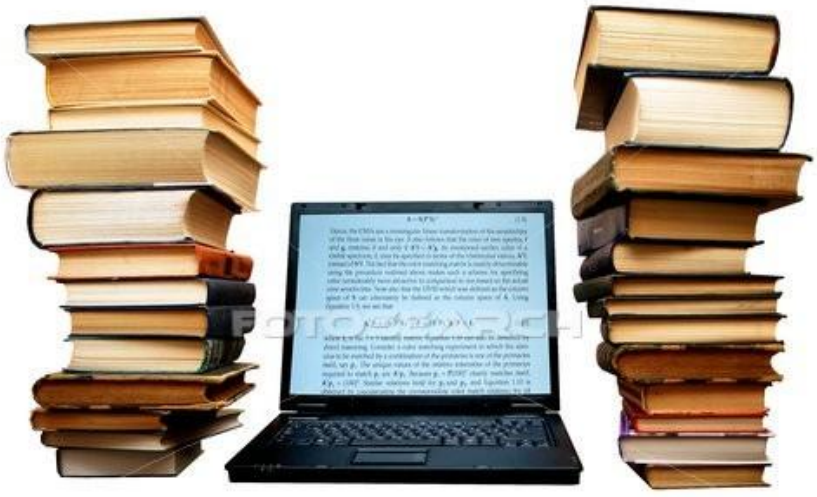
Review of Literature



CHAPTER II

REVIEW OF LITERATURE

Grain mold is a major yield-reducing disease especially in early-maturing sorghum cultivars and in areas where the crop flowers and matures under high humidity due to continuous rain and warm conditions. Grain mold drastically reduces both quantity and quality of sorghum grains and affects germination of seeds.

The seed borne nature of pathogens provides primary inoculum during crop season. It is the main source of introduction and spread of pathogen in disease free areas. The literature on brief account of sorghum seed borne fungi on various aspects has reviewed which is given below.

2.1: Pathological Investigations

2.1.1: Symptoms and signs observed on grains in nature due to infection of various pathogens

The exposed kernels of sorghum tightly bounded, covered by dense black velvet mat of conidiophores bearing numerous conidia of pathogen *Curvularia lunata* toward the apex were reported by Gallegos and Castro (1978). Rao and Williams (1977) observed initial mold symptoms appear as white or grey mycelia growth on rachis, glumes and anthers. Discoloration observed at physiological maturity includes blackish discoloration by *Curvularia* sp; pinkish discoloration by *Fusarium* sp; snow whitish discoloration by *Olpitrichum* sp; and grayish discoloration by *Alternaria* or *Drechslera* sp. The fruiting bodies of *Phoma* sp. and *Colletotrichum* sp. appear as small raised black dots.

Dark brown spot on seed coat are produced by the infection of *Exserohilum* spp., gray discoloration is due to the species of *Alternaria* and *Exserohilum*, dark black discoloration due to the species of *Curvularia* and *Exserohilum* and crimson red discoloration is mainly due to species of *Fusarium*. Infected sorghum seeds become shrivelled or deformed (Anon., 1980). Frederiksen *et al*. (1982) reported discolored grains such as black (*Curvularia* sp.) and pink (*Fusarium* sp.). Infected grains are

covered with a copious fungal growth, cream to pinkish tan in colour and were small and shrivelled. Mahalinga *et al*. (1988) found three species of *Fusarium* grow well on both germinated and not germinated seeds of sorghum with a thick mycelial coat develops on radicals as well as on plumules; development of necrotic lesion lead to stunted growth, seedling blight and death of seedling. Funnell (2006) reported significantly fewer fungal colonies of *Fusarium monliforme* and *Alternaria alternata* from white grains of sorghum.

Thakur *et al.* (2006) described symptoms produced by each fungus on the sorghum grains as white to pinkish white by *Fusarium* spp., shiny velvety black by *C. lunata*, grayish black by *A. alternata* and pin-head black pycnidia by *Phoma sorghina* while *Colletotrichum graminicola* produces small, black, enlarged acervuli studded with clusters of setae forming concentric rings on the grain. Cunfer and Griffin (2007) reported white to pink fungal growth with dense masses of spores of *Fusarium* sp. infected with sorghum earheads and *Alternaria* and *Curvularia* produce dark colonies with dark spores. Patil *et al*. (2008) observed *Fusarium culmorum* associated with dark brown and crimson red discolored seeds. Discoloration of seed coat and softening of grains associated with grain mold infection was reported by Somwanshi and Kurundkar (2008).

Kotgire (2009) found the fungi *viz*., *F. moniliforme* (38.75%), *Fusarium* spp. (21.50%), *Penicillium* sp. (4.00%), *Aspergillus niger* (3.00%) and *Macrophomina phaseolina* (2.50%) associated in pinkish discolored grains of sorghum. Blackish discoloration of sorghum grains showed association of *Curvularia* sp., *A. alternata*, *Bipolaris* sp., *F. moniliforme*, *A. niger*, *M. phaseolina*, *Fusarium* spp. and *Chaetomium* sp. in 18.00, 15.00, 14.50, 11.50, 6.25, 6.00, 5.00 and 2.00 per cent frequencies respectively. *F. moniliforme* and *Curvularia* sp. were predominantly associated with shriveled and smaller grains of sorghum.

2.1.2: Isolation of Pathogens

The isolation of pathogens from seed provides information regarding presence of pathogen on the surface and inside the seed. This is one of the most reliable techniques to determine seed health status, their further use as seed and future strategy or disease management during crop period.

Bhagwat and Pedgaonkar (1973) isolated *F. moniliforme, Fusarium oxysporum, C. lunata, Fusarium semitectum* from mouldy grains of sorghum. Gallegos and Castro (1977) found the association of the genus *Fusarium*, *Alternaria* and *Drechsler*a from infected sorghum grains. Rao and Williams (1978) isolated seventeen fungal species belonging to eleven genera from field-collected molded sorghum grain in England. The fungi isolated included *Alternaria triticina, Cladosporium tenniussimum, Cohiliobolus spicifer, Colletotrichum* sp., *C. lunata, Curvularia verruculosa, Drechslera halodes, Drechslera* sp., *F. semitectum, F. moniliforme, F. acuminatum, F. lateritium, Olpitrichum* sp., *Penicillium oxalicum, P. sorghina* and *Trichothecium roseum*. The most frequently isolated genera were *Fusarium, Curvularia, Phoma* and *Trichothecium*. Rana and Rao (1986) reported the predominant fungi deteriorating the sorghum grain quality in India to be *Curvularia, Fusarium, Alternaria, Helminthosporium* and *Phoma*. Association of about 33 fungal genera with mouldy sorghum grains have been reported by Joi *et al*. (1990). Among which species of field fungi such as *Alternaria, Curvularia, Fusarium, Exserohilum* and *Phoma* are of common occurrence on sorghum grains.

Major fungi associated with early infection with sorghum grains were species of *Fusarium, C. lunata, A. alternata* and *P. sorghina* as reported by Indira *et al*. (1991). Anahosur (1992) reported *F. moniliforme, C. lunata, P. sorghina, A. alternata, Exserohilum turcicum, Gonatobotrytis* spp. and *Aspergillus* spp. as the principle sorghum grain mold fungi in India. Landge (1992) found *A. alternata, A. niger* and *Drechslera* spp. associated with moldy seeds of sorghum. Meena and Mariappan (1994) studied colonization of sorghum seed by *A. niger*, *A. flavus*, *A. tenuis*, *C. lunata*, *F. moniliforme* and *Rhizopus stolonifer*. They found that seeds with higher moisture level were more colonized by the seed borne pathogens than those containing less moisture in respect of all the species of fungi. Among them, *R. stolonifer*, *C. lunata* and *F. moniliforme* revealed higher percentage of colonization irrespective of the moisture levels. Padule *et al*. (1997) reported that *A. alternata, Exserohilum rostratum, Fusarium culmorum, Aspergillus fumigatus* and *A. niger* were found associated with moldy seeds of sorghum.

Among 49 fungal species reported to be associated with sorghum grains, the species of *Alternaria, Aspergillus, Curvularia, Drechslera, Fusarium, Penicillium* and *Phoma* were identified as major ones by Navi *et al*. (1999). Prom *et al*. (2003) reported

two most common fungi with molded grains of sorghum *viz., Fusarium thapsinum* and *C. lunata*. Thakur *et al*. (2003) noted that major fungi recorded on sorghum grains in the field at post physiological maturity were species of *Fusarium, Alternaria, Curvularia, Cladosporium, Drechslera* and *Phoma.* Girish *et al.* (2004) found *A. alternata, Bipolaris sorghicola, C. lunata, Fusarium verticillioides, Exserohilum rostratum* and *P. sorghina* to be commonly associated with sorghum grains and these caused seed rot and reduced seed germination to considerable extent. Mohammed and Rajasab (2004) recovered 1873 *Fusarium* isolates from different sorghum grains that belong to eight species. *Fusarium verticilloides* was the most prevalent (39%) followed by *F. semitectum* (36%), *F. proliferatum* (10.8%) and *F. nygam*i (10.5%). Also, other *Fusarium* spp. *viz., F. compactum, F. oxysporum, F.solani* and *F. scirpi* were recovered.

Narnware *et al*. (2006) reported that the important fungi that are responsible for causing grain mold are *C. lunata, F. moniliforme* causing qualitative as well as quantitative losses. Patil *et al*. (2008) observed that *A. alternata* and *Drechslera rostrata* were found associated with gray discolored seeds. *Curvularia penniseti* and *Drechslera rostrata* were associated with dark black discolored seeds whereas *A. niger, A. fumigatus* and *R. stolonifer* were isolated from all discolored grades of sorghum seeds. Kotgire (2009) found association of grain-infecting fungi *viz., F. moniliforme, Fusarium* sp., *Curvularia* sp., *A. niger, A. flavus, A. alternata, Bipolaris* sp., *M. phaseolina, Penicillium* sp. and *Chaetomium* sp. with sorghum earheads.

2.2: Identification of pathogens

For identification of pathogens, different techniques are employed *viz.,* cultural character, physiological studies and morphological character of vegetative and reproductive parts.

Padwick (1950) described the fungus *C. lunata* from rice. Mycelium septate, branched, subhyaline to light brown in substratum, brown above it, single hyphae 2-5 um, conidiophore dark brown, unbranched, septate, bent and knotted near tip, 70-270 x 2-4 um. Conidia one or more at the tip, in a whorl one over other, boat shaped, rounded at tip, little constricted at base, with three septa, second cell much larger and darker colored than others, conidium bent at second cell, 19-30 x 8-16 um. Politis (1975) reported the

morphology of *C. graminicola*. The asci were cylindrical to clavate, with a discharge pore and a thick refractive ring at the apex. The eight ascospores were arranged biseriately and were curved. Gangopadhyay (1983) reported the morphology of *F. moniliforme* having hyaline, septate hyphae 1-8 um and 3-4um width. Microconida are pyriform, short naviculate to obovate, aseptate, hyaline 5-12 x 3-35u. Macroconidia are owl shaped, slightly sickle shaped or almost straight and narrowed at both ends, bent into a hook at the apex form in sporodochia or pionnotes, 2-7 septate and 30-50 x 2.5-3.5u. Ou (1985) described morphology of *P. sorghina*, pycnidia globose or subglobose, scattered or gregarious, 48-133 x 40-95 mm with protruding ostioles; ostiole opening about 10-18 um in diameter. Pycnidial walls dark brown, lighter below, yellowish brown at base, consisting three layers of cells, outermost larger with thick walled cells and cells of inner layer thin walled. Conidia are oblong to ovoid, smoky-hyaline 3-6 x 2-3 mm.

Ahmed and Reddy (1993) reported the morphology of *P. sorghina*, *A. niger* and *A. flavus*. The mycelium of *P. sorghina* is profuse, fluffy to dense and variable in color. Pycnidia are produced on aerial mycelial. Pycnidia may be immersed or erumpent, dark brown to black, shiny or dull. They are single or multistiolate, variable in shape, globose to subglobose and 60-150 mm in diameter. Beak is very small, conidia are hyaline, single-celled, globose to ovoid or shortly cylindrical and measure 1.4-4.4 x 3.5-8.8 mm in diameter and are straight and guttulate. Chlamydospores are frequently produced on aerial mycelium. They are single to several celled, dark, thick walled and irregular in shape. Whereas, *A. niger* produces scanty hyaline to white to light yellow mycelium. Conidiophores are 3 mm long, 15-20 um in diameter, hyaline to light brown, long, thin, unbranched, erect, brittle and terminate in an inflated apex on which phialides are formed. Conidial heads appear globose which split into few to several irregular or well defined columns of conidial chains. They are black, globose or radiate; conidia are produced in chains on sterigmata and are single celled, pale to dark brown, more or less globose, 4-5 mm in diameter. The mycelium of *A. flavus* is white to gray, tough felty mass, conidiophores stands erect, are simple, unbranched, colorless, transparent and 1 mm long and 10-20 mm thick. Apex of conidiophores is inflated into a vesicle upon which radiating phialides are formed. Conidial heads are biseriate, 300-500 mm in diameter, yellow green, olive brown to brown in colour. Conidia are hyaline, single

celled and produced in chains. They are globose to subglobose, 3-6 mm in diameter, elliptical to pyriform.

Tailor (1998) reported the morphology of *F. moniliforme*, *C. lunata*, *A. niger*, *A. flavus* and *A. alternata* isolated from sorghum grains. *F. moniliforme* was catenulate hyaline, one to two celled microconidia measuring 5.09-11.87 x 2.54-3.39 mm (Av. 7.57 x 3.12 mm). Macroconida were produced on macroconidiophore and are hyaline, 3-7 septate and 20.34-54.24 x 2.54-3.39 mm (Av. 45.69 x 3.15 mm), slender, owl shaped, falcate to straight and tapered towards either ends. They were slightly hooked at tip, thin walled, with apical cell slightly curved and tapering to both end points. The fungus *C. lunata* produces grayish black colony, conidiophores were solitary, straight and dark brown in colour. Conidia were curved, typically 3 septate and cells were hyaline, central cells bigger, dark brown, apical cell rounded, smooth walled, without protuberant hilum and measured 20.34-28.82 x 9.32-14.14 mm (Av. 25.15 x 12.10 mm). Also they described morphology of *A. niger* isolated from sorghum grain as mycelium dirty white to black hyaline and septate. The conidiophores were erect, straight, long aseptate, thick walled, hyaline and darker near vesicle. The vesicle was globose, thick walled and hyaline to brown. Conidia produced in chain were globose, hyaline to brown and measured 2.5-4.5 mm (Av. 3.6 mm). The fungus *A. flavus* produced compact globose to radiate conidial heads in shades of green. Mycelium white to gray in colour and grew rapidly. Conidiophores stand erect, simple, unbranched, colorless, transparent and smooth. Conidial heads were biseriate, globose to radiate or columnar, light to deep yellow green. Conidia were hyaline, single celled and in chains. They were globose, measured 3-6 mm in diameter. The fungus *A. alternata* having simple, erect and often clustered conidiophores. Conidia varying from obclavate, pyriform, ovoid and ellipsoidal, often with a short conical or cylindrical beak which may be up to one- third of the length of conidum, pale to mid-golden brown, smooth and up to transverse septa with several longitudinal and obligue septa. They measured 20.34-62.72 x 10.17-16.95 mm (Av. 41.09 x 13.49 mm).

Rashid (2001) described the fungus *C. lunata* from rice. Conidia were curved or more or less straight, black to dark brown, third cell from base darkest and largest, end cells sub hyaline and measured 30 x 12 mm. Patel (2003) recorded the morphology of *A.*

alternata, the mycelium irregularly branched at acute angle, conidiophores light brown, simple and septate bearing obclavate to oval, light to dark brown, muriform conidia with 1 to 4 transverse and 0 to 2 longitudinal septa, variable in size and shape with rudimentary beak and measuring 10.93 to 59.57 x 5.42 to 16.25 mm in size with an average size of 31.73 to 11.54 mm. Somwanshi (2005) reported *F. moniliforme*, *C. lunata* and *P. sorghina* associated with discolored sorghum grain and found colony of *F. moniliforme* growing rapidly with white aerial mycelium often tinged with purple, abundant microconidia in chains, hyaline 1 to 2 celled, oval to club shaped and slightly flattened at each end. Macroconidia hyaline, delicate with thin walls, curved to almost straight, formed infrequently. While *C. lunata* colony was brown, grey or black, hairy to cottony or cushion like and spread easily, conidiophores singly or in groups, simple or rearly branched, brown to dark brown, multi septate conidia ellipsoidal to fusiform or often disproportionately enlarged in the third cell and markedly geniculate or hook shaped. The colony of *P. sorghina* was little white or grey mycelium but produce large numbers of dark brown or black pycnidia on grain surface. Pycnidia were almost spherical, dark brown, thin walled and variable in size. Conidia were unicellular, oblong to oval and hyaline.

Kumar (2006) described morphology of *M. phaseolina*, mycelium of the fungus was initially white, gradually turned brown to black in colour due to formation of numerous small black microsclerotia. The colonies of *M. phaseolina* produced white profuse mycelial growth, which gradually turned brown black at centre due to the formation of numerous small black microsclerotia. The mycelium was hyaline to brown, branched, septate, dendroid and 2.58 to 7.18 um in width. The microsclerotia formed in culture were black, hard and 79.92 to 258.58 um in diameter. Kotgire (2009) reported cultural and morphological characters of grain infesting fungi of sorghum. The colonies of *F. moniliforme* were initially white with a little dark purple reverse. Conidiophores were medium in length, hyaline bearing conidia at the apex of branches. Microconidia were slightly sickle shaped to nearly straight, 0 to 1 septate, oval to clavate. Colonies of *Fusarium* sp. appeared lavender to purple on reverse; conidiophores were very short, hyaline and beared spore masses at their apex. Macroconidia were abundantly produced, sickle-shaped and thin-walled. Microconidial production was abundant, non-septate and

slightly curved or straight. The *Curvularia* sp. colonies appeared black with septate mycelium. Conidiophores were erect, brown, simple or branched and straight or little curved. Conidia were porosporous, sub elliptical and curved. The *A. niger* colonies were black, stipes were long and smooth-walled and terminated into spherical and biseriate vesicles. Conidiophores were unbranched, thick walled and erect while conidia were globose. *A. flavus* colony was olive green, wooly to cottony, mycelium was septate with subglobose vesicles. Conidia produced in chain were hyaline and one-celled. *A. alternata* isolate developed black growth, septate mycelium with straight and geniculate conidiophores. Conidia revealed both transverse and longitudinal septa and were produced acropetally. *M. phaseolina* isolate developed black colonies, with septate hyphae, black pycnidia which were globose and ostiolate. Conidiophores appeared hyaline and narrow apically. Conidia were hyaline and cylindrical. Microsclerotia were smooth, black and homogeneous in size.

2.3: Pathogenicity test

Arif and Ahmed (1969) found that all fungi isolated from sorghum grains reduced germination and that *Fusarium* was the most inhibitive followed by *Aspergillus*, *Penicillium* and *Helminthosporium*. Narasimhan and Rangaswamy (1969) observed reduction of seed viability by 40 to 80 per cent when healthy sorghum seeds were treated with grain mold isolates. Tripathi (1974) observed that the inhibition of seed germination in sorghum by *C. graminicola* and *F. moniliforme* was due to extracellular thermostable toxins and that by *A. flavus* by the production of aflatoxins. Rani *et al*. (1978) reported sorghum seeds inoculated with *Drechslera biseptata* and *Phoma lingam* produced no visible symptoms on sorghum seedlings but they caused a significant reduction in germination, root and shoot length.

Konde and Pokharkar (1979) observed that *A. alternata, C. lunata, Fusarium* sp. and *Drechslera* were responsible for causing reduction in seed germination and seedling mortality in sorghum. Gaudet (1986) found two *Fusarium* spp., *viz*, *F. oxysporum* and *F. tricinctum* were pathogenic to sorghum resulting in poor seed viability and stunting of roots of coleoptiles. Cardwell (1989) reported 23 per cent of the seedlings with necrotic lesions on mesocotyledonary sheaths, primary leaf laminae and primary roots and

development of new acervuli on the sedling after 2 week of incubation in sorghum seeds treated with *C. graminicola*. Pinto (2002) reported seed-borne fungi *F. moniliforme*, *Penicillium* spp., *A. alternata, Cladosporium* spp., *P. sorghina* pathogenic to sorghum seeds cultivar CMS 182R by seed inoculation technique.

Increased grain mold severity and reduced seed germination in sorghum seed inoculation with *Fusarium thapsinum*, *C. lunata* and a mixture of the two fungi in all sorghum cultivars tested were reported by Prom *et al*. (2003). In the greenhouse, artificial inoculation of sorghum plants at soft dough stage with *C. lunata, F. thapsinum* and *P. sorghina*, reduced seed germination by 52, 46 and 48 per cent, respectively, compared with inoculation at anthesis was observed by Tarekegn *et al*. (2004). Girish *et al*. (2004) detected the seed born nature of the sorghum seed fungi with infection appearing in seed coat, endosperm and embryo. Leslie *et al.* (2005) reported that *Fusarium* induces diseases including seed rot, seedling blight, grain mold, head blight, pre-emergence ear rot and stalk rot resulting into loss of the yield and grain quality and also produces toxic and carcinogenic secondary metabolites.

Das *et al*., (2008) proved the pathogenic nature of *M. phaseolina* in different sorghum cultivars. Kotgire (2009) found adverse effect on seed germination when sorghum seeds were treated with cultural filtrates of *A. alternata* (67.00%), *Fusarium* spp. (79.00 %), *M. phaseolina* (80.00%) and *F. moniliforme* (77.25%). They also reported shoot and root length decrease with *A. alternata* (72.29 and 70.55 %), *Fusarium* spp. (54.02 and 53.98%), *M. phaseolina* (63.28 and 63.19 %) and *F. moniliforme* (58.20 and 46.93 %).

2.4: Physiological investigation

2.4.1: To find out the superior media for growth and sporulation of various pathogens

Booth (1977) suggested Potato dextrose agar, potato sucrose agar and wheat meal agar as good media for the growth of *Fusarium* species. Wei and Swartz (1985) observed better growth of *A. alternata* with increase in toxin production and fungal mycelial weight in synthetic medium. Mistry (1992) found PDA superior for growth and sporulation of *A. alternata* while, Richard's solution was best for sporulation followed by

potato dextrose broth and Czapek's Dox medium. Sahi *et al*., (1992) reported maximum mycelial growth of *M. phaseolina* on PDA medium.

Ataga and Akueshi (1996) reported the growth of *Fusarium* sp. and *C. lunata* higher on PDA medium than on malt extract agar. Akhtar *et al.* (1999) found maximum mycelial growth of *F. moniliforme* on PDA than on nine other media tested. Haq *et al*. (1999) found greater mycelial growth of *A. alternata*, *C. lunata*, *M. phaseolina* and *R. solani* on glucose peptone agar and Brown's agar than on potato dextrose agar and oat meal agar.

Jha and Dubey (2000) recorded the best radial growth and excellent sclerotial formation of *M. phaseolina* on potato dextrose agar medium while maximum dry mycelial weight and sclerotial production was recorded in Richards' solution. Suriachandraselveran and Seetharaman (2000) reported that among the five culture broths tested for growth of *M. phaseolina*, Richards' broth followed by Czapek's Dox yielded the maximum mycelial dry weight while, it was minimum in the oat meal broth.

Aurangzeb *et al.* (2003) found potato dextrose agar to be best medium for the mycelial growth and sporulation of *F. moniliforme* followed by Wakasman's agar, basal medium, Czapek's Dox agar and Richard's medium. Patel (2003) found potato dextrose agar superior for the growth and sporulation of *A. alternata* followed by potato carrot sucrose agar, Czapek's Dox agar and Richard's agar. Patil (2003a) tested synthetic and semi-synthetic solid and broth media and found potato dextrose medium, potato carrot sucrose medium, Czapek's Dox medium and Richard's medium best for growth and sporulation of *A. alternata*. Tandel (2004) reported potato dextrose agar and Richards' Agar medium were the best for growth and sclerotial formation of *M. phaseolina* followed by oat meal agar as compared to the rest of the media tested. Chauhan and Kumar (2006) found maximum radial growth of A. alternata on PDA followed by PCA and YEDA showing 89.7, 87.3 and 87.0 mm growth, respectively. Kumar (2006) tested eight synthetic andsemi-synthetic solid and broth media and found Potato dextrose agar in semi-synthetic group while Richard's agar and Czapek's Dox agar in synthetic group significantly superior over the rest for mycelial growth and microsclerotial formation of

M. phaseolina. Tasiwal and Benagi (2009) reported Richard's agar were good for growth and sporulation of Colletotrichum sp.

2.4.2: Effect of grain molds on germination of sorghum seed

Reduced seed germination, viability, seed rot and seedling blight in infection due to seed and soil born *Fusarium* spp. was noticed by Tarr (1962). Tripathi (1974) reported 56 per cent seed germination of molded sorghum seeds as against 76 per cent germination in apparently healthy seeds. Further, they reported reduced germination due to *C. graminicola* (42%) followed by *C. lunata* (40%), *F. moniliforme* (37%), *Phoma insidiosa* (26%), *Penicillium* spp. (23%) and *Aspergillus flavus* (18%). *F. moniliforme* is a serious pathogen on sorghum seeds. Rao and Williams (1978) recorded the viability losses up to 100 per cent in sorghum seeds with severe *Fusarium* and *Curvularia* infection. The production of secondary metabolites by *F. moniliforme* is known to degrade seed quality and reduce seed viability as per Castor and Frederikson (1980).

Hiremath *et al*. (1993) observed 26 per cent reduction in germination of sorghum seed due to infection of *P. sorghina*. Somani and Indira (2001) isolated *C. lunata* and *F. moniliforme* from sorghum grains and were treated with seeds of sorghum cv. CSH 9 by soaking for 6 hr. in the supernatants. The average reduction in seed germination was 14.44 per cent due to *F. moniliforme* and 11.84 per cent due to *C. lunata,* indicating that the former fungus produced more toxic metabolites than the latter. Increased grain mold severity and reduced seed germination in sorghum seed inoculation with *Fusarium thapsinum, C. lunata* and a mixture of the two fungi in all sorghum cultivars tested were reported by Prom *et al*. (2003).

Navi *et al.* (2005) reported infected sorghum grains suffer breakdown of grain structure, loss of viability, increased chalkiness of endosperm and contamination with mycotoxins. Damage resulting from grain infecting fungal infection includes reduced kernel development, discoloration of grain, colonization and degradation of endosperm, decreased grain density, germination, seedling vigour and possible mycotoxin contamination. Narnaware *et al*. (2006) reported that *Fusarium* and *Curvularia* are the two most important fungal genera causing grain discoloration and reduction in viability of seed. Kotgire (2009) reported ten different fungi *viz., F. moniliforme, Fusarium* sp.,

Curvularia sp., *A. niger, A. flavus, A. alternata*, *Bipolaris* sp., *M. phaseolina*, *Penicillium* sp. and *Chaetomium* sp. and mixture of ten fungi exhibited significant adverse effects on seed germination as well as shoot and root length. Overall, fungi induced 12.33 to 60.28, 54.02 to 85.07 and 46.00 to 79.10 per cent reduction in seed germination, shoot and root length over healthy seeds, respectively. Grains inoculated with mixture of ten fungi induced significantly the maximum adverse effects.

2.5: Management of Sorghum Grain Molds

2.5.1: *In vitro* screening of plant extracts against pathogenic fungi

Disease resistance in some plants is known to be due to the presence of certain chemical substances in the host tissues and is known to possess antimicrobial properties, so that phytoextract have high potentialities of being used as botanical fungicides for the control of plant pathogens. The review of literature presented in this chapter is restricted to only antifungal properties of plants, which have been selected and tested during present investigation. Dubey and Dwivedi (1991) found fungitoxic properties of *Acacia arabica* L., *Allium cepa* L. and *A. sativum* L. against vegetative growth and sclerotial viability of *M. phaseolina*. Gohil and Vala (1996) studied the effect of 33 plant extracts on the growth of *F. moniliforme*; found garlic extract most effective in growth inhibition of the pathogen. Kadam (1997) studied antifungal effect of plant extracts on *A. alternata* (leaf spot of gerbera) and reported that bulb extract of *Allium sativum* recorded highest per cent inhibition of mycelial growth (89.96 %) at 10 per cent concentration followed by aqueous extracts of *Calophyllum inophyllum* and *Azadirachta indica* with 82.30 and 75.61 per cent inhibition of the pathogen over control.

Kumar *et al.* (1997) studied the biofungicidal properties of plant leaf extracts and reported aqueous leaf extract of *Calotropis procera, A. indica, Lantana camera* and *Ocimum basilicum* are responsible for cent per cent growth inhibition of *A. alternata*. Kannan and Subbaraja (1999) tested garlic bulb extract (10%), Neem cake extract (5%) and Neem Seed Kernal extract (5%) and reported maximum reduction in blight disease intensity with garlic bulb (19.83%) and Neem cake extract (25.61 %). Sindhan *et al*. (1999) reported that leaf extract of *A. indica* A. Juss, *Mentha arbensis* L., *Eucalyptus globulens* L., *Ocimum sanctum* L., *Datura alba* L., *Bougainvillea spectabelis* L., *Zingiber*

officinale L., *Allium sativum* L. and *A. cepa* L. inhibited the mycelial growth of *M. phaseolina*.Gawande (2003) tested Neem (*A. indica*) (5%) leaf extracts *in vitro* against *C. gloeosporioides* causing leaf spot of *piper longum*. The mycelial growth inhibition of *C. gloeosporioides* was 44.47 per cent with Neem leaf extract.

Jadhav (2003) observed that bulb extract of *Allium sativum* (10 %) showed highest mycelial growth inhibition of *A. alternata* (82.22 %). The extract of nine plant species evaluated for their antifungal activities against seed borne pathogens of sorghum revealed *Adenocalyma alliaceum*, *Prosopis juliflora*, *Allium sativum* and *A. indica* very effective recording minimum fungal growth of 12.15, 16.10, 22.20 and 30.22 percent, respectively as compared to control (60.25%) (Menaka *et al*., 2003). Thakare (2003) tested various botanical *in vitro* against *F. oxysporum* and found cent percent fungal growth inhibition with *Allium sativum* (10 %), *A. indica* (10%) followed by *Ocimum sanctum* (37.48%) and *Gliricidia maculata* (47.97%) both at 10 per cent concentration. Pawar (2004) screened different plant extracts against *F. oxysporum* in watermelon and found bulb extract of garlic (10 %) and leaf extract of Karanj (15 %) were most effective in inhibiting growth of pathogen recording 76.66 and 66.66 per cent inhibition over control.

Potphode (2004) studied the efficacy of six plant extracts against *C. gloeosporioides* causing anthracnose of Jasmine and reported maximum inhibition with Garlic extract (76.36%) followed by Sabja (44.81%), *Ocimum basillicum* and Neem (40.74%). Bhave (2005) screened seven plant extracts against *C. gloeosporioides* causing leaf spot of black pepper. The extracts of *Ocimum sanctum* (65.55%) was found most effective followed by *A. indica* (48.88%), *Bougainvillea spectabilis* (45.22%) and *Pongamia pinnata* (44.88%). Joshi (2005) tested various botanicals *in vitro*, among them Garlic cloves extract (10%) and Sadafuli leaf extract (15%) were effective against *F. solani* causing growth reduction of 87.2 per cent and 57.3 per cent, respectively. Bagade (2006) screened various plant extracts against *A. alternata* causing leaf blight of watermelon and observed that the bulb extract of Garlic was most effective in controlling mycelial growth. They also reported clove extrat of Garlic (*Allium sativum*) at 10 per cent concentration most effective in inhibiting growth of *F. oxysporum*. Haralpatil (2006)

reported Garlic (*Allium sativum*) clove extract, leaf extract of Neem (*A. indica*) and Tulsi (*Ocimum sanctum*) were most effective against *Sclerotium rolfsii* and *C. gloeosporioides.*

2.5.2: *In vitro* screening of antagonists against pathogenic fungi

Antagonism among the microorganisms is now well established, known and exploited in biological control of plant pathogens. Several scientists worked on bio-efficacy of different bio-control agents against different pathogenic fungi. Pande (1985) reported that the culture filtrates of three species of *Aspergillus* and *Trichoderma viride* Pers. significantly retarded the growth of *A. alternata, Drechslera* sp., *Fusarium oxysporum* Sacc., *Rhizoctonia bataticola* (Taubtnh.) Butl. and *Sclerotium rolfsii* Sacc. Elad *et al*. (1986) reported that *Trichoderma harzianum* inhibited linear growth and microsclerotia production of *M. phaseolina in vitro*. Alagarsamy and Sivaprakasam (1988) found that *Trichoderma viride* was capable of checking the growth of *M. phaseolina in vitro*. Medeiros and Menezes (1994) reported that *C. gloeosporiodes* showed high degree of sensitivity to *T. harzianum, T. polysporum* and *T. pseudokoningii.* Singh *et al.* (1995) reported that *T. harzianum* and *T. viride* inhibited the growth of *M. phaseolina* on PDA with *T. viride* most inhibitory to pathogen.

Chattopadhyay and Sen (1996) studied that *A.* niger isolate A_{27} and *T. viride* isolate T_4 were antagonistic to *F. oxysporum* causing wilt in muskmelon. Majumdar *et al.* (1996) reported that *T. viride, T. harzianum* and *Bacillus subtilis* were good antagonistic against *M. phaseolina*, among them *T. harzianum* caused maximum growth inhibition of the pathogen *in vitro*. While Selvarajan and Jeyarajan (1996) reported *T. viride, Trichoderma hamatum, T. harzianum, Laetisaria arvalis, B. subtilis* and *Pseudomonas fluorescens* formed inhibition zone on PDA against *M. phaseolina* and also reduced sclerotial size, germination and germ tube numbers. Chattopadhyay and Sastry (1997) observed the potential of *T. viride* as a bio-control against for *Fusarium oxysporum* f.sp. *carthami* causing wilt of safflower. Kadam (1997) observed that *T. viride* and *T. harzianum* completely inhibited mycelial growth of *A. alternata* causing leaf blight in gerbera. Ushamalini *et al*. (1997) studied antagonist effect of *T. viride, T. harzianum, T. hamatum, T. koningii, T. pseudokoningii, B. subtilis* and *P. fluorescens* against *M. phaseolina* in dual culture technique. All the antagonists significantly inhibited the

growth of *M. phaseolina* among them *T. viride* and *T. harzianum* were the most effective. Raut (1999) reported *Gliocladium virens* alone and its combined inoculation with *T. harzianum* and *T. viride* were the potential antagonists of *F. oxysporum* (root rot of gerbera) *in vitro,* inhibiting pathogens to the tune of 94.6 per cent over control.

Patel (2000) found that among seven antagonists evaluated, *T. viride* (66.40%), *T. harzianum* (60.64%) proved highly antagonistic against *C. gloeosporioides* followed by *G. virens* (58.67%). Paulkar (2000) studied the chick pea wilt caused by *F. oxysporum* f.sp. *ciceri* and reported that *T. harzianum* inhibited maximum growth of *F. oxysporum* in *in vitro* condition. Bhuvaneshwari and Rao (2001) found *T. viride* most inhibitory against the mycelial growth of *C. gloeosporioides* (56.83%), one of the post harvest pathogen of mango.Dubey (2002) found that *T. viride, T. harzianum* and *G. virens* inhibited the growth and sclerotial formation of *M. phaseolina* in dual culture. Ghosh *et al.* (2002) studied the management of leaf spot caused by *A. alternata* on gerbera. The maximum inhibition after 10 days in *in vitro* condition by Poison Food Technique was due to *T. viride* (87.49 %) followed by *Aspergillus awamori* (85.70 %) and *T. hamatum* (83.32 %). Lambhate *et al*. (2002) reported that *T. Viride, T. harzianum* and *A. niger* showed inhibitory effects on the growth of *M. phaseolina* to the extent of 87.6, 77.5 and 73.9 per cent respectively. Meena *et al*. (2002) reported *T. viride* as the most effective antagonist for *A. alternata*.

Raheja and Thakare (2002) reported the efficacy of bio-agents, plant extracts and physical factors on *C. gloeosporioides* causing anthracnose of yam. Bio-agents *viz., T. viride* and *T. harzianum* effectively inhibited the growth of the pathogen. Kucuk and Kivane (2003) found all filtrates of *T. harzianum* T_9, T_{10}, T_{15} and T_{19} were effective against plant pathogens *viz. Fusarium sulmorum, F. oxysporum, F. moniliforme, Rhizoctonia solani* and *S. rolfsii*. Interestingly, Indira and Muthusubramanian (2003) observed that bioagents enhanced the germination and vigour of the seedling obtained from moldy sorghum seeds of various treatments, *Pseudomonas fluorescens* showed maximum germination (88%) and seedling vigour (2636) followed by *T. viride*. Less grain mold incidence (12%) was observed in treatment with *P. fluorescens* followed by *T. viride* (13%) and Thiram (21%) as compared to 53 per cent mold incidence in molded seeds alone. The seedling obtained from the seeds treated with *P. fluorescens* and *T.*

viride showed good shoot and root length as compared to that of seedling obtained from untreated seeds.

Sharma and Chandel (2003) screened various bio-control agents such as *T. harzianum, T. viride, T. virens, T. hamatum* and *T. longibrachitum* in *in vitro* against *F. oxysporum* f.sp. *gladioli* gladiolus wilt pathogen. The effect of Thiram on enhancing germination of molded seeds was at par with treatment with *T. viride*, but did not enhance the vigour of seedling when compared to *P. fluorescens* and *T. viride* which increased the seedling emergence by 20 per cent in each cultivar as reported by Baig and Baig (2004). Bharathi *et al.* (2004) studied the efficacy of 13 plant growth promoting antagonistic rhizobacterial strains against chilli fruit rot and die-back incited by *Colletotrichum capsici*. Among them, *P. flurorescens* (PF1) and *B. subtilis* were found to be effective in increasing the seed germination and seedling vigour. Gurjar *et al.* (2004) reported that *T. harzianum* and *T. viride* gave effective management of *Fusarium* sp. in okra. Mishra *et al.* (2004) studied effect of *T. viride* on *Fusarium oxysporum* f.sp. *gladioli* under *in vitro* conditions. The proliferation of *Fusarium* was significantly reduced by *T. virens*.

Patel (2004) recorded that *A. niger, T. viride, T. harzianum, B. subtilis* and *P. fluorescens* were potent antagonists of *C. gloeosporioides* incitant of chilli anthracnose.Patibanda and Sen (2004) found *A. niger* Van Teigh more useful antagonist against *F. oxysporum* f. sp. *melonis* in the *in vitro* condition. Seven isolates of the antagonist *A. niger* Van Teigh and three isolates of the muskmelon wilt pathogen *F. oxysporum* f. sp. *melonis* were assayed for their *in vitro* interaction. Isolate AN 27 were found promising based on its bio control capabilities. Pawar (2004) studied the antagonistic effect of fungal bio agents against *A. alternata* causing leaf blight of watermelon. It revealed that *T. viride* was most effective in inhibiting growth of *A. alternata.*

Potphode (2004) studied the efficacy of *T. viride* and *T. harzianum* against *C. gloeosporioides* causing anthracnose of Jasmine and found that maximum inhibition of the pathogen was achieved by *T. harzianum* when placed at the center of the test fungus. Sangle and Bambawale (2004) evaluated the antagonistic effect of *Trichoderma* spp. against *F.oxysporum* f.sp. *sesami* in *in vitro* condition. *T. viride* reduced the growth of the

pathogen by 83.18 per cent whereas *T. harzianum* reduced it by 79.54 per cent after 7 days of incubation. The radial growth of *Fusarium oxysporum* f. sp. *sesami* without antagonist was 4.4 cm compared to only 0.90 cm and 0.74 cm, in the presence of *T. harzianum* and *T. viride* respectively. This was caused due to the strong antibiotic activity in *T. harzianum* and *T. viride* through several mechanisms such as hyper parasitism inhibition and antibiosis. Singh *et al.* (2004) observed good inhibitory effect of various bioagents such as *Aspergillus nidulans, G. virens, T. viride* and *T. harzianum* against *F. oxysporum* causing wilt of tomato. Tandel (2004) carried out interaction study of known antagonist by three methods *viz.*, dual culture, pathogen at centre and pathogen at periphery and found strong antagonistic effect on *M. phaseolina* with *T. longibrachyatum, T. harzianum, T. viride, G. virens* and *B. subtilis* in *in vitro.*

Bhave (2005) studied efficacy of *Trichoderma* spp. and found *T. harzianum* (P) and *T. viride* (JCR) proved to be most antagonistic against *C. gloeosporioides*. Chirame and Padule (2005) studied four biological agent's *viz. T. viride, T. harzianum, T. longiforum, T. koningii* against *F. moniliforme* isolated from cotton. Among all the biological agents, *T. viride* (94.00%) showed a highest inhibition of mycelial growth followed by *T. harzianum*. Suryawanshi (2005) reported *T. harzianum, T. viride* and *T. harzianum* as the potential antagonists of *Fusarium oxysporum* Schl. and recorded maximum inhibition in colony diameter of *F. oxysporum* Schl. due to *T. harzianum* (86.66%) followed by *T. viride* (83.44%) and *T. harzianum* (82.92%). Also maximum inhibition in colony diameter of *Colletotrichum vanillae* was achieved due to *T. harzianum* (P) (88.88%) followed by *T. viride* (JCR) (8.48%). Bagade (2006) revealed that antagonistic effect of fungal bio-agents; *Trichoderma koningi* and *T. harzianum* were much effective against *A. alternata*. Also *T. viride* and *T. harzianum* were effective in inhibiting the growth of *F. oxysporum* f. sp. *niveum* causing wilt in watermelon.

Haralpatil (2006) reported *Trichoderma lignorum, G. virens, P. fluorescens, T. harzianum* and *T. viride* were most effective antagonists of *S.rolfsii, C. gloeosporioides* and *Rhizoctonia bataticola.* Kumar (2006) reported strong antagonistic effect of *B. subtilis, A. niger* and *T. viride* against *M. phaseolina in vitro* whereas, *A. flavus, T. harzianum, T. longibrachyatum, G. virens* and *P. fluorescens* appeared as potent antagonists. Kumar *et al.* (2007) reported *T. viride* as the most effective antagonist for *A.*

alternata while Sempere and Santamarina (2007) found *T. harzianum* as the potential antagonist for *A. alternata*. Corona *et al.* (2008) reported strains with the best hyperparasitic behavior against *M. phaseolina* isolated from diseased sorghum grains were *Trichoderma* sp. (TCBG-2) and *Trichoderma koningiopsis* (TCBG-8), respectively. Patel (2008) reported strong antagonism of *T. longibrachyatum, T. harzianum and T. viride* against *A. alternata* (leaf spot of bitter gourd).

2.5.3: *In vitro* screening of fungicides by Poisoned Food Technique (PFT) against pathogenic fungi

Reddy (1977) found carbendazim (0.1%), triadimenol (0.1%) and mancozeb + captan (0.3% each) highly effective in growth inhibition of *C. lunata, F. moniliforme* and *F. roseum*.Ramados and Sivaprakasam (1989) studied efficacy of three fungicides against *M. phaseolina* causing root rot of cowpea. Carbendazim (0.1%), Quintozone (0.1%) and TMTD (0.2%) were highly effective in the control of root rot in *in vitro* test. The fungicides agrosan GN, captan, bavistin + thiram, bavistin SD and thiram were found effective as protectants for seed discoloring fungi of rice *viz., F. moniliforme, F. solani, P. oryzae, S. oryzae* and *A. alternata* (Mishra and Vir, 1990). Raza *et al*. (1993) found Topsin-M and Benlate most inhibitory for growth and sporulation of *F. moniliforme,* among five fungicides tested by poisoned food technique. Mehendale (1994) studied efficacy of eight fungicides against *C. gloeosporioides* causing anthracnose of 'Bakul' and reported that Mancozeb (0.20% and 0.25%), Bordeaux mixture (1%), Benlate, Carbendazim and Thiophanate at 0.1 and 0.15 per cent concentrations were very effective in inhibiting the growth of the fungus under *in vitro* conditions.

Korade (1995) studied efficacy of eight fungicides against *C. gloeosporioides* causing anthracnose of lily and reported Bordeaux mixture (0.8% and 1%), Fytolan (0.2% and 0.3%) and Bayleton (0.05% and 0.1%) the most effective in inhibiting the growth of the fungus under *in vitro* conditions. Ilyas and Iftikhar (1997) reported Topsin-M, Score-250 and Topas-100 most effective in inhibition of mycelial growth of *F. moniliforme* tested by poisoned food technique. Kadam (1997) reported that Copper oxychloride (1500 ppm) and Captan (1000 and 1500 ppm) were the most effective fungicides in inhibiting the growth of *A. alternata* causing leaf spot of gerbera.

Deshmukh (1997) screened 10 fungicides against *C. gloeosporioides* causing anthracnose of anthurium and reported that Bordeaux mixture (1.0 and 2.0 %) and Copper oxychloride (0.2%) were very effective in inhibiting the growth under *in vitro* conditions.

Aurangzeb *et al.* (1998) tested various fungicides *viz.,* Metalaxyl, Benomyl, Cabendazim, Difenoconazole and found Carbendazim most effective in inhibition of mycelial growth of *F. moniliforme* tested by poisoned food technique. *In vitro* screening of non-systemic fungicides *viz.,* diisopropyl ester, thiram, MEMC and mancozeb and among systemic fungicides, propiconazole, hexaconazole, cyproconazole and penoconazole were found most effective at all the three concentrations against *C. lunata*, while against *F. moniliforme*, non-systemic fungicides MEMC and thiram and systemic fungicides carbendazim and thiophanate methyl were most effective at all three concentration tried (Tailor, 1998). Kakade (1999) reported maximum inhibition in growth and sporulation of five fungi *viz., Aspergillus fumigatus, A. niger, A. flavus, M. phaseolina* and *Rhizopus stolonifer* with Carbendazim (0.1 %) and Thiram (0.2%) tested by poisoned food technique.

Chandel (2001) tested efficacy of systemic, non systemic and miscellaneous fungicides against *F. oxysporum* in carnation. They observed Bavistin and Benomyl completely inhibited the vegetative growth of fungus at 100 and 200 ppm and increased flower yield. Non systemic fungicides gave maximum mycelial inhibition. Chavan *et al.* (2001) studied *in vitro* efficacy of five fungicides against *F. oxysporum*. Among the fungicides tested, Carbendazim was significantly superior for inhibiting the fungal growth at all the concentrations tested. Suryawanshi and Deokar (2001) found Carbendazim (0.1 %) and Copper oxychloride (0.25%) completely inhibited the growth and sporulation of *F. oxysporum.* Nandoskar (2001) studied efficacy of nine fungicides against *C. gloeosporioides*. Among them, Bavistin (0.05 and 0.1%), Thiophanate methyl (0.05 and 0.1%), Emisan (0.15 and 0.25%), Propiconazole (0.05 and 0.1%) and Hexaconazole (0.2%) completely inhibited mycelial growth followed by Bordeaux mixture 1 per cent (92.26%) and Hexaconazole 0.1 per cent (91.55%).

Lambhate *et al.* (2002) tested six fungicides *in vitro* against the *M. phaseolina* causing root rot of cotton. Bavistin, Ridomil and Topsin M at 0.1, 0.2, and 0.3 per cent

showed a complete mycelium growth inhibition. While, Captan and Thiram at 0.1, 0.2 and 0.3 percent were also effective to inhibit the growth of *M. phaseolina* up to 77 to 83 per cent respectively. Blitox showed poor performance to inhibit the *M. phaseolina* in each concentration. Sharma *et al.*(2002a) investigated *in vitro* effect of 500, 1000 and 1500 ppm Mancozeb, Thiram, Copper oxychloride, Iprodione, Carbendazim, Metalaxyl, Chlorotholonil, Benomyl and Captan on the growth and sporulation of *F. oxysporum* f.sp. *lini* causing linseed wilt. The growth and sporulation of fungus was completely inhibited by Carbendazim, Benomyl and Copper oxychloride. Sharma *et al.* (2002b) evaluated nine fungicides by poisoned food technique against seed borne fungi, the minimum per cent mycelial growth was observed in Topsin-M against *A. niger*; cent per cent inhibition of mycelial growth was observed in Bavistin against *A. alternata* and *F. oxysporum*; Indofil M-45 against *A. alternata* and *M. phaseolina*; Ridomil-MZ against *M. phaseolina* and Tilt against *A. alternata* and *A. niger*.

Dubey and Kumar (2003) studied antifungal activity of Bavistin and Mancozeb and observed inhibition of growth of *M. phaseolina* by 86.3 per cent and 86.4 per cent respectively. Patel (2003) screened eleven fungicides *in vitro* by poisoned food technique against *A. alternata* and found propiconazole totally inhibitory to the mycelial growth at all the three concentration tried, whereas propineb, ziram and thiophanate methyl were effective at higher concentrations only. Patil (2003a) tested twelve fungicides *in vitro* by poisoned food technique and found Propiconazole, Difenoconazole and Hexaconazole highly fungitoxic to *A. alternata* at all three concentrations tried. Patil (2003b) reported that *F. oxysporum* was completely inhibited by Bordeaux mixture (1%), Bavistin (0.1 %) and Blue copper (0.2 %), followed by Tilt, which gave 98.16 per cent inhibition over control. Singh and Goswami (2003) reported that Emisan exhibited maximum inhibition (83.73%) of radial growth followed by Carbendazim (79.96%), Benomyl (78.91%) and Thiram (73.23%) against wilt of sugarcane caused by *F. moniliforme* in *in vitro* condition. Pawar (2004) tested 10 fungicides against *Fusarium oxysporum* f.sp. *niveum* causing wilt in watermelon. It was revealed that Carbendazim at 0.1 percent (88.33%) and Copper hydroxide at 0.2 per cent (87.00%) were quite effective. Further they found Propiconazole (0.05 %) and Tridemorph (0.05%) completely inhibited

the growth and sporulation of *A. alternata* causing leaf blight of watermelon while 48.96 per cent growth inhibition was observed with Carbendazim.

Potphode (2004) screened different fungicides against *C. gloeosporioides* causing anthracnose of Jasmine and found that Copper oxychloride (0.25%) and Benomyl (0.10%) caused cent per cent mycelial inhibition. Rajaram *et al.* (2004) reported that Benomyl (0.2%) gave best result followed by Captan (0.2%) and Carbendazim against corm rot of gladiolus caused by *F. oxysporum*. Rana *et al.* (2004) tested four fungicides against *F. oxysporum* of gladiolus. Three applications of Carbendazim (0.2%) + Captan (0.3%) effectively reduced disease severity and three applications of Benomyl (0.2%) alone reduced disease severity and post harvest rotting. Joshi (2005) found fungicides *viz*. Bavistin (0.05%) and Current M-45 (0.1%) were most effective in cent percent growth inhibition of the mycelial growth of *F. solani*. Suryawanshi (2005) reported that Bavistin (0.1%), Index (0.05%) and Tilt (0.05%) totally inhibited mycelial growth of *F. oxysporum* iniciting wilt of *Vanilla planifolia*. Bagade (2006) revealed that Tilt alone (0.05 %) proved most effective in controlling growth of *A. alternata* with cent per cent growth inhibition followed by Mancozeb + Copper oxychloride combination with 82.31 per cent inhibition over control. Also Carbendazim alone, Carbendazim + Copper oxychloride, Mancozeb + Carbendazim and Tilt alone, all provided cent per cent inhibition over control in case of mycelial growth and sporulation of *Fusarium oxysporum* f. sp. *niveum*.

Haralpatil (2006) reported Propineb (0.1%), Copper oxychloride (0.25%), Metiram (0.1%), Difenoconazole (0.05%), Hexaconazole (0.05%), Propiconazole (0.05%), Carbendazim (0.1%) and Thiophanate-methyl (0.1%) effective against *C. gloeosporioides*.