3. LITERATURE REVIEW

3.1 SEED-BORNE PATHOGENIC *FUSARIUM* SPECIES

Fusarium spp. are known as seed-borne, seed transmitted, soil-borne and soil-transient plant pathogens. They cause pre- and post-emergence death of seedlings, seed abortion, seed-, root-, stem- and seedling rots, blight, chlorosis, vascular wilt, die back, stunting and reduction in growth in a variety of host plants. Seed borne nature of *Fusarium* spp. have been well documented on various crops including cereals (Bottalico, 1997; Tankov, 1998), oil seed crops such as mustard and rape (Petrie, 1978; Geeta and Reddy, 1990), linseed (Sahay *et al.*, 1990; Fitt *et al.*, 1991; Mercer *et al.*, 1991), sunflower (Kaur *et al.*, 1990; Ahmed *et al.*, 1994) and condiments like capsicum, fenugreek and fennel (Hashmi, 1988; Basak *et al.*, 1996; Mushtaq and Hashmi, 1997).

Seeds and seedlings of *Brassica campestirs* var. *sarson* are known to be affected by *F. roseum* (Jain *et al.*, 1982). Severe *Fusarium* wilt of linseed has been reported in provinces Uttar Pradesh and Madhya Pradesh of India by Asthana (1956-57). Likewise *Fusarium* spp. showed wilting in sunflower kharif crop in India (Vijayalakshmi and Rao, 1986).

Fusarium head blight is a well-known and widespread disease of cereals, causing yield and quality losses and contaminating cereals by mycotoxins.

Aponyi *et al.* (1998) reported head blight of wheat caused by *Fusarium* spp. between flowering and harvest seasons in Hungry. Nyvall *et al.* (1999) also reported the occurrence of *Fusarium* head blight of cultivated and wild rice in Minnesota, where *F. graminearum* was the predominant species followed by *F. anthophilum* and *F. subglutinans*. Six species of *Fusarium viz., F. graminearum, F. moniliforme, F. equiseti, F. chlamydosporum, F. subglutinans* and *F. oxysporum* were isolated from head blight infected seeds of wheat in South Africa by Boshoff *et al.* (1998).

Fusarium anthophilum is reported as a systemic pathogen of capsicum where it caused wilting (Mushtaq and Hashmi, 1997). It is also reported seed borne in maize (Katta *et al.*, 1995) and cereals (Sala *et al.*, 1994), where it produced mycotoxin Fumonisin B1. Kanaan and Bahkali (1993) reported that *F. chlamydosporum* was the most frequently isolated species in 6 cultivars of maize, wheat, rice and barley in Saudi Arabia it also showed highest exocellulase activity as compared to other *Fusarium* spp. Moreover, it has been reported from seeds of pearlmillet from India (Bhatia and Kumar, 1996), Nigeria and Zimbabwe (Onyike and Nelson, 1991).

Fusarium equiseti is prevalent in warm temperate and subtropical areas (Marasas *et al.*, 1984). It is a seed-borne pathogen of capsicum (Neergaard, 1979) caused severe wilt in young seedlings (Mushtaq and Hashmi, 1997). It was also found associated with the pink rot, root rot, stunting and chlorosis in capsicum (Thind and Jhooty, 1985; Koleva and Vitanov, 1990). Eight *Fusarium* spp. including *F. acuminatum*, *F. culmorum*, *F. equiseti*, *F. graminearum*, *F. oxysporum*, *F. pallidoroseum*, *F. proliferatum* and *F. solani* were isolated from seeds and plants of infected wheat fields in East Azerbaijan (Babadoost, 1995). Bhutta (1998) reported the incidence of *F. equiseti* (< 1%) in maize seed samples collected from Punjab and NWFP, Pakistan alongwith other *Fusarium* spp. It is also reported to reduce growth of 3-leaf stage maize seedlings (Schumann and Zreik, 1994).

Fusarium moniliforme is widespread in both humid and sub humid temperate zones and extending into sub tropical and tropical zones throughout the world. It is uncommon in cooler temperate zones (Booth, 1971). It is reported to be air, seed and soil borne, soil invader and transient; causing foot rot, seedling blight, stunting, wilting and hypertrophy in a wide range of hosts including sunflower (Shahnaz and Ghaffar, 1990, 1991). The pathogen is also reported to decrease protein, carbohydrate and cholesterol contents in seeds of sunflower (Singh and Prasad, 1986; Sexana and Karan, 1991) and mustard (Podder and Purohit, 1993). It is a seed borne pathogen of capsicum and caused root rot, yellowing, wilting and fruit rot (Sultana *et al.*, 1988; Hashmi, 1989; SharfunNahar, 1992). Sala *et al.* (1994) isolated several *Fusarium* spp. predominantly from section Liseola from cereals in Spain, where *F. moniliforme* was the predominant species (85.7%). Several samples of corn seeds whose pericarp, endosperm and embryo were found severely infected by *F. moniliforme* showed poor germination and reduced growth (Kim *et al.*, 1984; Li and Wu, 1986). The shoot diameter, plant height, leaf length and plant weight was also found to be suppressed (Yates *et al.*, 1997).

Fusarium oxysporum is a cosmopolitan fungus. Several of its formae speciales are known to be seed borne and cause vascular wilt and damping off diseases in a variety of host plants. *F. oxysporum* f. sp. *lini* was reported devastating seed-borne pathogen of linseed causing wilting and seedling death (Baners *et al.*, 1991; Fitt *et al.*, 1991). It is found on the seed surface, endocarp and embryo causing organic and physiological disorders during germination (Zad, 1978). Infected seeds of flax were reported lighter in weight, and yellowish to dark brown rough and dull (Tu and Cheng, 1976). Kanwar and Khanna (1979) isolated *F. oxysporum* from seeds of *Brassica campestris* var. *sarson*. Similarly Straser (1985) reported it as seed borne pathogen of sunflower even from the endosperm of chemically treated seeds. Infected seeds had lowered oil contents, iodine values and high acid quantity (Ahmad *et al.*, 1994). In capsicum it caused root rot, wilting, die-back, seed rot and fruit rot (Hashmi, 1989; Khaleeque and Khan, 1991; SharfunNahar, 1992). It also produced chlorosis and stunting in capsicum plants in Bulgaria (Koleva and Vitanov, 1990). Saubois *et al.* (1996) isolated *Fusarium* spp. *viz.*, *F. graminearum, F. moniliforme, F. oxysporum and F. subglutinans* from maize seeds harvested from different fields of Argentina. Parfenova and Alekseeva (1995) tested culture filtrates of six *Fusarium* spp. including *F. oxysporum* on wheat varieties, that inhibited the germination of wheat caryopsis and suppressed development of the root and shoot of seedlings.

Fusarium pallidoroseum is cosmopolitan, common in tropical and subtropical countries. It was found seed borne in capsicum in China (Liang, 1990), and also produced tip rot in India (Thind and Jhooty, 1985). Cultural filtrate of *F. pallidoroseum* adversely affected seed germination and root/shoot elongation (Singh and Jain, 1996). It has also been reported seed borne in linseed (Kumar *et al.*, 1997), maize (Katta *et al.*, 1995), sunflower (Shahnaz and Ghaffar, 1991) and wheat (Babadoost, 1995).

Fusarium proliferatum frequently occurred in popcorn (Katta *et al.*, 1995) and maize seeds and maize-based foods along with *F. moniliforme* where both of them produced Fumonisin B1, B2 and B3. It produced maize stalk rot (Logrieco and Bottalico, 1986) wheat crown rot (Wyk *et al.*, 1987) and wheat spike infection (Babadoost, 1995).

Fusarium scirpi has been reported from seeds of maize, which was found toxic to rats (Hsia *et al.*, 1988). It also caused crown rot of wheat (Wyk *et al.*, 1987). *F. solani* is ubiquitous and occurs on seeds of wide range of hosts (Ram Nath *et al.*, 1970). It causes root and stem rots, wilting and fruit rot of capsicum (Fletcher, 1994; Koleva and Vitanov, 1990).

Fusarium sporotrichioides is reported seed borne in maize and wheat (Logrieco and Bottalico, 1986; Abramson *et al.*, 1987). Logrieco *et al.* (1993) examined samples of maize kernels harvested from fields of Peru for the occurrence of *Fusarium* spp. The most frequently recovered species were *F. subglutinans, F. moniliforme, F. equiseti, F. graminearum, F. acuminatum, F. solani, F. oxysporum* and *F. culmorum*. Katta *et al.* (1995) isolated *F. subglutinans* from commercial popcorn.

Apart from *Fusarium* spp. several other seed-borne fungi also produce severe diseases in important crop plants (Table 3.1). Whereas, several saprophytic fungi are also reported to cause severe pre- and post-harvest decay in crop plants. Species of *Absidia*, *Aspergillus*, *Cephalosporium*, *Chaetomium*, *Cladosporium*, *Curvularia*, *Memnoniella*, *Penicillium*, *Phialophora*, *Rhizopus*, *Scopulariopsis*, *Stachybotrys*, *Stemphylium* and *Syncephalastrum* cause storage decay, reduction in oil contents and germination of seeds.

3.2 BIOLOGICAL CONTROL OF *FUSARIUM* SPP.

Filamentous fungi such as species of *Chaetomium*, *Gliocladium*, *Myrothecium*, *Paecillomyces*, *Streptoverticillium* and *Trichoderma*, are used as bio-control agents against *Fusarium* spp. In current researches, yeast species are also emerging as successful biocontrol agents against *Fusarium* spp. and other plant pathogenic fungi. Due to rapid growth, short cell cycle, and comparatively easier

Table 3.1: Seed-borne pathogenic fungi of important crop plants other than *Fusarium* spp.

No.	Pathogen	Host	Disease(s)	Reference(s)
1	*Alternaria alternata*	Sunflower	Leaf and floral blight	Bhutta *et al.*, 1993
		Capsicum	Fruit rot	Khaleeq and Khan, 1991
		Linseed	Seed rot	Kumar *et al.*, 1997
2	*A. brassicae*	Mustard	seed and seedling rot	Jain *et al.*, 1982
			Damping off	Ansari *et al.*, 1989
3	*A. helianthi*	Sunflower	Leaf spot	Sahu *et al.*, 1991
4	*A. linicola*	Linseed	Seed rot	Cappelli and Ciriciofolo, 1991
5	*A. infectoria*	Linseed	Seed rot	Fitt *et al.*, 1991
6	*Bipolaris sorokiniana*	Wheat	Root rot	Goulart, 1996
7	*B. spicifera*	Capsicum	Seed rot	Simay, 1990
8	*Cephalosporium maydis*	Corn	Wilting	Abou-Elseoud, 1999
9	*Cladosporium oxysporum*	Wheat	Black point Disease	Ilyas *et al.*, 1999
10	*Cochliobolus sativus*	Wheat	Black point Disease	Ilyas *et al.*, 1999
11	*Colletotrichum acutatum*	Capsicum	Collar rot, Anthracnose	Kaur and Singh, 1990
12	*C. capsici*	Capsicum	Anthracnose	Pearson *et al.*, 1984
13	*C. coccodes*	Capsicum	Collar rot, Anthracnose	Thind and Jhooty, 1990
14	*C. gloeosporioides*	Capsicum	Collar rot, Anthracnose	Thind and Jhooty, 1990
15	*Curvularia lunata*	Wheat	Black point Disease	Ilyas *et al.*, 1999
16	*Drechslera hawaiiensis*	Wheat	Leaf blight	Hiremath *et al.*, 1991
17	*D. sorokiniana*	Wheat	Black point Disease	Ilyas *et al.*, 1999
18	*D. tetramera*	Wheat	Black point Disease	Ilyas *et al.*, 1999
19	*Myrothecium roridum*	Mustard	Seed rot	Jain *et al.*, 1982
20	*Macrophomina phaseolina*	Sunflower	Collar rot	Raut, 1985; Zazzerini *et al.*, 1985
21	*Phialophora asteris* f. sp. *helianthi*	Sunflower	Wilting	Tosi and Zazzerini, 1995
22	*Phoma helianthi*	Sunflower	Leaf blight	Pachkhede *et al.*,1985
23	*Phomopsis helianthi*	Sunflower	Leaf spot	Slyusar *et al.*, 1998
24	*Sclerotinia sclerotiorum*	Sunflower	Wilting	Weng *et al.*, 1990
25	*Sclerotium rolfsii*	Sunflower	Foot rot	Tarabeih and Al-Menoufi, 1987
		Sunflower	Damping off	Ahmed *et al.*, 1994
26	*Verticillium dahliae*	Linseed	Leaf and stem stripe	Fitt *et al.*, 1998

to form large amount of inoculum, yeasts are getting much attention in this connection. Suzzi *et al.* (1995) reported two strains of *Saccharomyces cerevisiae* and one of *Zygosaccharomyces* sp., which showed broad-spectrum antagonistic activity against *Aspergillus niger*, *Botrytis squamosa* [*Sclerotinia squamosa*], *Cladosporium variabile*, *Colletotrichum acutatum*, *Macrophomina phaseolina*, *Penicillium digitatum*, *Phomopsis longicolla*, *Rhizoctonia fragariae*, *Sclerotinia sclerotiorum* and *Trichoderma viride*. Dry rot of stored potato tubers caused by *Fusarium sambucinum* [*Gibberella pulicaris*] and *F. solani* var. *coeruleum* is reported to be controlled by *Cryptococcus laurentii* (Schisler *et al.*, 1995).

Montuschi and Ricci (1996) tested *in vitro* antagonistic activity of some strains of bacteria and yeasts for the effective control of seed-borne pathogenic fungi *viz.*, *Alternaria brassicicola*, *Fusarium oxysporum* and *Stemphylium botryosum* by seed dressing. It is interesting that in most of the cases yeast species are used to control post harvest diseases/rots of several fruits and vegetables. Wilson *et al.* (1993) used *Candida sake* and *C. tenuis* as microbial antagonists to control post harvest diseases of fruits and vegetables caused by *Botrytis cinerea* and *Penicillium expansum*. Similarly *Debaryomyces hansenii* and *Pichia guilliermondii* are also known to reduce infection of *B. cinerea* (Wisniewski *et al.*, 1991). Droby *et al.* (1993) reported that *P. guilliermondii* effectively controls green and blue molds (*Penicillium digitatum* and *P. italicum*) of citrus fruits. In another report Elad *et al.* (1994) recorded the efficacy of *Rhodotorula glutinis* and *Cryptococcus albidus* for the control of gray mold (*Botrytis cinerea*).

Stangarlin and Pascholati (1994) used *Saccharomyces cerevisiae* as a biological control of *Exserohilum turcicum* for the protection of maize seedlings. Cell suspension or culture filtrates of *S. cerevisiae* were also used for the inhibition of conidial germination and appressorium formation in *Colletotrichum graminicola* infecting maize leaves under green house conditions (Silva and Pascholati, 1992).

3.3 MYCOTOXINS/SECONDARY METABOLITES OF *FUSARIUM* SPP.

The toxigenicity of the species of *Fusarium* has been studied fairly extensively, especially with regard to the estrogenic and emetic effects in swine and some other animals and toxicoses in man, animals and plants (Mirocha *et al.*, 1971; Bristol and Djurikovic, 1971; Vesonder *et al.*, 1973; Joffe, 1978). The most important toxicosis of man caused by *Fusarium* is the alimentary toxic aleukia (ATA). According to Joffe (1965), fusariogenin, epicladosporic acid and fagicladosporic acid are suspected as toxic metabolites of Fusaria causing ATA.

A lesser number of mycotoxins have been reported from seed-borne plant pathogen, *F. chlamydosporum*. These included Chlamydosporol (Grove and Hitchock, 1991), Isochlamydosporol (Solfrizzo *et al.*, 1994a,b) and 4-Methoxy-7,8-dimethyl-2*H*-pyrano[4,3-*b*]pyridin-2-one (Grove and Hitchock, 1991; Visconti *et al.*, 1994).

Fusarium equiseti, a soil saprophyte, is common in subtropical and tropical areas of the world. It has been found associated with dead and dying plant tissue. Seed rot, root-, stem- and fruit rots of a great variety of plants is reported (Booth, 1971; Joffe and Palti, 1967; Domsch *et al.*, 1980). In the mycotoxicological literature, *F. equiseti* has been reported under a variety of other names such as *F. scirpi*, *F. roseum* 'Scirpi', *F. roseum* 'Equisetii' and *F. roseum* 'Gibbosum'. In this wide sense, *F. equiseti* is known to produce the following mycotoxins:

T-2 toxin (Burmeister *et al.*, 1972; Ueno *et al.*, 1973, 1975)
Neosolaniol (Ueno *et al.*, 1973, 1975)

4 β-acetoxyscirpen-3α, 15-diol (=acetoxyscirpenol) (Ishii *et al.*, 1978)

15-acetoxyscirpe-3α, 4β-diol (monoacetoxyscirpenol) (Pathre *et al.*, 1976)

Diaetoxyscirpenol (Ueno *et al.*, 1973; Pathre *et al.*, 1976)

Scirpenol (Pathre *et al.*, 1976)

4β, 8α, 15-triacetoxy-3α, 7α-dihydroxy-12,13-epoxytrichothec-9-ene (Grove, 1970c)

3-acetyldeoxynivalenol (Grove 1970a)

Butenolide (4-acetamido-4-hydroxy-2-butenoic acid--lactone) (Ellis and Yates, 1971; Burmeister *et al.*, 1971)

Zearalenone (Bottalicao *et al.*, 1983)

5-Amino-2,3-dihydro-6-(3-hydroxy-4-methoxy-1-oxobutyl)-2,2-dimethyl-4*H*-1-benzopyran-4-one (Xie *et al.*, 1990)

Equisetin (Burmeister, 1974; Turos *et al.*, 1989)

N-(2,5-Dihydro-5oxo-2-furanyl)acetamide (Grove and Weisleder, 1973)

3/-*N*-Acetylfusarochromanone (Xie *et al.*, 1991b)

3/-*N*-Acetyl-4/-*O*-(9-octadecenoyl) fusarochromanone (Xie *et al.*, 1991b)

3/-*N*-Acetyl-4/-*O*-(14-methylpentadecanoyl) fusarochromanone (Xie *et al.*, 1991b)

3/-*N*-Acetyl-4/-*O*-(14-methylheptadecenoyl) fusarochromanone (Xie *et al.*, 1991b)

Diacetylfusarochromanone (Xie *et al.*, 1991a)

Formylfusarochromanone (Xie *et al.*, 1991a)

3/-*N*-Acetylfusarochromanone (Xie *et al.*, 1991b)

3/-*N*-Acetyl-4-*O*- (9-octatadecanoyl) (Xie *et al.*, 1991b)

3/-*N*-Acetyl-4/-O-(14-methylpentadecanoyl) fusarochromanone (Xie *et al.*, 1991b)

Deaminofusarochromanone (Xie *et al.*, 1991b)

4,8,15-Tri-Ac {deriv. of 3,4,7,8,15-Scirpenepentol} (Grove, 1970b)

8-Ketone,4,15-di-Ac {deriv. of 3,4,7,8,15-Scirpenepentol} Syn. Nivalenol diacetate (Cole, *et al.*, 1981)

3,4,15-Scirpenetriol (Bamburg *et al.*, 1968)

There is experimental evidence from Pakistan (Irfan, 1971), India (Kalra *et al.*, 1980), China (Qin *et al.*, 1981) and the United States (Kosuri *et al.*, 1970) that gangrenous diseases (also called Degnala disease, sore foot disease or Fescue foot disease) in buffaloes and cattles which have certain similarities to ergotism may be caused by fescue hay or rice straw colonized by *F. equiseti* and/or *F. pallidoroseum*. Although butenolide produced by both species of *Fusarium* may be involved the mycotoxin(s) responsible have not been conclusively identified. *F. equiseti* has been reported to induce necrosis of the skin and corneal damage in the eye of rats, haemorrhage of skin tissues in rabbits, severe food refusal and slight emesis in poultry (Palti, 1978).

Fusarium equiseti is also known to produce an antibiotic "equisetin" *in vitro.* Equisetin is active against several strains of gram +ve bacteria, *Mycobacterium phlei, Bacillus subtilis* and *Staphylococcus areus* and gram –ve bacterium *Neisseria perflava.* Equisetin however is ineffective against other gram –ve bacteria and fungi (Burmeister *et al.*, 1974; Vesonder *et al.*, 1979). The fungus has also been shown to produce moniliformin in corn in low quantities (Rabie *et al.*, 1982).

Fusarium moniliforme has a world-wide distribution on a great variety of host plants and in soil. It is predominantly associated with corn in most of the corn-producing areas of the world (Booth, 1971; Neergaard, 1979). The fungus is also known to cause the Bakanae disease of paddy (Ou, 1972). It is frequently transmitted by seed (Noble and Richardson, 1968) and is more common in the warmer than in the cooler regions. The toxins formed by *F. moniliforme* belong to the zearalenone group, including the so-called F2 and F3 toxins (Mirocha *et al.*, 1969). The metabolites of *F. moniliforme* are related to intermediates in the formation of gibberellins (Serebryakov *et al.*, 1970).

Several isolates of *F. moniliforme* from corn are highly toxic to experimental animals and have been shown to cause equine leukoencephalomalacia in horses (Wilson *et al.*, 1973). *F. moniliforme* is also reported to cause the hepatocellular carcinoma and esophageal carcinogenesis in rats (Van Rensburg *et al.*, 1971; Kriek *et al.*, 1981). A significantly higher incidence of *F. moniliforme* has been observed in home grown corn produced in an area with a high human esophageal cancer rate than in a low rate area in Transkei, Southern Africa (Marasas *et al.*, 1979a, 1981; Thiel *et al.*, 1982). *F. moniliforme* has also been reported to be one of the most prevalent fungi associated with staple food stuffs in a high risk area for esophageal cancer in china (Li *et al.*, 1980; Yang, 1980).

Various metabolites of *F. moniliforme* produced are the acute toxins like, moniliformin (Cole *et al.*, 1973), an estrogen, zearalenone (Nelson *et al.*, 1983), mutagenic compound fusarin C (Wiebe and Bjeldanes, 1981), fusariocin C (Ito *et al.*, 1981), Fusarin A, D and F (Gelderblom *et al.*, 1984a,b; Savard and Miller, 1992) and several fumonisins such as fumonisin A1, A2, B1, B2, B3, B4, FP3 and isofumonisin (Bezuidenhout *et al.*, 1988). The mycotoxin moniliformin (sodium or potassium salt of 1-hydroxycyclobut-1-ene-3,4-dione) was first purified by Cole *et al.* (1973) from *F. moniliforme* isolated from corn seed damaged by southern leaf blight in the United States. Subsequent studies have shown *F. moniliforme* producing high levels (7 to 15g/Kg) of moniliformin in cultures on corn (Allen *et al.*, 1981; Burmeister *et al.*, 1979, 1980). Moniliformim causes necrosis and interveinal chlorosis in corn and tobacco plants (Cole *et al.*, 1973). In tobacco, moniliformin produces distortion of leaf shape and thickening of the midrib by inducing hypertrophy and hyperplasia or both and also causes "rosetting" of leaves, presumably by destroying the apical dominance. In rats it causes progressive muscular weakness, respiratory distress, cyanosis, coma and death (Kriek *et al.*, 1977).

Fusarin C is a secondary metabolite of several strains of *F. moniliforme* and occurs naturally in both *Fusarium*-infected and healthy-looking corn kernels (Farber and Sanders, 1986). It is a highly mutagenic metabolite with potency comparable to the potent mutagens like aflatoxin B1 and sterigmatocystin (Wiebe and Bjeldanes, 1981; Gelderblom *et al.*, 1984b). Fusariocin A, a compound toxic to HeLa cells has also been isolated and characterized from *F. moniliforme* (Arai and Ito, 1970).

Zearalenone or F-2 a natural estrogenic metabolite, and a chemically related metabolite, F-3, which was also suspected of having estrogenic activity, were first isolated from *F. moniliforme* by Mirocha *et al.* (1969). Zearalenone is usually produced on corn and barley during storage the seeds when fed to animals, particularly swine, cause a condition commonly referred to as hyperestrogenism. It is known to cause severe genital disorders in dairy cattles (Mirocha *et al.*, 1971; Caldwell *et al.*, 1970), but in nature it is most commonly reported to affect swine where in severe cases pregnant sows may abort. The abortion part of this syndrome is not due to zearalenone, but to the trichothecene toxins which may occur together with zearalenone, depending on the particular isolate of *Fusarium* involved (Mirocha *et al.*, 1977). Infertility and reduced litter size as well as weak piglets are part of this syndrom. Extracts of cultures of *F. moniliforme* isolated from moldy sweet corn produced T-2 toxin and diacetoxyscirpenol alongwith zearalenone (Ghosal *et al.*, 1978). These have been found to induce emetic activity in pigeon, dermal toxicity in albino rats and hyperestrogenism in albino mice.

Fusarium oxysporum is an important plant pathogen of worldwide distribution. It causes surface rot of sweet potato tubers (*Ipomea batatas* L.), where high concentrations of a toxic substance ipomeamarone has been detected in infected tissue, but not in surrounding healthy tissue (Martin *et al.*, 1976). Lack of human poisoning by eating sweet potatoes may be because visibly diseased portions are discarded before consumption. Culture extracts from two strains of *F. oxysporum* isolated form potato and sorghum were toxic to brine shrimp (Siegfried and Langfeld, 1978) and cockerels (Diener *et al.*, 1981). The mycotoxin(s) produced by these strains of *F. oxysporum* have however, not been chemically characterized. *Fusarium oxysporum* produces both in nature and in culture trichothecene compounds *viz.*, T-2, HT-2 toxin and fusarenon-x (Bilai, 1970; Ueno *et al.*, 1972). Diacetoxynivalenol and fusarenon-x have been isolated from *F. oxysporum* "niveum" (Ueno *et al.*, 1973). In addition, zearalenone has also been reported from cultures of *F. oxysporum* (Mirocha and Christensen, 1974). Beside these, Bikaverin (Koning and Giles, 1988), Bostrycoidin and Javanicin (McCulloch *et al.*, 1982), Cytomycin (Otake *et al.*, 1965), Lycomarsmine (Popplestone and Unrau., 1973), Nectriafurone (Tatum *et al.*, 1987) and Novarubin (Holenstein and Defago., 1983) have also been reported from cultures of *F. oxysporum*. In humans, *F. oxysporum* has been found to cause skin and nail diseases and corneal ulcers (Gutmann *et al.*, 1975).

Fusarium pallidoroseum occurs as a saprophyte in soil and on decaying plant tissues in the warmer parts of Africa, the Americas and Asia (Booth, 1971; Domsch *et al.*, 1980). *F. pallidoroseum* has also been isolated from overwintered cereals in USSR (Joffe, 1965). *F. pallidoroseum* is also implicated in causing degnala disease of buffaloes and cattles in Pakistan (Irfan, 1971), India (Kalra *et al.*, 1980), and sore foot disease of cattles in China (Qin *et al.*, 1981). *F. pallidoroseum* is reported to produce monoacetoxyscirpenol, 4-acetoxyscirpenol, scirpentriol (Ishii *et al.*, 1978), diacetoxyscirpenol, nivalenol, fusarenone-x (Suzuki *et al.*, 978), T-2 toxin, butenolide (Burmeister *et al.*, 1971), zearalenone (Hagler and Mirocha, 1980), zearalenol and 8-hydroxyzearalenone (Hagler *et al.*, 1979). Apart from these mycotoxins, *F. pallidoroseum* also produces antibiotic apicidin and apicidin-A that are active against gram +ve and –ve bacteria (Singh *et al.*, 1996).

Fusarium solani is a cosmopolitan soil saprophyte and a parasite associated with root rot, stem canker and storage rot of a great variety of host plants. Besides, the fungus also produces keratitis and opportunistic infections of humans and animals (Booth, 1971; Joff and Palti, 1972; Domsch *et al.*, 1980; Cucro, 1980). The toxins formed by *F. solani* have been shown to comprise of T-2, HT-2, solaniol, neosolaniol and traces of other trichothecenes like fusarenone-x and diacetoxyscirpenol (Ishii *et al.*, 1971; Sato *et al.*, 1975; Ueno *et al.*, 1972). *F. solani* also produces a number of naphthaoquinone-type pigments including anhydrofusarubin, bostrycoidin, dihydrofusarubin, fusarubin, javanicin, norjavanicin, marticin and isomarticin, some of which have antimicrobial, phytotoxic, insecticidal and antitumor properties (Ammar *et al.*, 1979; Tatum and Baker, 1983).

Fusarium sporotrichioides is a well-known seed-borne plant pathogen and produces several important mycotoxins and secondary metabolites. These include neosolaniol mycotoxins, such as 8-butanoylneosolaniol, 8-hexanoylneosolaniol, 8-isobutanoylneosolaniol, 8-pentanoylneosolaniol and 8-propanoylneosolaniol (Corley *et al.*, 1986), sambucoins (Corley *et al.*, 1987a,b), toxin T2 tetrol, NT2 Toxin, 4,8-diacetyl-T2-tetrol (Cole *et al.*, 1981), toxin FS1, toxin FS2, epi FS2, HT2 toxin (Corley *et al.*, 1986) and trichotriol (Corley *et al.*, 1987b). All mentioned neosolaniol group of secondary metabolites (that are actually trichothecenes antibiotic) and NT2 toxin inhibit protein synthesis (Bekele *et al.*, 1991; Ellison and Kotaonia, 1976).

Fusarium subglutinans occurs on a wide range of hosts, particularly Poaceae, in many areas of the world (Booth, 1971; Marasas *et al.*, 1979a, 1981). *F. subglutinans* infected homegrown corn has been found to produce high incidence of human esophageal cancer in Transkei, south Africa (Marasas *et al.*, 1979b, 1981). Production of moniliformin on corn (Kriek *et al.*, 1977; Steyn *et al.*, 1978) and unspecified 12,13-epoxytrichothecenes *in vitro* and in mango shoots and inflorescences (Ghosal *et al.*, 1976) by *F. subglutinans* has been reported.