacinum, P. nigriceps, P. frequentans, P. chrysogenum and various deuteromycetes like Alternaria humicola, Cladosporium oxysporum, C. cladosporioides, Fusarium oxysporum, Fusarium sp., Helminthosporium spp., Pestalotiopsis versicolor, Pullularia sp., Paecilomyces variotii, Pestalotia sp., Hyalostachybotrya sp. and Trichoderma sp. were proved quite sensitive to these fungicides.

Interestingly certain forms like Alternaria sp., Paecilomyces fuscispinus, Cladosporium cladosporioides, Sarcinella sp., Phoma hibernica, Fumago sp. and Bipolaris sp. were found to appear more frequently in fungicides treated soils than in untreated control soils.
On testing the effects of these fungicides against five selected common soil fungi viz. *Alternaria alternata*, *Curvularia lunata*, *Drechlera spicifera*, *Fusarium equiseti* and *Pestalotiopsis versicolor* on agar plates and in the soil, it was found that all the fungicides were capable of causing very strong antifungal effects on all the test fungi. Though their fungitoxic effects were appeared to be more pronounced on agar plates than in soil.

With a view to finding out the fate of various fungicides, their relative persistence was investigated in the soil. All the five fungicides were found to be degraded by physico-chemical as well as by biological factors of the soil. Almost all the five monocultures of the test fungi were found capable of degrading these fungicides in the soil.

Besides pH as well as E. conductivity of the soil were also found to be disturbed by the addition of these fungicides in the soil. Generally pH was increased towards alkalinity for some times and than it was found to be decreased. E. conductivity of the soil was also increased in fungicides treated soil. Though in higher concentrations of some fungicides these effects were more remarkable and long lasting. Interestingly slight changes in pH and E. conductivity were also observed even in the untreated control soils. However there appeared to be no clear cut correlation between pH and E. conductivity of the soil.
As also evident from the results of present study, fungicides used for the control of various plant diseases may caused beneficial or harmful effects on seed mycoflora, seed germination, and subsequent growth of seedlings of various crops commonly sown in the soil. Seed mycoflora of all the three crop seeds were adversely affected by almost all the five fungicides. In general most of the fungicides at their lower concentrations either increased or did not cause significant effects on seed germination as well as seedling shoot-root length of all the three crops. However at higher concentrations of almost all the fungicides well marked adverse effects were noticed on seed germination as well as on shoot-root length of the seedlings of all the three crops. Majority of fungicides also caused considerable mortality and various types of abnormalities in the seedlings. Comparatively however Linum usitatissimum (variety JLS-1) was more adversely affected by various fungicides than the local variety of Pisum sativum and Sorghum vulgare.

On the whole vegoll [(Methoxyethylene mercury chloride) containing 6% mercury] was found to be most toxic fungicide throughout the study. It showed strong deleterious effects on microbial population, seed mycoflora, seed germination and seedling growth. Its application in the soil caused reduction in the frequency of almost all the soil fungi. However Aspergillus versicolor, A. niveus, Gliocladium sp., Fusarium sp., Penicillium chrysogenum, Pullularia sp., Pestalotia sp.,
Verticillium terrestre; and most of the mucoraceous forms including *A. butleri*, *Cunninghmania verticillata*, *Rhizopus nigricans*, *R. nodosus* were more severely affected. Whereas *Aspergillus niger*, *A. flavus*, *Alternaria alternata*, *Curvularia lunata*, *Cephalosporium roseo-griseum*, *Fusarium equiseti*, *Trichoderma viride*, *Monodictys* sp. and *Drechslera spicifera* were found to be somewhat resistant particularly at its lower concentrations.

Interestingly although all the five selected test fungi were very strongly inhibited by this fungicide in agar plates, its performance against these fungi in soil however appeared to be less remarkable. Besides vegoll was also found to cause maximum change in the soil pH.

Results of persistence study revealed that vegoll may remain active for more than 42 days after its application in the soil. However *Pestalotia versicolor* and *Fusarium equiseti* were found quite efficient for degrading this fungicide in the soil.

Bavistin being a systemic in nature was proved to be a broad spectrum antimicrobial fungicide. However it caused strongly toxic effects against *Aspergillus sydowi*, *Aspergillus* sp., *Cladosporium* sp., *Curvularia* sp. *I*, *Penicillium lilacinum*, *Penicillium* sp., *Trichoderma viride*, *Trichoderma* sp., and *Verticillium* sp. On the other hand *Aspergillus niger*, *A. fumigatus*, *Alternaria alternata*, *Curvularia lunata*, *C. pallescens*,...
Drechslera spicifera, Fusarium equiseti and F. oxysporum were comparatively less severely affected by this fungicide.

Interestingly in *in vitro* antifungal effects of bavistin appeared to be most remarkable against *Fusarium equiseti* and *Pestalotiopsis versicolor* both in agar plates as well as in soil. However this fungicide could not be degraded easily and its toxic effects remained long lasting both in sterilized as well as in unsterilized soil. Nevertheless certain test fungi including *Alternaria alternata*, *Curvularia lunata* and *Drechslera spicifera* were found capable of inactivating this fungicide in the soil. Bavistin appeared to be favourable for *Rhizopus nigricans* and *Cunninghamella* sp. which were stimulated in the seed mycoflora of almost all the three crop seeds. Seed germination and seedling growth were also stimulated or not adversely affected in most of the concentrations of this fungicide. As such on the whole this fungicide appeared to be less harmful to crop plants.

Both of the carbamate fungicides including dithane M-45 and thiride showed profound adverse effects on fungal as well as on the bacterial population of the soil. But fungal population was found to be more deleteriously affected than bacterial population by both the fungicides in soil. In thiride treated soil *Aspergillus ornatus*, *A. sydowi*, *A. candidus*, *Curvularia* sp. I, *Fusarium* sp. II were comparatively more adversely affected than other soil fungi. While dithane M-45 caused more remarkable deleterious effects on species of
Helminthosporium, Paecilomyces variotii, Penicillium nigricans and Rhizoctonia sp. However Aspergillus niger, Curvularia lunata, Asternaria alternata, Fusarium equiseti and Trichoderma viride were found to be tolerant for both of these fungicides.

These two fungicides were proved less toxic in seed germination and seedling growth of almost all the three crops although their treatment caused some toxic effects on seedling growth. Dithane M-45 and thiride showed a well marked adverse effect on seed mycoflora of almost all the three crops. But thiride caused comparatively more adverse effects against almost all the test fungi in agar plates and in the soil than dithane M-45.

Both of these fungicides were also found to a slight change in the pH and E. conductivity of the soil though pH returned back to its normal level after some time in both the cases. Both fungicides were degraded in the soil by physico-chemical as well as by biological factors of the soil. However both dithane M-45 and thiride persisted for more than 42 days in the soil but degradation of thiride was observed comparatively more than dithane M-45. In monoculture studies Pestalotiopsis versicolor caused better degradation of dithane M-45 while thiride was more efficiently degraded by Curvularia lunata.

Although brassical also caused adverse effects on fungal population but on the whole this fungicide was found to be comparatively less toxic than other fungicides. A number of
soil fungi including _Aspergillus niger_, _A. flavus_, _A. fumigatus_, _Curvularia lunata_, _Fusarium equiseti_, _Helminthosporium tetramera_, _Penicillium nigricans_, _P. lilacinum_, _Trichoderma viride_ and _Cephalosporium roseo-griseum_ were found comparatively more resistant to this fungicide whereas _Aspergillus terreus_, _A. niveus_, _A. versicolor_, _Absidia butleri_, _Curvularia pallescens_, _Hyalostachybotrys_ sp., _Mycelia sterilia_ I and _Rhizopus nigricans_ were found to be more severely affected by this fungi.

Bacterial population in the soil, seed germination and seedling growth were either increased or not much affected in most of the concentrations of this fungicide. Nevertheless seedling mortality and various abnormalities were observed in seedlings of almost all the three crops. Besides this fungicide was also found to be degraded earlier than the other fungicides. As compared to other monocultures, comparatively _Curvularia lunata_ and _Drechslera spicifera_ were found more efficient for the degradation of this fungicide in the soil.

Chemical fertilizers on the other hand generally showed stimulatory effects on soil microflora, seed mycoflora, seed germination as well as seedling growth of all the three crops. However at higher concentrations these chemicals also caused toxic effects. A noticeable change in pH and E. conductivity was also observed in the soils after the treatment of these chemical fertilizers.
Thus on the whole following facts of importance appeared to be noteworthy.

(i) All the five fungicides as well as chemical fertilizers at their high dosage rates caused a remarkable adverse effects on soil microflora, seed germination, seedling growth and changed the chemical nature and reaction of the soil (pH and E. conductivity), therefore, use of fungicides and chemical fertilizers in high dosage rates as well as their continuous application in the soil should be resorted to most carefully and in a judicious way.

(ii) Use of vegoll, a mercurial fungicide, due to its strong deleterious effects on soil microbes, seed germination and seedling growth should be avoided as far as possible.

(iii) In order to regulate the usage of these fungicides periodic microbial monitoring should be done.