Chapter II

Review of Literature

Plant diseases are more common when a large number of the same kinds of plants are grown together in a cultivated field. Such condition provides ideal factors for the development and spread of a particular pathogen. Repeated growing of crops of the same type in the same field is also responsible for building up a large population of pathogens of one kind or another. These pathogens may remain present inside the seed or contaminate the surface of the seeds. These pathogens associated with seeds in such way are called seed-borne pathogens coming from the crop fields along with the seeds.

It was after the First World War that the significance of seed–borne pathogens was realized. When fungal pathogens transmitted by seeds were studied by many workers they realized the need of seed health testing.

The first case of seed transmission of the fungal pathogen was demonstrated by Frank in 1885, he demonstrated that bean anthracnose pathogen, *Colletotrichum lindemuthianum* was transmitted through seed. These realizations of seed transmission of plant pathogen led to organized seed testing, which started in Germany as early as 1869. The first seed health testing laboratory was founded in 1919 at the Government seed testing station, Wageningen. A plant protection station was opened in Leningrad in 1920 and Dorogin (1923) published a scheme for the detection of seed–borne fungi of various crops in Russia. Seed testing stations were set up in Europe and U. S. A. during the last century. These lead to the establishment of International Seed Testing Association (ISTA) in 1924 in Norway. One of the foremost achievements of ISTA is the adoption of International Rule for Seed Testing. These rules prescribe testing techniques based upon scientific evidences, which are accurate, within stated statistical limits and practicable within everyday operations. These rules are followed in carrying out seed testing work. In India the first seed testing station was established in 1961 and in 1976, forty seven such stations had been set up. It became essential to establish common methods of testing, in order to secure uniformity in evaluation and test results. Agarwal, Mathur and Neergaard (1972) did seed health testing with respect to seed borne fungi of black gram along with wheat, rice, green gram and soybean. They isolated several pathogens which were known to cause

economically important diseases. Basak and Woong (2002) in Korea showed prevalence and transmission of seed-borne fungi of maize. Fungi namely *Alternaria alternata*, *Aspergillus niger*, *Fusarium moniliforme*, *Fusarium* sp., *Penicillium* sp. and *Ustilago zeae* were found to be associated with maize seeds. Prevalence of seed-borne fungi also was variable. The highest percentage of seed-borne fungi was recorded with *Fusarium moniliforme* and the lowest in *Penicillium* sp. Among these seed-borne fungi, *Alternaria alternata, Fusarium moniliforme* and *Fusarium* sp. produced distinct seed rot and seedling infection symptoms. All the transmitted seed-borne fungi might be primary source of infection to the maize crop.

Seed-borne fungi or mycoflora associated with seeds were studied by various workers

Orton (1931) from U. S. A., Alcock (1931) from Scotland and Doyer (1938) from Netherlands published tests for seed–borne fungi. Amongst those Doyer's manual is a landmark in seed pathology. Boroduline (1941) showed that the natural microflora that exists on the seed coat establishes on the roots of cultivated plants.

A study of the externally and internally seed borne fungi of some vegetable seeds were studied by Suryanarayana and Bhombe in 1961. They showed that dominant external mycoflora consisted of *Alternaria, Aspergillus* and *Fusarium* and endophytic mycoflora was dominated by *Colletotrichum, Helminthosporium* and *Phomopsis*. Jain and Patel in 1969 reported that *Aspergillus, Alternaria, Helminthosporium* and *Fusarium* played an important role in the emergence and vigour of guar seedlings. Pathogens, which cause seed rot and seedling infection in groundnut, like *Aspergillus, Macrophomina* and *Rhizopus* were reported by Gupta and Chouhan (1970). Flannigan in 1970 reported strong resemblance among the seed borne mycoflora of barley, oats and wheat.

Pandey (1976) found fewer internally seed–borne fungi in chilli seed. He showed that some fungi like *Aspergillus niger* stimulated seed germination. Aulack *et al.* (1976) showed that in maize *Aspergillus flavus, A. niger, Fusarium*

moniliforme and *Penicillium* sp. caused seed rot and seedling infection. Konde and Pokharkar in 1979 detected seed borne fungi of sorghum. They detected eight fungi, *Aspergillus* sp., *Curvularia lunata, Alternaria tenuis, Drechslera sorghicola, D. rostrata* and *D. tetramera* by blotter and agar plate methods. Lal and Kapoor (1979) studied the change in the mycoflora of wheat and maize grain. They observed field fungi which were abundant at the time of harvests; those were replaced by storage fungi as the length of storage period increased. Karmakar *et al.* (1980) showed that the dominant fungi in soybean seeds were *Alternaria, Fusarium, Cercospora, Macrophomina* and *Collectotricum.* The incidence of seed–borne fungi in maize was reported by Subbaiah *et al.* (1982). Arya and Mathew in 1991 studied seed mycoflora of pigeon pea. Sharma and Roy (1991) studied seed–borne fungi of Urdbean. Seed mycoflora of buck wheat and its pathogenic potential were detected by Sharma, Basandrai *et al.* (1992). They showed that *Alternaria alternata, Cladosporium cladosporioides, Fusarium oxysporum* and *Nigrospora* sp. were seed mycoflora of wheat.

Paul and Mishra (1992) reported seasonal variation in mycoflora associated with maize. The most common and frequently occurring fungi were *Alternaria alternata, Aspergillus candidus, A. flavus, A. niger, A. terreus, Fusarium moniliforme, Penicillium* spp. and *Rhizopus nigricans.* Their studies of seasonal variations have shown the occurrence of the field fungi along with other seed-borne pathogenic fungi during the rainy and summer seasons. The prominent field fungi recorded were *Alternaria* spp., *Aspergillus* spp., *Cephalosporium acremonium, Cladosporium cladosporioides, Curvularia lunata, Drechslera maydis, Fusarium* spp., *Penicillium* spp., *Trichoderma viride, Verticillium albo-atrum* etc. Most of these field fungi were replaced by the storage fungi in the winter season e.g. *Aspergillus flavus, A. niger, A. ruber, A. terreus, Penicillium* sp., etc were reported on maize. Satyanarayana, Reddy and Hussaini (1993) studied the effect of incidence of seed-borne fungi on seed size and germination in sorghum. Due to high incidence of *Fusarium moniliforme* the seed size and germination in infected sorghum seeds were reduced considerably. Lokesh and Hiremath (1993) studied the effect of relative humidity on seed mycoflora and

nutritive value of red gram (*Cajanus cajan* Linn). Effect of mixed fungal infection in soybean seed was studied by Singh (1993). He showed that the seed borne pathogens produced coloration such as purple (*Cercospora kikuchii*), reddish brown (*Fusarium oxysporum*), dark brown (*Botrytis cinnerea*), brown (*Cephaliophora irregularis*), black (*Alternaria alternata*), microsclerotial seeds (*Phoma betae)* and seed with white growth (*Actinomyces* sp.). More than one pathogens infect soybean seed e. g. *Collectotrichum truncatum* and *Phomopsis* sp., *Collectotrichum truncatum* and *Cercospora sojina*, *Fusarium oxysporum* and *Papulaspora coprophilla.* Comparative histopathological studies of mixed pathogens revealed antagonistic or additive effects on deterioration of seed tissues. Seed borne microflora of French bean (*Phaseolus vulgaris* L.) in Himachal Pradesh examined by Chandrani and Paul (1993) consisted 31 fungal species and two bacterial species, *Fusarium, Aspergillus,* and *Penicillium* species being predominant. *Colletotrichum lindemuthianum, C. dematium, Rhizoctonia solani, Isariopsis griseola, Cercospora canescens* and *Phytophthora* species were isolated from French bean seeds. Biodeterioration of French bean seeds due to seed microflora was studied by Chandrani and Paul (1993). They observed that the collected seeds, heavily infected with *Isariopsis griseola, Colletotrichum lindemuthianum, Rhizoctonia solani, Cercospora canescens* caused deterioration. They isolated *Alternaria* and *Penicillium* also from the seeds of French bean.

Impact of various storage methods on the composition of seed mycoflora in soybean (*Glycine max*) was studied by Sandikar, Gaikwad and Jamge (1994) in case of soybean studied the mycoflora of freshly harvested as well as seeds stored in container for the period of one year, observed that, *Alternaria, Aspergillus, Chaetomium, Curvularia, Dreschlera, Fusarium, Macrophomina, Rhizoctonia,* and *Rhizopus* were associated with one or more storage method. Raj and Saharan (1994) reported seed mycoflora of sunflower and its effect on seed and plant health. Fungi like *Acremonium strictum, Aspergillus cerneus, Bipolaris tetramera* and *Fusarium chlamydosporum* are new records on sunflower seeds. *Rhizopus oryzae, Sclerotinia sclerotiorum* and *Aspergillus parasiticus* caused 68-78 per cent inhibition in seed germination. Randhawa and Aulakh in 1994 reported the

effect of maturity on the incidence of seed borne fungi of wheat and incidence of different fungi on developing seeds of nine varieties of *Triticum aestivum* and one variety each of durum wheat. They recorded eight seed–borne fungi, *Alternaria alternata, Cephalosporium* sp. *Cladosporium cladosporioides, Cochliobolus sativus, Epicoccum purprpurascens, Fusarium moniliforme, Rhizopus stolonifer* and *Trichothecium roseum* associated with wheat. Dubay and Tripathi (1994) isolated different fungi from stored seeds of *Zea mays* collected from five districts of eastern U. P. *Aspergillus flavus* and *A. niger* were found to be dominant and the frequency of *A. niger* was higher. Nair and Arora (1994) carried out cultural characterization of some seed–borne fungal pathogens of legume crops. They reported nine seed borne fungal pathogens i.e. *Alternaria alternata, Verticillium* sp., *Macrophomina phaseolina, Rhizoctonia bataticola, Gliocladium virens, A. niger, A. flavus, Phoma* sp., *Botryodiplodia theobromae* from diseased and wrinkled seeds of legume crops.

Arya and Chauhan (1995) observed seed mycoflora of chickpea. They observed that Deuteromycetous fungi and species of *Aspergillus* were dominant. Four fungal species were reported for the first time on chickpea seeds by them. Bhatia *et al.* (1995) studied seed mycoflora of guar in Rajasthan and its phytopathological effects. They reported 46 fungi, of which *Alternaria alternata, A. tenuissima, Aspergillus flavus, A. niger, Cladosporium oxysporum, Colletotrichum dematium, Fusarium oxysporum, Rhizoctonia bataticola* and *Scopulariopsis brevicaulis* were dominant even after chlorine pretreatment. Seed-borne infection of *A. flavus, A. alternata, C. dematium, F. oxysporum* and *R. bataticola* affected seed germination adversely and produced infected seedlings.

Vishawanathan (1996) studied seed mycoflora in sunflower. Kumar and Agarwal in 1998 investigated seed–borne fungi associated with discolored maize seeds. Seed borne inocula of *Bipolaris maydis* (responsible for black and white streaks), *Botryodiplodia theobromae* (responsible for black pointed dots), *Curvularia lunata* (responsible for dark black streaks) and *Fusarium moniliforme* (responsible for white streak) were detected in all components of seeds whereas

C. pallescens and *B. carbonum* were detected in tip cap, pericarp and endocarp region respectively.

El-Nagerabi, Elshafie and Abdalla in 2000 observed composition of mycoflora and aflatoxins in pea seeds from Sudan. The genus *Aspergillus* (11 species and 5 varieties) was the most common followed by *Rhizopus* (2 species), *Alternaria* (7 species), *Fusarium* (7 species), *Emericella* (2 species and 3 varieties), *Drechslera* (2 species), *Cladosporium* (4 species) and *Penicillium* (5 species). Pathogens of pea plants, *A. alternata* (2.07%), *A. flavus* var. *columnaris* (3.75%), *A. flavus* var. *flavus* (3.70%), *C. cladosporioides* (1.88%), *D. australiensis* (2.46%), *F. oxysporum* (1.58%), *F. solani* (1.88%) and *Pythium ultimum* (1.50%) were recovered from pea seeds. Rao, Giridhar and Reddy (2000) observed fungal succession on sorghum seed harvested at different stages of maturity. Parveen and Kumar in 2000 investigated seed-borne mycoflora of wheat collected from Rajasthan with special attention to *Alternaria* species, who reported 22 species of seed borne fungi in wheat. They recorded four species of *Alternaria* and *A. alternata* associated with seed samples collected from all the districts and was predominant. Rao, Giridhar and Reddy (2001) showed the effect of culture filtrates of some seed borne-fungi on seed germination and seedling growth of Sorghum. Effect of culture filtrates of *Colletotrichum gloeosporioides, Dreschslera maydis, Fusarium oxyporum* and *Nigrospora oryzae* on seed germination and root and shoot elongation of two varieties (CSH-5 and local yellow) of sorghum was studied by them. CSH-5 variety was more susceptible to the toxic effect of culture filtrates of these fungi than local yellow. *C. gloeosporioides* was more toxic in its effect while *N. oryzae* was mild pathogen. Gupta (2001) showed that role of seed mycoflora in deterioration of soybean seed during storage under ambient condition. The field fungi were (*Cladosporium cladosporioides, Alternaria alternata, Acremonium* sp., *Fusarium moniliforme, F. semitectum, Curvularia lunata* and *mycelia sterilia*) replaced by storage fungi (species of *Aspergillus, Pencillium, Rhizopus, Mucor, Chaetomium, Epicoccum* and *Trichothecium*). Paul (2002) have studied biodeterioration of French bean seed and its management.

Dawar, Ghaffar, Shaukat and Rasheed (2004) studied seedborne mycoflora of groundnut. They investigated 14 genera and 28 species of fungi associated with Groundnut. 18 fungal species, i.e. *Absidia corymbifera, Alternaria citri, Aspergillus awamori, Aspergillus candidus, Aspergillus japonicus, Aspergillus luchuensis (Aspergillus awamori), Aspergillus panamensis, Aspergillus penicillioides, Aspergillus terricola, Aspergillus terreus, Aspergillus wentii, Chaetomium globosum, Chaetomium indicum, Cladosporium oxysporum, Paecilomyces variotii, Syncephalastrum racemosum, Trichoderma hamatum* and *Trichothecium roseum* were recorded on groundnut seeds. Among these, *Macrophomina phaseolina, Rhizoctonia solani, Fusarium solani, F. oxysporum, Aspergillus flavus* and *Aspergillus niger* were predominant. Higher number of fungi was isolated with blotter method as compared to the number developed on agar plate and deep-freezing method. The surface sterilization of seeds reduced the incidence of *Aspergillus flavus* and *Aspergillus niger* on Groundnut. Shabbir and Rajasab (2004) showed diversity of *Fusarium* species on sorghum grain. Analysis of *Fusarium* flora on sorghum seeds revealed presence of six species on sorghum grain i.e.. *Fusarium scirpi, F. proliferatum, F. compactum, F. semitectum, F. nygamai* and *F. oxysporum*. Prom (2004) detected effects of *Fusarium thapsinum, Curvularia lunata* and their combination on sorghum seed germination. This study examined the effect of the two most common grain mold fungi, *Fusarium thapsinum* and *Curvularia lunata* inoculated singly and together, on germination and other seed mycoflora. Singh *et al.* (2004) detected seed mycoflora of gram. Singh, Rawal and Bhargava (2004) studied the pathogenic potential and control of seed mycoflora of Groundnut. Ten fungal species from 7 genera were found to be associated with the seeds. Among these, *Aspergillus flavus, A. niger, Fusarium moniliforme, F. oxysporum* were found to be dominant and pathogenic, which reduced seed germination and length of root and shoot in seedling. Toorray, Verma, Thakur and Sinha (2005) studied the evaluation of chickpea accessions by standard blotter method. Associations of seed borne mycoflora with 75 accessions of chickpea were studied. The fungal flora greatly influenced the germination and post-emergence mortality in different accessions.

Eight fungi, *Aspergillus niger, A. flavus, Rhizoctoni* sp., *Rhizopus* sp., *Fusarium* sp., *Alternaria* sp., *Curvularia* sp. and *Ascochyta* sp. were isolated from seeds. Reddy and Muhammad in 2004 studied seed mycoflora of pigeon pea.

Nahar, Mushtaq and Hashmi (2005) studied seed-borne mycoflora of sunflower. They reported *Acremonium fusidioides, Arthrobotrys oligospora, Aspergillus ochraceus, Bipolaris bisepta, Cephaliophora tropica, Chaetomium spinosum, Cladobotryum varium, Cladosporium cladosporioides, Emericella nidulans, Gonatobotrys simplex, Humicola grisea, Memnoniella echinata, Mucor mucedo, Myrothecium verrucaria, Phialophora verrucosa* and *Syncephalastrum racemosum* as new seed-borne fungal species of sunflower. *Absidia corymbifera, Alternaria alternata, Aspergillus flavus, A. niger, A. terreus, Chaetomium bostrychodes, C. globosum, Emericella nidulans, Fusarium pallidoroserum, F. solani, Macrophomina phaseolina, Penicillium* spp., *Rhizoctonia solani* and *Rhizopus stolonifer* were predominantly isolated by two techniques. During seed component plating, *Aspergillus awamori, A. ustus* and *Exerohilum halodes* were found to be new reported species. *Macrophomina phaseolina, Rhizoctonia solani* and *Trichoderma harzianum* were isolated from all component parts, whereas *Fusarium solani* was isolated only from cotyledons and axis. Tariq, Dawar, Abid and Shaukat (2005) reported seed borne mycoflora of soybean. A total number of 20 species of fungi belonging to 12 genera were isolated from soybean seed by using blotter, agar plate and deep freezing methods as recommended by ISTA. Of these methods blotter method yielded highest number of fungi as compared to agar plate and deep freezing methods. Sud and Sharma *et al.* (2005) studied seed mycoflora in kidney bean (*Phaseolus vulgaris* L.) in Himachal Pradesh and reported the comparative occurrence of mycoflora on vegetables and pulses. Major storage and pathogenic fungi recorded were the species of *Alternaria, Aspergillus, Cladosporium, Colletotricum, Fusarium, Penicillium, Rhizoctonia, Rhizopus, Stemphylium* and *Trichoderma.* They found that presence of mycoflora on seed had little effect on seed germination; however, higher germination was recorded in surface sterilized seeds of both types of beans.

Hashmi and Ghaffar (2006) studied seed-borne mycoflora of wheat, sorghum and barley. Fungi most frequently isolated and identified were *Absidia* sp., *Alternaria alternata, Aspergillus* sp., *A. candidus, A. flavus, A. niger, A. sulphureus, Cephalosprium* sp., *Chaetomium globosum, Cladosporium herbarum, Curvularia lunata, Drechslera dematioidea, D. halodes, D. hawaiiensis, D. tetramera, Fusarium moniliforme, F. oxysporum, F. pallidoroseum, F. subglutinans, Nigrospora oryzae, Penicillium* sp., *Piptocephalis* sp., *Rhizoctonia solani, Rhizopus* sp., *Stemphylium* sp., *Syncephalastrum racemosum, Trichoderma hamatum, Trichothecium roseum* and *Ulocladium* sp. This was first report of *Chaetomium globosum* and *D. hawaiiensis* on wheat. *A. sulphureus, Fusarium subglutinans, Nigrospora oryzae, Piptocephalis* sp., *Syncephalastrum racemosum* and *Trichoderma hamatum* on sorghum and *A. niger, Cephalosprium* sp., *Cladosporium herbarum, Drechslera dematioidea, D. tetramera, Trichothecium roseum, Stemphylium* sp., and *Ulocladium* sp., were new records on barley. However, there was no previous report of *Absidia* sp., *Aspergillus sulphureus, Fusarium subglutinans* and *Rhizoctonia solani* on wheat in Pakistan. For the isolation of *Alternaria alternata, Cladosporium herbarum, Drechslera* spp. and *Fusarium* spp. deep freezing method showed better results. Ch. Ramesh and Avitha (2005) showed the presence of external and internal mycoflora on sunflower seeds. They observed that the external seed borne mycoflora were *Alternaria alternata, Rhizopus nigricans, Chaetomium globosum, Cladosporium herbarum, Aspergillus flavus, A. niger, Penicillium spp, Trichoderma.* Internally seed borne fungi recorded were *Aspergillus flavus, A. niger, Alternaria alternata, Rhizopus nigricans, Chaetomium globosum, Cladosporium herbarum.*

Agarwal, Dev, Singh, Indra, and Khetarpal (2006) reported seed-borne fungi in consignments of soybean seeds (*Glycine max*) imported into India. There were 21 pathogens, including *Peronospora manshurica* which was not present in India. Seed-borne fungi of high economic significance included, *Ascochyta sojicola, Botryotinia fuckeliana, Cercospora kikuchii, Colletotrichum dematium, Corynespora cassicola, Diaporthe phaseolorum* var. *sojae, Fusarium oxysporum, Glomerella cingulata, Glomerella glycines, Macrophomina phaseolina, Nectria*

haematococca, Passalora sojina, Thanatephorus cucumeris as well as other fungal pathogens for which soybean is not a host such as *Alternaria padwickii, Cochliobolus sativus, Fusarium culmorum, Fusarium poae, Glomerella graminicola, Setosphaeria rostrata, Verticillium albo-atrum* etc. Some of the fungi detected had very wide host range. Ahammed, Anandam, Babu, Munikrishnaiah and Gopal (2006) studied seed mycoflora of soybean and its effect on seed and seedling quality. Rizvi (2006) investigated deterioration of seed quality in relation to vigour by seed mycoflora in forage Sorghum. Muley and Baig in 2007 studied mycoflora of four oilseeds (Groundnut, Sunflower, Sesame and Soybean) and observed that the agar plate method was suitable as there was higher percentage of incidence of seed mycoflora. *Aspergillus flavus, A. niger, A. terreus, Alternaria alternata, Fusarium oxysporum* were dominant in all seeds. Nutritional impact on extracellular protease activity of some seed borne fungi in legume was studied by Gachande, Mandge and Mukadam (2007). They isolated six highly proteolytic fungi, *Alternaria alternata, Drechslera tetramera, Aspergillus flavus, Fusarium roseum, Curvularia lunata* and *Macrophomina phaseolina* from different legume. Incidence of seed borne *Fusarium* spp. in commercial maize seed lots was reported by Rodriguez, Robertson and Kanobe (2007). They showed that infection of maize by *Fusarium* spp. can result in seedling blight, stalk rots, ear rots, and mycotoxin contamination of grain. Other seed borne fungi detected in seed included *Penicillium oxalicum, Aspergillus flavus, A. niger* and *Cephalosporium maydis*. Dawar, Syed and Ghaffar (2007) showed seed borne fungi associated with chickpea in Pakistan. A total number of 21 species belonging to 13 genera of fungi were isolated and *Absidia glauca, Rhizoctonia solani, Syncephalastrum* sp., and *Trichoderma harzianum* were new reports from Pakistan. Pathogenic fungi, *Fusarium moniliforme, F. oxysporum, Macrophomina phaseolina* and *Rhizoctonia solani,* and saprophytic fungi like *Aspergillus niger* and *A. flavus* were pre-dominant. *M. phaseolina* and *R. solani* were also isolated from seed coat, cotyledons and axis of seed.

The effect of different factors on the emergence and seed mycoflora was also studied by various workers.

According to Neergaard and Saad (1962) the length of the period of incubation was dependent on the temperature. The optimum temperature requires for the growth of pathogens, but other factors such as competition by saprophytes and sprouting of the seeds might interfere and impose modification in the selection of incubation temperatures. Christensen (1970) stated that favourable humidity stimulated sporulation, spore germination and thus inocula on the surface of seeds were responsible for increase of rate of seed deterioration. Neergaard (1977) has dealt with all aspect of seed pathology in his generous reference book. Rao and Reddy (1987) reported the influence of relative humidity on seed mycoflora and deterioration of Sorghum. Tariq, Dawar and Mehdi (2005) showed effect of different moisture and storage temperature on seedborne mycoflora of soybean. Soybean seed with 8, 12 and 16 % moisture and stored at 4, 25, 30 and 40^0C showed that infection of *Aspergillus flavus* was highest at 16% moisture level where as infection of pathogenic fungi was maximum at 8 and 12% moisture levels when stored at 25^0C. Infection of mold fungi increased with the increase in storage time whereas germination of seed decreased with the increase in storage time.

Seed mycoflora and their control were also studied by various workers. Seed mycoflora of cluster bean and their control by seed treatment was shown by Karwasra and Singh (1982). Singh *et al.* (1987) studied the mycoflora of 176 samples of corn seed from tribal areas and reported its effect on seed germination and seedling survival. Control of seed-borne fungi of wheat with fungicides was studied by Hydar-Ali and Fakir (1993). They observed that significant reduction of seed-borne infection by *Alternaria tenuis, Aspergillus flavus, Bipolaris sorokiniana, Curvularia lunata* and *Fusarium semitectum* could be achieved in the laboratory by treating seeds with Dithane M-45, Granosan-M, Homai 80 wp, Panoctirie CG/450, Vitavax-200 and Vitavax-300. Deshmukh, Raut and Udepurkar (1993) reported fungi associated with glumes and corresponding seeds at three stages of seed development in sorghum. They observed maximum stimulation of toxin production in *Alternaria carthami* due to supplementation of serine, lysine, thiamine, casein and maltose. Dithane –M- 45 proved to be less

inhibitory for growth and toxin production in the fungi when compared with other fungicides. Culture filtrates of *A. carthmi* and *Aspergillus flavus* were found to be more toxic for varieties Tara and Bhima while less to variety NRS 209.

Gupta, Chaudhary and Basu (1995) reported seed borne fungi of bhindi, brinjal and chillies grown in Sikkim. The fungi *Fusarium semitectum, Aspergillus* sp. and *Penicillium* sp. were efficiently controlled with fungicides thiabendazole, thiabendazole plus thiram and tolylfluanid M.

Pensalwar, Solanke and Kore (1996) reported seed borne fungi of sunflower and response of *Fusarium moniliforme* to various seed dressers. The response of EC-68414 was less to *Fusarium moniliforme* pathogen in thiram than aureofungin-sol and subeej DS. Thiram and Aureofungin-Sol. improved the seed germination percentage. Moreover, they caused lesser pre and post emergence mortality than subeej DS. Inhibition per cent of *Fusarium moniliforme* was maximum with thiram. Rao, Giridhar and Reddy (1996) reported effect of volatile compound on seed mycoflora of sorghum. They observed vapours of acetic acid and formaldehyde completely eliminated fungi from the seed surface, while ethyl alcohol and ethyl acetate were responsible for elimination of *Aspergillus flavus* and *A. niger* from the seed surface. Petroleum ether was also effective in checking the growth of seed borne fungi except *F. oxysporum.*

Ranf, Bhatti and Ahmed (1997) studied the effect of seed–borne fungi on oil content and fatty acid profile in sunflower. Efficacy of different seed dressing chemicals on seed mycoflora, seed germination and seedling vigour of sunflower (*Helianthus annuus* L.) was shown by Thippeswamy and Lokesh (1997). They used three different fungicides to test their efficacy in controlling the seed mycoflora of sunflower. Among these Captan and Captafol were highly effective in controlling seed mycoflora. Dithane M-45 failed to control seed mycoflora at the lower dosage and showed phytotoxic effect on seedling at higher dosage. In contrast, Captan and Captafol did not show any adverse effect on seed germination. Solanke, Kore and Pensalwar in 1997 reported effect of fungicidal seed treatment on seed viability and mycoflora during storage of sorghum. The

germination was significantly superior in thiram treated seed (65%) than ABC dust (59%) and untreated control (57%).

Reddy and Sugunakar *et al.* (1998) studied the effect of seed treatment with fungicides and insecticides on seed borne fungi, storage insect pest, seed viability and seedling vigour of groundnut. Seed treatment with Thiram (@ 3.0g/kg seed) controlled seed borne fungi effectively and also protected seeds of groundnut from the attack of *Corcyra cephalonica* for a considerable period and maintained seed viability and vigour up to 18 months in polythene bags. Solanke, Kore and Sudewad (1998) detected soybean seed borne pathogens and effect of fungicides. The response of soybean seed i.e. MACS-13 and PK-472 to *Fusarium moniliforme, Aspergillus flavus* and *Aspergillus niger* inoculation was less in thiram dry seed treatment than carbendazim, captan, captafol, mancozeb and thiram plus carbendazim and untreated control. Thiram improved the germination percentage and controlled, pre and post emergence mortality caused by these fungi.

Efficacy of fungicides for increasing storage ability of grain mould infected seed of sorghum i.e. hybrid CSH 14 was studied by Padule, Mahajan, Perane and Patil in 1999. They studied that Thiram (0.2%) plus Carbendazim (0.2%) in 1:1 ratio was effective in controlling seed mycoflora. The predominant fungi associated with the seeds of sorghum hybrid CSH 14 were *Alternaria alternata, Curvularia lunata, Drechslera sorghicola* and *Fusarium moniliforme*. Thakur (1999) reported the effect of fertilizer doses on the seedborne mycoflora of soybean. The predominant mycoflora associated were the species of *Aspergillus, Penicillium, Fusarium, Phoma* and *Colletotrichum.* Out of 10 seed samples 8 had the association of *C. dematium* f. sp. *truncata* and other seedborne fungi.

Gupta and Aneja (2001) studied mycofloral spectrum during storage and its effect on seed viability of soybean seeds under ambient conditions. The percent occurrence of themophilic/thermotolerant flora was 29.8% as against 70.2% of mesophilic flora, irrespective of treatments. Amongst the two storage containers, polylined bag harbored low incidence of mycoflora (37.6%) as

compared to cloth bag packaging (62.4%). Amongst seed treatments, mancozeb (78.6%) and thiram (65.1%) seed dressings controlled seed mycoflora more effectively than treatments with nimbecidine (10.1%) and bleaching powder (13.0%). With advancing storage period, the field fungi (*Cladosporium cladosporioides, Alternaria alternata, Acremonium sp., Fusarium moniliforme, F. semitectum, Curvularia lunata* and *mycelia sterilia*) were replaced by storage fungi (species of *Aspergillus, Pencillium, Rhizopus, Mucor, Chaetomium, Epicoccum* and *Trichothecium*). Seed mycoflora as an important factor responsible for seed deterioration during storage under ambient conditions was observed by Gupta and Aneja (2001).

Screening of soybean cultivars for seed mycoflora and effect of Thiram treatment was done by Raj, Kant and Kulshrestha (2002). Three fungi namely *Aspergillus flavus, A. niger* and *Alternaria alternata* were found dominant. Thiram seed treatment (@ 2g/kg seed) significantly improved germination and field emergence and reduced the seed mycoflora of soybean. Rai, Lokesh and Khan (2002) studied occurrence and management of some seed borne fungal pathogens of maize and sorghum. Maize samples showed high incidence of *Fusarium moniliforme.* Fungi like *Verticillium albo-atrum, Trichoderma harzianum, Sclerotium rolfsii, Botryodiplodia theobromae* reduced seed germination to a higher extent. Maize seeds treated with *Sclerotium rolfsii* resulted in higher percentage of abnormality in seedlings. They observed that extracts of *Thuja*, Vinca and lower dosage of Cinnamon oil and higher dosage of Clove oil favored the colonization of *F. moniliforme* and Arecanut leachate, Neem leaves extract proved to be promising in reducing the incidence of *F. moniliforme* in sorghum. Agarwal and Singh (2002) reported plant lattices as biopesticide against seed-borne fungi of okra. Varshney, Ganar, Gaur and Sharma (2002) studied impact of plant product on quality of carry –over seeds of sorghum under storage.

Rathour and Paul (2004) investigated pathogenicity and management of seed mycoflora of pea. 30 species of fungi belonging to 15 genera were found associated with pea seeds. *Alternaria tenuissima, A. tenuis, Ascochyta pinodes, A.*

pisi., Aspergillus flavus, Aspergillus niger, Cladosporium herbarum, Fusarium moniliforme, F. oxysporum Penicillium sp., *Phoma medicaginis, Rhizoctonia solani* and *Sclerotinia sclerotiorum* were frequently encountered species. Sharma, Singh and Gour (2004) investigated pathogenic potential and management of seed microflora of pea (*Pisum sativum* L.). They detected 17 species of microorganisms, *Alternaria alternata, Aspergillus niger, Fusarium oxysporum, Rhizoctonia solani, Macrophomina phaseolina* were found associated with pea seeds. Kumar, Saifulla, and Byre Gowda (2004) studied management of seed mycoflora of pigeon pea. Shailbala and Tripathi (2004) studied the effect of seed treatment with fungicides and biocontrol agent on pathogens in urdbean seeds and recorded *Rhizoctonia solani*, *Fusarium* sp., *Rhizopus* sp., *Aspergillus* sp., and *Colletotrichum* sp., Krishnapp and Deepak (2004) studied seed borne fungal diseases of French bean (*Phaseolus vulgaris* L.) in Karnataka. They observed that *Fusarium* sp., *Macrophomina phaseolina* and *Colletotrichum lindemuthianum* were important seed borne fungal pathogens.

Shafique and Arshad *et al.* (2005) showed fungitoxicity of aqueous extracts of allelopathic plants against seed-borne mycoflora of maize. Efficacy of aqueous leaf extracts of three allelopathic plants viz. sunflower, sorghum and *Melia azedarach* L. was tested against seed-borne fungi of maize. Four species of fungi viz. *Aspergillus niger*, *A. fumigatus*, *Penicillium* sp. *Rhizopus arrhizus* and *A. fischer* were isolated from the contaminated stored maize grains. Pawar, Solanke, Mirza, Baig and Somwanshi (2005) studied seed–borne fungi of chilli. Fungi isolated were *Fusarium moniliforme, Colletotrichum capsi, Aspergillus niger, Alternaria* and *Curvularia lunata.* Dry seed treatment with thiram (0.15 %) plus carbendazim(0.5 %) and thiram (0.3%) considerably increased the germination percentage, vigour index and reduced seed mycoflora in all the cultivars as compared to other treatments and untreated control. Khayum, Gopal, Prasad baby and Munikrishnaiah (2005) showed fungicidal control of seed–borne fungi in Soybean. They observed eight fungal species associated with ten varieties of soybean seeds. Fungi in agar plate method showed more colonies than in blotter method. Bhowal *et al.* (2006) investigated seed–borne microflora in

groundnut and their management. Singh *et al.* (2006) showed effect of fungicidal seed treatment on seed–borne fungi and germination of chilli. Singh *et al.* (2007) investigated seed borne mycoflora of chilli and suggested their management. They reported *Alternaria solani, Aspergillus flavus, A. niger, A. tenuis, Chetomium, Collectotricum, Fusarium, Penicillium, Rhizopus* on chilli seeds. Pandey, Kumar and Tripathi (2007) investigated inhibition of fungal deterioration of pigeon pea seeds by Cuminum cyminum oil. Seventeen fungal species were associated with the seeds of pigeon pea. They reported *Alternaria alternata, Aspergillus flavus, A. niger, A. parasiticus, Curvularia lunata. A. terreus, Fusarium oxysporum, Penicillium chrysogenum, P. italicum, Colletotrichum* sp., and *Cladosporium cladosporioides* on seeds of pigeon pea. Tamuli and Nath (2007) investigated seed mycoflora of wheat and its control. They isolated seed borne fungi *Fusarium oxysporum, Aspergillus flavus, Aspergillus niger, Fusarium solani, Alternaria alternata, Penicillium digitatum, Penicillium italicum, Rhizopus stolonifer* and *Mucor varians* from wheat. Effectiveness of fungicides on seed borne mycoflora, seedling vigour and bio-chemical constituents during early emergence of bhendi was studied by Murthy and Raghavendra (2007). They observed that, bhendi seeds treated individually and in combination of Carbendazim, Metalaxyl and Dithane M-45 indicating the control of seed-borne mycoflora and with enhancement of germination, seedling vigour and biochemical constituents during early emergence.