SEED - BORNE FUNGI OF COMMON VEGETABLES AND THEIR ROLE IN CAUSING SEEDLING DISEASES

BY

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THESIS

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Dedicated to my Brother
and family

Declaration

I hereby declare that this thesis entitled "Seed-borne fungi of common vegetables and their role in causing seedling diseases" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis entitled "Seed-borne fungi of common vegetables and their role in causing seedling diseases" is a record of research work done independently by Sri. Mathew George under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

INTRODUCTION

Vegetables are among the essential requirements of our diet for the maintenance of normal health. The daily minimum consumption of vegetables should be about 280g/head while the present average daily consumption in India is less than 25g/head. Therefore, there is an urgent need to increase the production of vegetables in India. The area under vegetables in India is about three million hectares. As an important factor in increasing the production, more attention has to be given to the control of diseases of vegetable crops in the field, at harvest, in transit, in storage and in the market places for developing suitable measures to minimise the losses caused by the diseases.

Seed infection forms a major way of dispersal of causal agents of many vegetable diseases. The seeds may be infected both externally and internally by seed-borne fungi. Thus the seeds carry several destructive pathogens that often cause several diseases on crops raised from them. The diseased seedlings besides themselves suffering from damage also produce in certain cases abundant quantities of spores which further spread the disease to the healthy plants in the field. Seeds may also introduce pathogens into new areas. In many cases infection reduces the market value of the produce. The damages caused by seed-borne fungi to seeds and to the crops arising from diseased seeds include failure of germination, seedling blight and rot and disease symptoms in adult plants. Some of these fungi are known to produce mycotoxins which are toxic even to human beings. Control of seed-borne pathogens with fungicides by seed treatment is the cheapest and the easiest method and can be economic even for the small holders. Seed treatment provides an economical and relatively non polluted method compared to other field application systems because only a small amount of material is applied per hectare and in immediate contact with target site. Moreover, seed treatments will increase crop yields even if there is no infection.

In India, especially in Kerala, not much work has been done on the microorganisms associated with seeds and their control. For laying down seed health standards against seed-borne diseases of vegetables, considerable background information is needed regarding the mycoflora associated with seeds, their role on the disease outbreaks and the nature and extent of damage caused by them. In this context, the present study was carried out to identify the seed-borne fungi of common vegetables and the role of these fungi in causing seed deterioration and disease at seedling stage. Based on the observations various seed treatment methods with common seed treatment fungicides were carried out to formulate suitable methods for controlling different seed-borne fungi which causes seedling diseases. Studies on the effect of toxins produced by the seed-borne fungi in the culture filtrate on seeds and seedlings were also carried out during the present investigations.

Review of Literature

2. REVIEW OF LITERATURE

1.1 Seed-borne fungi of vegetables

Many externally as well as internally seed-borne fungi have been isolated from vegetable seeds from different parts of the world. Miller and Crosier (1936) reported that *Alternaria solani* was commonly present in tomato seeds and *Fusarium bulbigenum* var. *lycopersici* was noted occasionally. Seed transmission of *Didymella lycopersici* in tomato was observed by Ogilvie (1945). Groves and Skolko (1945) conducted studies on different species of *Curvularia* in vegetable seeds and observed *C. geniculata* and *C. inequalis* from pea, *C. trifolii* from soybean, pea, cucumber and pumpkin, *C. lunata* from chilli and *C. pallescens* from turnip. Seed-borne nature of *Rhizoctonia solani* in chilli was reported by Baker (1947). Skolko and Groves (1948) recorded *Chaetomium elatum* from carrot, pea and radish, *C. dolicotrichum* from pea and radish, *C. funicolum* from cucumber, soybean, tomato and pea, *C. indicum* from carrot, tomato, bean and pea and *C. reflexum* from tomato, pea, okra and chilli.

Jacks (1951) isolated *Fusarium* sp., *Alternaria* sp. and *Mucor* sp. from tomato seeds. The pycnidia of *Didymella lycopersici* was observed within the testa of tomato seeds by Derbyshire (1960). Suryanarayana et al. (1963) tested seeds of vegetables, viz., bean, bottle gourd, pea, pumpkin, bhindi, tinda, brinjal and tomato. They reported that Aspergillus, Penicillium and Rhizopus were the most common fungi isolated from most of the samples tested while Gloeosporium, Fusarium and Rhizoctonia on beans and bhindi, Fusarium on peas, Rhizopus and Fusarium on tinda, Phomopsis and Helminthosporium on brinjal and Alternaria on tomato were the most important pathogens on the respective crops. Kudrina (1967) studied the role of humidity and temperature on the incidence of seed-borne fungi in onion, cucumber and tomato seeds. He observed the presence of Penicillium, Aspergillus and Mucor when the seeds were stored at humidity less than 70 per cent and temperature of 10 or 20°C. At humidity more than 70 per cent the number of Penicillium and Aspergillus increased.

Grover and Bansal (1970) observed that the seeds obtained from diseased and healthy chilli fruits carried Colletotrichum capsici, both internally and externally. The seed-borne nature of Fusarium redolens in tomato was confirmed by Wilcox et al. (1970). Staunton (1971) recorded F. oxysporum f.sp. lycopersici in tomato crop in Ireland and proved its seed-borne nature.

Some of the seed-borne pathogens are found to reduce seed germination. Thus Alternaria capsici-annui, Colletotrichum piperis and Fusarium semitectum caused reduction in seed germination in chilli and egg plant (Kharkova et al., 1974). Rhizoctonia solani, Pythium sp. and Phytophthora parasitica were reported to be seed-borne in tomato and they caused seed rots (Raicu and Stan,1974). Sharma and Sohi (1975) found that Phytophthora parasitica was seed-borne in tomato, both internally and externally. Skvortsova et al.(1975) noted that on seeds stored below critical moisture, Cladosporium and Alternaria spp. were replaced by Aspergillus and Penicillium spp. and the highest number of microorganisms was isolated from seeds stored at 15°C. Manoharachary et al. (1975) conducted studies on the mycoflora of sesame, sunflower, egg plant and tomato. The commonest isolates were Aspergillus spp., Alternaria alternata and Rhizopus arrhizus. Curvularia lunata,Penicillium sp. and Sclerotium oryzae were also present.

Drechslera papendorfii, a new addition to the fungi of India and to the seed mycoflora of Capsicum frutescens was reported by Manoharachary and Padmavathy (1976). Botryodiplodia palmarum was observed to be seed-borne in Capsicum by Maholay and Sohi (1977). Jharia et al. (1978) reported Alternaria sp., Colletotrichum capsici, Phoma sp., Helminthosporium sp. and Fusarium equiseti associated with chilli seeds.

Alternaria alternata, isolated from Capsicum annuum fruits was reported to be seed-borne by Shawokat et al.(1978). Kuniyasu (1979) observed the presence of Fusarium oxysporum f.sp.lagenariae from the seeds of bottle gourd. The fruit rot pathogen F. oxysporum f.sp.cucurbitae was reported to be seed-borne by Hall et al. (1981). Vidhyasekaran and Thiagarajan (1981) isolated Fusarium oxysporum from chilli seeds.

Huang and Sun (1982) observed the seed-borne nature of F. oxysporum f.sp.lycopersici, the causal agent of tomato wilt. Franceschini et al., (1982) isolated Alternaria alternata f.sp.lycopersici from the seeds of tomato on which it caused a serious wilt in glass house. Orlova et al. (1982) isolated 23 species of fungi from tomato seeds of which 15 were isolated from seed surface and eight from the internal parts of the seeds.Fusarium spp.(F. culmorum,F. gibbosum and F. solani) Alternaria chartarum, Stemphylium sp. and Ulocladium chartarum were the most frequent causing internal infection while Penicillium and Aspergillus spp. predominated on the surface.

Candida tropicalis and Pichia membranefaciens, two yeast fungi, were isolated from seeds of chilli and their internally seed-borne nature was proved by Ibe and Ike (1982).

Macrophomina phaseolina was isolated from infected seeds of bottle gourd, squash and musk melon by Maholay and Sohi (1983). Naseema *et al*.(1983) reported *Aspergillus flavus* *A. niger* and *Rhizopus stolonifer* to be externally and internally seed-borne in common vegetable seeds. Seed-borne infection of *Myrothecium* in sesame, brinjal, chillies,tomato and cowpea was reported by Chauhan and Chauhan (1984). Deena and Basuchaudhary (1984) gave an annotated list of twenty five fungi isolated from seeds of chilli. These include *Aspergillus* sp., *Alternaria alternata*, *A. solani*, *Alternaria* sp.,*Chaetomium* sp.,*Cladosporium oxysporum*, *Coleophoma empetri*,*Colletotrichum* sp.,*C. capsici*, *Curvularia eragrostidis*, *C. geniculata*,*C.lunata*, *C. pallescens*,*Drechslera bicolor*,*D.tetramera*, *Fusarium culmorum*,*F.equiseti*,*F.moniliforme* var. *subglutinans*, *F.semitectum*,*Nigrospora oryzae*, *Penicillium oxalicum*, *Phoma* sp.,*Rhizopus stolonifer* and *Stemphylium botryosum*. *Cephalosporium curtipes* has been isolated from ripe fruits of *Capsicum annuum* by Mittal (1984). Fakir and Mridha (1985) detected that *Colletotrichum dematium* and *Macrophomina phaseolina* causing die-back of bhindi were seed-borne. Varthanian and Endo (1985) isolated *Phytophthora infestans* from seeds extracted from tomato fruits.

A low incidence of 1-4 per cent in dry seed inspection and 1 - 8 per cent in standard blotter method of *Rhizoctonia solani* was recorded in chilli seeds by Chitkara *et al*.(1986). Mishra and Rath (1986) found the association of two species of *Fusarium* with chilli seeds, viz., *F. oxysporum* and *F. solani*. Park and Kim (1986) detected *Cercospora capsici*, *Drechslera hawaiensis* and *Verticillium albo-atrum* from chilli seeds. Varshney (1986) reported *Alternaria zinniae* from seeds of bhindi.

Adiver *et al*. (1987) isolated *Colletotrichum*, *Cladosporium*, *Alternaria*, *Drechslera* and *Curvularia* spp. from discoloured seeds of *Capsicum annuum*. Fischl (1987) reported *Curvularia ovoidea* from *Capsicum* seeds. Bhardwaj *et al*. (1987) observed that *Phytophthora nicotianae* var. *nicotianae* remained viable for more than one year inside infected seeds of *Capsicum annuum*.

Gupta and Basuchaudhary (1987) studied the seed-borne organisms of vegetables, viz., radish, brinjal, tomato, chillies and bhindi. *Alternaria alternata* was isolated from all vegetable seeds, *Alternaria* spp. from tomato and chillies and *Colletotrichum dematium* from chillies. Khulbe and Sati (1987) observed five species of *Alternaria* associated with seeds under storage and field conditions. They are *Alternaria alternata*, *A. solani*, *A. tenuis* and

A. raphani. Meon and Nik (1988) isolated Colletotrichum capsici from the surface of Capsicum annuum seeds. Sultana et al. (1988) reported that in the seeds of Capsicum annuum, Alternaria alternata was the pre-dominant pathogen. A. tenuissima and Fusarium moniliforme were also frequently isolated.

Cladosporium chlorocephalum, C. cladosporioides, C. colocasiae, C. cucumerinum, C. fulvum, C. oxysporum, C. sphaerospermum and C. spongiosum were isolated from tomato, red pepper (Capsicum annuum) and bell pepper (C. frutescens) by Sati et al. (1989). Pathogeniciy tests by seed infestation showed that C. cladosporioides, C. oxysporum and C. sphaerospermum were pathogenic. Dhyani et al. (1990) reported the seed-borne nature of Phoma destructiva in chilli seeds.

1.2 Effect of seed-borne fungi on germination of seeds and on seedlings.

The inhibitory effects of seed-borne fungi on germination of seeds are greatly influenced by temperature and humidity. Studies conducted by Field and King (1962) on pea seeds inoculated with Aspergillus flavus, A. ruber, A. candidus, A. restrictus and A. amstelodami under controlled conditions of temperature and humidity have shown that there was moderate to drastic reduction in the germination of seeds with the increase in moisture content and storage temperature for a period of 2-8 months. Aspergillus spp. under certain circumstances contributed greatly to loss of germination of seeds (Christensen,1967). Lalithakumari et al.(1970) reported that eight species of Aspergillus isolated from stored pods and kernels of groundnut caused seed germination failures and reduction in seedling vigour. Harman and Pfleger (1974) in their studies with common storage fungi found that pea seeds were infected and their germination reduced by Aspergillus glaucus and A. restrictus. Squash seeds were infected by six isolates of Aspergillus but germination was reduced only by a single isolate of A.flavus. Rati and Ramalingam (1974) observed that A.flavus caused different types of infection such as seed rot, non emergence of cotyledons, infection of the plumule which lead to death of seedlings and cotyledon infection in some tropical crop plants.

Jenkins and Winstead (1959) isolated a new species of Colletotrichum from water melon fruits and its seed-borne nature was proved. It differed from Colletotrichum lagenarium in morphology and pathogenicity. On cucumber and watermelon it was most destructive as an incitant of damping off of seedlings and fruit rot. Grover and Bansal (1970) found that the seeds of chilli carried Colletotrichum capsici both internally and externally leading to damping off. Seedlings that died after emergence produced abundant acervuli and spores which could become a potential source of primary infection. Prasanna (1985) reported the anthracnose fungus of cowpea, *Colletotrichum lindemuthianum* to be seed-borne and the germination percentage decreased with an increase in seed infection which caused seed rot and seedling mortality. Adiver *et al*. (1987) observed that germination of discoloured seeds of *Capsicum annuum* was considerably reduced. They reported that the most commonly occurring seed-borne fungi of chilli were *Colletotrichum*, *Cladosporium*, *Alternaria*, *Drechslera* and *Curvularia* spp. and they affected the root elongation more adversely than shoot elongation.

Wilcox and Jackson (1970) reported that *Fusarium redolens* in tomato caused yellowing of cotyledons and lower leaves and a marked vascular necrosis of the stem. *Helminthosporium* sp., *Fusarium* sp. and *Alternaria* sp. were found associated with seeds of cauliflower, bean and pea and were proved to be pathogenic causing considerable post-emergence damage. (Sekhon and Sivapuri, 1971). Vidhyasekaran and Thiagarajan (1981) observed that *F. oxysporum* infection caused a reduction in seed germination, growth rate and fruit yield of chilli and the fungus was frequently isolated from its seeds. Seed-borne infection induced wilting and fruit rot in the transplanted crop. Onesirosan (1983) studied the effect of season of harvest on the level of microfloral infection, quality and viability of the seeds of cowpea. He found that the wetness which accompanies harvest in the first part of the growing season greatly reduced quality and viability of seeds with wrinkled testa. Reduction in quality in the form of mouldness was due primarily to invasion by Fusarium equiseti which along with a Pseudomonas sp. was also responsible for loss in viability.

The reduced germination of seeds, wilting, damping off and leaf blight of seedlings of tomato as a result of infection of seeds with a sporulating culture of Alternaria raphani was reported by Khulbe and Sati (1987).

In experiments conducted by Ogilvie (1945) infected seeds of tomato sown in sterilized soil gave rise to seedlings infected with Didymella lycopersici to the extent of 8.5 per cent in one test and nearly 5 per cent in another. The tips of cotyledons were shrivelled and appeared to have been infected directly from the seeds which were carried up above the soil. Later the badly diseased ones died off, while infected cotyledons on otherwise healthy plants drooped and the plants recovered. Skolko and Groves (1948) reported that vegetable seed samples heavily infected by different species of Chaetomium showed a corresponding low germination.

Rhizopus spp.caused pre-emergence rot in groundnut seeds as reported by Frank (1969). Agarwal and Joshi (1971) observed that the seed-borne purple stain pathogen of soybean Cercospora kikuchi adversly affected the emergence both in the laboratory and in the field as compared to healthy ones. Raicu and Stan (1974) described Rhizoctonia solani, Pythium sp. and Phytophthora parasitica as the pathogens causing seed rot and damping off of tomato. Sharma and Sohi (1975) reported that tomato seeds infected by Phytophthora parasitica did not germinate or if the seedlings were pushed out of the seed, they were immediately killed by the fungus.

Botryodiplodia palmarum caused pre-emergence mortality of capsicum seeds (Maholay and Sohi 1977). Maholay and Sohi (1983) studied the role of the seed-borne fungus Macrophomina phaseolina in the germination of seeds of bottle gourd, squash and musk melon and reported that inoculation had no effect on the germination of squash and bottle gourd seeds but musk melon seeds showed 20 and 35 per cent pre-emergence mortality in blotter and soil tests. Mittal (1984) observed the seed-borne nature of Cephalosporium curtipes in Capsicum. The fungus produced cottony white to grey colony on the seeds which in later stages caused stem rotting.

Vartanian and Endo (1985) studied the pathogenicity of Phytophthora infestans in seeds of tomato. They found that when freshly extracted wet or dried discoloured seeds were planted in steamed soil mix or in field soil in the greenhouse, some of the seedlings emerging from the wet seeds were infected (average 20 per cent) whereas seedlings emerging from dry seeds were healthy. In pathogenicity tests with Phoma destructiva, Dhyani et al. (1990) found that the fungus caused 32.65 and 38.46 per cent seedling infection out of 49 and 52 per cent germinated seeds of Pusa Jwala and local cultivars of red pepper while in bell pepper 30.61 and 31.60 per cent seedling infection was recorded out of 49 and 38 per cent germinated seeds of Bullnose and California Wonder cultivars, respectively.

Suryanarayana et al. (1963) reported that various seed-borne fungi of vegetables caused failure of germination and rot or blight of seedlings. Neergard (1977) recorded an annual loss of 15 per cent due to seed-borne diseases alone in tomato. Sharma et al. (1981) while conducting studies on the fungi associated with seeds of amaranthus and their effect on seedlings found that the seven species of fungi, viz., Alternaria alternata, Cladosporium cladosporioides, Fusarium moniliforme, Penicillium sp., Phoma amaranthi, Rhizopus oryzae and Trichoderma viride significantly reduced the number of normal seedlings and caused stem rot and seedling blight. Germination of seeds of Capsicum was reduced to less than 10 per cent in a week by inoculation of fruits of large red Capsicum with cells of yeast (Candida tropicalis and Pichia memfranefaciens) (Ibe and Ike, 1982). Abnormal germination was observed after four days and dead seeds were prominent after six days. Naseema et al (1983) reported that Aspergillus flavus, A.niger and Rhizopus stolonifer which were externally and internally seed-borne in the seeds of amaranthus, bhindi, brinjal, bottle gourd, cowpea, cucumber, pumpkin, snake gourd and tomato caused maximum inhibition of germination of the seeds from which they were isolated. They further reported that seedling rotting was caused by Fusarium equiseti in amaranthus, Aspergillus niger and A.gangeticus in bhindi, Drechslera rostrata in cowpea and Rhizopus stolonifer in tomato.

1.3 Effect of culture filtrates of seed-borne fungi on seed germination and on seedlings.

Ludwig (1957) demonstrated the growth inhibitory property of culture filtrates of Helminthosporium sp. in common cereals. He found that H. oryzae reduced germination of rice seeds and caused seedlings to grow abnormally. Pringle and Scheffer (1964) studied the effect of cell free culture filtrates of Helminthosporium victoriae on oat seedlings and found that susceptible seedlings were killed even by filtrates diluted 90 times with water.

Thermostable nature of toxins was observed in the culture filtrates of Colletotrichum fuscum (Goodman,1960). Culture filtrates of Colletotrichum gloeosporioides boiled at 100 ^{o}C for ten minutes were slightly less toxic than unboiled culture filtrates (Sharma and Sharma,1969). Narain and Das, (1970) while investigating the role of culture filtrates of Colletotrichum capsici as well as extracts of the fungal mats on seed germinability, seedlings, leaves and fruit tissues of chillies found that all the test samples exhibited severe toxic effects. Kumar and Mahmood (1986) assayed culture filtrates of five isolates of Colletotrichum dematium on seeds and seedlings of chilli and found that there was marked inhibition in germination of seeds. The culture filtrates were thermostable and caused toxicites in chilli seedlings.

Narain and Omprakash (1968) reported that the culture filtrates of Aspergillus niger reduced seed germination and disorganised the succulent scales and green leaf tissues of onion. The toxic principle was reported to be thermostable and acted as protoplasmic poison on host tissues. Lalithakumari et al. (1970) observed that the culture filtrates of Aspergillus sp. did not inhibit seed germination of groundnut but had marked effect on root and shoot elongation. Omprakash and Siradhana (1978) reported that at higher concentrations, the antimetabolites produced by *Aspergillus flavus*, *A. niger*, *A. tamarii* and *A. terreus* in liquid culture caused complete wilting of the seedlings but at lower concentrations only tip and marginal burning of tomato seedlings were noticed. Tomato seedlings could be used as toxin indicator plants. Pandey and Gupta (1987) found that the metabolites of *Aspergillus flavus* and *A. niger* caused a reduction in the per cent germination and sprouting of all the five test cucurbits. The metabolites of the former were most detrimental.

White and Starrat (1967) found that zinniol produced by *Alternaria zinniae* inhibited seed germination of zinnia, tomato, lettuce and watermelon. Nair (1969) found that the toxic principle in culture filtrate of *Trichoconis padwickii* was active even after boiling at $100^{o}C$ for 20 minutes or autoclaving at 15 lb for 20 minutes and reported that it inhibited the germination of rice seeds. Bhale *et al.* (1982) gave a detailed account of the inhibitory effect of culture filtrate of *T. padwickii* on rice during their studies on the effect of metabolites of seed-borne fungi on seeds. They obtained indication for the killing of plumule by the fungal metabolites resulting in germination failure.

Brian et al. (1961) found that Fusarium equiseti produced toxic metabolites that inhibited elongation of stem of beans at concentrations as low as one ppm.

Vidhyasekaran et al. (1969) in their studies with seed-borne fungi of rice, viz., Aspergillus flavus, Curvularia pallescens, C. lunata, and Fusarium moniliforme found that culture filtrates of the fungi caused reduction in seed germination ranging from 24 to 67 per cent. The toxins produced by the above seed-borne fungi were found to significantly inhibit the root length of seedlings. George (1970) reported that Corynespora cassiicola produced toxic metabolites in vitro that cause wilting of cut shoots of tomato, sesamum and rubber as well as seedlings of tomato and sesamum. The toxicity of culture filtrate was not affected by heat indicating that the toxic metabolite was thermostable. The culture filtrate inhibited germination of tomato seeds and caused discolouration and disintegration of germinating sesamum seeds. It also inhibited radicle and plumule elongation of both tomato and sesamum seeds. Rajagopalan (1971) observed that the culture filtrate of Diplodia natalensis caused considerable reduction in the per cent germination of cucumber and snake gourd seeds.

The culture filtrates of the following seed-borne fungi of vegetables, viz., Aspergillus flavus, A. niger,

A. *ochraceus*, *Botryodiplodia theobromae*, *Colletotrichum lagenarium*, *Curvularia lunata*, *Fusarium equiseti*, F. *solani* and *Penicillium* sp. caused inhibition in the germination of the seeds of amaranthus, bhindi, brinjal, chillies, cowpea and cucumber (Naseema,1981). The toxic metabolites produced by *Myrothecium* in the culture filtrate were found to have phytotoxic effects on seeds and healthy plants of different vegetable crops (Chauhan and Chauhan,1984).

Jose Joseph (1986) reported that the culture filtrates of *Aspergillus flavus*, *Alternaria padwickii*, *Bipolaris oryzae*, *Curvularia lunata* and *Sarocladium oryzae* exerted considerable influence on the germination of seeds of rice. The root initiation of the emerging seedlings was also found to be inhibited by the culture filtrates of A. *flavus*, C. *lunata* and A. *padwickii*. Root and shoot elongation were also reduced by all the culture filtrates.

1.4 Effect of seed treatment chemicals on seed-borne fungi.

Doolittle and Beecher (1946) obtained improved stands of tomato by seed treatment with Spergon, Arasan and Semesan all at 0.3 per cent, Yellow Cuproside at 1.5 per cent and new improved Ceresan at 0.5 per cent. Foster (1947) showed that seed treatment with copper sulphate and cuprous oxide accelerated germination of seeds of beet, egg plant, pepper and spinach.

Jacks (1951) conducted experiments to study the effect of Cuproside, Spergon, Panogen, TMTD, Ferbam, Dow 7B, and 36 L on vegetable seeds namely Imperial lettuce, Laxton superb pea,Candian Wonder french bean, Early Snowball turnip, Dewars Improved Red garden beet, Early Market tomato and Giant White celery. The treatments appeared to confer increased vigour, thus enabling a greater number to survive post-emergence attack. Khandelwal and Prasada (1970) observed that seed treatment with Agrosan GN completely controlled the seed-borne fungi of cucumber.

Ellis et al. (1975) used captan, thiram and benomyl to treat soybean seeds with high levels of internally seed-borne fungi and low percentage of germination. Seeds treated with fungicides had a higher germination in vitro and emergence in vermiculite and field soil than untreated control.

Sohi (1977) reported that seed treatment with Ceresan dry gave maximum germination in bottle gourd, cowpea and mexican bean, whereas thiram was most effective on water melon and melon. Hexasan and Captan were the best on chilli for seed dressing against seed-borne infection. Maholay and Sohi (1977) recorded that seeds from naturally infected fruits of *Capsicum frutescens* and *C. annuum* germinated 66 per cent and 40 per cent, respectively, after treatment with Ceresan. Germination of untreated seeds was only 34 and 10 per cent.

Sharma *et al.* (1981) reported that by using seven of the 25 species of seed-borne fungi of amaranthus, the seed treatments with Agrosan (ethyl mercuric chloride) at 0.2 per cent and Ceresan dry (phenyl mercuric chloride + phenyl mercuric acetate) at 0.2 per cent gave best check of the different seed-borne fungi.

While conducting studies on the effect of fungicidal treatment on seed mycoflora of tomato, Singh *et al.*(1982) observed that folpet at 100 ppm had given the best results in inhibiting all the fungi associated with tomato seeds and had no adverse effect on germination. Naseema *et al.*(1983) reported that Thiride (thiram) was superior to all other fungicides tested against various seed-borne fungi of vegetables. Muthuswamy *et al.*(1983) recommended Captan (4g/kg), Sulphur dust (4g/kg), Bavistin (carbendazim) (2g/kg), Vitavax (carboxin)(2g/kg) and Benlate (benomyl)(4g/kg) for seed treatment of chilli, since all the fungicides tested have improved seed germination. Singh and Singh (1986) observed that the mycoflora of broad bean was most effectively controlled by Dithane M-45.

Bakshy and Aponyi (1988) used potassium iodide, acetic acid, sulphuric acid, sodium hypochlorite, and 12 fungicides for evaluation as seed treatment chemicals of tomato. They applied 0.5 per cent hydrochloric acid and 1.0 per cent sodium hypochlorite followed by a fungicide to eliminate pathogens from seed surface. Of the two, sodium hypochlorite was the most effective for improving germination. Among the fungicidal treatments carbendazim + furasolidon, carbendazim + mancozeb + kasugamycin and chlorothalonil + mancozeb + kasugamycin combination were the most effective.

Jawahara Raju and Sivaprakasam (1989) reported that cabbage seeds treated with carbendazim at 2g/kg in hot water at 50°C for 30 minutes and thiram at 2g/kg produced longer roots. The seedlings raised from seeds treated with hot water, carbendazim, thiram and the antagonist *Trichoderma viride* produced longer shoots and those from seeds treated with carbendazim, *T.harzianum*, hot water, thiram and *T.viride* produced higher dry matter. Carbendazim and hot water increased the vigour index values.

Ramadoss and Sivaprakasam (1989) treated cowpea seeds with three fungicides, viz., carbendazim, quintozene, and TMTD and four insecticides, viz., chloropyriphos, phosalone, monocrotophos and carbosulfan and also in combinations. Seed treatment with carbendazim and TMTD at the rate of 2g/kg seed as dry seed dressing, controlled most of the seed-borne fungi.

Haskell (1944) reported that among the tomato diseases partially controllable by seed treatment were anthracnose (*Colletotrichum phomoides*) and blight (*Septoria lycopersici* and *Alternaria solani*). Seeds may be treated by 25 minutes immerson in hot water (122^{O}F) or five minutes in mercuric chloride (1 in 2000) or in new improved Ceresan (1 ounce in 9 gallon) followed in all cases by the use of protectants against damping off and seed decay, e.g.,one hour immerson in copper sulphate (2 ounce per gallon) or dusting with Semesan (1/2 ounce per 15 pounds) or Arasan (1 teaspoon per pound). *In vitro* experiments with fungicide treated seeds revealed that thiram, Bis-Dithane and Vitavax,were effective in checking the seed-borne *Colletotrichum capsici* of chilli, but in pot culture experiments, among the ten fungicides tried, treatments with thiram, Brassicol and Bis-Dithane gave maximum control of the disease (Grover and Bansal,1970). Juangbhanich and Chana (1975) reported that seed treatment with Ceresan at 0.16 per cent on Delsine at 0.8 per cent of seed weight gave complete control of Colletotrichum piperatum (Glomerella cingulata) and C. capsici in Capsicum frutescens. Siddiqui et al. (1977) obtained best control of Colletotrichum dematium on Capsicum by seed treatment with thiram at 0.2 per cent followed by three sprays of Difolatan (captafol) at 0.25 per cent or thiram at 15 days interval starting 60 days after transplanting.

During the course of investigations on chemical control of Colletotrichum lagenarium causing anthracnose and scab of bottle gourd, Madaan and Grover (1979) found that its spores are sensitive to benomyl, thiabendazole, Ohric, Dyrene and Dithane M-45, but less sensitive to Dithane Z-78 and thiophanate methyl. In pot culture experiments using systemic fungitoxicants as seed treatment on bottle gourd, benomyl protected the seedlings for 14 days while thiophanate methyl gave good control up to seven days only. Ohric was effective when used as seed treatment.

Deena and Basuchaudhary (1984) reported that seed treatment with carbendazim, carboxin, phenyl mercuric acetate, quintozene and zineb caused reduction in the colonization by fungi. Most of the saprophytic fungi were eliminated by quintozene and mancozeb; Drechslera tetramera by quintozene and PMA; Colletotrichum capsici and Colletotrichum sp. by zineb. Perane and Joi (1988) found that among the five seed treatments tested, thiram gave the best control of seed-borne infection of Colletotrichum capsici in Capsicum frutescens. Sharma (1988) observed that the radial growths of C. gloeosporioides, B. theobromae and Fusarium moniliformae were completely inhibited by 1000 ppm of Dithane M-45 while growth of C. capsici was completely inhibited by 2000 ppm of it.

Voughan (1944) observed that the new improved Ceresan (ethyl mercuric phosphate) at the rate of 1 in 24,000 proved as effective as mercuric chloride in the control of diseases of tomato caused by seed-borne fungi notably early blight (Alternaria solani). Lucic and Slobodanka (1967) reported that for the control of seed-borne Alternaria tenuis in tomato , 0.3 per cent Polygram combi. and 0.25 per cent Orthophaltan were the most effective.

Tandon et al. (1976) found that seed treatment with Dithane M-45 gave 83 per cent control of Fusarium semitectum in Luffa cylindrica.

Sinha and Khare (1977) observed that out of nine systemic and non systemic fungicides tested, Bavistin and benomyl were excellent in controlling the seed-borne Macrophomina phaseolina and Fusarium equiseti associated with cowpea seeds in laboratory pots and field. The non systemic fungicides, like Ceresan dry, Difolatan and Thiram were most effective against M. phaseolina. On the other hand Ceresan dry, Difolatan and captan effectively controlled F. equiseti. Nedumaran and Vidhyasekaran (1981) showed that seed treatments with Difolatan (captafol) and Bavistin (carbendazim) at 1g/kg of seed were effective to control Fusarium semitectum infection in tomato seeds. Vidhyasekaran and Thiagarajan (1981) reported that Bavistin or Vitavax treatment resulted in eradication of the seed-borne pathogen Fusarium oxysporum from seeds of chilli and induced good growth of the plants and higher yield. Huang and Sun (1982) found that 1 hour benomyl dip effectively disinfected seeds of tomato contaminated with F. oxysporum f.sp. lycopersici. Dithane M-45 (0.2 per cent) has been found to inhibit the radial growth of F. oxysporum (Qadri et al. 1982). Sharma and Jain (1984) reported that Dithane M-45 and Bavistin were effective in inhibiting the radial growth of F. moniliforme. Seed treatment with systemic fungicides like Tecto TBZ (thiabendazole), Vitavax 200 (carboxin + thiram) and Topsin M-70 (thiophanate methyl) were effective in controlling the root rot pathogen of faba bean caused by F. solani (Yehia and El-Hassan, 1985).

Saifutdinova (1985) observed that seed treatment with thiram reduced infection by Rhizoctonia and Fusarium spp. on cucumber from 59.2 per cent to 16.7 per cent and on tomato from 33.3 per cent to 13 per cent, while after treatment with Demosan (chloroneb) the incidence was 11 per cent and 6.5 per cent, respectively.

Greenhouse evaluation of seed treatment fungicides for the control of damping off of tomato and chilli caused by Fusarium solani and Pythium aphanidermatum was conducted by Sajitha and Hooda (1987) and they found that copper oxychloride was the best fungicide for controlling damping off of both the test crop plants caused by F .solani, whereas for the control of damping off due to P. aphanidermatum methoxy ethyl mercuric chloride (MEMC) was the best fungicide. However, for controlling damping off caused by both the fungi MEMC and captan were very promising on tomato and captafol in chilli. Taha et al.(1988) tested many fungicides against Fusarium solani, Pythium aphanidermatum and Rhizoctonia solani on tomato and found that Homai (thiophanate methyl + thiram) and Benlate (benomyl) were the most effective under laboratory conditions. Ridomyl (metalaxyl) , Vitavax (carboxin), thiram and thiophanate methyl + thiram were used as seed treatment, soil drench and root dip to control root rot caused by the above fungi. Benomyl and thiophanate methyl + thiram gave good control and metalaxyl selectively inhibited P. aphanidermatum.

Padmanabhan *et al*. (1963) conducted experiments on fungicidal control of pre-emergence damping off in vegetable crops, viz., brinjal, bhindi and tomato caused by *Pythium aphanidermatum*. The fungicides, viz., Cerenox, ESD/AM, ESD/HS were found to be equally efficacious in controlling pre-emergence damping off of brinjal. In the case of bhindi, Cerenox, Arasan and Ceresan were found to be equally effective in controlling the disease. In tomato the fungicide ESD/AM was found to be very effective closely followed by Cerenox and Ceresan.

In glasshouse and field trials against *Phytophthora capsici* disinfection of Capsicum seeds with fungicides based on captan and folpet gave good results (Aleksic *et al*.,1976). Elenkov and Khrelkova (1977) found that *Phytophthora capsici* on chilli could be controlled by seed treatment with Morpan or Orthocide 75.

Lewin and Natarajan (1971) conducted fungicidal seed treatment trials for the control of root rot of groundnut caused by *Rhizoctonia bataticola*. Of the ten seed dressing fungicides tested, Arasan, New improved Ceresan, captan,thiram and Ceresan which ensured higher germination and emergence have minimised post emergence root rot incidence to a considerable extent and have also recorded increased yield ranging from 23.2 to 13.2 per cent over control. Vir (1976) controlled damping off of Capsicum seedlings caused by Rhizoctonia bataticola by seed treatment (0.25 per cent) or soil drenching (0.1 per cent) with Bavistin in pot tests. Vyas et al.(1981) indicated that for seed treatment against Rhizoctonia bataticola (Macrophomina phaseolina) on french bean, egg plant and tomato, Bavistin (carbendazim) which is absorbed and translocated to the upper parts of the seedlings could be used.

Frank (1969) found that among different fungicides tested, three parts of 75 per cent captan plus one part 75 per cent PCNB (quintozene) at 3g/kg seed gave satisfactory control of Aspergillus niger and Rhizopus spp. in groundnut. Jacobsen and Williams (1971) reported that soaking of seeds for 24 hours in 0.2 per cent suspensions of benomyl and thiabendazole eradicated the fungus Phoma lingam from infected cabbage and brocoli seeds. Naseema (1981) obtained good inhibition of growth of Botryodiplodia theobromae with 1000 ppm Dithane M-45. She observed that against Drechslera rostrata it was more effective than captan and Aureofungin sol while it was found to be superior to Aureofungin sol, Brassicol and Dithane Z-78 in its effect against Aspergillus flavus. Reddy and Kabebeh (1989) reported that treatment of chick pea (Cicer arietinum) seeds with thiabendazole eliminated Ascochyta rabiei from the seed without any deleterious effect on seed germination. Bretag

(1985) noted that application of thiabendazole as seed dressing increased grain yield of field peas by reducing the severity of the blight caused by Mycosphaerella pinodes, Ascochyta pisi and Phoma medicaginis var. pinodella. In their studies on the pathogenicity and control of Phoma destructiva, a seed-borne pathogen of chilli, Dhyani et al. (1990) found that seed treatment with thiram gave effective control. The other fungicides found effective were captafol, Dithane M-45 whereas Bavistin, Brassicol, Topsin and Vitavax did not show much effect against this fungus.

Edington et al. (1971) reported that with the exception of Torula herbarum all members of porosporae (of which Curvularia is a member) of the class deuteromycetes were insensitive to Benomyl. Donald Erwin (1973) reported that dark spored members of deuteromycetes are insensitive to Benomyl.

Jharia et al. (1978) reported that fungicide treatment enhanced the germination of chilli seeds infected by seed-borne fungi such as Alternaria sp., Colletotrichum capsici, Phoma sp., Helminthosporium sp. and Fusarium equiseti. Germination of seeds was best in the treatment with thiram + captan (85.5 per cent) followed by Benlate, thiram and Dithane M-45 as compared to that in control. Post emergence losses were minimum in thiram + captan (4.4 per cent) followed by Benlate. The total losses in nursery were minimum in the treatment thiram + captan (18.9 per cent) followed by Benlate, thiram and Dithane M-45. Of the seven fungicides tested by Mali and Joi (1985) Difolatan (captafol) thiram and Vitavax (carboxin) were the most effective against colony growth and sporulation of seed-borne fungi of chilli, viz.,Alternaria alternata, Colletotrichum capsici,Curvularia clavata,C.lunata, Drechslera rostrata and Macrophomina phaseolina. Sharma (1988) noted that the growth of Curvularia clavata and C. lunata were inhibited by 3000 ppm of Dithane M-45.

Materials and Methods

3. MATERIALS AND METHODS

3.1 Collection of seeds.

The seeds for the present investigation were collected from Vellayani and Vellanikkara during February-March 1990 and 1991.

Seeds of the following vegetables were used.

1. Amaranthus : *Amaranthus gangeticus* L.
2. Chilli : *Capsicum annuum* L.
3. Tomato : *Lycopersicon esculentum* Mill.
4. Ash gourd : *Benincasa hispida* (Thumb) Cogn.
5. Snake gourd : *Trichosanthes anguina* L.

3.2 Isolation of seed-borne fungi.

Seed-borne fungi were isolated from vegetable seeds by the method described by Suryanarayana and Bhombe (1961). About 100 seeds were taken at random for isolating the fungi.

Externally seed-borne fungi were isolated by placing the seeds without surface sterilization on a thin layer of potato dextrose agar (PDA) in sterilized petri dishes. The seeds were arranged at the rate of 5 to 10 seeds per petridish depending upon the size of seeds. The petridishes were incubated at room temperature.

Internally seed-borne fungi were isolated after surface sterilizing the seeds with 0.1 per cent mercuric chloride for one minute and washing in three changes of sterile distilled water. The seeds were then placed on a thin layer of PDA in petridishes as described above and incubated at room temperature.

In both the above cases,the plates were examined periodically for ten days. As soon as fungal growth appeared, it was transferred to PDA slants. The cultures were purified by single spore isolation and maintained on PDA slants.

The isolations of both internally and externally seed-borne fungi were done at monthly intervals for three months until no new fungus was recorded. The pure cultures of some of the fungi were sent to Commonwealth Mycological Institute, UK for identification.

3.3 Effect of seed-borne fungi on germination of seeds and on seedlings.

The method described by Srivastava and Gupta (1981) was used for this experiment.

Effect of seed-borne fungi on germination of seeds was determined for all the five vegetables. Ten seeds of amaranthus, tomato and chilli and five seeds of ash gourd and snake gourd were taken for each treatment. Surface sterilized seeds were rolled over 10-15 day old sporulating culture of the fungus. They were then sown in sterilized soil in polythene bags. Four replications were maintained for each treatment. Uninoculated surface sterilized seeds sown in separate polythene bags served as control. Observations on the number of seeds germinated and seedling infection, if any, in germinated seeds were recorded up to two weeks. The per cent inhibition in germination of seeds was calculated in each case.

3.4 Effects of culture filtrates of seed-borne fungi.

The effect of culture filtrates of the following fungi were studied against the crop mentioned. (Common toxin producing fungi and those fungi which considerably reduced the germination of respective crops were selected for this study.)

Crop	Fungus
1. Amaranthus	1. Aspergillus aculeatus Iizuka.
	2. Fusarium equiseti (Corda) Sacc.
	3. Fusarium sp.1
	4. Fusarium sp.2
	5. Fusarium sp.3
	6. Fusarium sp.4
	7. Penicillium pinophilum Hedgcock.
	8. Rizopus oryzae Went & Prinsen Geerligs.
2. Chilli	1. Aspergillus flavus Link.
	2. Curvularia clavata Jain.
	3. Penicillium pinophilum Hedgcock.
	4. Penicillium purpurogenum Stoll.
	5. Scytalidium sp.Pesante.
3. Tomato	1. Aspergillus chevalieri Thom & Church.
	2. Aspergillus flavipes (Bainier & Sartory)-Thom & Church.
	3. Fusarium solani (Mart) Sacc.
	4. Paecilomyces inflatus (Burnside) Carmichael.
	5. Penicillium pinophilum Hedgcock.
	6. Penicillium purpurogenum Stoll.
	7. Penicillium simplicissimum (Oudem) Thom.

4. Ash gourd

1. *Aspergillus aculeatus* Iizuka.
2. *Aspergillus chevalieri* Thom & Church.
3. *Aspergillus ochraceus* Wilhelm.
4. *Aspergillus sydowii* (Bainier & Sartory)- Thom & Church.
5. *Chaetomium erectum* Skolko & Groves.
6. *Curvularia clavata* Jain.
7. *Penicillium pinophilum* Hedgcock.
8. *Talaromyces flavus* (Klocker) Stolk & Samson.

5. Snake gourd

1. *Aspergillus chevalieri* Thom & Church.
2. *Aspergillus flavus* Link.
3. *Chaetomium brasiliense* Batista & Pontual.
4. *Fusarium pallidoroseum* (Cooke) Sacc.
5. *Gilbertella persicaria* (Eddy) Hesselt.
6. *Penicillium pinophilum* Hedgcock.

3.4.1 Effect of culture filtrates on germination of seeds.

The method described by Vidhyasekaran *et al*. (1969) was employed to assess the effect of culture filtrates of the fungi on seed germination.

Richard's solution was taken at the rate of 100 ml per flask in 250 ml conical flasks and sterilized by autoclaving. Then each of the flask was inoculated by aseptically transferring 5 mm culture discs cut from actively growing cultures of the above fungi with a sterile cork borer. After incubation for a period of 15 days, the cultures were filtered through whatman No.1 filter paper. The filtrates thus obtained were used for the study.

The seeds, surface sterilized as mentioned earlier were soaked in the culture filtrate for 24 hours and spread on whatman No.1 filter paper placed in sterile petridishes. An aliquot of 5 ml of the culture filtrate was poured into each petridish over the filter paper and the petri dishes were incubated at room temperature. Twenty seeds of amaranthus, chilli and tomato and ten seeds of ash gourd and snake gourd were used for each treatment. In the controls surface sterilized seeds soaked in sterile Richard's solution and sterile water for 24 hours were used and the filter papers in these petri dishes were moistened with sterile Richard's solution and sterile water, respectively. Observations on the number of seeds germinated were recorded after ten days incubation at room temperature and the percentage of germination was calculated.

3.4.2 Effect of culture filtrates on plumule elongation.

Healthy seeds of the five vegetables were placed on sterile filter papers kept in sterilized petri dishes and moistened with sterile water. Germinated seeds with a plumule length of 5 mm were transferred on to sterile filter paper kept in sterilized petri dishes at the rate of five each and then irrigated with five ml of culture filtrate. Control plates were irrigated with sterile Richard's solution and sterile water. Three replications were maintained for each treatment. Observations on plumule length were taken after 48 hours.

3.4.3 Effect of culture filtrates on radicle elongation.

Healthy seeds were placed in sterile filter papers kept in sterilized petri dishes and moistened with sterile water. Seeds germinated as mentioned in 3.4.2. with a radicle length of 5 mm were transferred on to sterile filter papers kept in sterilized petri dishes at the rate of five seeds each and then irrigated with 5 ml of culture filtrate. Each treatment was replicated three times. Control plates were irrigated with sterile Richard's solution and sterile water. Observations on radicle length were recorded after 48 hours.

3.4.4 Effect of untreated culture filtrates on seedlings.

Thirty day old healthy seedlings of the vegetables grown in pots were carefully removed and the roots were washed thoroughly under running water. The stem and roots of these plants were dipped in 0.1 per cent mercuric chloride solution for one minute and then washed in three changes of sterile water. These were then placed in test tubes, each containing the culture filtrate with the root system completely immersed in it. Each tube contained one seedling and three such test tubes constituted one replication. The seedlings were kept in position by means of sterile cotton wrapped around the stem at the mouth of the test tube. Each treatment was replicated three times. Seedlings placed in test tubes containing sterile Richard's solution and sterile water served as controls. The plants were kept under observation at room temperature.

3.4.5 Effect of heat treated culture filtrates on seedlings.

This experiment was done as described in 3.4.4 except that the culture filtrates were boiled for 10 minutes.

3.5 Effect of seed treatment fungicides.

3.5.1 Effect of fungicides on seed-borne fungi.

The effect of the following five fungicides on the growth of various seed-borne fungi was tested by poisoned food technique (Zentmyer,1955).

Trade name	Generic name	Chemical name	Concentration
1.Hexacap	Captan	N-trichloromethyl thio-4 cyclohexene 1,2 dicarboximide	500 ppm 1000ppm 2000ppm
2.Foltaf	Captafol	Cis N-(1,1,2,2 tetrachloroethyl thio)-4 cyclohexene 1,2 dicarboximide	500ppm 1000ppm 2000ppm
3.Luzem 45	Mancozeb	Manganese ethylene bis dithiocarbamate 78% and 2% zinc ions	500ppm 1000ppm 2000ppm
4.Blue copper 50	Copper oxychloride	Copper oxychloride	500ppm 1000ppm 2000ppm
5.Bavistin	Carbendazim	Methyl 2 benzimidazole carbamate	250ppm 500ppm 1000ppm

The fungicides were tested against the following seed-borne fungi which considerably reduced the germination of seeds of the respective crops from which they were isolated.

1. *Aspergillus aculeatus* Iizuka.
2. *Aspergillus chevalieri* Thom & Church.
3. *Aspergillus flavus* Link.
4. *Aspergillus ochraceus* Wilhelm.
5. *Chaetomium brasiliense* Batista & Pontual.
6. *Chaetomium erectum* Skolko & Groves.
7. *Curvularia clavata* Jain.
8. *Fusarium equiseti* (Corda) Sacc.
9. *Fusarium pallidoroseum* (Cooke) Sacc.
10. *Fusarium solani* (Mart) Sacc.
11. *Fusarium* sp.5 Link.
12. *Gilbertella persicaria* (Eddy) Hesselt.
13. *Humicola fuscoatra* Traaen.
14. *Penicillium pinophilum* Hedgcock.
15. *Rhizopus oryzae* Went & Prinsen Geerligs.
16. *Scytalidium* sp. Pesante.

Stock solutions of chemicals were prepared in sterile distilled water. The requisite quantity of each fungicide was added separately to 50 ml of sterilized PDA so as to get the desired concentration of the commercial material. Fifteen ml each of the poisoned media was poured into sterile petri dishes after thorough mixing. Culture discs of 5 mm diameter cut with a sterile cork borer from seven day old culture of the test fungus on PDA was placed in the centre of each plate. Sterile petri dishes with sterile media inoculated with culture disc of the test fungus served as control. The plates were then incubated at room temperature and colony diameter was measured when maximum growth was observed in control plates. The radial growth was calculated by deducting the diameter of the culture disc placed in the centre of the medium from the final colony diameter. The per cent inhibition over control was calculated by the formula.

$$\text{Per cent inhibition } I = \frac{C - T}{C} \times 100$$

C - radial growth in control

T - radial growth in treatment

3.5.2 Comparative efficacy of different fungicides against individual species of seed-borne fungi.

The mean value of the effects of different fungicides as per the table 17 were calculated and compared to find out the comparative efficacy of the five fungicides tested, viz., Bavistin, Blue copper 50, Foltaf, Hexacap and Luzem 45 against the individual species of seed-borne fungi.

3.5.3 Effect of fungicides on seedling emergence.

The seeds of the vegetables were inoculated with the following seed-borne fungi before fungicidal treatment.

Crop	Seed-borne fungi
Amaranthus	1. Rhizopus oryzae
	2. Aspergillus aculeatus
	3. Fusarium equiseti
	4. Fusarium sp.5
Chilli	1. Curvularia clavata
	2. Scytalidium sp.
	3. Aspergillus flavus
	4. Penicillium pinophilum
Tomato	1. Fusarium solani
	2. Rhizopus oryzae
	3. Aspergillus chevalieri
	4. Humicola fuscoatra
Ash gourd	1. Aspergillus ochraceus
	2. Chaetomium erectum
	3. Aspergillus chevalieri

Snake gourd

1. <u>Chaetomium brasiliense</u>
2. <u>Fusarium pallidoroseum</u>
3. <u>Gilbertella persicaria</u>

The spores of the fungi were harvested from actively sporulating culture and a suspension was made in sterile water. The concentration was adjusted to 50 to 60 spores per field under the low power objective of microscope. The spore suspensions of the different fungi against each crop as indicated above were mixed together and the surface sterilized seeds were soaked in this suspension for 12 hours. The seeds were then taken out and air dried.

The inoculated seeds were treated with the fungicides by dry, slurry and soak method. In dry treatment, the seeds were mixed with the required quantity of fungicide by thorough mixing. Slurry treatment was given by mixing the seeds with the required quantity of fungicide and adding minimum quantity of water to make it in a slurry form. In soak method, the seeds were soaked in the fungicidal suspension for 30 minutes and then drained. The treated seeds were planted in sterilized soil in polythene bags. Ten seeds of amaranthus, chilli and tomato and five seeds of ash gourd and snake gourd were taken for each treatment. Four replication were maintained for each treatment. Seeds without fungicide treatment planted in sterilized soil served as control. Observations on germination and post emergence mortality were made up to two weeks.

Results

4. RESULTS

4.1 Isolation of seed-borne fungi.

A number of externally and internally seed-borne fungi were isolated from seeds of five vegetables (Table 1). The externally seed-borne fungi isolated include Aspergillus aculeatus, Fusarium equiseti, Fusarium spp., Gonatobotryum apiculatum and Penicillium pinophilum from amaranthus, Aspergillus flavus, Chaetomium globosum, Curvularia clavata, Penicillium pinophilum, P. purpurogenum and Rhizopus oryzae from chilli, Aspergillus chevalieri, A. flavipes, Chaetomium globosum, Fusarium solani, Humicola fuscoatra, Paecilomyces inflatus, Penicillium purpurogenum, P. simplicissimum, Rhizopus oryzae and Syncephalastrum racemosum from tomato, Aspergillus aculeatus, A. chevalieri, A. niger, A. ochraceus, A. sydowii, A. terreus, Chaetomium brasilense, C. erectum, P. pinophilum, P. simplicissimum and Talaromyces flavus from ash gourd, A. flavus, Gilbertella persicaria, P. pinophilum, Rhizopus oryzae and Syncephalastrum racemosum from snake gourd.

The internally seed - borne fungi isolated were Chaetomium funicola, Fusarium spp. and Rhizopus oryzae from amaranthus, Penicillium pinophilum and Scytalidium sp. from chilli, Chaetomium globosum, Fusarium solani and Penicillium pinophilum from tomato, A. flavus, A.sydowii, Corynascus sepedonium, Curvularia clavata, Mucor sp., P. pinophilum, Talaromyces flavus and Zopfiella karachiensis from ash gourd and A. chevalieri, Chaetomium brasiliense, C. globosum, F. pallidoroseum, P. pinophilum, Rhizopus oryzae and Syncephalastrum racemosum from snake gourd.

When isolation of fungi was made after storing the seeds for one or two months, the most prevalent fungi were species of Aspergillus and Penicillium.

4.2 Effect of seed - borne fungi on germination of seeds and on seedlings.

Many of the seed - borne fungi were found to cause reduction in germination of seeds and damping off of seedlings in the respective vegetable crops.

4.2.1 Amaranthus.

In amaranthus, seeds inoculated with spores of Fusarium equiseti showed significant reduction in germination

Table 1. Fungi isolated from vegetable seeds

o.	Crop	Isolations **	Externally seed-borne fungi	Internally seed-borne fungi
	Amaranthus	First	1.Aspergillus aculeatus Iizuka. 2.Fusarium equiseti (Corda) Sacc. 3.Fusarium sp.2* Link.	1.Fusarium sp.1* Link. 2.Fusarium sp.2* Link. 3.Rhizopus oryzae Went & Prinsen Geerligs.
		Second	1.Fusarium sp.4* Link. 2.Fusarium sp.5* Link. 3.Gonatobotryum apiculatum (Peck) S.Hughes.	1.Chaetomium funicola Cooke. 2.Fusarium sp.3* Link.
		Third	1.Penicillium pinophilum Hedgcock.	Nil
	Chilli	First	1.Aspergillus flavus Link. 2.Chaetomium globosum Kunze. 3.Curvularia clavata Jain. 4.Penicillium pinophilum Hedgcock. 5.Penicillium purpurogenum Stool. 6.Rhizopus oryzae Went & Prinsen-Geerligs.	1. Penicillium pinophilum Hedgcock.
		Second	Nil	Nil
		Third	1.Scytalidium sp. Pesante.	Nil.
	Tomato	First	1.Chaetomium globosum Kunze. 2.Rhizopus oryzae Went & Prinsen-Geerligs. 3.Syncephalastrum racemosum-Cohn ex Schroter.	1.Chaetomium globosum Kunze. 2.Fusarium moniliforme Sheldon. 3.Fusarium solani (Martius) Sacc. 4.Penicillium pinophilum Hedgcock.
		Second	1.Aspergillus chevalieri Thom & Church. 2.Fusarium solani (Martius) Sacc. 3.Humicola fuscoatra Traaen. 4.Paecilomyces inflatus (Burnside) Carmichael.	Nil
		Third	1.Aspergillus flavipes (Bainier & Sartory) Thom & Church. 2.Penicillium purpurogenum Stool. 3.Penicillium simplicissimum (Oudem)	Nil.

Table 1. (con.)

Ash gourd	First	1. *Aspergillus aculeatus* Iizuka. 2. *Chaetomium brasiliense* Batista & Pontual. 3. *Talaromyces flavus* (Klocker) Stolk & Samson.	1. *Curvularia clavata* Jain. 2. *Mucor* sp. 3. *Talaromyces flavus* (Klocker) Stolk & Samson. 4. *Zopfiella karachiensis* (Ahmed & Azad) Guarro.
	Second	1. *Aspergillus niger* 2. *Aspergillus ochraceus* Wilhelm. 3. *Aspergillus sydowii* (Bainier & Sartory) Thom & Church. 4. *Aspergillus terreus* Thom.	1. *Aspergillus flavus* Link. 2. *Corynascus sepedonium* (Emmons) Von-Arx.
	Third	1. *Aspergillus chevalieri* Thom & Church. 2. *Chaetomium erectum* Skolko & Groves. 3. *Penicillium pinophilum* Hedgcock. 4. *Penicillium simplicissimum* (Ouden) Thom.	1. *Aspergillus sydowii* (Bainier & Sartory) Thom & Church. 2. *Penicillium pinophilum* Hedgcock.
Snake gourd	First	1. *Gilbertella persicaria* (Eddy) Hasselt. 2. *Rhizopus oryzae* Went & Prinsen Geerligs. 3. *Syncephalastrum racemosum* Cohn ex Schroter.	1. *Aspergillus chevalieri* Thom & Church. 2. *Chaetomium brasiliense* Batista & Pontual. 3. *Fusarium pallidoroseum* (Cooke) Sacc. 4. *Rhizopus oryzae* Went & Prinsen Geerligs. 5. *Syncephalastrum racemosum* Cohn ex-Schroter
	Second	1. *Aspergillus flavus* Link. 2. *Penicillium pinophilum* Hedgcock.	Nil.
	Third	Nil	1. *Chaetomium globosum* Kunze. 2. *Penicillium pinophilum* Hedgcock.

** First isolation – Immediately after collection of seeds.
Second isloation – One month after storage.
Third isolation – Two months after storage.
* *Fusarium* sp.1,2,3,4 and 5 are different isolates of *Fusarium* sp.

percentage. The highest inhibition of germination of 47.9 per cent was caused by *Fusarium equiseti*. Another species of *Fusarium*, (*Fusarium* sp.5) caused 41.4 per cent inhibition and *Rhizopus oryzae* caused 27.1 per cent inhibition. Fungi like *Aspergillus aculeatus*, *Chaetomium funicola* and *P. pinophilum* caused only lesser inhibition (Table 2, Fig. 1). Damping off of seedlings was also caused by seed - borne fungi. *Fusarium* sp.3 caused significant incidence of damping off in amaranthus seedlings (Table 2, Fig.1).

4.2.2 Chilli.

In chilli, the fungus *Penicillium pinophilum* caused 95 per cent inhibition in germination of seeds. Other species of fungi like *Aspergillus flavus* (62.56 per cent), *Curvularia clavata* (65.45 per cent) and *Scytalidium* sp. (52.63 per cent) also caused significant inhibition in the germination of chilli seeds. But reduction in per cent germination was comparatively less for seeds inoculated with fungi like *Chaetomium globosum*, *Penicillium purpurogenum* and *Rhizopus oryzae* (Table 3, Fig. 2).

Aspergillus flavus caused highest incidence of damping off in chilli seedlings although not significant. The extent of the disease was low in seeds inoculated with

Table 2. Effect of seed-borne fungi on seeds and seedlings of amaranthus

Sl. No.	Treatment	Per cent inhibition of germination**	Per cent damping-off of seedlings**
1.	*Aspergillus aculeatus*	15.90 (22.72)	0.00 (0.00)
2.	*Chaetomium funicola*	21.60 (27.70)	0.00 (0.00)
3.	*Fusarium equiseti*	47.90 (43.78)	15.15 (22.90)
4.	*Fusarium* sp.1	19.50 (26.19)	2.69 (9.44)
5.	*Fusarium* sp.2	21.80 (27.86)	0.81 (5.17)
6.	*Fusarium* sp.3	6.20 (14.42)	15.12 (22.88)
7.	*Fusarium* sp.4	20.00 (26.56)	12.50 (26.70)
8.	*Fusarium* sp.5	41.40 (40.02)	40.58 (39.54)
9.	*Gonatobotryum apiculatum*	27.10 (31.39)	0.00 (0.00)
10.	*Penicillium pinophilum*	21.60 (27.70)	0.00 (0.00)
11.	*Rhizopus oryzae*	27.10 (31.39)	3.78 (11.20)
12.	Control	18.80 (25.67)	4.47 (12.20)
	F (11, 36)	1.77*	2.56*
	SE	12.349	7.208
	CD	16.209	20.601

* Significant at 5% level.

** Figures in parentheses are transformed values in angles.

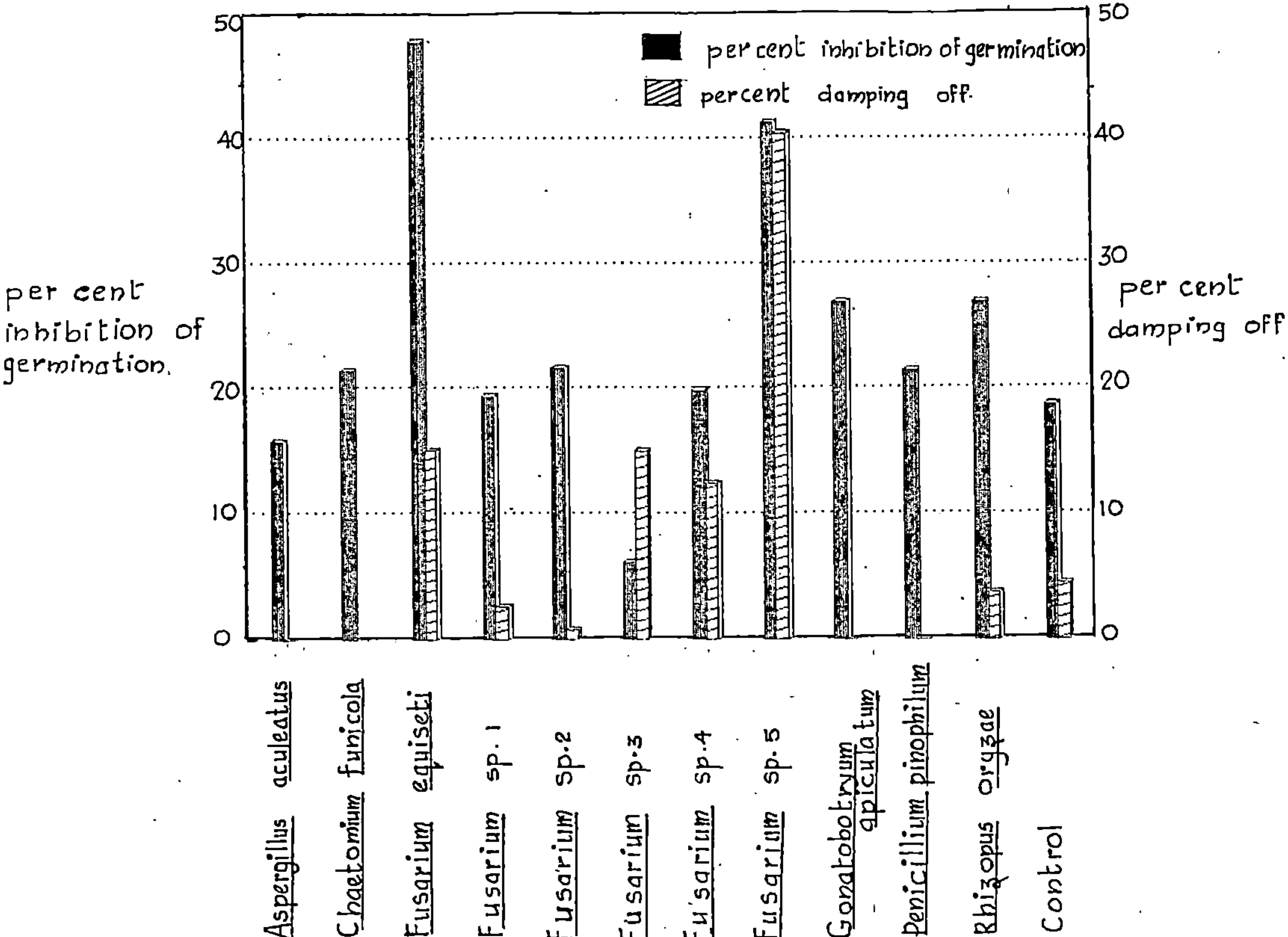

Fig. 1. Effect of seed-borne fungi on seeds and seedlings of amaranthus.

Chaetomium globosum, Penicillium pinophilum, P. purpurogenum and Scytalidium sp. (Table 3, Fig. 2).

4.2.3 Tomato.

Many species of fungi isolated from tomato seeds caused considerable inhibition in germination of the seeds. They were Humicola fuscoatra, Rhizopus oryzae, Penicillium pinophilum, P. purpurogenum, Aspergillus chevalieri, F. solani, A. flavipes and Syncephalastrum racecmosum. Among them the highest inhibition of 42.47 per cent was caused by H. fuscoatra while S. racemosum caused the least inhibition of 25.57 per cent. Chaetomium globosum caused least per cent reduction (7.47) in germination (Table 4, Fig.3). P. purpurogenum caused highest incidence of damping off (13.40 per cent) in tomato seedlings although not significant. Humicola fuscoatra, P. simplicissimum and A. flavus did not cause damping off in tomato seedlings (Table 4, Fig.3).

4.2.4 Ash gourd.

In ash gourd, none of the seed - borne fungi inhibited germination of the seeds significantly. But Chaetomium erectum caused the maximum inhibition of

Table 3. Effect of seed-borne fungi on seeds and seedlings of chilli

Sl. No.	Treatment	Per cent inhibition of germination**	Per cent damping-off of seedlings**
1.	*Aspergillus flavus*	62.56 (52.25)	65.15 (53.80)
2.	*Chaetomium globosum*	25.32 (30.20)	1.70 (7.50)
3.	*Curvularia clavata*	65.45 (53.98)	17.60 (24.80)
4.	*Penicillium pinophilum*	95.02 (77.08)	14.16 (22.50)
5.	*Penicillium purpurogenum*	36.08 (36.90)	7.70 (16.11)
6.	*Rhizopus oryzae*	34.66 (36.05)	22.58 (28.36)
7.	*Scytalidium* sp.	52.63 (46.49)	13.87 (21.86)
8.	Control	36.70 (37.27)	0.00 (0.00)
	F (7,24)	4.82*	1.77
	SE	6.835	12.005
	CD	19.952	

* Significant at 5% level.
** Figures in parentheses are transformed values in angles.

Fig. 2. Effect of seed-borne fungi on seeds and seedlings of chilli

Table 4. Effect of seed-borne fungi on seeds and seedlings of tomato

Sl. No.	Treatment	Per cent inhibition of germination**	Per cent damping-off of seedlings**
1.	*Aspergillus chevalieri*	33.21 (35.18)	2.89 (9.78)
2.	*Aspergillus flavipes*	30.87 (33.74)	0.00 (0.00)
3.	*Chaetomium globosum*	7.47 (15.85)	0.81 (5.17)
4.	*Fusarium solani*	32.71 (34.87)	0.72 (4.86)
5.	*Humicola fuscoatra*	42.48 (40.66)	0.00 (0.00)
6.	*Paecilomyces inflatus*	24.04 (29.39)	0.65 (4.61)
7.	*Penicillium pinophilum*	37.33 (37.35)	1.97 (8.06)
8.	*Penicillium purpurogenum*	33.58 (33.40)	13.40 (21.46)
9.	*Pencillium simplicissimum*	22.37 (28.22)	0.00 (0.00)
10.	*Rhizopus oryzae*	38.89 (38.56)	0.94 (5.55)
11.	*Syncephalastrum racemosum*	28.57 (32.30)	0.65 (4.61)
12.	Control	2.57 (9.21)	0.00 (0.00)
F (11, 36)		1.31	1.02
S E		8.877	5.760

** Figures in parentheses are transformed values in angles.

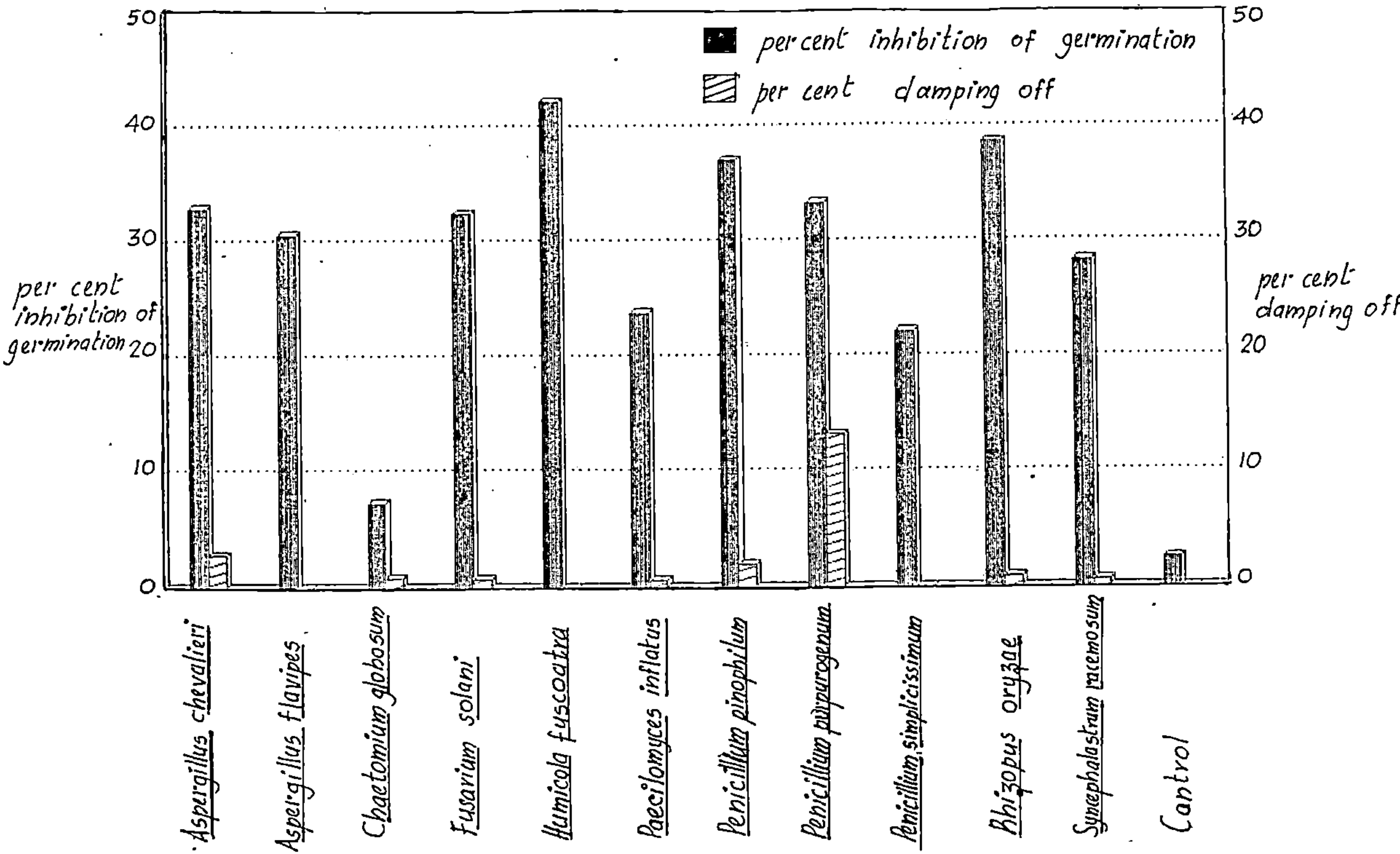

Fig. 3. Effect of seed-borne fungi on seeds and seedlings of tomato

germination of 33.21 per cent followed by Penicillium pinophilum and Talaromyces flavus with 15.38 per cent. A. sydowii, A. terreus and Corynascus sepedonium caused only 1.34 per cent inhibition while A. flavus and A. niger did not cause inhibition of germination of ash gourd seeds (Table 5, Fig. 4).

Although not statistically significant, high incidence of damping off of ash gourd seedlings was caused by A. sydowii, Talaromyces flavus, Penicillium pinophilum and Corynascus sepedonium. Among them, the highest incidence of 16.48 per cent was caused by A. sydowii. A. aculeatus and Curvularia clavata did not cause damping off (Table 5, Fig. 4).

4.2.5 Snake gourd.

The germination of snake gourd seeds was inhibited to the maximum extent by Fusarium pallidoroseum, Chaetomium brasiliense and Gilbertella persicaria causing 76.30, 61.98 and 60.48 per cent inhibitions, respectively. The lowest inhibition of germination, viz., 29.5 per cent was caused by Penicillium sp. (Table 6, Fig. 5).

Penicillium sp. caused significant damping off of

Table 5. Effect of seed-borne fungi on seeds and seedlings of ash gourd

Sl. No.	Treatment	Per cent inhibition of germination**	Per cent damping off of seedlings**
1.	*Aspergillus aculeatus*	5.28 (13.27)	0.00 (0.00)
2.	*Aspergillus chevalieri*	14.64 (22.49)	1.33 (6.64)
3.	*Aspergillus flavus*	0.00 (0.00)	5.28 (13.28)
4.	*Aspergillus niger*	0.00 (0.00)	5.78 (13.28)
5.	*Aspergillus ochraceus*	14.64 (22.49)	1.33 (6.64)
6.	*Aspergillus sydowii*	1.34 (6.64)	16.48 (23.94)
7.	*Aspergillus terreus*	1.34 (6.64)	5.28 (13.28)
8.	*Chaetomium erectum*	33.21 (35.18)	1.34 (6.64)
9.	*Corynascus sepedonium*	1.34 (6.64)	12.59 (20.77)
10.	*Curvularia clavata*	10.96 (19.33)	0.00 (0.00)
11.	*Mucor* sp.	5.28 (13.28)	1.70 (7.50)
12.	*Penicillium pinophilum*	15.38 (23.08)	13.00 (21.63)
13.	*Penicillium simplicissimum*	11.61 (19.92)	5.97 (14.14)
14.	*Talaromyces flavus*	15.38 (23.08)	11.77 (20.05)
15.	Control	5.28 (13.28)	0.00 (0.00)
	F (14,45)	1.23	1.32
	S E	8.877	7.033

** Figures in parentheses are transformed values in angles.

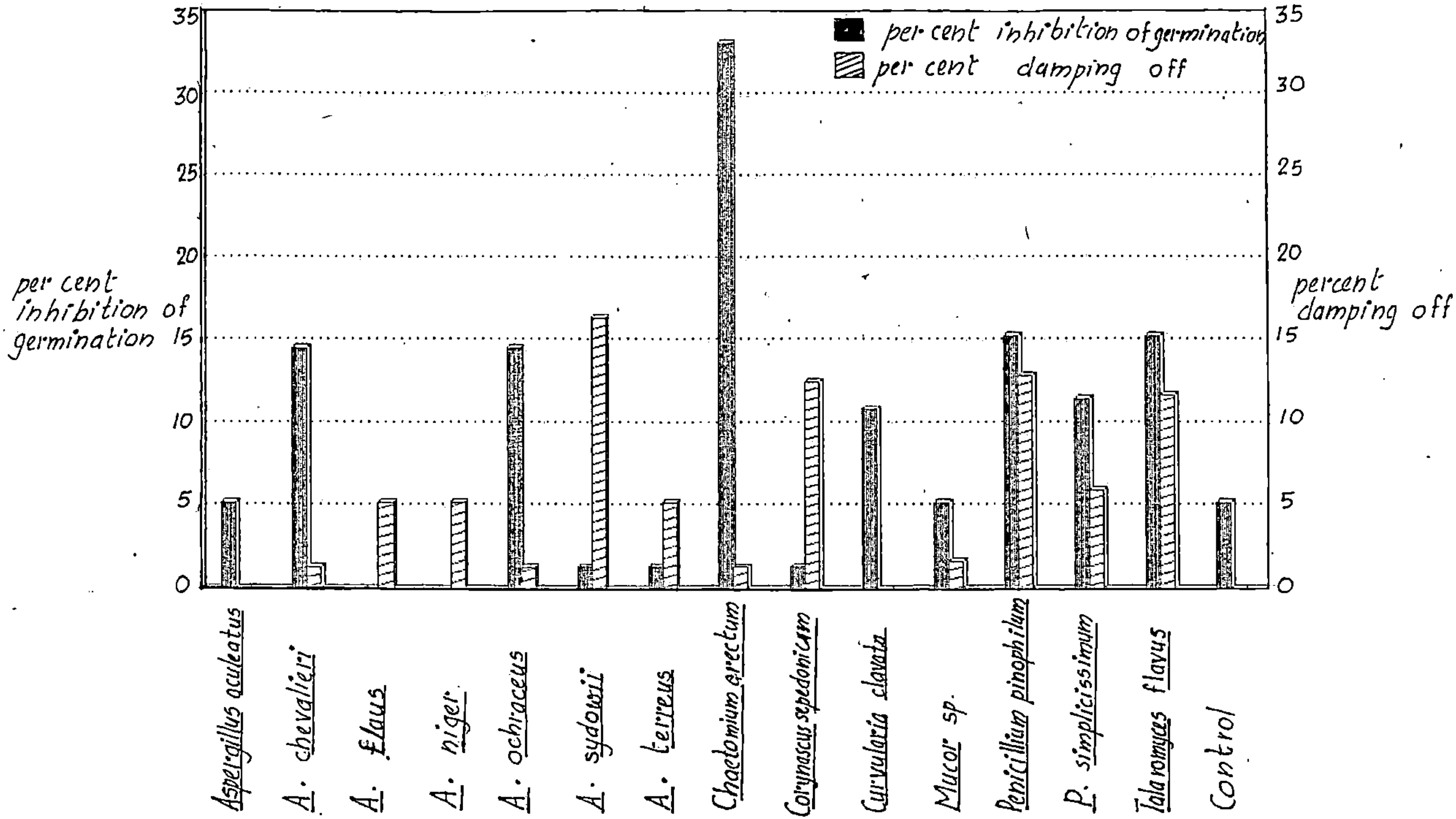

Fig. 4. Effect of seed-borne fungi on seeds and seedlings of ash gourd

snake gourd seedlings (18.02 per cent) while most of the other fungi tested did not cause damping off (Table 6, Fig.5).

4.3 Effect of culture filtrates of seed-borne fungi.

4.3.1 Effect of culture filtrtes on amaranthus seeds and seedlings.

4.3.1.1 On germination of seeds.

Culture filtrates of many of the seed-borne fungi significantly reduced the germination of seeds. Culture filtrates of *Fusarium* spp. and *Rhizopus oryzae* caused significant inhibition in germination of amaranthus seeds. The percentage of inhibition caused by these fungi ranged from 39.86 to 99.99. Maximum inhibition of germination was caused by *Fusarium* spp. The inhibition caused by *A. aculeatus* and *P. pinophilum* was not significant (Table 7).

4.3.1.2 On elongation of plumule and radicle.

Culture filtrates of *Fusarium* spp., *Aspergillus aculeatus*, *Penicillium pinophilum* and *Rhizopus oryzae* caused significant inhibition on the

Table 6. Effect of seed-borne fungi on seeds and seedlings of snake gourd

Sl. No.	Treatment	Per cent inhibition of germination**	Per cent damping off of seedlings **
1.	*Aspergillus chevalieri*	44.48 (41.82)	3.81 (11.25)
2.	*Aspergillus flavus*	29.50 (32.89)	0.00 (0.00)
3.	*Chaetomium brasiliense*	61.98 (51.91)	0.00 (0.00)
4.	*Chaetomium globsum*	44.97 (42.10)	0.00 (0.00)
5.	*Fusarium pallidoroseum*	76.30 (60.84)	3.81 (11.25)
6.	*Gilbertella persicaria*	60.48 (51.03)	0.00 (0.00)
7.	*Penicillium pinophilum*	44.48 (41.82)	0.00 (0.00)
8.	*Penicillium* sp.	29.50 (32.89)	18.02 (25.11)
9.	*Rhizopus oryzae*	38.51 (38.34)	0.00 (0.00)
10.	Control	15.38 (23.08)	0.00 (0.00)
	$F_{(9,30)}$	1.80	2.25*
	S E	8.136	5.697
	C D		16.451

* Significant at 5% level.
** Figuresin parentheses are transformed values in angles.

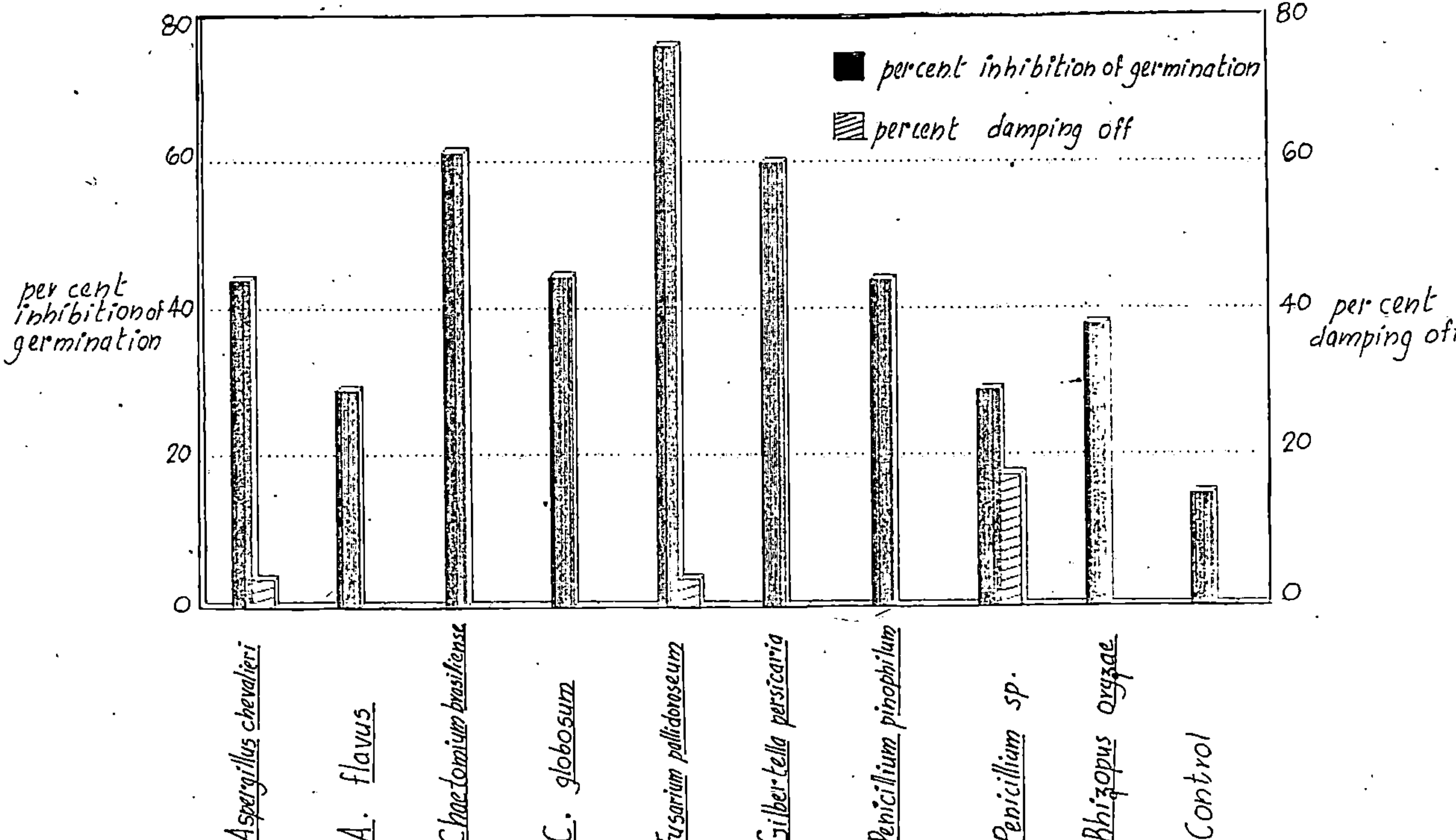

Fig.5. Effect of seed-borne fungi on seeds and seedlings of snakegourd

elongation of plumule and radicle (Plate 1 & Plate 2). Maximum inhibition on plumule elongation was caused by the culture filtrates of P. pinophilum and A. aculeatus. Fusarium sp.3 caused the maximum inhibition on radicle elongation closely followed by P. pinophilum. It was noticed that sterile medium used as control I also caused considerable inhibition of plumule and radicle elongation (Table 7).

4.3.1.3 On Seedlings.

The culture filtrates of Fusarium spp., (except Fusarium sp.3) Rhizopus oryzae and Aspergillus aculeatus caused 99.99 per cent wilting while P. pinophilum caused 84.07 per cent wilting of the seedlings (Plate 3). Even after boiling for 10 minutes the culture filtrates of all the above mentioned fungi caused significant wilting of seedlings (Table 7).

4.3.2 Effect of culture filtrates on chilli seeds and seedlings.

4.3.2.1 On germination of seeds.

In chilli, among the culture filtrates tested, only those of Curvularia clavata and Penicillium pinophilum showed significant inhibition of germination. The former inhibited

Plate I Effect of culture filtrate of _Fusarium equiseti_ on inhibition of plumule elongation in amaranthus.

1. Control (sterile water)
2. Culture filtrate.

Plate II Effect of culture filtrate of _Fusarium equiseti_ on inhibition of radicle elongation in amaranthus.

1. Control (sterile water)
2. Culture filtrate.

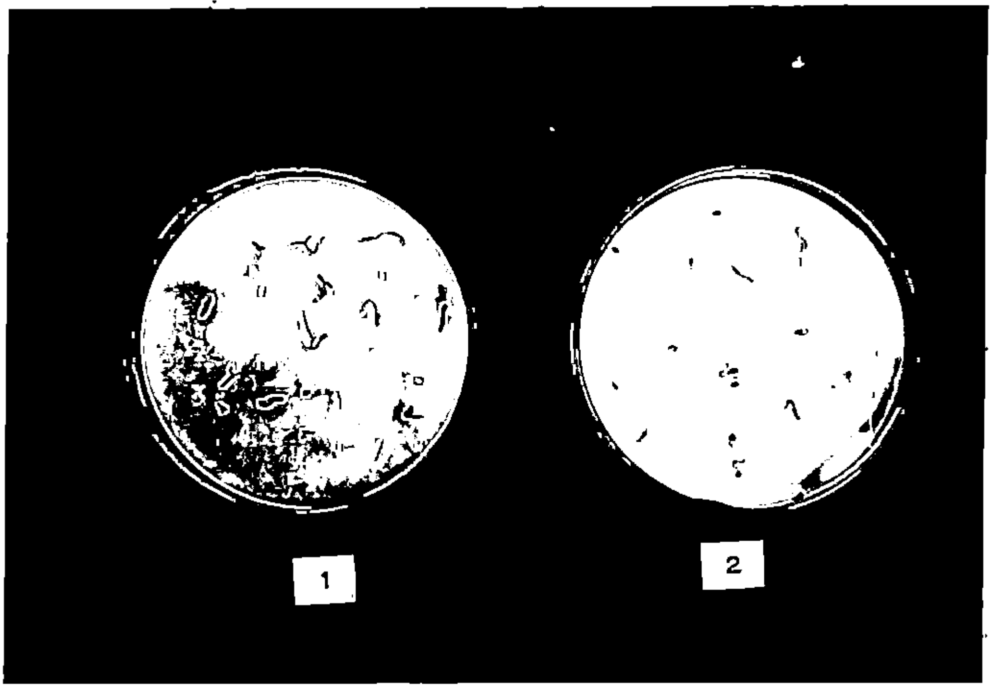

Plate I

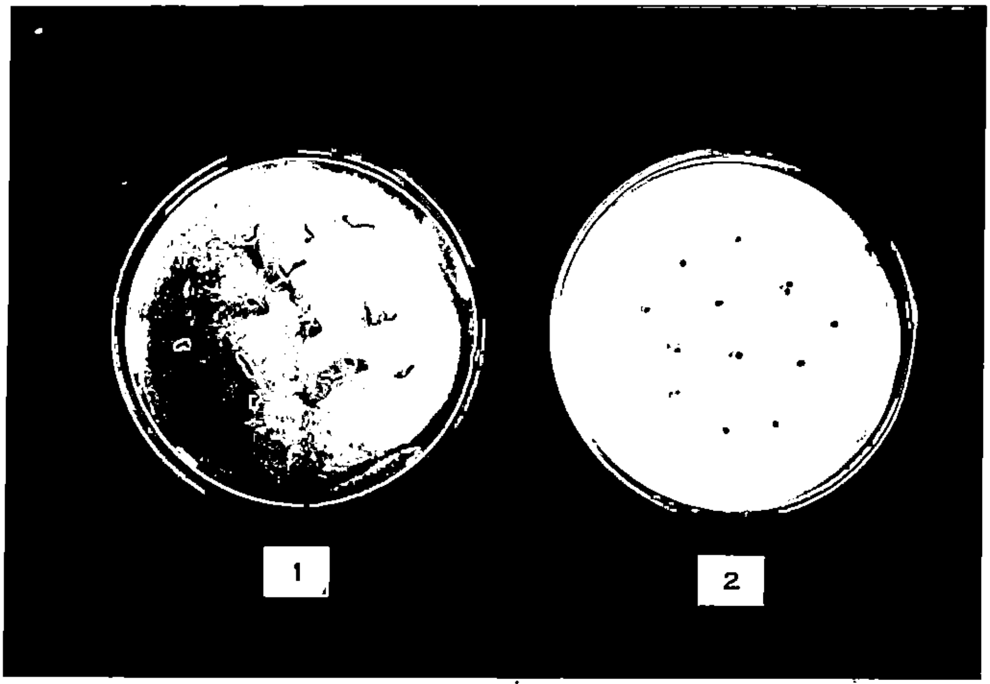

Plate II

Plate III Effect of culture filtrate of Fusarium equiseti on one month old amaranthus seedling.

1. Control (sterile water)
2. Culture filtrate.

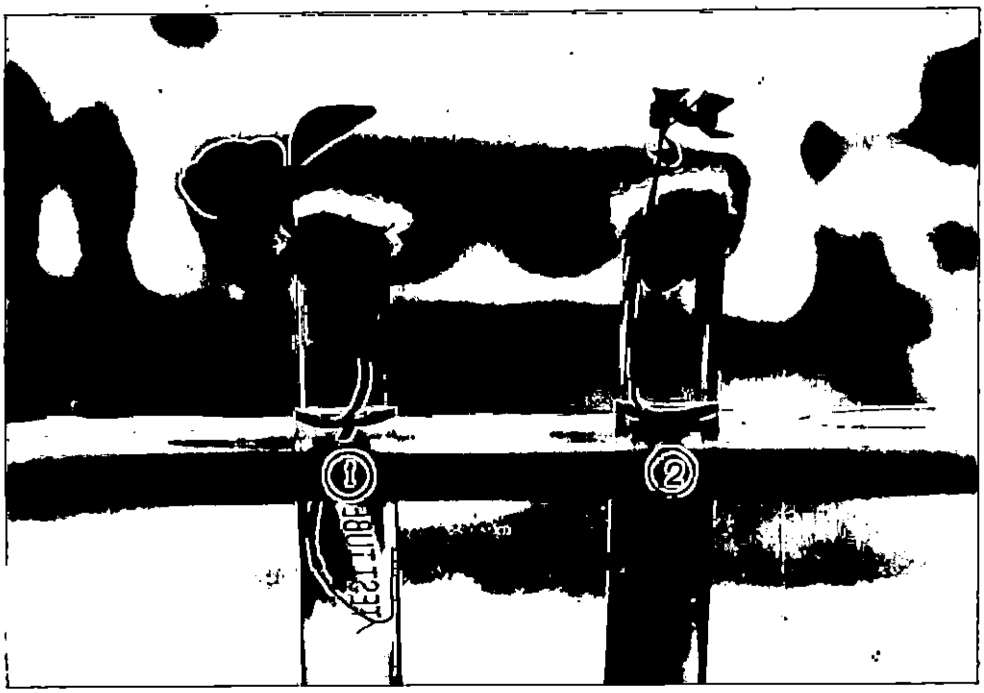

Plate III

Table 7. Effects of culture filtrates of seed-borne fungi on seeds and seedlings of amaranthus

Sl. No.	Treatment	Percentage of inhibition of germination**	Effect on plumule and radicle elongation: Plumule length (mm)	Radicle length (mm)	Percentage of wilted seedlings: In fresh culture filtrate**	In culture filtrate boiled for 10 minutes**
1.	*Aspergillus aculeatus*	25.29 (30.18)	6.8	8.1	99.99 (90.00)	95.86 (78.22)
2.	*Fusarium equiseti*	99.99 (90.00)	9.1	7.9	99.99 (90.00)	95.86 (78.22)
3.	*Fusarium* sp.1	93.31 (74.98)	11.1	10.1	99.99 (90.00)	84.07 (66.45)
4.	*Fusarium* sp.2	99.99 (90.00)	8.6	10.0	99.99 (90.00)	95.86 (78.22)
5.	*Fusarium* sp.3	99.99 (90.00)	9.0	6.2	33.30 (35.23)	33.30 (35.23)
6.	*Fusarium* sp.4	39.86 (39.13)	10.9	10.6	99.99 (90.00)	99.99 (90.00)
7.	*Penicillium pinophilum*	29.67 (32.99)	6.6	7.0	84.07 (66.45)	55.59 (48.19)
8.	*Rhizopus oryzae*	86.99 (74.98)	11.1	10.1	99.99 (90.00)	84.07 (66.45)
9.	Control I	29.67 (32.99)	10.9	14.4	15.90 (23.49)	4.15 (11.74)
10.	Control II	13.01 (21.14)	13.7	21.7	0.00 (0.00)	0.00 (0.00)
	F (9,20)	49.55*	42.45*	69.00*	57.16*	11.92*
	S E	4.021	0.34	0.56	4.251	8.812
	C D	11.861	1.00	1.66	12.539	25.997

Plate IV Effect of culture filtrate of _Aspergillus flavus_ on one month old chilli seedling.

1: Control (sterile water)
2. Culture filtrate.

seed germination by 76.99 per cent while the latter by 60.32 per cent. Culture filtrate of Scytalidium sp. showed the least inhibition of germination (Table 8).

4.3.2.2 On elongation of plumule and radicle.

The culture filtrates of all the five fungi tested, significantly inhibited the elongation of plumule and radicle in chilli. The culture filtrates of Penicillium pinophilum caused the maximum inhibition of plumule elongation followed by Curvularia clavata. The least effect was shown by culture filtrates of P. purpurogenum. In the case of radicle elongation, the culture filtrate of Aspergillus flavus caused maximum inhibitory effect followed by P. pinophilum. The culture filtrate of Scytalidium sp. had the least effect (Table 8).

4.3.2.3 On seedlings.

The culture filtrates of Aspergillus flavus, Penicillium pinophilum and Curvularia clavata caused significant wilting of chilli seedlings, the per cent wilting being 99.99, 95.86 and 84.07 respectively (Plate 4). There was no marked change in the toxic effect of the culture filtrates when they were used after boiling for 10 minutes,

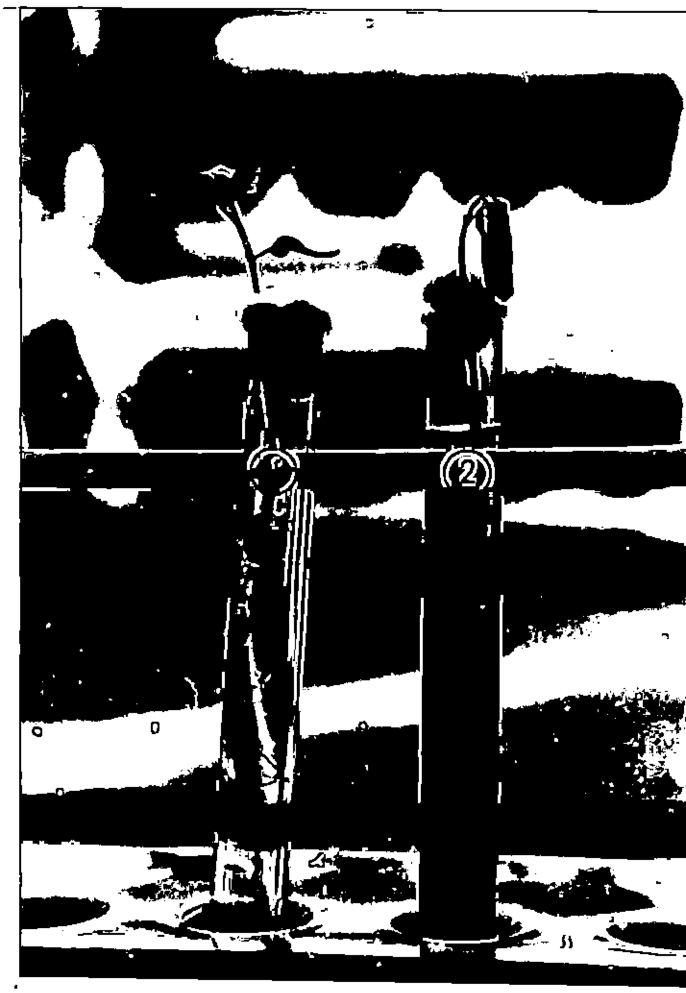

Plate IV

except in Curvularia clavata wherein the percentage of wilted seedlings was reduced from 84.07 to 15.9 (Table 8).

4.3.3 Effects of culture filtrates on tomato seeds and seedlings.

4.3.3.1 On germination of seeds.

While culture filtrates of Fusarium solani, Penicillium pinophilum and Aspergillus flavipes significantly inhibited the germination of tomato seeds as compared to control I (culture medium), the culture filtrates of Fusarium solani, P. pinophilum, A. flavipes, A. chevalieri and P. simplicissimum significantly inhibited the germination as compared to control II (sterile water). Maximum inhibition of 80.69 per cent was caused by F. solani. The inhibition was least (39.71 per cent) by culture filtrates of P. purpurogenum (Table 9).

4.3.3.2 On elongation of plumule and radicle.

The culture filtrates of F. solani, P. simplicissimum, A. chevalieri and P. pinophilum caused significant inhibition in elongation of plumule and radicle (plate 5), while culture filtrates of A. flavipes and p. purpurogeum significantly

Table 8. Effects of culture filtrates of seed-borne fungi on seeds and seedlings of chilli

Sl. No.	Treatment	Percentage of inhibition of germination**	Effect on plumule and radicle elongation		Percentage of wilted seedlings.	
			Plumule length (mm)	Radicle length (mm)	In fresh culture filtrate**	In culture filtrate boiled for 10 minutes**
1.	*Aspergillus flavus*	29.72 (33.02)	9.0	6.1	99.99 (90.00)	99.99 (90.00)
2.	*Curvularia clavata*	76.99 (61.31)	8.6	8.3	84.07 (66.45)	15.90 (23.49)
3.	*Penicillium pinophilum*	60.32 (50.93)	7.3	6.3	95.86 (78.22)	99.99 (90.00)
4.	*Pencillium purpurogenum*	33.17 (35.15)	9.7	7.6	4.15 (11.74)	15.90 (23.49)
5.	*Scytalidium* sp.	29.20 (32.70)	9.7	8.6	15.90 (23.49)	15.90 (23.49)
6.	Control I	33.09 (35.10)	13.5	11.7	4.15 (11.74)	0.00 (0.00)
7.	Control II	23.18 (28.77)	22.8	19.0	0.00 (0.00)	0.00 (0.00)
	F (6,14)	10.12*	774.64*	552.82*	13.73*	25.08*
	S E	3.736	0.19	0.19	9.935	7.688
	C D	11.336	0.58	0.58	30.140	23.321

* Significant at 5% level.
** Figure in parentheses are transformed values in angles.

Plate V. Effect of culture filtrate of <u>Penicillium pinophilum</u> on inhibition of plumule elongation in tomato.

1. Control (sterile water)
2. Culture filtrate.

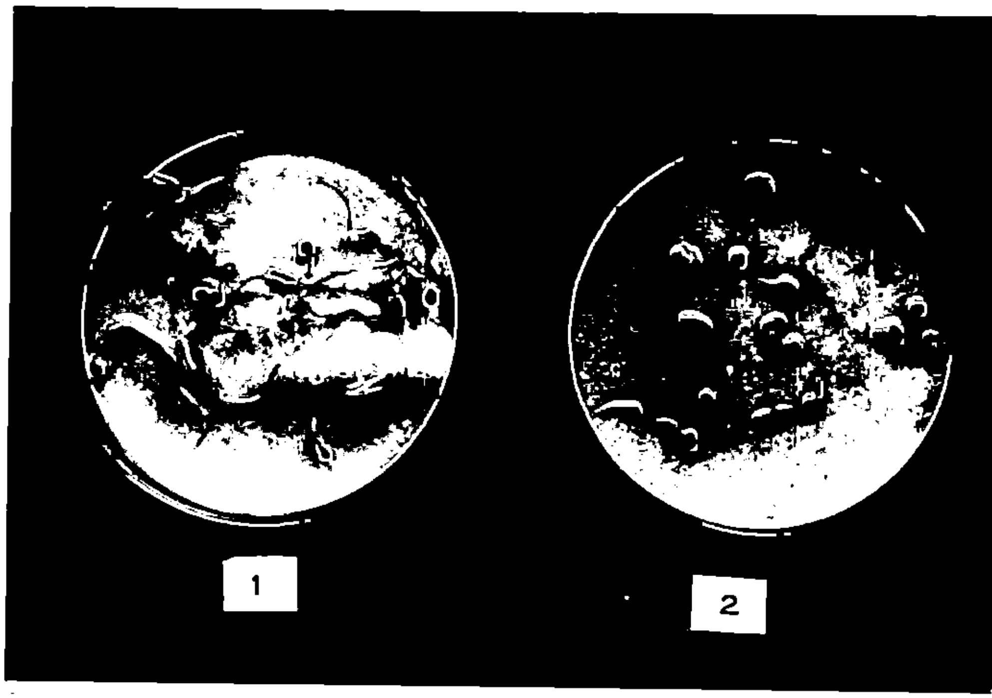

Plate V

inhibited the elongation of plumule only. The plumule elongation was inhibited to the maximum extent by the culture filtrate of P. simplicissimum. The culture filtrate of A. chevalieri caused maximum inhibition of radicle elongation (Table 9).

4.3.3.3 On seedlings.

The culture filtrates of most of the seed-borne fungi of tomato caused significant wilting of the treated seedlings. The culture filtrate of A.chevalieri caused 99.99 per cent wilting of seedlings. Among other species of fungi, P. simplicissimum caused 95.86 per cent, P. pinophilum, 84.07 per cent, A. flavipes and F. solani, 55.59 per cent wilting of seedlings. It was noticed that boiling considerably reduced the toxic effect of the culture filtrates of A.flavipes and A. chevalieri on tomato seedlings (Table 9).

4.3.4 Effect of culture filtrates on ash gourd seeds and seedlings.

4.3.4.1 On germination of seeds.

The inhibition in germination of ash gourd seeds caused by culture filtrates of Curvularia clavata (56.69 per cent), Aspergillus ochraceus (53.35 percent) and

Table 9. Effects of culture filtrates of seed-borne fungi on seeds and seedlings of tomato

Sl. No.	Treatment	Percentage of inhibition of germination**	Effect on plumule and radicle elongation		Percentage of wilted seedlings	
			Plumule length (mm)	Radicle length (mm)	In fresh culture filtrate**	In culture filtrate boiled for 10 minutes**
1.	*Aspergillus chevalieri*	50.00 (44.98)	9.7	5.7	99.99 (90.00)	33.30 (35.23)
2.	*Aspergillus flavipes*	56.74 (48.86)	11.0	10.0	55.59 (48.19)	4.15 (11.74)
3.	*Fusarium solani*	80.69 (63.90)	6.3	6.1	55.59 (48.19)	55.59 (48.19)
4.	*Paecilomyces inflatus*	37.72 (37.87)	9.9	6.7	66.60 (54.67)	44.30 (41.71)
5.	*Penicillium pinophilum*	60.04 (50.77)	8.9	6.0	84.07 (66.45)	55.59 (48.19)
6.	*Penicillium purpurogenum*	39.71 (39.05)	11.5	10.0	4.15 (11.74)	0.00 (0.00)
7.	*Penicillium simplicissimum*	44.93 (42.07)	6.2	7.2	95.86 (78.22)	55.59 (48.19)
8.	Control I	29.79 (33.06)	15.5	9.1	4.15 (11.74)	0.00 (0.00)
9.	Control II	24.29 (29.52)	20.00	22.7	0.00 (0.00)	0.00 (0.00)
	F (8,18)	5.77*	208.36*	165.19*	14.01*	16.87*
	S E	4.101	0.29	0.39	7.982	5.531
	C D	12.099	0.87	1.16	23.548	16.317

* Significant at 5% level.
** Figures in parantheses are transformed values in angles

Penicillium pinophilum (46.65 per cent) was statistically significant when compared with control I and II, while the inhibition caused by A. chevalieri (43.15 per cent) and Talaromyces flavus (32.91 per cent) was significant only when compared with control II. Culture filtrates of A. aculeatus caused least inhibition of germination of ash gourd seeds (Table 10).

4.3.4.2 On elongation of plumule and radicle.

The culture filtrates of all the fungi tested, significantly inhibited elongation of plumule and radicle in ash gourd. The extent of inhibition was maximum by the culture filtrates of Aspergillus sydowii and A. aculeatus on plumule elongation (Plate 6). Culture filtrates of Chaetomium erectum caused maximum inhibition of elongation of radicle followed by A. aculeatus. Among all the treatments, the culture filtrates of Talaromyces flavus caused the least inhibition of both plumule and radicle elongation (Table 10).

4.3.4.3 On seedlings.

The culture filtrates of A. sydowi, Chaetomium erectum, Penicillium pinophilum and A. chevalieri caused cent per cent wilting of the treated seedlings. Those

Plate VI Effect of culture filtrate of <u>Aspergillus</u> <u>aculeatus</u> on inhibition of radicle elongation in ash gourd.

1. Control (sterile water)
2. Culture filtrate.

Plate VI

of *Curvularia clavata*, *A. ochraceus* and *A. aculeatus* caused 95.86 , 95.86 and 84.07 per cent wilting respectively. It was noticed that the toxic effect of the culture filtrates of *C.clavata* and *A. ochraceus* was considerably reduced as a result of boiling for 10 minutes (Table 10).

4.3.5 Effect of culture filtrates on snake gourd seeds and seedlings.

4.3.5.1 On germination of seeds.

Culture filtrates of none of the fungi caused significant inhibition of germination of seeds. The maximum inhibition was caused by the culture filtrate of *Penicillium pinophilum* with 60.14 per cent inhibition. The least inhibition was caused by the culture filtrate of the fungus *Chaetomium brasiliense* (Table 11).

4.3.5.2 On elongation of plumule and radicle.

The culture filtrates of all the six species of fungi tested significantly inhibited elongation of both plumule and radicle in snake gourd. Among them culture filtrate of *Aspergillus flavus* showed maximum inhibitory effects on both plumule and radicle elongation while that of *F. pallidoroseum* showed least inhibitory effects (Table 11).

Table 10. Effects of culture filtrates of seed-borne fungi on seeds and seedlings of ash gourd.

Sl. No.	Treatment	Percentage of inhibition of germination**	Effect on plumule and radicle elongation		Percentage of wilted seedlings	
			Plumule length (mm)	Radicle length (mm)	In fresh culture filtrate**	In culture filtrate boiled for 10 minutes**
1.	<u>Aspergillus</u> <u>aculeatus</u>	22.15 (28.07)	6.0	6.3	84.07 (66.45)	84.07 (66.45)
2.	<u>Aspergillus</u> <u>chevalieri</u>	43.16 (41.05)	6.4	7.0	99.99 (90.00)	99.99 (90.00)
3.	<u>Aspergillus</u> <u>ochraceus</u>	53.35 (46.90)	7.9	7.3	95.86 (78.22)	4.15 (11.74)
4.	<u>Aspergillus</u> <u>sydowii</u>	26.20 (30.77)	6.0	7.3	99.99 (90.00)	95.86 (78.22)
5.	<u>Chaetomium</u> <u>erectum</u>	30.00 (33.20)	7.5	6.0	99.99 (90.00)	44.30 (41.71)
6.	<u>Curvularia</u> <u>clavata</u>	56.69 (48.83)	7.9	8.0	95.86 (78.22)	15.90 (23.49)
7.	<u>Penicillium</u> <u>pinophilum</u>	46.65 (43.06)	7.0	6.5	99.99 (90.00)	95.86 (78.22)
8.	<u>Talaromyces</u> <u>flavus</u>	32.91 (34.99)	8.8	9.3	15.90 (23.49)	4.15 (11.74)
9.	Control I	26.52 (30.98)	10.6	10.6	15.90 (23.49)	0.00 (0.00)
10.	Control II	16.36 (23.85)	15.5	14.5	0.00 (0.00)	0.00 (0.00)
	F (9,20)	5.74*	135.91*	220.12*	16.84*	14.27*
	S E	3.494	0.18	0.18	8.318	9.337
	C D	10.306	0.73	0.52	24.537	27.543

* Significant at 5% level.
** Figures in parentheses are transformed values in angles.

Plate VII Effect of culture filtrate of _Aspergillus_ _flavus_ on one month old snake gourd seedling.

1. Control (sterile water)
2. Culture filtrate.

4.3.5.3 On seedlings.

The culture filtrate of the fungi Penicillium pinophilum and Gilbertella persicaria showed maximum toxic effect on snake gourd seedlings causing 95.86 per cent wilting. Other fungi also caused significant wilting but to a lesser extent (Plate 7). In general, as in other crops, the culture filtrates of the test fungi retained their toxicity even after boiling for 10 minutes, except in A. chevalieri where the toxicity was reduced significantly after boiling (Table 11).

4.4 Effect of seed treatment fungicides.

4.4.1 Effect of fungicides on the growth of seed-borne fungi.

4.4.1.1 Bavistin (Carbendazim).

Bavistin caused complete inhibition of the growth of Chaetomium brasiliense, C. erectum and Fusarium equiseti at all the three concentrations. There was complete inhibition of growth of F. pallidoroseum at 500 and 1000 ppm and Aspergillus flavus at 1000 ppm. Bavistin was least effective against Curvularia clavata and Rhizopus oryzae at all the concentrations tested (Table 12, Fig. 6).

Table 11. Effects of culture filtrates of seed-borne fungi on seeds and seedlings of snakegourd.

Sl. No.	Treatment	Percentage of inhibition of germination**	Effect on plumule and radicle elongation		Percentage of wilted seedlings	
			Plumule length (mm)	Radicle length (mm)	In fresh culture filtrate**	In culture filtrate boiled for 10 minutes**
1.	*Aspergillus chevalieri*	43.16 (41.05)	8.3	9.8	44.30 (41.71)	4.15 (11.74)
2.	*Aspergillus flavus*	53.36 (46.90)	6.2	6.7	66.80 (54.67)	44.30 (41.71)
3.	*Chaetomium brasiliense*	32.91 (34.99)	8.3	9.3	0.00 (0.00)	0.00 (0.00)
4.	*Fusarium pallidoroseum*	39.38 (38.34)	8.9	9.2	44.30 (41.71)	4.15 (11.74)
5.	*Gilbertella persicaria*	46.50 (42.98)	7.1	7.6	95.86 (78.22)	95.86 (78.22)
6.	*Penicillium pinophilum*	60.14 (50.83)	7.5	6.9	95.86 (78.22)	84.07 (66.45)
7.	Control I	32.78 (34.91)	11.3	13.3	4.15 (11.74)	0.00 (0.00)
8.	Control II	18.35 (25.36)	15.1	22.6	0.00 (0.00)	0.00 (0.00)
	F (7,16)	2.37	269.02*	311.62*	16.30*	13.53*
	S E	5.149	0.17	0.30	7.900	8.625
	C D		0.52	0.90	23.684	25.859

* Significant at 5% level.

** Figures in parentheses are transformed values in angles.

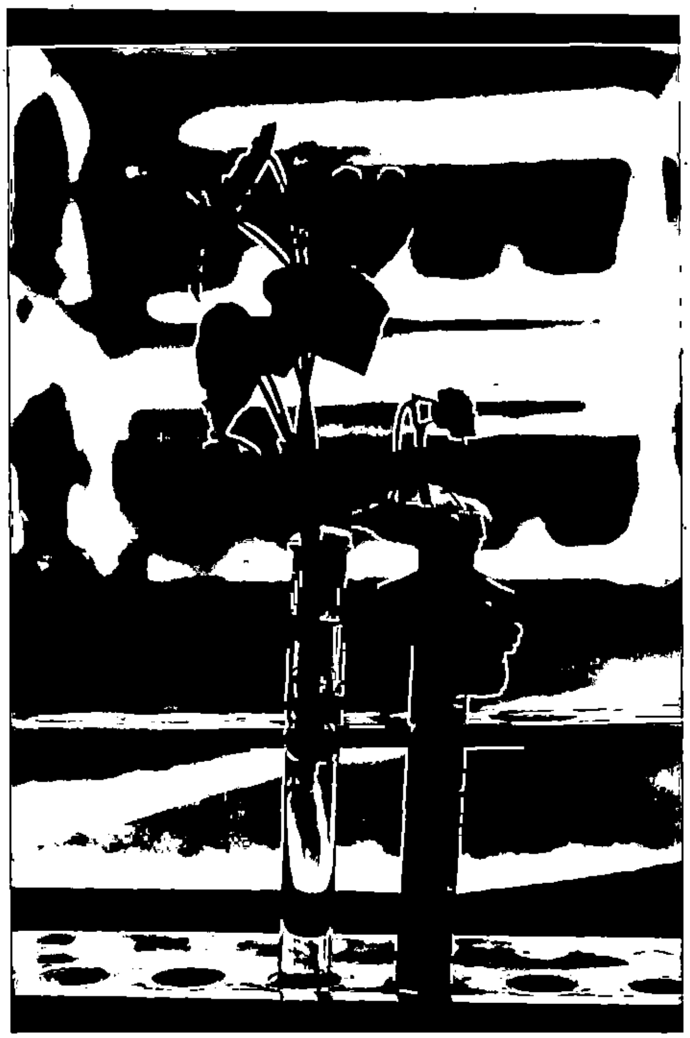

Plate VII

Table 12. Effect of Bavistin (carbendazim) on the growth of seed - borne fungi.

Sl. No.	Fungus	Per cent inhibition of radial growth over control* level 1 250 ppm	level 2 500 ppm	level 3 1000 ppm	Mean
1.	Aspergillus aculeatus	98.50 (82.99)	99.12 (84.63)	99.85 (87.77)	92.28 (85.31)
2.	Aspergillus chevalieri	88.10 (69.84)	94.40 (76.33)	99.51 (86.00)	95.20 (77.30)
3.	Aspergillus flavus	94.70 (76.70)	97.00 (80.06)	99.99 (90.00)	98.20 (82.25)
4.	Aspergillus ochraceus	72.70 (58.47)	71.90 (57.99)	99.25 (90.00)	85.00 (67.17)
5.	Chaetomium brasiliense	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
6.	Chaetomium erectum	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
7.	Curvularia clavata	2.00 (8.13)	16.80 (24.23)	23.90 (29.28)	12.30 (20.55)
8.	Fusarium equiseti	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
9.	Fusarium pallidoroseum	90.80 (72.29)	99.99 (90.00)	99.99 (90.00)	98.90 (84.10)
10.	Fusarium solani	95.80 (67.89)	90.50 (72.07)	92.00 (73.60)	89.60 (71.19)
11.	Fusarium sp.5	85.30 (67.43)	97.80 (81.47)	99.99 (90.00)	96.80 (79.69)
12.	Gilbertella persicaria	51.50 (45.83)	65.50 (54.03)	83.00 (65.73)	67.40 (55.20)
13.	Humicola fuscoatra	46.90 (43.22)	56.70 (48.85)	88.10 (69.79)	65.40 (53.96)
14.	Penicillium pinophilum	84.30 (66.63)	88.40 (70.11)	91.20 (72.72)	88.10 (69.82)
15.	Rhizopus oryzae	6.30 (15.49)	11.20 (19.56)	19.50 (26.17)	12.20 (20.41)
16.	Scytalidium sp.	71.50 (57.75)	80.40 (63.75)	88.40 (70.12)	80.60 (63.87)
	Mean	78.90 (62.60)	86.40 (68.32)	93.60 (75.39)	

CD treatment : 5.253
CD fungicide x fungus : 3.037
CD fungicide x concentration : 1.315

* Figures in parentheses are transformed values in angles.

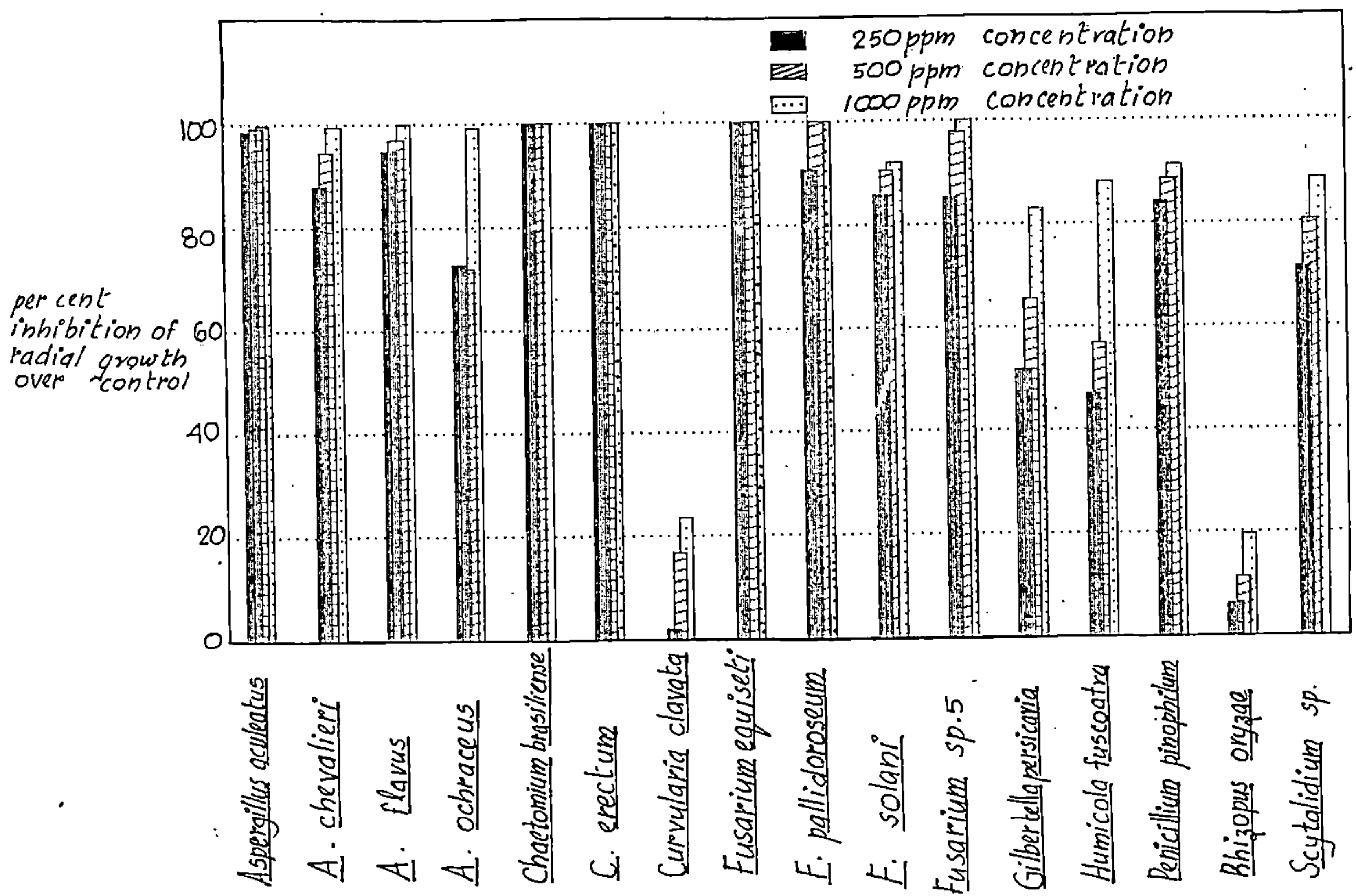

Fig.6. Effect of Bavistin (carbendazim) on the growth of seed-borne fungi

4.4.1.2 Blue copper 50 (Copper Oxychloride).

Blue copper 50 did not cause complete inhibition of growth of any of the seed - borne fungi tested. The maximum inhibitory effect observed was 99.36 per cent against Rhizopus oryzae at 2000 ppm concentration. It was found to have significant inhibitory effects against Curvularia clavata, Fusarium solani and Aspergillus flavus at 2000 ppm and against Chaetomium erectum at 1000 and 2000 ppm. This was least effective against Fusarium pallidoroseum and Fusarium sp.5 at 500 ppm (Table 13, Fig. 7).

4.4.1.3 Foltaf (Captafol).

Foltaf caused complete inhibition of growth of seed-borne fungi like Fusarium equiseti, F. solani, Gilbertella persicaria and Rhizopus oryzae in vitro when tested at 1000 and 2000 ppm concentrations. The growth of all the other seed - borne fungi tested was also significantly inhibited by Foltaf. Over 99 per cent inhibition was observed in the case of Aspergillus aculeatus, A. chevalieri, A. ochraceus and Curvularia clavata. This fungicide was least effective against Humicola fuscoatra (Table 14, Fig. 8).

Table 13. Effect of Blue Copper 50 (copper oxychloride) on the growth of seed - borne fungi.

Sl. No.	Fungus	Per cent inhibition of radial growth over control* level 1 500 ppm	level 2 1000 ppm	level 3 2000 ppm	Mean
1.	Aspergillus aculeatus	27.10 (31.35)	62.70 (52.33)	76.60 (61.10)	55.70 (48.26)
2.	Aspergillus chevalieri	26.40 (30.93)	36.10 (36.94)	81.60 (64.57)	48.50 (44.15)
3.	Aspergillus flavus	81.70 (64.65)	83.10 (66.75)	93.60 (75.30)	87.00 (68.90)
4.	Aspergillus ochraceus	30.80 (33.72)	48.90 (44.34)	49.50 (44.73)	42.90 (40.93)
5.	Chaetomium brasiliense	48.30 (44.02)	61.10 (51.41)	64.40 (53.35)	58.00 (49.59)
6.	Chaetomium erectum	88.00 (69.72)	91.30 (72.79)	93.60 (75.35)	91.10 (72.62)
7.	Curvularia clavata	44.00 (41.53)	80.20 (63.55)	89.90 (71.49)	73.20 (58.85)
8.	Fusarium equiseti	28.70 (32.37)	39.90 (39.18)	59.80 (50.62)	53.00 (46.73)
9.	Fusarium pallidoroseum	5.80 (13.96)	22.20 (28.13)	41.30 (39.98)	21.10 (27.36)
10.	Fusarium solani	9.80 (18.26)	72.90 (58.61)	91.40 (72.96)	58.60 (46.94)
11.	Fusarium sp.5	4.20 (11.78)	56.40 (48.67)	83.40 (65.97)	45.00 (46.14)
12.	Gilbertella persicaria	44.10 (41.62)	71.40 (57.64)	73.40 (58.97)	63.40 (52.70)
13.	Humicola fuscoatra	20.90 (27.24)	45.90 (42.66)	76.50 (61.02)	47.60 (43.64)
14.	Penicillium pinophilum	35.10 (36.34)	49.00 (44.45)	63.90 (53.07)	49.30 (44.62)
15.	Rhizopus oryzae	70.40 (57.07)	78.60 (62.45)	99.36 (85.40)	86.30 (68.30)
16.	Scytalidium sp.	53.80 (47.15)	80.10 (63.48)	80.60 (63.88)	72.20 (58.17)
	Mean	37.30 (37.61)	62.30 (52.09)	78.50 (62.36)	

CD treatment : 5.259
CD fungicide x fungus : 3.037
CD fungicide x concentration : 1.315

* Figures in parentheses are transformed values in angles.

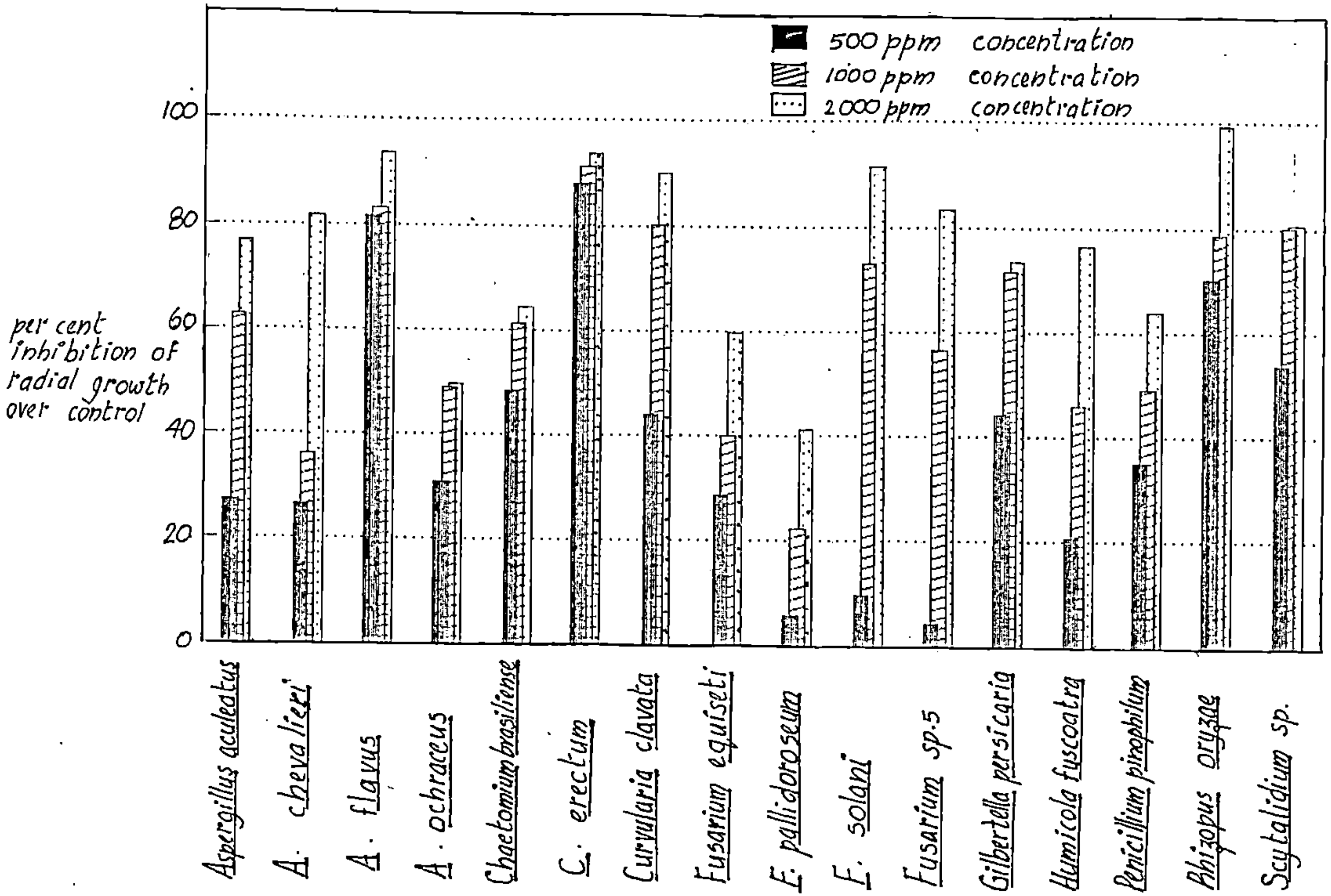

Fig. 7. Effect of Blue Copper 50 (copper oxy chloride) on the growth of seed-borne fungi

Table 14. Effect of Foltaf (captafol) on the growth of seed-borne fungi.

Sl. No.	Fungus	Per cent inhibition of radial growth over control* level 1 500 ppm	level 2 1000 ppm	level 3 2000 ppm	Mean
1.	*Aspergillus aculeatus*	96.90 (79.85)	98.40 (82.65)	99.85 (87.77)	98.70 (83.04)
2.	*Aspergillus chevalieri*	56.30 (78.86)	99.36 (85 40)	99.84 (87.70)	98.90 (83.99)
3.	*Aspergillus flavus*	89.10 (70.68)	91.30 (72.81)	93.80 (75.53)	91.50 (73.00)
4.	*Aspergillus ochraceus*	87.30 (69.11)	88.80 (70.42)	99.10 (84.55)	93.00 (74.64)
5.	*Chaetomium brasiliense*	65.70 (54.16)	67.60 (55.28)	74.00 (59.36)	69.10 (56.26)
6.	*Chaetomium erectum*	88.90 (70.52)	94.00 (75.85)	95.50 (77.68)	93.00 (74.68)
7.	*Curvularia clavata*	82.20 (65.06)	92.00 (73.53)	99.55 (86.14)	93.20 (74.91)
8.	*Fusarium equiseti*	88.40 (70.13)	99.99 (90.00)	99.99 (90.00)	98.70 (83.38)
9.	*Fusarium pallidoroseum*	75.10 (60.06)	83.10 (65.74)	83.70 (66.17)	80.80 (63.99)
10.	*Fusarium solani*	88.10 (69.85)	99.99 (90.00)	99.99 (90.00)	98.60 (83.28)
11.	*Fusarium* sp.5	73.90 (59.26)	79.10 (62.82)	91.20 (72.79)	82.10 (64.96)
12.	*Gilbertella persicaria*	98.30 (82.60)	99.99 (90.00)	99.99 (90.00)	99.81 (87.53)
13.	*Humicola fuscoatra*	44.60 (41.88)	61.90 (51.88)	82.20 (65.08)	63.70 (52.95)
14.	*Penicillium pinophilum*	41.20 (39.91)	53.70 (47.11)	77.30 (61.53)	57.90 (49.52)
15.	*Rhizopus oryzae*	90.60 (84.44)	99.99 (90.00)	99.99 (90.00)	99.90 (88.15)
16.	*Scytalidium* sp.	82.70 (65.40)	92.30 (73.84)	97.70 (81.24)	91.90 (73.49)
	Mean	83.90 (66.36)	92.00 (73.58)	96.40 (79.10)	

CD treatment : 5.253
CD fungicide x fungus : 3.037
CD fungicide x concentration : 1.315

* Figures in parentheses are transformed values in angles.

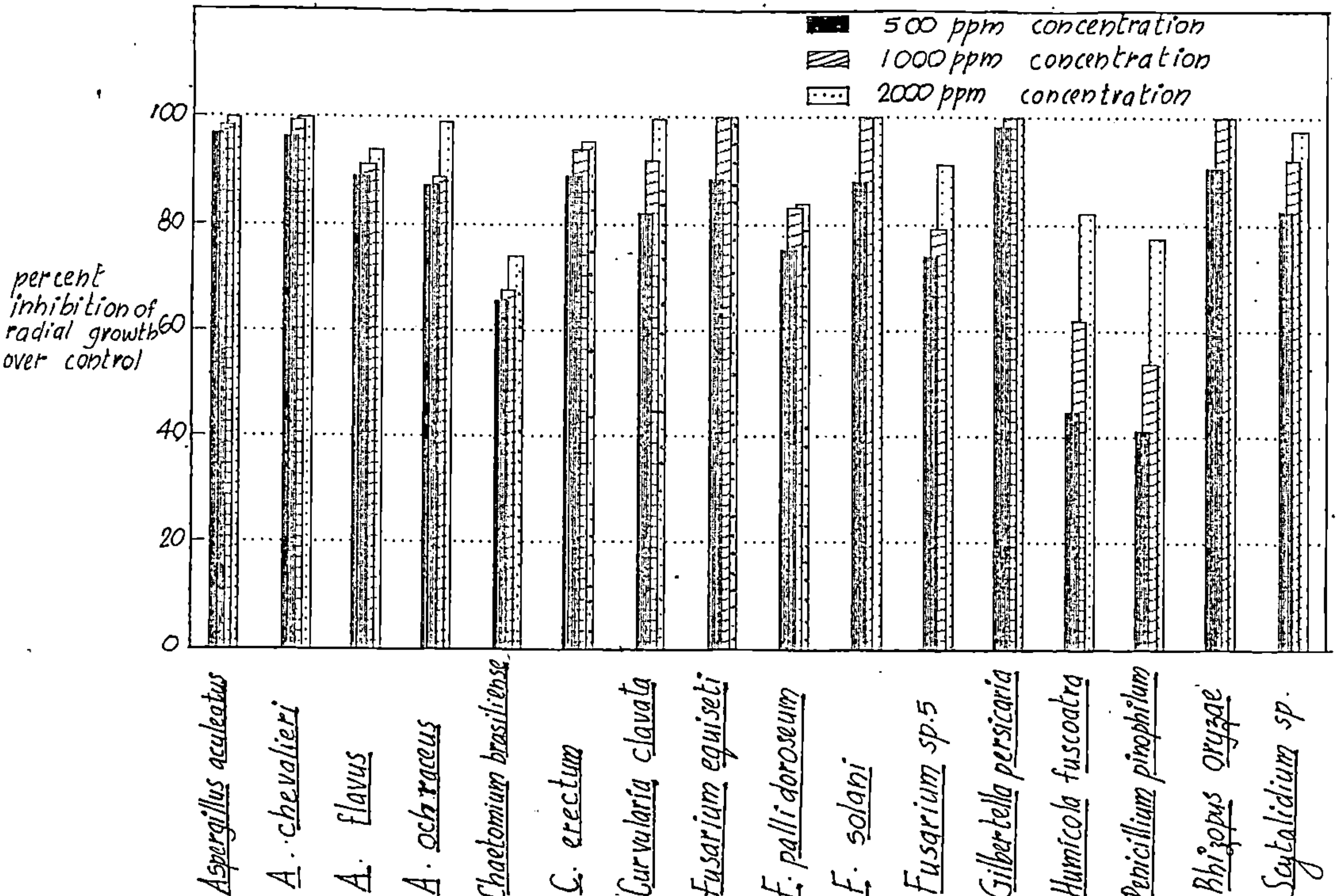

Fig. 8. Effect of Foltaf (captafol) on the growth of seed-borne fungi.

4.4.1.4 Hexacap (Captan).

Hexacap caused complete inhibition of the growth of Chaetomium erectum at 2000 ppm and Fusarium solani at 1000 and 2000 ppm. Significantly high inhibition was also observed against Rhizopus oryzae and A.aculeatus at 1000 as well as 2000 ppm and also against A. chevalieri, A. ochraceus and Chaetomium brasiliense at 2000 ppm. Very little inhibitory effect was noticed against F. pallidoroseum at 500 ppm and Penicillium pinophilum at 500 and 1000ppm (Table 15, Fig. 9).

4.4.1.5 Luzem 45 (Mancozeb).

Luzem 45 caused complete inhibition of growth of Aspergillus ochraceus, Curvularia clavata, Fusarium equiseti, F. pallidoroseum, F. solani, Fusarium sp.5, Gilbertella persicaria, Humicola fuscoatra and Scytalidium sp. at all the three concentrations tested. This fungicide was least effective against A. flavus at all the concentrations, against Chaetomium brasiliense at 500 and 1000 ppm and against Penicillium pinophilum at 500 ppm (Table 16, Fig. 10).

Table 15. Effect of Hexacap (captan) on the growth of seed-borne fungi

Sl. No.	Fungus	Per cent inhibition of radial growth over control*			
		level 1 500 ppm	level 2 1000 ppm	level 3 2000 ppm	Mean
1.	Aspergillus aculeatus	97.80 (81.48)	98.60 (83.32)	99.40 (85.55)	98.70 (83.45)
2.	Aspergillus chevalieri	91.10 (73.45)	97.40 (80.78)	98.60 (83.10)	96.40 (79.11)
3.	Aspergillus flavus	88.20 (69.96)	91.30 (72.81)	97.10 (80.23)	92.70 (74.30)
4.	Aspergillus ochraceus	93.40 (75.15)	97.80 (81.53)	99.85 (87.79)	97.80 (81.49)
5.	Chaetomium brasiliense	92.10 (73.72)	95.00 (77.02)	98.30 (82.59)	95.50 (77.77)
6.	Chaetomium erectum	92.60 (74.23)	97.90 (81.68)	99.99 (90.00)	98.10 (81.97)
7.	Curvularia clavata	79.30 (59.20)	83.30 (65.85)	95.60 (77.82)	88.50 (67.62)
8.	Fusarium equiseti	81.10 (64.20)	85.80 (67.85)	93.10 (74.73)	87.10 (68.93)
9.	Fusarium pallidoroseum	33.30 (64.01)	76.00 (60.65)	87.90 (69.62)	67.40 (55.16)
10.	Fusarium solani	80.80 (64.01)	99.99 (90.00)	99.99 (90.00)	97.70 (81.34)
11.	Fusarium sp.5	87.20 (69.08)	91.00 (72.54)	97.90 (81.57)	92.80 (74.40)
12.	Gilbertella persicaria	84.40 (66.77)	93.30 (74.96)	97.60 (81.01)	92.60 (74.25)
13.	Humicola fuscoatra	83.20 (65.78)	87.80 (69.53)	91.60 (73.15)	88.20 (69.89)
14.	Penicillium pinophilum	69.90 (56.72)	74.50 (59.68)	75.40 (60.29)	73.30 (58.90)
15.	Rhizopus oryzae	97.10 (80.23)	98.60 (83.10)	99.99 (90.00)	98.80 (83.68)
16.	Scytalidium sp.	89.90 (71.42)	92.90 (74.60)	98.30 (82.40)	94.30 (76.14)
	Mean	85.40 (67.54)	93.10 (74.74)	97.30 (80.47)	

CD treatment : 5.253
CD fungicide x fungus : 3.037
CD fungicide x concentration : 1.314

* Figures in parentheses are transformed values in angles.

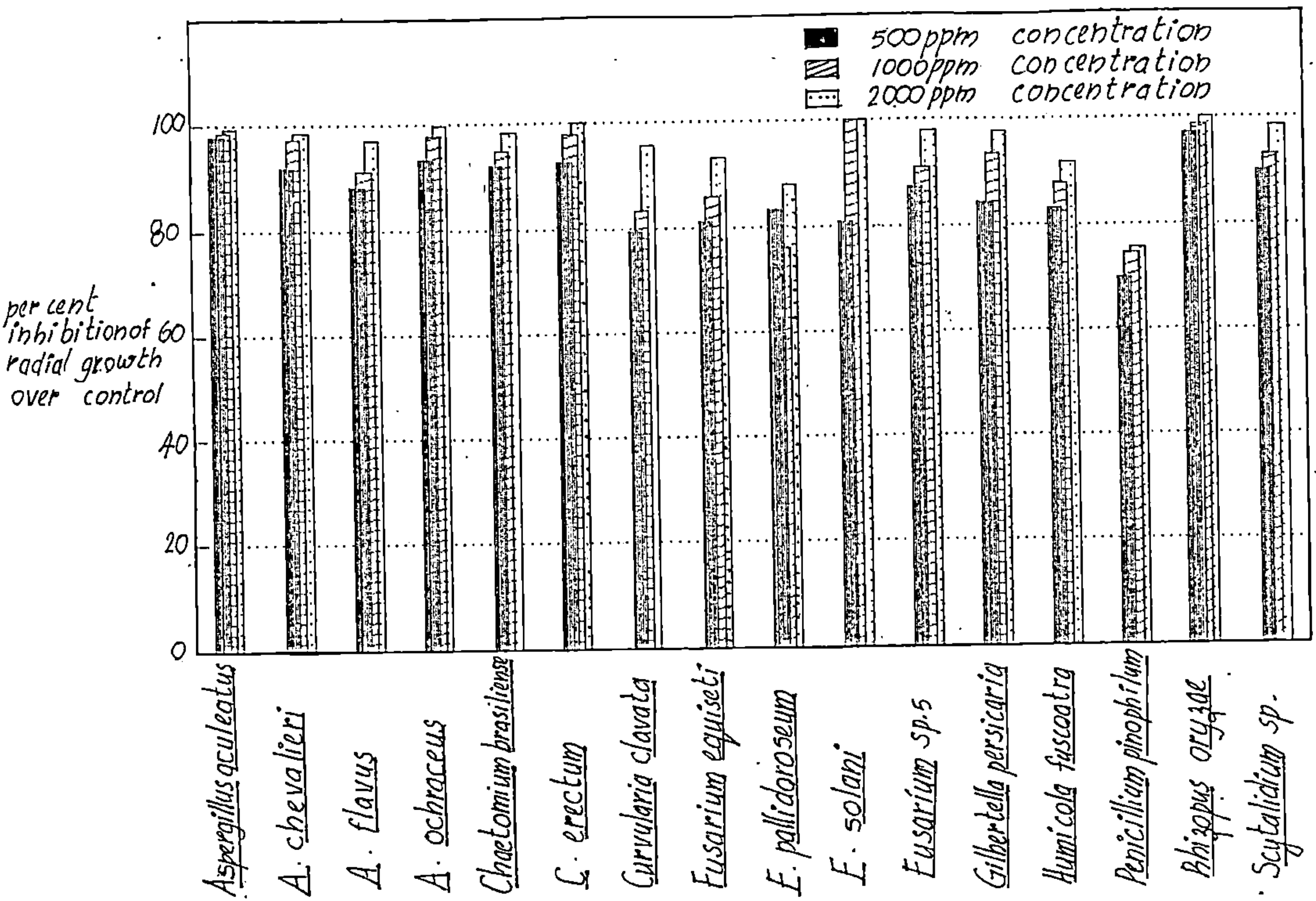

Fig. 9. Effect of Hexacap (captan) on the growth of seed-borne fungi.

Table 16. Effect of Luzem 45 (mancozeb) on the growth of seed-borne fungi

Sl. No.	Fungus	Per cent inhibition of radial growth over control*			
		level 1 500 ppm	level 2 1000 ppm	level 3 2000 ppm	Mean
1.	Aspergillus aculeatus	97.00 (80.06)	99.40 (85.55)	99.99 (90.00)	99.30 (85.20)
2.	Aspergillus chevalieri	85.30 (67.47)	99.99 (90.00)	99.99 (90.00)	98.30 (82.49)
3.	Aspergillus flavus	59.20 (50.20)	62.20 (52.09)	66.20 (54.45)	62.60 (52.28)
4.	Aspergillus ochraceus	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
5.	Chaetomium brasiliense	58.40 (49.86)	66.20 (54.45)	80.60 (63.86)	68.80 (56.06)
6.	Chaetomium erectum	93.50 (75.23)	95.00 (77.13)	95.50 (77.75)	94.70 (76.70)
7.	Curvularia clavata	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
8.	Fusarium equiseti	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
9.	Fusarium pallidoroseum	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
10.	Fusarium solani	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
11.	Fusarium sp.5	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
12.	Gilbertella persicaria	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
13.	Humicola fuscoatra	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
14.	Penicillium pinophilum	62.20 (52.09)	74.00 (59.37)	77.50 (61.68)	71.80 (57.94)
15.	Rhizopus oryzae	78.60 (62.47)	82.20 (65.02)	99.99 (90.00)	90.00 (72.49)
16.	Scytalidium sp.	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)	99.99 (90.00)
	Mean	95.70 (78.01)	97.70 (80.85)	98.80 (83.61)	

CD treatment : 5.253
CD fungicide x fungus : 3.037
CD fungicide x concentration : 1.315

* Figures in parentheses are transformed values in angles.

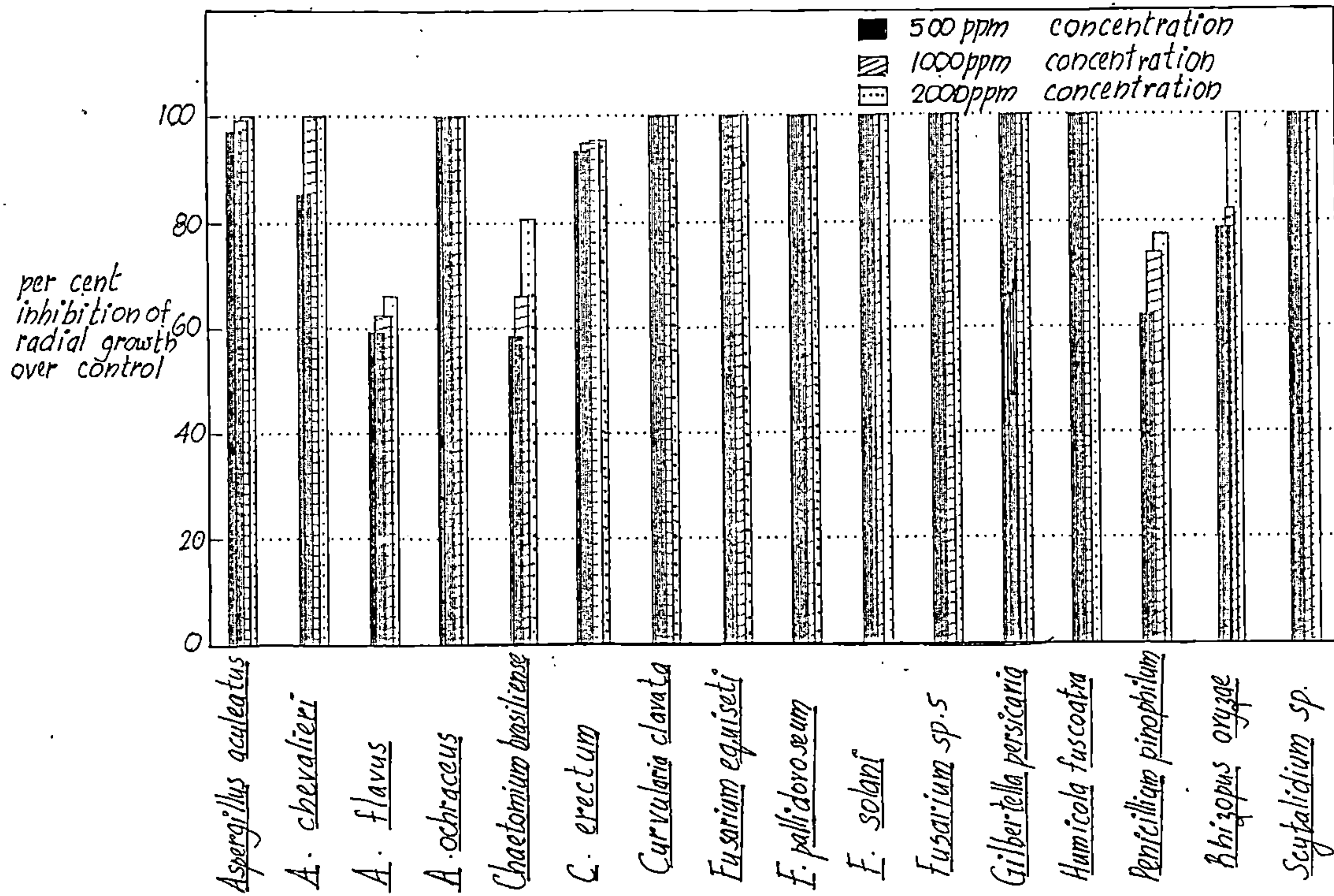

Fig. 10. Effect of Luzem 45 (mancozeb) on the growth of seed-borne fungi.

4.4.2 Comparative efficacy of different fungicides against individual species of seed - borne fungi.

The data on the analysis of the mean effect of different fungicides on individual species of fungi are presented in Table 17.

4.4.2.1 Aspergillus aculeatus.

The inhibitory effects of Luzem 45, Hexacap, Foltaf and Bavistin on the growth of A. aculeatus were on par while Blue copper 50 was least effective (Fig. 11a).

4.4.2.2 Aspergillus chevalieri.

Luzem 45 and Foltaf were the most effective fungicides against A. chevalieri and their inhibitory effects were on par. The least effective fungicide was Blue copper 50 (Fig. 11a).

4.4.2.3 Aspergillus flavus.

Bavistin caused the maximum inhibitory effect against A. flavus followed by Hexacap and Foltaf. Luzem 45 was found to be the least effective (Fig. 11a).

Table 17. Mean effect of different fungicides on the growth of seed-borne fungi.

Sl. No.	Fungus	Bavistin	Blue copper 50	Foltaf	Hexacap	Luzem 45
		Mean value of per cent inhibition of radial growth over control by*				
1.	*Aspergillus aculeatus*	92.28 (85.31)	55.70 (48.26)	98.70 (83.42)	98.70 (83.45)	99.30 (85.20)
2.	*Aspergillus chevalieri*	95.20 (77.39)	48.50 (44.15)	98.90 (83.99)	96.40 (79.11)	98.30 (82.49)
3.	*Aspergillus flavus*	98.20 (82.25)	87.00 (68.90)	91.50 (73.01)	92.70 (74.30)	62.6 (52.28)
4.	*Aspergillus ochraceus*	85.00 (67.17)	42.90 (40.93)	93.00 (74.69)	97.80 (81.49)	99.99 (90.00)
5.	*Chaetomium brasiliense*	99.99 (90.00)	58.00 (49.59)	69.10 (56.26)	95.50 (77.77)	68.80 (56.06)
6.	*Chaetomium erectum*	99.99 (90.00)	91.10 (72.62)	93.00 (74.68)	98.10 (81.97)	94.70 (76.70)
7.	*Curvularia clavata*	12.30 (20.55)	73.20 (58.85)	93.20 (74.91)	88.50 (67.62)	99.99 (90.00)
8.	*Fusarium equiseti*	99.99 (90.00)	53.00 (46.73)	98.70 (83.38)	87.10 (68.93)	99.99 (90.00)
9.	*Fusarium pallidoroseum*	98.90 (84.10)	21.10 (27.36)	80.80 (63.99)	67.40 (55.16)	99.99 (90.00)
10.	*Fusarium solani*	89.60 (71.19)	58.60 (49.94)	98.60 (83.28)	97.70 (81.34)	99.99 (90.00)
11.	*Fusarium* sp.5	96.80 (79.67)	45.00 (42.14)	82.1 (64.96)	92.80 (74.40)	99.99 (90.00)
12.	*Gilbertella persicaria*	67.40 (55.20)	63.40 (52.74)	99.81 (87.53)	92.60 (74.25)	99.99 (90.00)
13.	*Humicola fuscoatra*	65.4 (53.96)	47.60 (43.64)	63.70 (52.95)	88.20 (69.89)	99.99 (90.00)
14.	*Penicillium pinophilum*	88.10 (69.82)	49.30 (44.62)	57.90 (49.52)	73.30 (58.90)	71.80 (57.94)
15.	*Rhizopus oryzae*	12.20 (20.41)	86.30 (68.30)	99.90 (88.15)	98.80 (83.68)	90.00 (72.49)
16.	*Scytalidium* sp.	80.6 (63.87)	72.20 (58.17)	91.90 (73.49)	94.30 (76.14)	99.99 (90.00)
	Mean	86.90 (68.79)	59.90 (50.68)	91.50 (73.01)	92.60 (74.25)	97.50 (80.82)

CD fungicide x fungus : 5.253

* Figures in parentheses are transformed values in angles.

4.4.2.4 Aspergillus ochraceus.

Luzem 45 and Hexacap were the most effective fungicides against A. ochraceus and their inhibitory effects were on par. Blue copper 50 was the least effective (Fig. 11a).

4.4.2.5 Chaetomium brasiliense.

Bavistin was the most effective fungicide against this fungus followed by Hexacap, while Blue copper 50 was the least effective fungicide (Fig. 11b).

4.4.2.6 Chaetomium erectum.

Bavistin was the most effective fungicide against Chaetomium erectum followed by Hexacap, and their effects were on par. The least effective fungicide was Blue copper 50 (Fig. 11b).

4.4.2.7 Curvularia clavata.

Luzem 45 was found to be the best fungicide for checking the growth of C.clavata followed by Hexacap and Foltaf. Bavistin was the least effective (Fig.11b).

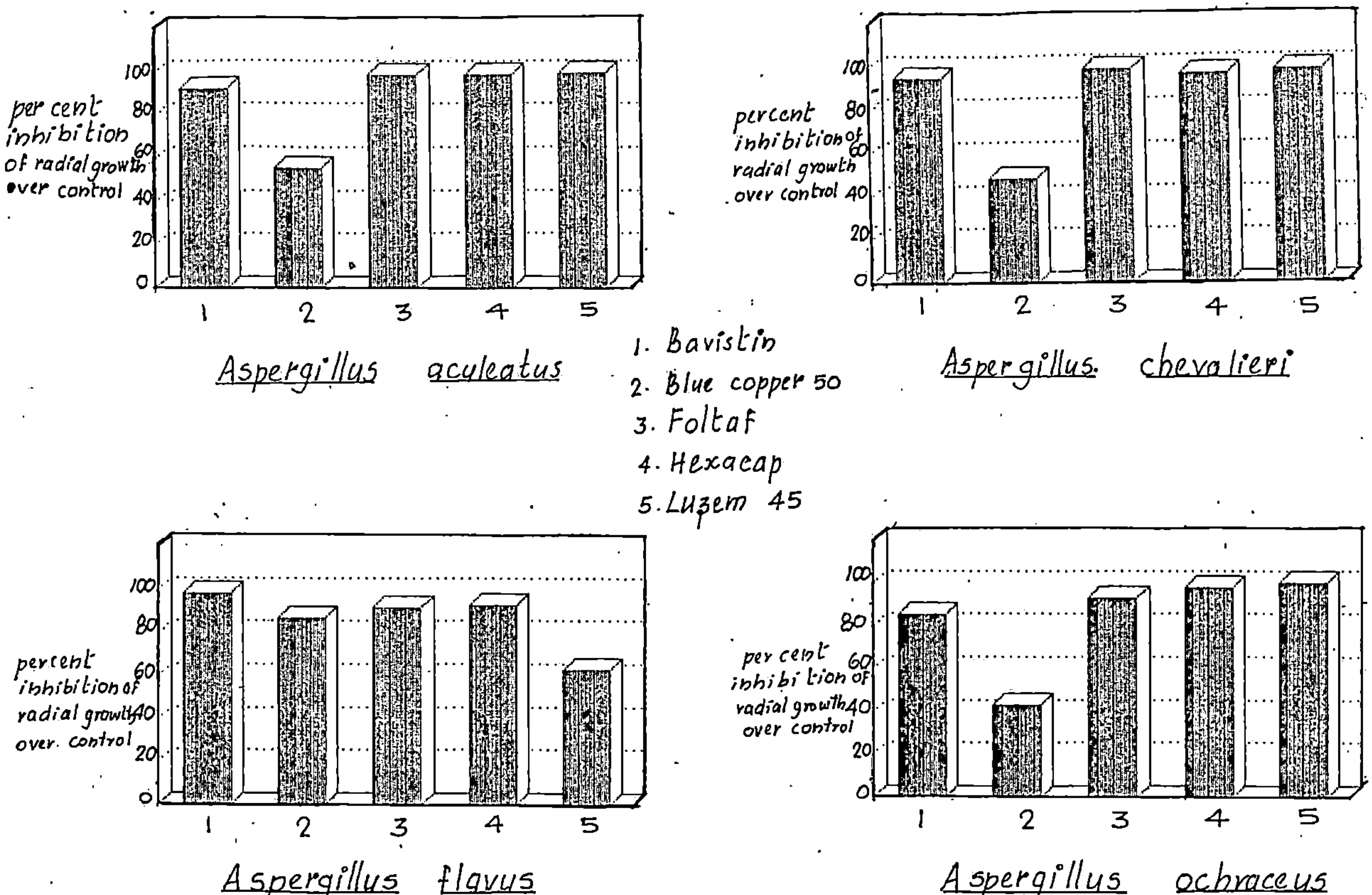

Fig. 11a. Comparative efficacy of different fungicides against different seed-borne fungi.

4.4.2.8 *Fusarium equiseti*.

Luzem 45 and Bavistin caused complete inhibition of the growth of this fungus. Foltaf also showed significant inhibitory effect, followed by Hexacap. Blue copper 50 was the least effective fungicide (Fig. 11b).

4.4.2.9 *Fusarium pallidoroseum*.

Luzem 45 caused maximum inhibitory effects against this fungus followed by Bavistin. Blue copper 50 was the least effective fungicide (Fig. 11c).

4.4.2.10 *Fusarium solani*..

Luzem 45 was the most effective fungicide against this fungus. This was followed by Foltaf and Hexacap, the effects of which were on par. The least effective fungicide was Blue copper 50 (Fig. 11c).

4.4.2.11 *Fusarium* sp.5.

Luzem 45 was the most effective fungicide against *Fusarium* sp.5 and this was followed by Bavistin and Hexacap. Blue copper 50 was the least effective fungicide (Fig. 11c).

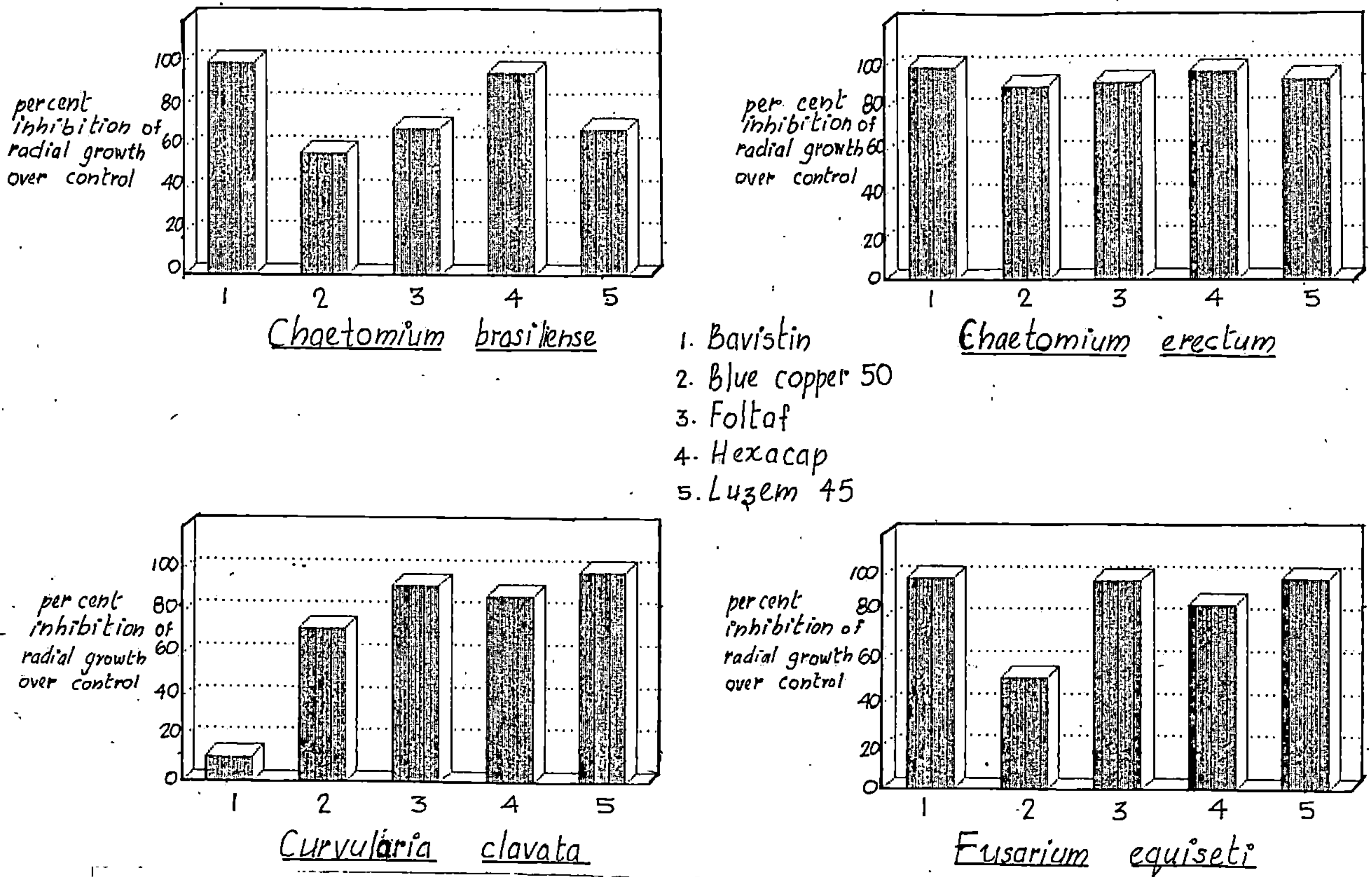

Fig. 11 b. Comparative efficacy of different fungicides against different seed-borne fungi

4.4.2.12 Gilbertella persicaria.

Luzem 45 and Foltaf were the most effective fungicide against this fungus and their effects were on par. Blue copper 50 was the least effective fungicide (Fig. 11c).

4.4.2.13 Humicola fuscoatra.

Luzem 45 was the most effective fungicide against H. fuscoatra followed by Hexacap and Foltaf. Blue copper 50 was the least effective fungicide (Fig. 11d).

4.4.2.14 Penicillium pinophilum.

Bavistin caused maximum inhibitory effects against this fungus followed by Hexacap and Luzem 45. Blue copper 50 was the least effective(Fig. 11d).

4.4.2.15 Rhizopus oryzae.

Foltaf was the best fungicide for inhibiting the growth of the fungus R. oryzae. The other fungicides in the order of their efficacy were Hexacap and Luzem 45. Bavistin was found to be the least effective (Fig. 11d).

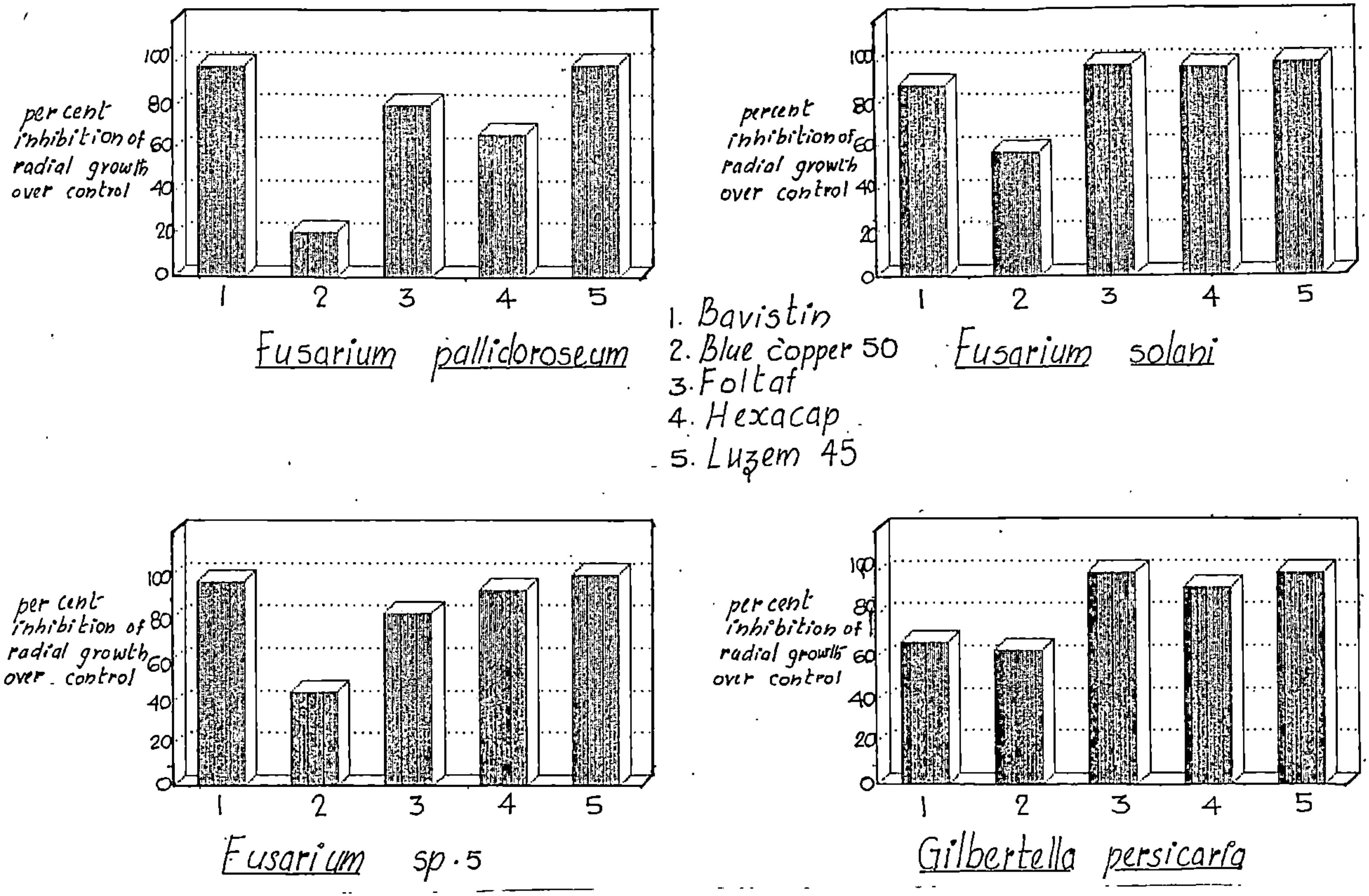

Fig. 11 c. Comparative efficacy of different fungicides against different seed-borne fungi.

4.4.2.16 Scytalidium sp.

Luzem 45 caused maximum inhibitory effects against Scytalidium sp. followed by Hexacap and Foltaf. Blue copper 50 was the least effective (Fig. 11d).

Among the five fungicides tested, Luzem 45 exhibited maximum inhibitory effects against the growth of ten out of 16 species of fungi tested. This was followed by Hexacap, Foltaf and Bavistin in the descending order. Blue copper 50 had the least effect in checking the growth of the seed-borne fungi tested during the investigations.

4.4.3 Effect of fungicides on seedling emergence.

4.4.3.1 Amaranthus.

Among the five fungicides tested in different methods of seed treatment, high germination of seeds was obtained with Hexacap and Blue copper 50. The slurry treatment with the fungicide Hexacap had given the maximum germination of 91.85 per cent for amaranthus seeds, while dry seed treatment with Blue copper 50 and soak treatment with Luzem 45 resulted in 90.95 and 90.57 per cent germination, respectively. The least germination of seeds was observed in dry treatment with Foltaf (55.41 per cent) and soak treatment with Blue copper 50 (69.13 per cent).

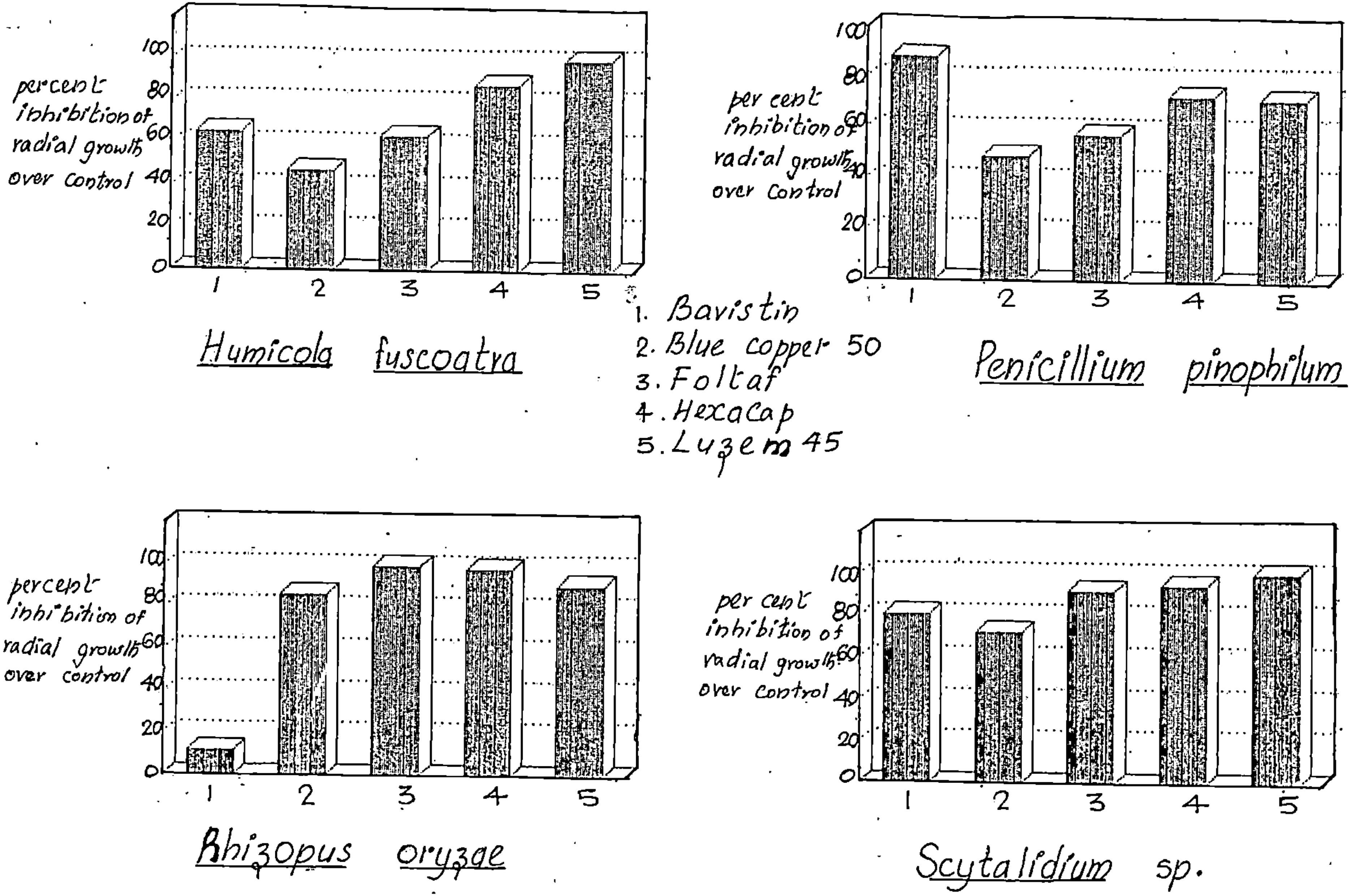

Fig. 11 d. Comparative efficacy of different fungicides against different seed-borne fungi.

When the overall effects of fungicides on germination of amaranthus seeds were compared maximum germination was observed in treatments with Hexacap while minimum was noticed with Foltaf although the difference between them was not significant. Similarly the difference between the effects of the three seed treatment methods were also not statistically significant, but the slurry treatment gave the best effects among the three methods. The incidence of damping off of seedlings was low in the different chemical treatments. The lowest incidence was noticed in treatments with Luzem 45 (Table 18, Fig. 12).

4.4.3.2 Chilli.

In chilli, seed treatment with Bavistin Hexacap and Luzem 45 resulted in high germination of seeds. The maximum germination of 70.6 per cent was obtained by slurry treatment with Bavistin and Luzem 45, while by slurry treatment with Hexacap and soak treatment with Luzem 45, the per cent germination being 70.25 and 67.57, respectively. The least germination of seeds was 39.9 per cent in soak treatment with Blue copper 50.

When the mean effects of fungicides were compared, maximum per cent germination of seeds was obtained with Luzem 45 treatment and minimum with Blue copper 50. Among the

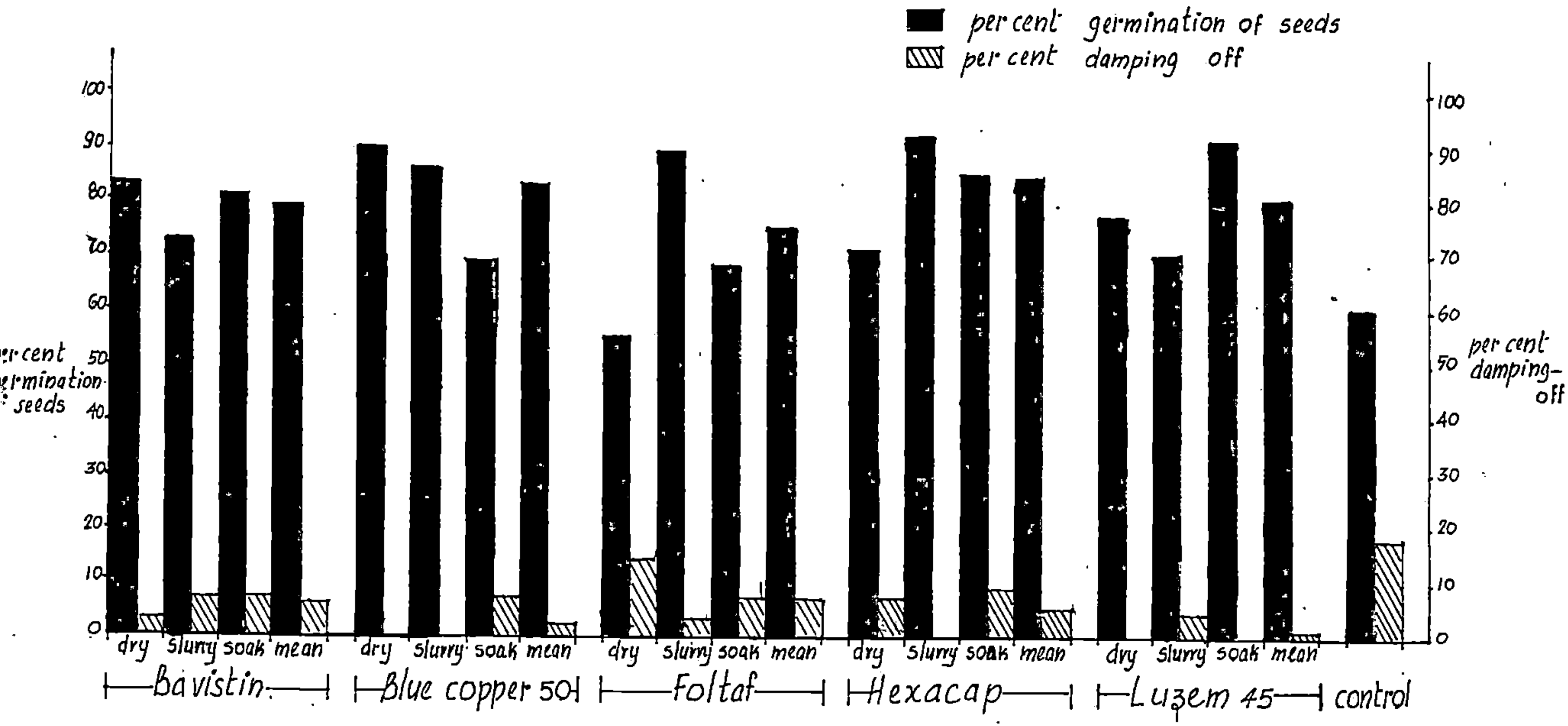

Fig. 12. Effect of fungicides on germination and seedling emergence of amaranthus.

three different methods of seed treatment, the slurry method was superior to the other two. However the effects of fungicides and methods of treatments were not statistically significant. The least incidence of damping off was noticed in treatment with Bavistin and Luzem 45 (Table 18, Fig. 13).

4.4.3.3 Tomato.

In tomato, there was significant difference between the effects of fungicides tested as seed treatment chemicals and between the different methods of seed treatment. The interactions between these two were also significant. Dry treatment with Bavistin and Luzem 45, slurry treatment with Hexacap (90.57 per cent germination in each), slurry treatment with Blue copper 50, soak treatment with Luzem 45 (85.36 per cent germination in both) and dry treatment with Hexacap (82.76 per cent) have resulted in significantly high per cent germination. When the mean effects of fungicides were compared, seed treatment with Bavistin, Foltaf, Hexacap and Luzem 45 resulted in significantly high germination and Luzem 45 was the most effective fungicide. The effects of other three fungicides, viz., Bavistin,Foltaf and Hexacap were on par. Blue copper 50 was least effective. Among the different seed treatment methods, dry and slurry treatments which gave the maximum effect, were on par. Although the incidence of damping off was considerably low in all the

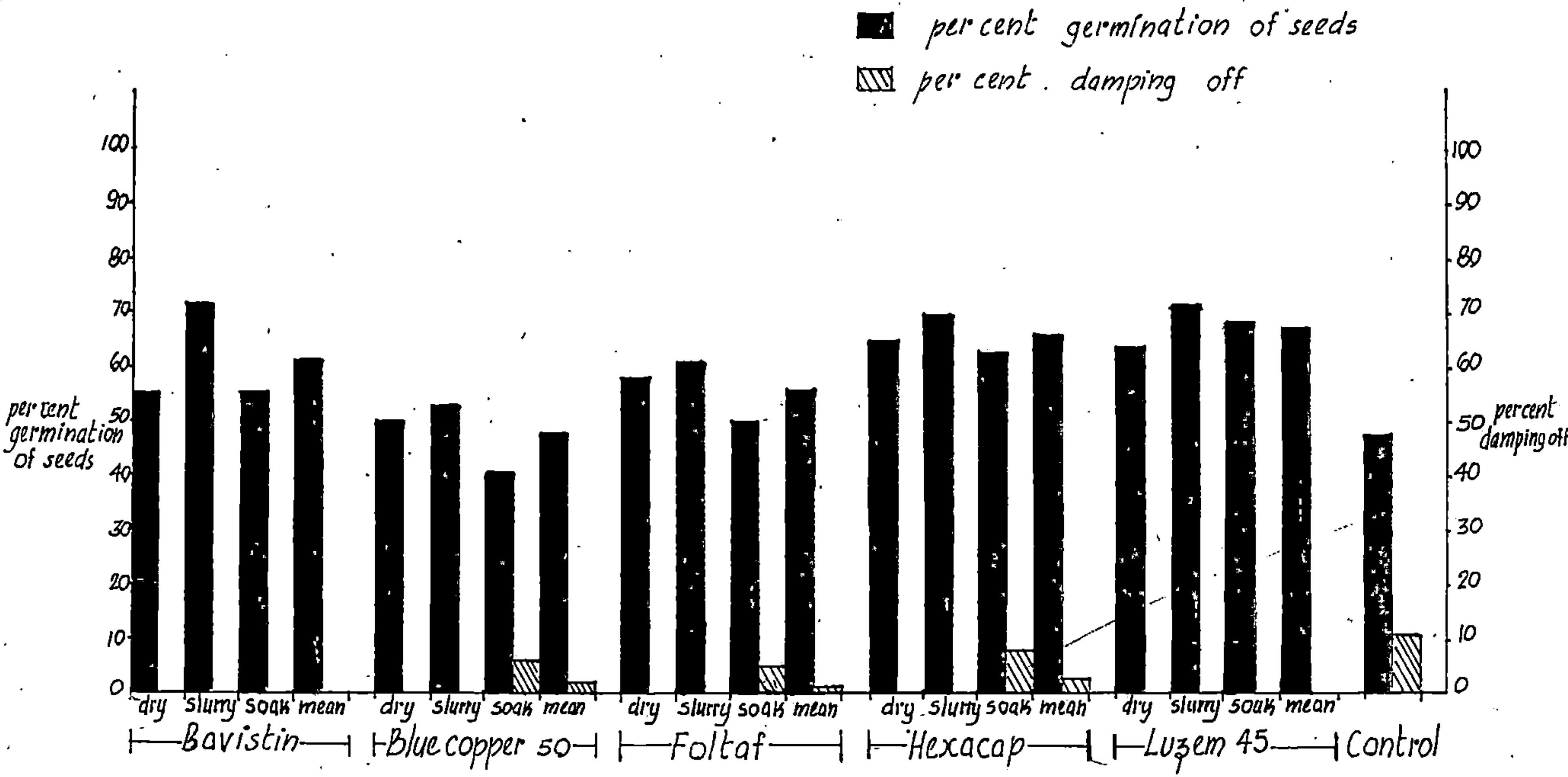

Fig. 13. Effect of fungicides on germination and seedling emergence of chilli

treatments, there was no damping off in treatments with Bavistin and Luzem 45 (Table 18, Fig. 14).

4.4.3.4 Ash gourd.

In ash gourd, the difference between the effects of different fungicides and methods of seed treatment were not significant. Among the different treatments, dry treatment with Bavistin showed maximum germination of 91.99 per cent followed by 84.63 per cent germination in soak treatment with Bavistin as well as slurry treatment with Hexacap while the least effect was shown by soak treatment with Blue copper 50. When the mean values of per cent germination of seeds were compared, Bavistin was found to have maximum effect with 82 per cent germination followed by Hexacap with 78.8 per cent germination and the least effect was shown by Blue copper 50 with only 57.1 per cent germination. Dry seed treatment was found to be the most effective method followed by slurry seed treatment. Incidence of damping off was considerably low in all the treatments, but there was no incidence of damping off in treatments with Bavistin and Hexacap (Table 18, Fig. 15).

4.4.3.5 Snake gourd.

In snake gourd also there was no significant difference between the effects of different fungicides and the different methods of seed treatment. The maximum

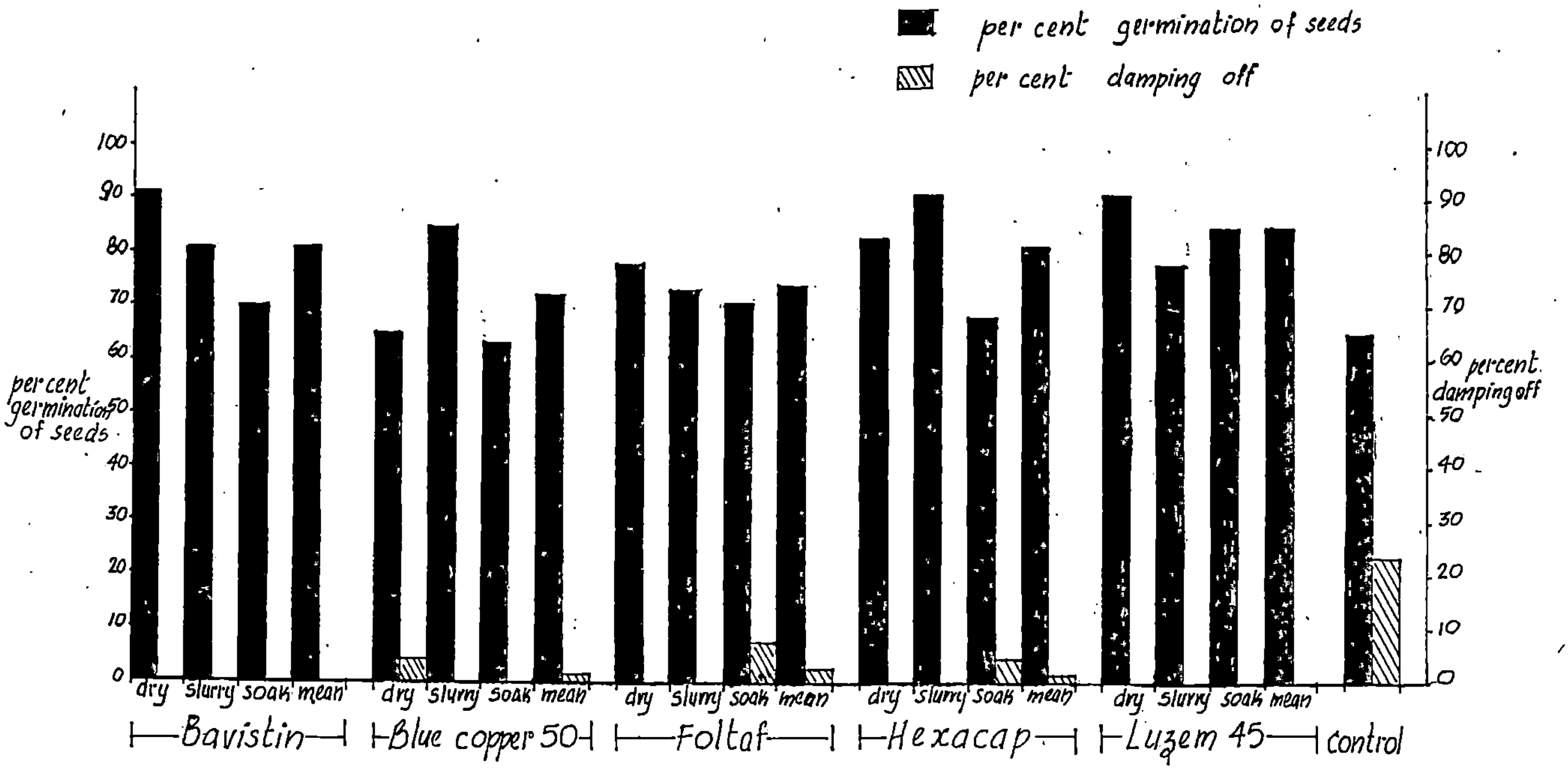

Fig. 14. Effect of fungicides on germination and seedling emergence of tomato.

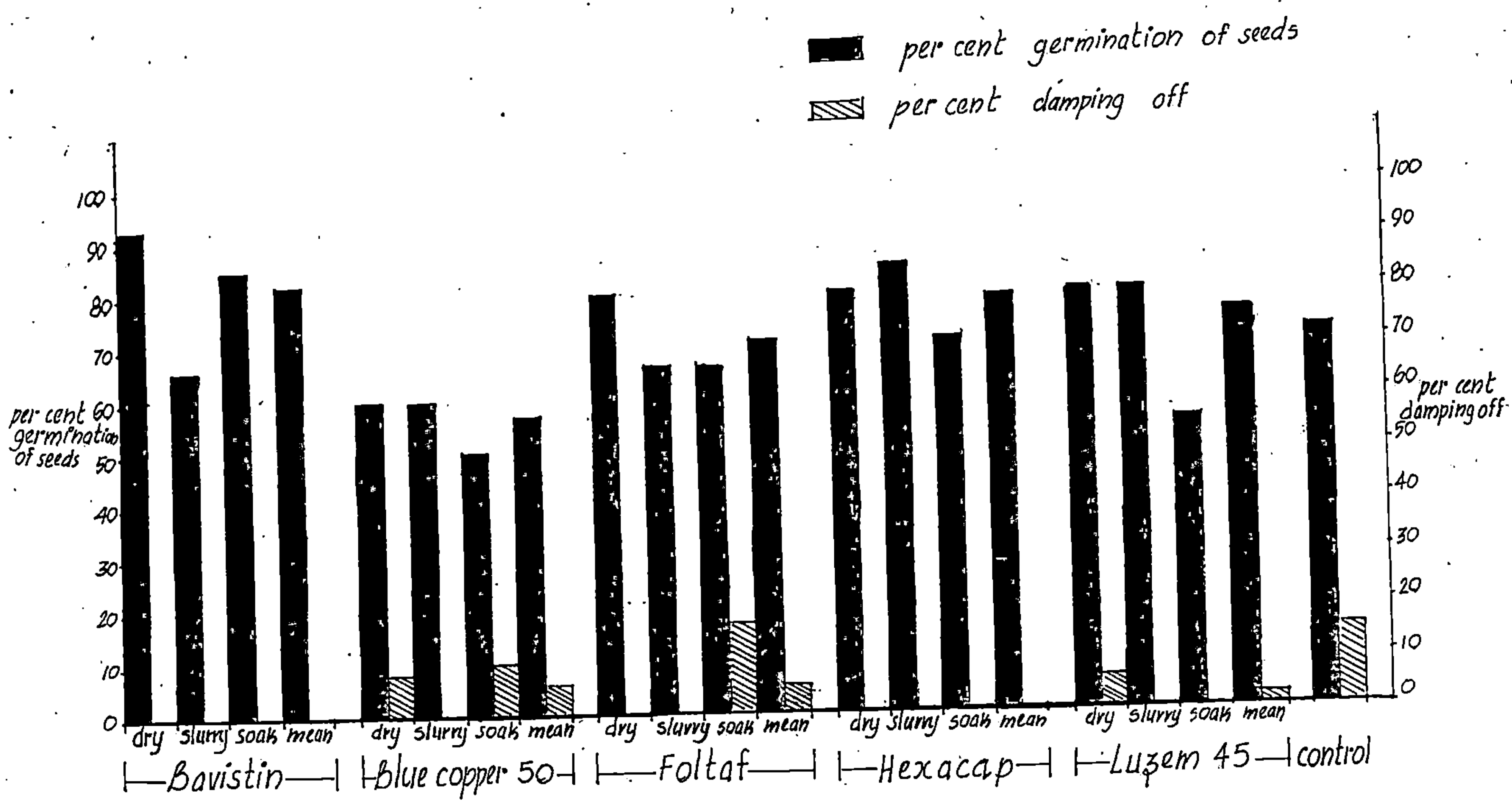

Fig. 15. Effect of fungicides on the germination and seedling emergence of ashgourd.

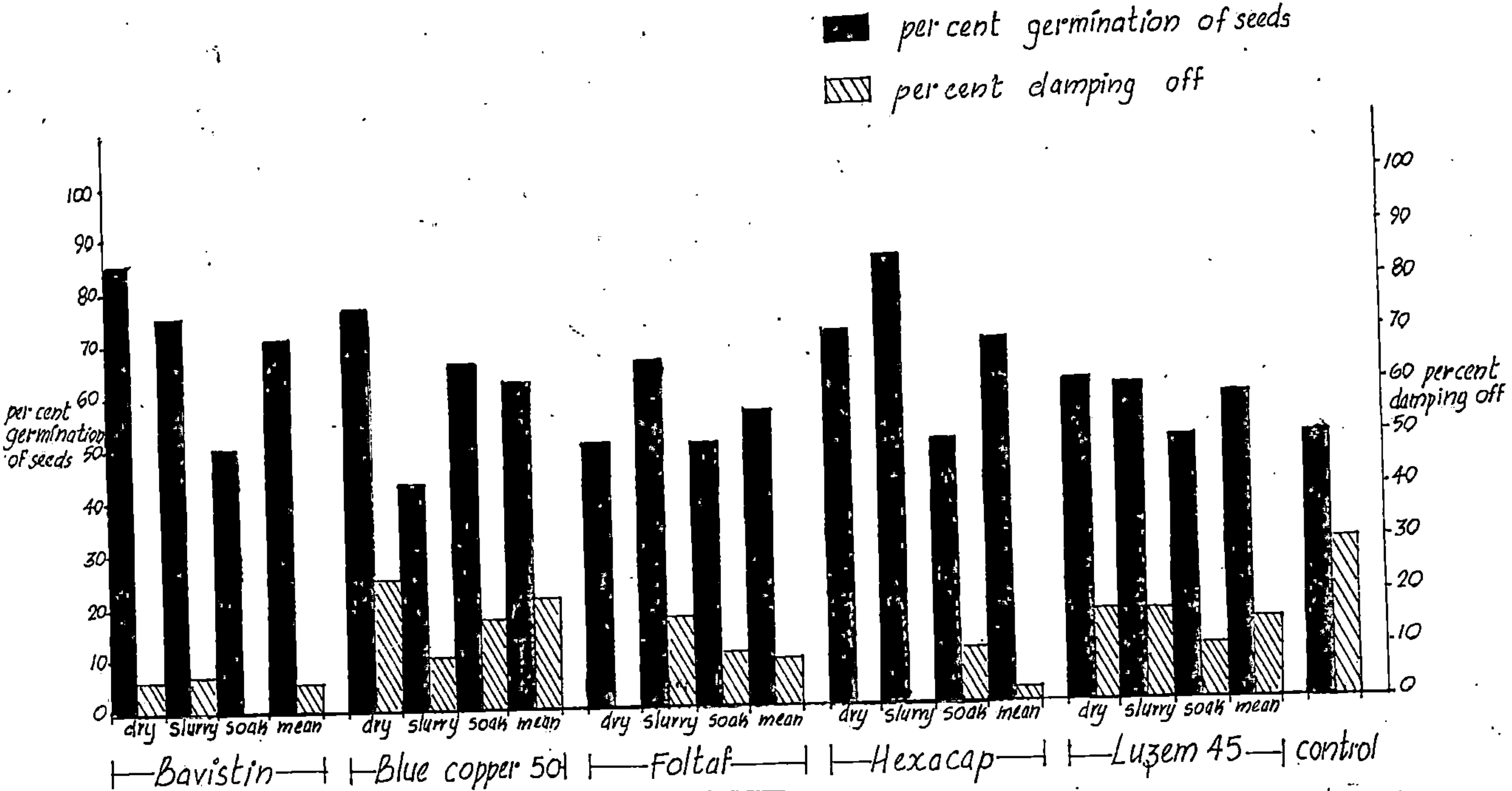

Fig. 16. Effect of fungicides on germination and seedling emergence of snake gourd.

Table 18. Ef

Sl. No.	Fungicide		Amaranthus				Chilli			
			Dry	Slurry	Soak	Mean	Dry	Slurry	Soak	Mean
1.	Bavistin	Per cent germination*	83.26 (65.82)	71.53 (57.73)	80.83 (64.01)	78.70 (62.52)	55.13 (47.93)	70.60 (57.14)	55.13 (47.93)	60.50 (50.99)
		Per cent Damping off**	3.22	7.14	6.66	5.60	0.00	0.00	0.00	0.00
2.	Blue copper 50	Per cent germination*	90.45 (72.46)	85.81 (67.84)	69.13 (56.23)	82.80 (65.51)	50.11 (45.05)	52.63 (46.49)	39.89 (39.15)	47.50 (43.56)
		Per cent Damping off**	0.00	0.00	7.41	2.06	0.00	0.00	6.25	1.74
3.	Foltaf	Per cent germination*	55.41 (48.08)	88.81 (70.43)	78.18 (62.13)	75.30 (60.21)	57.63 (49.37)	60.59 (51.09)	50.00 (44.98)	56.10 (48.43)
		Per cent Damping off**	13.63	2.94	6.90	7.07	0.00	0.00	5.00	1.48
4.	Hexacap	Per cent germination*	70.60 (57.17)	91.85 (73.38)	85.36 (67.47)	83.50 (66.00)	65.45 (53.98)	70.25 (56.92)	63.04 (52.53)	66.30 (54.48)
		Per cent Damping off**	7.14	0.00	8.82	5.19	0.00	0.00	8.00	2.51
5.	Luzem 45	Per cent germination*	76.84 (61.21)	70.25 (56.92)	90.52 (72.08)	79.90 (63.40)	64.03 (53.13)	70.60 (57.14)	67.57 (55.26)	67.40 (55.18)
		Per cent Damping off**	0.00	3.57	0.00	1.08	0.00	0.00	0.00	0.00
	General mean	Per cent germination*	76.40 (60.94)	82.50 (65.26)	81.30 (64.39)	-	58.50 (48.89)	65.61 (53.76)	55.20 (47.97)	-
		Per cent Damping off**	4.80	2.73	5.96	-	0.00	0.00	3.86	-
	Control	Per cent germination*		60.11 (50.81)				47.48 (43.54)		
		Per cent Damping off**		16.66				10.53		

CD treatments

CD fungicides

CD method of fungicidal treatment

* Figures in parantheses are transformed values in angles.
** Data not statistically analysed.

ect of fungicides on seedling emergence

Tomato				Ash gourd				Snake gourd			
Dry	Slurry	Soak	Mean	Dry	Slurry	Soak	Mean	Dry	Slurry	Soak	Mean
90.57 (72.09	80.52 (63.78)	70.25 (56.92)	81.10 (64.26)	91.99 (73.54)	65.81 (54.20)	84.63 (66.89)	82.00 (64.88)	84.63 (66.89)	75.4 (60.2	49.51 (44.70	70.70 (57.28)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	6.6	0.00	4.83
65.45 (53.98)	85.36 (67.47)	62.93 (52.47)	71.90 (57.97)	60.48 (51.03)	60.48 (51.03)	50.00 (44.98)	57.10 (49.01)	76.30 (60.84)	43.4 (41.2	66.34 (54.51)	62.40 (52.19)
4.17	0.00	0.00	1.16	8.33	0.00	10.00	6.19	25.00	10.0	16.66	20.56
78.17 (66.12)	72.62 (58.43)	70.25 (56.92)	73.80 (59.16)	80.00 (63.41)	65.81 (54.20)	65.81 (54.20)	70.80 (57.27)	50.49 (45.26)	66.34 (54.5	50.00 (44.98)	55.70 (48.25)
0.00	0.00	7.14	2.25	0.00	0.00	16.66	4.83	0.00	16.6	10.00	9.38
82.76 (65.44)	90.57 (72.09)	67.82 (55.42)	81.20 (64.32)	80.44 (63.73)	84.63 (66.89)	70.50 (57.08)	78.80 (62.57)	70.95 (57.36)	84.6 (66.8	50.00 (44.98)	69.40 (56.41)
0.00	0.00	3.70	1.04	0.00	0.00	0.00	0.00	0.00	0.0	10.00	2.48
90.57 (72.09)	78.17 (62.12)	85.36 (67.47)	85.00 (67.23)	80.00 (63.41)	80.44 (63.73)	65.34 (53.91)	75.50 (60.35)	60.96 (51.31)	60.4 (51.0	50.00 (44.98)	57.10 (49.11)
0.00	0.00	0.00	0.00	6.25	0.00	0.00	2.25	16.60	16.60	10.00	14.69
82.30 (65.14)	81.80 (64.78)	71.70 (57.84)	-	79.40 (63.02)	71.90 (58.01)	67.80 (55.41)	-	69.30 (56.34)	66.7 (54.7	53.20 (46.83)	-
0.83	0.00	2.17	-	2.92	0.00	5.33	-	9.57	10.0	9.33	-
	65.05 (53.76)				71.89 (57.96)				50.00 (44.98)		
	23.07				15.38				30.00		
	10.697										
	6.176										
	4.783										

germination of seeds was noticed in dry treatment with Bavistin and slurry treatment with Hexacap, the per cent germination in both the treatments being 84.63 followed by dry treatment with Blue copper 50 with 76.3 per cent germination. The lowest per cent germination of 43.46 was noticed in slurry treatment with Blue copper 50.

Among the fungicides tested, Bavistin gave maximum germination of seeds followed by Hexacap and Foltaf gave the least. Dry treatment of seeds was superior to the other two methods. The least incidence of damping off was noticed in treatments with Hexacap (Table 18, Fig 16).

Discussion

5. DISCUSSION

Vegetable seeds are known to harbour large number of fungi, externally as well as internally. These include storage as well as field fungi. Both these groups are known to cause damages to the seeds and to the seedlings. The common seed-borne fungi include species of *Alternaria*, *Aspergillus*, *Chaetomium*, *Colletotrichum*, *Curvularia*, *Fusarium*, *Helminthosporium*, *Mucor*, *Penicillium*, *Rhizopus* etc.

In the present study, *Aspergillus aculeatus*, *Chaetomium funicola*, *Fusarium equiseti*, *Fusarium* spp., *Gonatobotryum apiculatum*, *Penicillium pinophilum* and *Rhizopus oryzae* were found associated with amaranthus seeds. Sharma *et al.* (1981) observed fungi like *Alternaria alternata*, *Cladosporium cladosporioides*, *Fusarium moniliforme*, *Penicillium* sp., *Phoma amaranthi*, *Rhizopus oryzae* and *Trichoderma viride* from amaranthus seeds. Among the different fungi isolated from seeds of amaranthus in the present study, *Aspergillus aculeatus*, *Chaetomium funicola* and *Gonatobotryum apiculatum* are new reports.

The fungi isolated from chilli seeds included *A. flavus*, *Chaetomium globosum*, *Curvularia clavata*, *P. pinophilum*, *P. purpurogenum*, *R. oryzae* and *Scytalidium* sp.

Groves and Skolko (1945) observed the association of Curvularia lunata with chilli seeds while Mali and Joi (1985) reported association of C. clavata with chilli seeds. Deena and Basuchaudhary (1984) reported 25 different fungi associated with chilli seeds which included Aspergillus sp., Chaetomium sp., Curvularia lunata, Penicillium oxalicum, Rhizopus stolonifer etc. Penicillium pinophilum, P. purpurogenum, R. oryzae and Scytalidium sp. obtained in the present study are new reports of seed-borne fungi from chilli.

Aspergillus chevalieri, A. flavipes, Chaetomium globosum, Fusarium moniliforme, F. solani, Humicola fuscoatra, Paecilomyces inflatus, Penicillium pinophilum, P. purpurogenum, P. simplicissimum, Rhizopus oryzae and Syncephalastrum racemosum were isolated from tomato seeds during the present study. The earlier reports of seed-borne fungi from tomato include Fusarium sp. (Jacks, 1951), Penicillium, Aspergillus and Rhizopus (Suryanarayana et al., 1963), Penicillium, Aspergillus and Mucor (Kudrina, 1967), Aspergillus and Penicillium (Skvortsova et al., 1975), Aspergillus sp., Chaetomium sp., Rhizopus stolonifer and P. oxalicum (Deena and Basuchaudhary, 1984) and Fusarium solani, Penicillium spp. and Aspergillus spp. (Orlova et al., 1982). Among the fungi isolated in the present study many are already reported. However Humicola fuscoatra, Paecilomyces inflatus and Syncephalastrum racemosum have not been reported from tomato seeds.

The seed-borne fungi found associated with ash gourd seeds during the present study were Aspergillus aculeatus, A. chevalieri, A. flavus, A.niger, A. ochraceus, A. sydowii, A.terreus, Chaetomium brasiliense, C. erectum, Corynascus sepedonium, Curvularia clavata, Mucor sp., Penicillium pinophilum, P. simplicissimum, Talaromyces flavus and Zopfiella karachiensis while those associated with snake gourd were A.chevalieri,A. flavus, Chaetomium brasiliense, C. globosum, Fusarium pallidoroseum, Gilbertella persicaria, Penicillium pinophilum, Rhizopus oryzae and Syncephalastrum racemosum. From among different cucurbit seeds, Groves and Skolko (1945) reported Curvularia funicolum and C. trifoli on cucumber and Suryanarayana et al. (1963) noted Aspergillus, Penicillium and Rhizopus as the most common fungi associated with bottle gourd and pumpkin. Kudrina (1967) also reported the association of Aspergillus spp. Mucor spp. and Penicillium spp. with the seeds of vegetables including cucumber. Kuniyasu (1979) observed the presence of Fusarium oxysporum f. sp. lagenariae with seeds of bottle gourd. Naseema (1981) reported Aspergillus flavus, A. niger and *A. stolonifer* from the seeds of snake gourd. Therefore among the different fungi isolated from seeds of ash gourd and snake gourd, all the fungi isolated from ash gourd and *A. chevalieri*, *Chaetomium globosum*, *C. brasiliense*, *Fusarium pallidoroseum*, *Gilbertella persicaria*, *Penicillium pinophilum*, *Rhizopus oryzae* and *Syncephalastrum racemosum* from snake gourd seeds are new reports. On perusal of literature it is found that no work has so far been conducted on seed-borne fungi of ash gourd.

In the present study, it was found that among the different seed-borne fungi, the occurrence of storage fungi like *Aspergillus* spp. and *Penicillium* spp. increased with increase in duration of storage while there was a gradual decrease in the number of field fungi like *Fusarium* spp., *Curvularia clavata* etc. This may probably be due to the innate ability of the storage fungi to survive for longer periods. When the percentage of humidity was more than 70, the number of *Penicillium* sp. and *Aspergillus* sp. in stored seeds increased (Kudrina, 1967). In the present study the humidity and temperature at which the seeds were stored have not been regulated by any treatment. The room temperature at Vellayani, which ranged between 22° C and 34°C and humidity mostly over 70 per cent might have aided to enhance the survival of storage fungi. The decrease in the number of field fungi with the increase in the duration of storage is also not unexpected since the field fungi are known to have only lesser capacity to survive during storage especially in competition with storage fungi.

Some of the seed-borne fungi of vegetables caused reduction in germination of seeds, rotting of seeds and damping off of seedlings. The extent of damage varied with fungi involved and the seeds infected. In amaranthus Fusarium equiseti caused highest inhibition of germination of 47.9 per cent followed by Rhizopus oryzae which caused 27.1 per cent inhibition. The highest incidence of damping off of amaranthus seedlings was caused by Fusarium sp.3. Sharma et al. (1981) observed that fungi like Fusarium moniliforme, Rhizopus oryzae and Penicillium sp. significantly reduced the number of normal seedlings and caused stem rot and seedling blight in amaranthus. Naseema et al. (1983) found that seedling rotting was caused in amaranthus by Fusarium equiseti. Therefore based on the earlier works by other scientists and from the results of the present study, it can be stated that Fusarium spp. are very important seed-borne fungi of amaranthus, causing considerable inhibition of germination of seeds and high incidence of damping off of seedlings.

In chilli, the fungus <u>Penicillium pinophilum</u> caused 95 per cent inhibition of germination of seeds. Other fungi like <u>Aspergillus flavus</u>, <u>Curvularia clavata</u> and <u>Scytalidium</u> sp. also caused significant inhibition of germination of seeds. There are earlier reports on the role of seed-borne fungi in the inhibition of germination of seeds as well as in causing damping off of chilli seedlings. Grover and Bansal (1970) found that infection of chilli seeds with <u>Colletotrichum capsici</u> caused damping off of seedlings. Maholay and Sohi (1977) reported that <u>Botryodiplodia palmarum</u> caused pre-emergence mortality in chilli seeds. Dhyani <u>et al</u>. (1990) found that <u>Phoma destructiva</u> caused significant seedling infection in chilli. Naseema <u>et al</u> (1983) reported that <u>A. flavus</u>, <u>A. niger</u>, and <u>Rhizopus stolonifer</u> caused maximum inhibition of germination of vegetable seeds from which they were isolated. Although the fungi except <u>Scytalidium</u> sp. obtained from chilli seeds in the present study were reported earlier, their effects on germination of seeds or on the growth of chilli seedlings were not subjected to detailed investigations. The results of the present study indicated that some of the seed-borne fungi caused only inhibition of germination of seeds while <u>A. flavus</u> was an important seed-borne fungus which caused inhibition of germination of seeds as well as damping off of seedlings.

Seed-borne fungi like Humicola fuscoatra, Rhizopus oryzae, Penicillium pinophilum, P.purpurogenum, A.chevalieri, A.flavipes,Fusarium solani and Syncephalastrum racemosum caused considerable inhibition of germination of tomato seeds. P. purpurogenum caused highest incidence of damping off of seedlings. Naseema et al. (1983) found that seed-borne fungi like A. flavus, A. niger, and Rhizopus stolonifer caused significant inhibition of germination in vegetable seeds including tomato. Further, they observed that Rhizopus stolonifer caused seedling rotting also in tomato. But in the present investigation although R. oryzae was found to cause inhibition of germination of tomato seeds, it did not cause any damage to the seedlings, whereas P. purpurogenum caused both inhibition of germination of seeds as well as damping off of seedlings.

In ash gourd, none of the seed-borne fungi caused significant inhibition of germination. Fungi like Aspergillus sydowii, Talaromyces flavus, P. pinophilum and Corynascus sepedonium caused considerable incidence of damping off of the seedlings, but these were also not significant. In snake gourd, Penicillium sp. caused significant damping off of seedlings. Eventhough the seed-borne fungi did not cause considerable reduction in germination of ash gourd seeds, some of these fungi caused considerable damping off of the seedlings. This indicated the need for seed treatment against seed-borne fungi.

The culture filtrates of many seed-borne fungi have been reported to have certain toxic effects like inhibition of seed germination, inhibition of plumule and radicle elongation and wilting of seedlings.

In the present investigation, the culture filtrates of Fusarium spp. and Rhizopus oryzae isolated from amaranthus seeds caused significant inhibition of germination of seeds, inhibition of elongation of plumule and radicle and wilting of amaranthus seedlings while culture filtrates of Aspergillus aculeatus and Penicillium pinophilum had significant effect only on inhibition of elongation of plumule and radicle and on wilting of seedlings. The culture filtrates caused significant wilting even after boiling them for 10 minutes, eventhough the percentage of wilted seedlings was slightly less.

In chilli, the culture filtrates of Curvularia clavata and P. pinophilum had significant effects on all the three aspects studied (i.e. inhibition of germination of seeds, inhibition of elongation of plumule and radicle and wilting of seedlings). Culture filtrates of A. flavus caused inhibition of plumule and radicle elongation and wilting of seedlings while those of P. purpurogenum and Scytalidium sp. caused only wilting of seedlings. All the culture filtrates, except those of Curvularia clavata retained their toxic effect even after boiling for 10 minutes. The toxic effect of the culture filtrate of Curvularia clavata was significantly reduced by boiling for 10 minutes.

The culture filtrates of Aspergillus chevalieri, Fusarium solani, Penicillium pinophilum and P.simplicissimum caused significant inhibition of germination of tomato seeds, inhibition of plumule and radicle elongation and wilting of seedlings. A. flavipes showed significant effect in all the aspects studied except in inhibition of plumule and radicle elongation. P. purpurogenum caused significant wilting of seedlings and inhibition of plumule elongation. As in amaranthus and chilli, the culture filtrates retained their infectivity even after boiling for 10 minutes except those of A.flavipes and A. chevalieri wherein the percentage of wilted seedlings decreased significantly after boiling the culture filtrate for 10 minutes.

The culture filtrates of all the seed-borne fungi of ash gourd which were studied, caused significant inhibition of plumule and radicle elongation, whereas culture filtrates of only A. chevalieri, A. ochraceus, Curvularia clavata and P. pinophilum caused inhibition of germination of seeds and wilting of seedlings. Further the culture filtrates of all the fungi except C. clavata and A. ochraceus were found to be thermostable while the toxicity of culture filtrates of C. clavata and A.ochraceus decreased sighificantly after boiling for 10 minutes.

In snake gourd, while the culture filtrates of all the isolates of seed-borne fungi showed significant inhibitory effects on plumule and radicle elongation, the culture filtrates of A. chevalieri, A.flavus, Fusarium pallidoroseum, Gilbertella persicaria and P. pinophilum caused only wilting of seedlings. The inhibitory effects of the culture filtrates of all fungi except A. chevalieri was not reduced even after boiling for 10 minutes.

The results of the present investigation are in agreement with the findings of many earlier workers. The culture filtrates of many species of seed-borne fungi caused varying degrees of inhibitory effects on germination of seeds of the respective crops. The inhibitory effects of culture filtrates of seed-borne fungi on germination of vegetable seeds were studied by Naseema (1981) and found that the culture filtrates of Aspergillus flavus, A. niger, A.ochraceus, Fusarium equiseti, F. solani and Penicillium sp. caused inhibition in the germination of seeds of amaranthus, bhindi, brinjal, chilli, cowpea and cucumber. Jose Joseph (1986) observed that the culture filtrates of Aspergillus flavus, Alternaria padwickii and Curvularia lunata caused considerable inhibition in the germination of rice seeds. Rajagopalan (1971) found that the culture filtrate of Diplodia natalensis isolated from dry rot affected guava fruits caused considerable reduction in the per cent germination of cucumber and snake gourd seeds. Pandey and Gupta (1987) found that the metabolites of Aspergillus flavus and A. niger caused reduction in the per cent germination of seeds of five species of cucurbits. Vidhyasekaran et al. (1969) in their studies with seed-borne fungi of rice, viz., A. flavus, Curvularia lunata, C. pallescens and F. moniliforme found that the culture filtrate of the fungi caused reduction in seed germination. Bhale et al. (1982) in their studies with the effects of culture filtrates of Trichoconis padwickii on rice seeds, attributed the germination failure to be due to killing of the plumule by the fungul metabolite.

In the present investigation it was noticed that the plumule and radicle elongation was considerably inhibited by the culture filtrates of most of the seed-borne fungi. Lalithakumari et al.(1970) observed that the culture filtrates of Aspergillus sp. had marked inhibitory effect on root and shoot elongation of groundnut. George (1970) reported that the toxic metabolites of Corynespora cassicola inhibited plumule and radicle elongation in tomato and sesamum seeds. Root and shoot elongation of rice seeds were significantly reduced by the culture filtrates of Aspergillus flavus, Alternaria padwickii, Bipolaris oryzae, Curvularia lunata and Sarocladium oryzae (Jose Joseph, 1986).

The effect of culture filtrates on seedlings was also studied by many investigators. Pringle and Scheffer (1964) studied the effect of culture filtrate of Helminthosporium victoriae on oat seedlings and found that the susceptible seedlings were killed even by culture filtrates diluted 90 times with water. Kumar and Mahmood (1986) assayed culture filtrate of Colletotrichum dematium and found that it caused toxicities in chilli seedlings. Omprakash and Siradhana (1978) reported that at higher concentrations, the toxic metabolites produced by A. flavus, A. niger, A. tamarii and A. terreus in liquid culture caused complete wilting of tomato seedlings. The toxic metabolites produced by Myrothecium were found to have phytotoxic effects on healthy plants of different vegetable crops. In the present investigation also the culture filtrates were found to cause significant wilting of the seedlings.

There are many reports on the thermostable nature of toxins produced by seed-borne fungi. Kumar and Mahmood (1986) reported the thermostable nature of culture filtrates of Colletotrichum dematium isolated from chilli seeds. Nair (1969) found that the toxic principle in culture filtrate of Trichoconis padwickii from rice seeds was active even after boiling for 20 minutes or autoclaving at 15 lb for 20 minutes. George (1970) reported the thermostable nature of toxic metabolites of Corynespora cassicola isolated from tomato seeds. In the present study also it was found that the culture filtrates of most of the seed-borne fungi retained their toxic effect even after boiling for 10 minutes.

In some cases there was slight decrease in the toxic effect of culture filtrates after boiling for 10 minutes. Similar observations were reported by Sharma and Sharma (1969) who observed that the culture filtrate of Colletotrichum gloeosporioides boiled for 10 minutes was slightly less toxic than fresh culture filtrate. The culture filtrate may contain many toxic materials and there may be proteinaceous as well as nonproteinaceous metabolites among them. The culture filtrates which retained their toxic effects even after boiling for 10 minutes may be containing only nonproteinaceous materials contributing to their toxic effects whereas those in which there is slight reduction in toxicity after boiling may be having some toxic proteinaceous metabolites also, the effect of which was lost after boiling. The toxic effect of culture filtrates of some of the seed-borne fungi in the present study, viz., A. chevalieri, A. flavipes, A. ochraceus and Curvularia clavata were reduced considerably after boiling for 10 minutes. It is felt that the toxic effects of the culture filtrates of these fungi may be due to the presence of some proteinaceous metabolites which are denatured by boiling.

The culture medium also showed some inhibitory effects on germination of seeds, plumule and radicle elongation and caused slight wilting of seedlings. The slight toxic effects exhibited by the culture medium may be due to the presence/concentration of certain chemical constituents of the medium.

Studies on the effect of fungicides on the growth of seed-borne fungi revealed that Luzem 45 was the best and could completely inhibit the growth of nine species of fungi, viz., Aspergillus ochraceus, Curvularia clavata, Fusarium equiseti, F.pallidoroseum, F.solani, Fusarium sp.5., Gilbertella persicaria, Humicola fuscoatra and Scytalidium sp. at the minimum concentration tested.

Hexacap which was ranked second, completely inhibited Fusarium solani at 1000 and 2000 ppm and Chaetomium erectum and Rhizopus oryzae at 2000 ppm concentrations. Among other fungicides tested, Foltaf completely inhibited the growth of Fusarium equiseti and Fusarium solani at 1000 ppm concentration, while Bavistin completely inhibited Chaetomium brasiliense, C. erectum and Fusarium equiseti at the minimum concentration of 250 ppm. Bavistin was least effective against Curvularia clavata. Blue copper 50 had the least inhibitory effect among all the five fungicides tested. However this fungicide was able to cause over 99 per cent inhibition of the growth of Rhizopus oryzae at 2000 ppm.

When the mean effect of each fungicide against individual species of seed-borne fungi was analysed, it was found that Luzem 45 was the most effective against Aspergillus aculeatus, A. chevalieri, A. ochraceus, Curvularia clavata, Fusarium pallidoroseum, F. solani, Fusarium sp.5, Gilbertella persicaria, Humicola fuscoatra and Scytalidium sp. Hexacap was most effective against A. aculeatus, A. ochraceus and Chaetomium erectum while Foltaf was most effective against A. chevalieri, Gilbertella persicaria and Rhizopus oryzae and Bavistin was most effective against A. flavus, Chaetomium brasiliense, F. equiseti and Penicillium sp.

Some earlier investigators have revealed that mancozeb (Dithane M-45) had significant inhibitory effect against many fungi. Naseema (1981) obtained good inhibition of growth of Aspergillus flavus, Botryodiplodia theobromae and Drechslera rostrata with Dithane M-45. Sharma (1988) observed that the growth of Botryodiplodia theobromae, Colletotrichum gloeosporioides and F. moniliforme was completely inhibited by 1000 ppm of Dithane M-45 while growth of Colletotrichum capsici was completely inhibited by 2000 ppm and Curvularia clavata and C. lunata by 3000 ppm. Mali and Joi (1985) observed that Difolatan (captafol) was the most effective fungicide against the growth and sporulation of seed - borne Colletotrichum capsici, Curvularia clavata, C. lunata, Drechslera rostrata and Macrophomina phaseolina.

During the study it was noticed that Bavistin was least effective against Curvularia clavata. Edington et al. (1971) reported that all members of porosporae (of which Curvularia is a member) of the class deuteromycetes are insensitive to benomyl. Donald Erwin (1973) reported that dark spored members of deuteromycetes are insensitive to benomyl. Bavistin (carbendazim) and benomyl are very closely related benzimidazole fungicides and in both the cases the compound responsible for fungitoxicity is methyl-2-benzimidazole carbamate. Hence the result of the present study shows that as in the case of benomyl, carbendazim is also not effective against Culvularia.

Among the different fungicides tested, Hexacap (captan) treatments aided maximum germination in all the vegetable seeds. The other fungicides in the order of their efficacy were Bavistin and Luzem 45. In amaranthus, chilli and tomato, slurry treatment of seeds with 0.2 per cent Hexacap resulted in high per cent germination of seeds. In ash gourd and snake gourd also slurry treatment with Hexacap resulted in maximum germination of seeds although difference in the effect of Hexacap with other fungicides was not statistically significant. In tomato seeds the dry seed treatment with Hexacap caused significant increase in germination.

When the mean effects of different fungicides were compared, Hexacap was found to have maximum effect in increasing the germination of amaranthus seeds and Hexacap treatment resulted in least incidence of damping off in ash gourd and snake gourd seedlings.

There are many other reports on the effectiveness of Hexacap (captan) as seed treatment fungicide for the control of seed - borne fungi and also for enhancement of seed germination. Muthuswamy et al. (1983) recommended captan at the rate of 4g per kg of seed for seed treatment of chilli for improving seed germination. Aleksic et al. (1976) reported that in glasshouse and field trials against Phytophthora capsici, treatment of chilli seeds with fungicides based on captan gave good results. Sajitha and Indra Hooda (1987) found captan as very promising for controlling damping off of tomato caused by Fusarium solani and Pythium aphanidermatum. Ellis et al. (1975) found that soybean seeds treated with captan had a higher percentage of germination in vitro and emergence in field soil than non treated control and Lewin and Natarajan (1971) reported that seed dressing with captan for the control of root rot of groundnut caused by Rhizoctonia solani ensured higher germination and emergence and minimised post emergence root rot to a considerable extent.

Although not to the extent as that of Hexacap, Bavistin seed treatments also had very good effects on the germination of vegetable seeds tested. Slurry treatment with 0.1 per cent Bavistin resulted in considerable increase in germination of chilli seeds while dry treatment with Bavistin was the most effective in tomato. Dry and soak treatment with Bavistin gave maximum germination in ash gourd and dry treatment with Bavistin was the best for snake gourd, though not statistically significant. Bavistin showed the maximum effect in controlling damping off of seedlings as treatment with the fungicide resulted in least incidence of the disease in chilli, tomato and ash gourd.

There are various reports on the varying degree of efficiency of Bavistin in enhancing seed germination and control of seed-borne fungi. Muthuswamy et al. (1983) recommended Bavistin (2g/kg) for seed treatment of chilli which improved the seed germination. Vidhyasekaran and Thiagarajan (1981) reported that Bavistin treatment resulted in eradication of the seed-borne pathogen *Fusarium oxysporum* from seeds of chilli and induced good growth of the plants and resulted in higher yield. Vir (1976) reported control of damping off of chilli seedlings caused by *Rhizoctonia bataticola* by seed treatment (0.25 per cent) with Bavistin, in pot tests. Nedumaran and Vidhyasekaran (1981) showed that seed treatment with Bavistin at the rate of 1g/kg of seed was effective to control *Fusarium semitectum* infection in tomato seeds. The results of the present study are also in agreement with these findings.

In the present study it was observed that Hexacap and Bavistin are very good fungicides for seed treatment against seed-borne fungi. But certain treatments with Luzem 45 (mancozeb) also have given good effects in increasing germination of the treated seeds. Treatment with 0.2 per cent Luzem 45 caused significant increase in germination of tomato seeds. When the mean effect of different fungicides were compared, Luzem 45 was found to have maximum effect in chilli and tomato. Treatment with Luzem 45 resulted in least incidence of damping off in amaranthus, chilli and tomato. These findings are in agreement with many earlier reports like that of Dhyani et al. (1990) who found that in chilli, seed treatment with Dithane M-45 (mancozeb) was effective in controlling the seed-borne pathogen Phoma destructiva. Singh and Singh (1986) also reported that mycoflora of broad bean could be most effectively controlled by Dithane M-45. Deena and Basuchudhary (1984) reported that mancozeb seed treatment eliminated most of the saprophytic fungi from the seeds.

When the mean values of effect of different methods of fungicidal application were compared, slurry treatment was found to be the best in case of amaranthus and chilli while dry treatment gave maximum effect in tomato, ash gourd and snake gourd.

In general, there was variation between the results obtained in in vitro studies and in the pot culture experiments conducted to evaluate the efficacy of common fungicides against seed-borne fungi. In the in vitro studies Luzem 45 was found to have the maximum effect in controlling the growth of seed-borne fungi. This was followed by

Hexacap, Foltaf and Bavistin in the order of their inhibitory effect while the effect of Blue copper 50 was found to be the least.

In the pot culture experiments, Bavistin and Hexacap were found to be more effective than other fungicides. In the *in vitro* studies, the interacting components are only the fungus and the fungicide while in the pot culture experiments other factors like soil, living plant etc are involved. Moreover, Bavistin which is a systemic fungicide will get modified by interaction with the plant sap resulting in changes in its fungicidal property. The above reasons can be attributed for the variations in the results of *in vitro* studies and pot culture experiments.

Summary

SUMMARY

In the present study many fungi were found to be associated with vegetable seeds, both externally and internally. The externally seed-borne fungi isolated include Aspergillus aculeatus, Fusarium equiseti, Fusarium spp., Gonatobotryum apiculatum and Penicillium pinophilum from amaranthus, Aspergillus flavus, Chaetomium globosum, Curvularia clavata, Penicillium pinophilum, P.purpurogenum, and Rhizopus oryzae from chilli, Aspergillus chevalieri, A. flavipes, Chaetomium globosum, Fusarium solani, Humicola fuscoatra, Paecilomyces inflatus, Penicillium purpurogenum, P.simplicissimum, Rhizopus oryzae and Syncephalastrum racemosum from tomato, Aspergillus aculeatus, A. chevalieri, A.niger, A.ochraceus, A.sydowii, A.terreus, Chaetomium brasiliense, C.erectum, P.pinophilum, P.simplicissimum and Talaromyces flavus from ash gourd, A.flavus, Gilbertella persicaria, P.pinophilum, Rhizopus oryzae and Syncephalastrum racemosum from snake gourd.

The internally seed-borne fungi isolated were Chaetomium funicola, Fusarium spp. and Rhizopus oryzae from amaranthus, Penicillium pinophilum and Scytalidium sp. from chilli, Chaetomium globosum, Fusarium moniliforme,

Fusarium solani, and Penicillium pinophilum from tomato, A.flavus, A.sydowii, Corynascus sepedonium, Curvularia clavata, Mucor sp., P. pinophilum, Talaromyces flavus and Zopfiella karachiensis from ash gourd and A.chevalieri, Chaetomium brasiliense, C. globosum, F.pallidoroseum, P.pinophilum, Rhizopus oryzae and Syncephalastrum racemosum from snake gourd. Species of Aspergillus and Penicillium were the most prevalent fungi when isolation was done after storing the seeds.

When the effect of seed-borne fungi on germination of seeds and seedlings was studied it was observed that while Fusarium sp.3 caused significant inhibition of germination and significant incidence of damping off, another species of Fusarium i.e. Fusarium equiseti caused only significant inhibition of germination of seeds in amaranthus. In chilli, Aspergillus flavus caused significant inhibition of germination of seeds. The maximum inhibition of germination of 95 percent was caused by Penicillium pinophilum. Penicillium purpurogenum caused considerable inhibition of germination of seeds as well as incidence of damping off of tomato seedlings. Highest incidence of damping off of ash gourd seedlings was caused by A.sydowii. The germination of snake gourd seeds was considerably inhibited by

Fusarium pallidoroseum, Chaetomium brasiliense and Gilbertella persicaria while Penicillium sp. caused significant damping off of snake gourd seedlings.

In the present investigation, the culture filtrates of Fusarium spp. and Rhizopus oryzae isolated from amaranthus seeds caused significant inhibition of germination of seeds, inhibition of elongation of plumule and radicle and wilting of amaranthus seedlings, while culture filtrates of Aspergillus aculeatus and Penicillium pinophilum had significant effect only on inhibition of elongation of plumule and radicle and on wilting of seedlings. In chilli, the culture filtrates of Curvularia clavata and P.pinophilum had significant effects on all the three aspects studied while culture filtrate of A.flavus caused inhibition of radicle and plumule enlongation and wilting of seedlings. The culture filtrates of Aspergillus chevalieri, Fusarium solani, Penicillium pinophilum and P.simplicissimum had significant effects on all the aspects studied in tomato. In ash gourd, culture filtrates of A. chevalieri, A.ochraceus, Curvularia clavata and Penicillium pinophilum caused significant inhibition of germination of seeds, inhibition of elongation of radicle and plumule and wilting of ash gourd seedlings. The culture filtrates of Aspergillus chevalieri, A. flavus, Gilbertella persicaria and P. pinophilum had significant effects on inhibition of elongation of radicle and plumule and wilting of seedlings of snake gourd. In general the culture filtrates of the fungi except A.chevalieri, A.flavipes, A.ochraceus, and Curvularia clavata retained their toxic effect of wilting of seedlings even after boiling for ten minutes, while the toxicity of the culture filtrates of the latter fungi decreased significantly after boiling.

When the inhibitory effect of different seed treatment fungicides against different seed-borne fungi was studied, it was observed that Luzen 45 (mancozeb) was the best and could completely inhibit the growth of nine species of fungi, viz., Aspergillus ochraceus, Curvularia clavata, Fusarium sp.5, Gilbertella persicaria,Humicola fuscoatra and Scytalidium sp. at the minimum concentration tested. Hexacap (captan) which was ranked second, completely inhibited Fusarium solani at 1000 and 2000 ppm and Chaetomium erectum and Rhizopus oryzae at 2000 ppm concentrations. Among other fungicides tested, Foltaf (captafol) completely inhibited the growth of Fusarium equiseti and Fusarium solani at 1000 ppm concentration while Bavistin (carbendazim) completely inhibited Chaetomium brasiliense, C.erectum and Fusarium equiseti at the minimum concentration of 250 ppm. Blue copper 50 (copper oxychloride) had the least inhibitory effect among all the five fungicides tested. Eventhen, it was able to cause over 99 per cent inhibition of the growth of Rhizopus oryzae at 2000 ppm. When the mean effect of different fungicides against individual species of seed-borne fungi was analysed, it was found that Luzem 45 was the most effective against Aspergillus aculeatus, A.chevalieri, A.ochraceus, Curvularia clavata, Fusarium pallidoroseum, F. solani, Fusarium sp.5, Gilbertella persicaria, Humicola fuscoatra and Scytalidum sp. Hexacap was most effective against A.aculeatus, A. ochraceus and Chaetomium erectum while Foltaf was most effective against A.chevalieri, Gilbertella persicaria and Rhizopus oryzae and Bavistin was most effective against A. flavus, Chaetomium brasiliense, F. equiseti and Penicillium sp.

When the different seed treatment fungicides were tested to observe their effects on germination of seeds and control of damping off of seedlings, Hexacap treatment had shown maximum effect in all the vegetables tested. The other fungicides in the order of their efficacy were Bavistin and Luzem 45. In amaranthus, chilli and tomato, slurry treatment of seeds with 0.2 percent Hexacap resulted in high per cent germination of seeds. In ash gourd and snake gourd also slurry treatment with Hexacap resulted in maximum germination of seeds although the effects were not significant. When the mean effect of different fungicides were compared, Hexacap was found to have maximum effect in increasing the germination of amaranthus seeds and treatment with it resulted in least incidence of damping off in ash gourd and snake gourd seedlings. Although not to the extent as that of Hexacap, Bavistin seed treatments also had some good effects on the germination of vegetable seeds tested. Dry treatment with Bavistin was the most effective in tomato. Dry and soak treatment with Bavistin gave maximum germination in ash gourd. Bavistin showed the maximum effect in controlling damping off of seedlings as treatment with it resulted in least incidence of the disease in chilli, tomato and ash gourd. Certain treatments with Luzem 45 also have given good effects in increasing germination of treated seeds. When mean effects were compared Luzem 45 was found to have maximum effect in chilli and tomato and treatment with it resulted in least incidence of damping off in amaranthus, chilli and tomato. Slurry treatment with Blue copper 50 resulted in significant increase in germination of tomato seeds. When the mean values of effect of different fungicidal seed treatment methods were compared, slurry treatment was found to be the best in case of amaranthus and chilli while dry treatment gave maximum effect in tomato, ash gourd and snake gourd.

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* Originals not seen.

Appendices

APPENDIX I

COMPOSITION OF CULTURE MEDIA

(i) Potato Dextrose Agar

Pealed and sliced potato	-	200.00g.
Dextrose	-	20.00g.
Agar agar	-	20.00g.
Distilled water	-	1000.00ml.

(ii) Richard's Solution

Potassium nitrate	-	10.00g.
Potassium dihydrogen orthophosphate	-	5.00g.
Magnesium sulphate	-	2.50g.
Ferric chloride	-	0.02g.
Sucrose	-	50.00g.
Distilled water	-	1000.00ml.

APPENDIX II

Abstract of ANOVA for tables 12 to 17.

Effect of fungicides on the growth of seed-borne fungi.

Source	DF	MSS	F
Treatment	239	1078.93	99.88**
A (fungicide)	4	18636.31	1725.25**
B (fungus)	15	1730.03	160.16**
C (concentration)	2	11372.00	1052.76**
A x B	60	1921.19	177.85**
B x C	30	121.75	11.27**
A x C	8	587.88	54.42**
A x B x C	120	91.65	8.48**
Error	480	10.80	
Total	719		

** Significant at 1% level.

APPENDIX III

Abstract of ANOVA for table 18

Effect of fungicides on seedling emergence

Source	DF	Amaranthus		Chilli		Tomato		Ash gourd		Snake gourd	
		MSS	F	MSS	F	MSS	F	MSS	F	MSS	F
Treatment	15	241.68	1.26	117.63	1.88	189.61	3.36*	224.54	1.22	278.33	0.94
A (fungicide)	4	66.16	0.34	270.45	4.32*	181.14	3.20*	454.82	2.47	202.97	0.68
B (method of fungicidal treatment)	2	104.25	0.54	173.70	2.77	338.48	5.99*	299.36	1.63	519.72	1.75
A x B	8	318.19	1.65	18.94	0.30	143.77	2.55*	118.43	0.64	262.91	0.88
Control vs Treated	1	606.64	3.16	183.69	2.93	292.42	5.78*	2.73	0.01	220.45	0.74
Error	48	192.99		62.61		56.47		184.02		297.11	
Total	63										

* Significant at 5% level.

SEED - BORNE FUNGI OF COMMON VEGETABLES AND THEIR ROLE IN CAUSING SEEDLING DISEASES

BY
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ABSTRACT OF A THESIS
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ABSTRACT

A number of fungi were found associated with vegetable seeds, both externally and internally, during the present study. This include nine species of *Fusarium*, eight species of *Aspergillus*, four species each of *Chaetomium* and *Penicillium*. Other fungi like *Corynascus sepedonium*, *Curvularia clavata*, *Gilbertella persicaria*, *Gonatobotryum apiculatum*, *Humicola fuscoatra*, *Paecilomyces inflatus*, *Rhizopus oryzae*, *Scytalidium* sp., *Syncephalastrum racemosum*, *Talaromyces flavus* and *Zopfiella karachiensis* were also found to be seed-borne in vegetables. In amaranthus, *Fusarium* sp.3 caused significant inhibition of germination and significant incidence of damping off. In chilli, *Aspergillus flavus* was found to be a serious seed-borne fungus while in tomato *Penicillium purpurogenum* caused considerable inhibition of germination of seeds as well as incidence of damping off of its seedlings. *Fusarium pallidoroseum*, *Chaetomium brasiliense*, *Gilbertella persicaria* and *Penicillium* sp. were found to be serious pathogens in snake gourd.

Culture filtrates of most of the fungi tested during the present study caused significant inhibition of germination of seeds, inhibition of elongation of plumule and radicle, and

wilting of seedlings of the corresponding vegetables. While most of the culture filtrates were found to be thermostable, culture filtrates of some of the fungi lost their toxicity by boiling.

When the inhibitory effect of different seed treatment fungicides against different seed-borne fungi was studied, Luzem 45 (mancozeb) was found to be the best one and it could completely inhibit the growth of nine species of fungi at the minimum concentration tested. Hexacap (captan) was ranked second while Blue copper 50 (copper oxychloride) was found to be the least effective fungicide in inhibiting the growth of different seed-borne fungi.

When the different seed treatment fungicides were tested for their efficacy in increasing the germination of seeds and decreasing damping off of seedlings, Hexacap treatment had shown maximum effect in all the vegetable tested. The other fungicides in the order of their efficacy were Bavistin and Luzem 45. When the mean value of effect of different fungicidal seed treatment methods were compared, slurry treatment was found to be the best in case of amaranthus, and chilli while dry treatment gave maximum effect in tomato, ash gourd and snake gourd.