International Journal of Innovative Research and Review ISSN: 2347 – 4424 (Online)
An Online International Journal Available at http://www.cibtech.org/jirr.htm
2016 Vol. 4 (2) April-June, pp.62-71/Sharma
Review Article

A REVIEW ON SEED-BORNE FUNGAL DISEASES OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) AND THEIR MANAGEMENT

***Dilip Kumar Sharma**
Vardhaman Mahaveer Open University (VMOU), Kota, Rajasthan, India
**Author for Correspondence*

ABSTRACT
Sunflower (*Helianthus annuus* L.) of family Asteraceae, is one of the major oil seed crops grown for edible oil in the world. Sunflower seeds contain 40-50% oil and 23% protein and constitute excellent source of unsaturated fats, crude protein, fiber and important nutrients like vitamin E, selenium, copper, zinc and B-complex vitamin as well. Harvested fruits and vegetables are vulnerable to attack by microorganisms because of their high moisture content and rich nutrients. The plant is attacked by numerous diseases caused by fungi, bacteria, viruses and insects or is of non-parasitic origin. The various diseases reduced the biochemical constituents of edible oil as well as quality and quantity of seeds.

Keywords: *Sunflower, Asteraceae, Seed-Borne Diseases, Post-Harvest Diseases, Integrated Management*

INTRODUCTION
Fats and oils are important ingredients of human food. Sunflower (*Helianthus annuus* L.) of Asteraceae is native of Central America. It is one of the important oil yielding seed crops of India and fourth largest area under sunflower production in the world and accounts for 10 per cent of the world acreage. Its share in total world production is about five per cent (1.20 MT), the yield at 570 kg/ha is the lowest among the major sunflower producing countries in the world. In India, the large-scale cultivation of sunflower in India started after 1972 the introduction of high yielding Russian varieties. Sunflower cultivated in Karnataka (largest sunflower growing), Maharashtra, Andhra Pradesh, Haryana, Tamil Nadu, Punjab and Uttar Pradesh. Karnataka accounts for half of the total area under the crop in the country and 30 per cent of the total output (Anonymous, 2010).

The Plant
The sunflower has a rough, hairy stem; broad laminated, coarsely toothed, rough leaves and flowers as compound inflorescence called capitulum. The capitulum consists of 1,000-2,000 individual flowers joined together by a receptacle base. A mature flower is actually composite flower of numerous florets crowded together. The florets of circular head are called disc florets, which mature into seeds. Most commonly the plant grows to heights between 1.5 and 3.5 m (5–12 ft) but for the better growth of capitulum of sunflowers require full sun light, fertile, moist, well-drained soil with heavy mulch.

Vegetable oil is extracted from seeds and fruits of different crops and trees (Butt and Ali, 2005). The sunflower oil is extracted from mature seeds and the edible oil used for cooking, as a carrier oil and to produce margarine or biodiesel. The seeds contain about 32 to 45% of light golden-yellow oil equal to olive oil in its medicinal and food value. The seeds are also a good source of food for birds and poultry. The oil cake is excellent for stock and the whole plant is often grown for ensilage. The oil of sunflower has semidrying properties which render it useful in the point, varnish and soap industries. Its high oil content with better quality oil makes it attractive to the users (Kochhar, 1998; Sharma, 2006). Other parts of plant such as leaves used as cattle feed, while the stems which may be used in paper production due to good fibre.

A range of sunflower varieties exist with differing fatty acid compositions; some high oleic types contain a higher level of monounsaturated fats in their oil than even olive oil. It also produces latex, subjected to producing hypoallergenic rubber. Sunflowers can be used to extract toxic ingredients from soil, such as lead, arsenic and uranium. They were used to remove cesium-137 and strontium-90 from a nearby pond after the Chernobyl disaster (Hatim and Abassi, 1994; Gonzalez *et al.*, 2002). Farmers of Northern

Karnataka, Marathwada and Rayalseema grow sunflower as a highly profitable crop where the crop is largely cultivated under rainfed conditions during late kharif/rabi season.

Review of Literature

The plant suffers from a large number of diseases caused by fungi, bacteria, viruses and mycoplasma. This crop is subjected to a few fungal and viral diseases in India and in some areas this seems to be a limiting factor for expansion of the area under this crop. In this article the brief account of fungal species associated with crop is given here.

About 100 species of *Helianthus* L. are found globally, mostly occur in North American and eleven known in India. Seed-borne microflora as *Alternaria alternata, A. helianthi, A. zinnia, Botryodiplodia theobromae, Cladosporium cladosporioides, Drechslera hawaiiense, Erysiphe cichoracearum, Fusarium equiseti, F. moniliforme, F. oxysporium, Helminthosporium helianthi, Leveillula taurica, Macrophomia phaseolina, Puccinia helianthi, Rhizoctoria solani, Sclerotinia sclerotiorum, S. rolfosii, Sphaerotheca fuliginea, Verticillium* spp. and Sunflower mosaic, Mosaic virus of Poppy, Yellow spot disease are found associated with crop that effected the market value of crop (Vidhyasekaran *et al.*, 1981; Mukherji and Bhasin, 1986; Lodha and Kothari, 1988; Neergard, 1990; Richardson, 1979, 1981, 1990; Godika, 1995, 1999; Sharfun-nahar *et al.*, 2005).

Jamaluddin *et al.*, (2004) reported leaf and stem spot (*Alternaria alternate, A. zinniae*), leaf spot and blight (*A. helianthi*), leaf blight (*Botryodiplodia theobromae*), leaf spot (*Cladosporium cladosporioides*), powdery mildew (*Erysiphae cichoracearum, Leveillula taurica, Sphaerotheca fuliginea*), wilt (*Fusarium oxysporum*), leaf spot (*Helminthosporium helianthi)*, charcoal rot (*Macrophomia phaseolina*), leaf rust (*Puccinia helianthi*), leaf blight and damping off (*Rhizoctonia solani*), stem rot (*Sclerotinia sclerotirum*) and white or collar rot (*Sclerotium rolfsii*).

Sunflower is attacked by a number of diseases caused by fungi as fungal foliar diseases, leaf spot caused by *Alternaria helianthi, Septoria helianthi, Albugo tragopogonis* and *Plasmopara halstedii,* inducing brown and grey spots, white rust and downy mildew (Masirevic and Jasnic, 2006). Afzal *et al.*, (2010) reported as important fungal species infected the plant as *Aspergillus flavus, A. niger, A. ocheraceus, Alternaria alternata, Fusarium solani, Penicillium digitatum, Rhizopus arrihizus, Acremonium fusidioides, Arthrobotrys oligospora, 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.*

Several diseases are known to cause yield loss in sunflower and many of these diseases are seed-borne *viz.*, Alternaria leaf blight, downy mildew, charcoal rot, head rot etc. Among these, Alternaria leaf blight (*Alternaria helianthi* (Hansf.) Tubaki and Nishihara) have been considered as a potentially destructive disease in many parts of the sunflower growing countries (Allen *et al.*, 1983; Morris *et al.*, 1983; Lipps and Herr, 1986). It has been reported from different parts of the world including India and is known to cause reduction in flower size, number of seeds per head, seed yield per plant, seed weight and also oil content (Balasubrahmanyam and Kolte, 1980). The loss in yield varies from 11.30 to 73.33 per cent depending on the stage and extent of infection (Reddy and Gupta, 1977).

Using standard blotter technique, 45 fungal species belonging to 27 genera and by deep-freezing technique, 38 fungal species belonging to 23 genera were isolated and identified from 35 samples of *Helianthus annuus*. The fungal species *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* were found to be new records of seed-borne fungal species on sunflower (Nahar *et al.*, 2005) from Pakistan.

Rangaswami and Mahadevan (2008) reported that the plant effected by several disease namely leaf spot (*Alternaria helianthi, Drechslera helianthi*), rust (*Puccinia helianthi*), head rot (*Rhizopus* spp.), leaf mottle (*Verticillium albo-atrum*), wilt (*Verticillium dahliae*), powdery mildew (*Erysiphe cichoracearum*),

downy mildew (*Plasmopara halsteddi*), base rot or collar rot (*Sclerotium rolfsii*), Septoria leaf spot (*Septoria helianthi*), white blister blight or white rust (*Albugo tragopogo*), Aster yellow and Mosaic virus. It is also reported various threatening diseases including different types of carcinoma in humans may develop if contaminated seeds are consumed as food (Nahar *et al.*, 2005). Nine species of *Aspergillus* were isolated from seed samples which produce different groups of aflatoxins (natural fungal toxins) hazardous to animals and man (Shahnaz and Ghaffar, 1990, 1991a, b; Abdel-Mallek *et al.*, 1994). Among them, *Aspergillus flavus* and *A. niger* showed highest occurrence, that may lower the seed quality. Ramegowda (1980) recorded species of *Alternaria*, *Aspergillus*, *Fusarium, Penicillium* and *Rhizopus* on stored sunflower seeds.

The fungi attack on the plants at different stages of development and subsequently during harvesting and storage (Vaidehi, 2002; Morar *et al.*, 2004). In Pakistan, Ahmed *et al.*, (1993) reported several seed-borne fungi including species of *Alternaria*, *Aspergillus*, *Cladosporium*, *Curvularia*, *Drechslera*, *Fusarium* and *Penicillium* from sunflower seeds (Reddy, 1989; Kaur *et al.*, 1990; Shahnaz and Ghaffar, 1991a, b). Biochemically seed-borne fungi decrease protein, carbohydrate, cholesterol contents, iodine values and increase acid quantity of the seed (Singh and Prasad, 1986; Sexana and Karan, 1991; Ahmad *et al.*, 1994). Low quality with reduced and discolored oil contents of sunflower seeds are reported to be caused by species of *Rhizopus* (Zad, 1979; Singh and Prasad, 1977). Seed infection and biodeterioration during storage and reduction in germination reported due to attack by *Alternaria alternata* (Prasad and Singh, 1983). El-Wakil (2014) reported that the deteriorating of sunflower oil due to seed-borne fungi is of a great importance. Ten seed-borne fungi were isolated from abnormal sunflower seeds collected from different locations in Egypt i.e. *Aspergillus flavus, A. niger, Alternaria alternata, Curvularia lunata, Fusarium moniliforme, F. oxysporum, F. semitectum, Penicillum digitatum, Stemphylium* sp., and *Trichoderma* spp.

A noticeable variation was recorded in sunflower oil samples such as chemical properties i.e. saponification number, fatty acid value, iodine number, peroxide value also, physical properties i.e. moisture content, gravity, odor absorbent, absorbance (470nm) and oil colour, these differences are due to the secondary metabolites produced by storage fungi. Some of the tested fungi gave remarkable differences in both of absorbance and odor i.e. with *F. semitectum* and *Stemphylium* sp. Treatments. Leaf blight, floral blight and fruit infection are also reported on sunflower (Kumar *et al.*, 1997; Svetov, 1975; Kumar and Dwivedi, 1981).

Fusarium wilt is an important disease caused by *Fusarium* species (*Fusarium solani, F. oxysporum, F. helianthi, F. moniliforme, F. equestii,*) associated with seeds results in spread of several other diseases in fields such as foot rot, seedling blight, stunting, wilting and hypertrophy (Shahnaz and Ghaffar, 1990, 1991a) and wilting (Vijayalakshmi and Rao, 1986; Masirevic and Jasnic, 2006 b). Straser (1985) reported *Fusarium oxysporum* as seed-borne pathogen of sunflower even from the endosperm of chemically treated seeds. Nahar *et al.*, (2005) reported fungi associated with sunflower seeds were detected by standard blotter, deep-freezing and seed component plating techniques. This mycoflora was compared with that reported by Richardson (1979, 1981, 1983). *Sclerotina* wilt and head rot are caused by *Sclerotinia sclerotiorum* (El-Deeb *et al*., 2000).

The plant is also attacked by several bacterial diseases *viz.* apical chlorosis (*Pseudomonas syringae* pv. *tagetis, Pseudomonas syringae* pv. *aptata, P. cichorii*), bacterial leaf spot (*Pseudomonas syringae* pv. *helianthi, Pseudomonas syringae* pv. *mellea),* bacterial wilt (*Ralstonia solanacearum*), crown gall (*Agrobacterium tumefaciens*), Erwinia stalk rot and head rot (*Erwinia carotovora* subsp. *carotovora, E. carotovora* subsp. *atroseptica*), infecting sunflower (*Verticillium dahliae*) (Bradbury, 1986).

The association of seed-borne fungi causing several seed-borne diseases in sunflower (Mishra *et al.*, 1972; Bhaskaran and Kandaswamy, 1980; Wadhwani, 1982; Raut, 1983, 1985; Hiremath *et al.*, 1993; Rauf Bhutta *et al.*, 1997; Prasad and Kulshrestha, 1999). Chohan and Jasmit (1975) isolated seed-borne fungi namely *Alternaria tenuis* Nees (32 to 35%), *Aspergillus flavus* Link ex Fries (0.5 to 47%), *A. niger* van Tieghem (8.7 to 40%) and *Rhizopus arrhizus* by Standard blotter method from the four varieties of sunflower *viz*., Sunrise, Local variety, EC 68413 and EC 68414. Anilkumar and Urs (1976) recorded

mainly *Alternaria*, *Aspergillus niger*, *Aspergillus flavus*, *Penicillium* spp. and *Rhizopus* spp. from sunflower cv. EC-68414.

In southern India, Alternaria leaf blight causes more than 80 per cent of the yield loss under epiphytotic conditions. The incidence of infection by *A. helianthi* ranging from 20-46 per cent has been reported in sunflower seed lots and this seed-borne infection is known to cause a reduction in seed germination to an extent of 35 per cent over apparently healthy seeds (Hiremath *et al.,* 1993). Venkataramana *et al.,* (1995) and Amaresh (1998, 2000) reported that Alternaria blight was a serious problem during late *kharif*. Prasad and Kulshreshta (1999) recorded 32.8 and 19 per cent reduction in germination of sunflower seeds naturally infected and artificially inoculated with *A. helianthi* respectively. Wagan *et al*., (2006) isolated *Alternaria helianthi* from sunflower seeds. Saulastiano *et al*., (2006) found efficacy of blotter method in detecting *A. helianthi* but Gowder *et al*., (2007) observed that standard blotter method was better for isolation of large number of fungal species.

Jeffrey *et al.,* (1985) observed that sunflower seed inoculated with conidial suspensions (410, 4100 and 41,000/ml), produced infected seedlings when grown out in sterile vermiculite.

Prasad and Kulshrestha (1999) reported an increase in number of seedlings showing blight incidence with the increase in spore load of *A. helianthi* on seeds. There was significant increase in seedlings showing stem and leaf lesions with increase in spore load on seeds. The pathogen was recovered from infected seedlings grown from naturally infected seeds on water agar under laboratory conditions (Raut, 1985). The pathogen not only spread and survives on seed but also on crop debris (Sahu *et al.,* 1991). Infection most commonly occurred in the seed coat (10% of samples) and also in the endosperm (2%) and cotyledon (2%) but only rarely in the plumule and radical (0.8%) (Krishnappa and Shetty, 1990). Raut (1985) detected the pathogen *A. helianthi* in 65 per cent of the endosperms and 25-30 per cent of the embryos of two samples of infected seeds. The pathogen caused pre-emergence as well as post-emergence death of seedlings due to seedling rot (Sadashivaiah *et al.,* 1986). A total of 13 different fungi belonging to 9 distinct genera in 12 families were isolated and identified on the basis of their cultural and morphological characteristics. These were *Alternaria alternata* Nees, *A. helianthi* (Hansf.) Tubaki & Nishihara, *Aspergillus flavus* Link ex Gray, *A. fumigatus* Fre., *A. niger* van Teighem, *Curvularia lunata* (Wakker) Boed, *Drechslera tetramera* (Mchinney) Sub & Jain, *Fusarium solani* (Mart) App. & WR, *F. moniliforme* Sheldon, *Macrophomina phaseolina* (Tasssi) Goid, *Mucor mucedo*, *Penicillium* and *Rhizopus* spp (Laxminarayana, 2006; Afzal *et al*., 2010).

Macrophomina phaseolina is important seed-borne pathogens of sunflower causing seed-rot, root-rot and charcoal rot (Raut, 1987). The seed-borne infection of *Macrophomina phaseolina* (Tassi) Goid (imperfect state: *Rhizoctonia bataticola* (Taub) Butler) was also reported (Jhamaria *et al.,* 1975; Sadashivaiah *et al.,* 1986; Raut and Somani, 1987; Abawi and Pastor Corrales, 1990; Singh and Kaiser, 1995). Godika *et al.,* (1999) found that the agar plate method was more suitable for isolation of *M. phaseolina* but they also detected *A. helianthi* by the blotter method. Sadashivaiah *et al.,* (1986) and Raut (1987) recorded the higher infection counts of *M. phaseolina* in the blotter method as compared to potato dextrose agar method in sunflower seeds.

The downy mildew disease (*Plasmopara halstedii* (Farl.) Berl.et de Toni) has been found associated with sunflower seeds from naturally infected plants, either as mycelium or oospores (Novotel'nova, 1966). A few other records of seed infection were known from Iran (Zad, 1978, 1979) and Turkey (Döken, 1989).

Seed transmission is particularly important since sunflower plants growing from such seeds may or may not produce disease symptoms (Doken, 1989).

The latent (symptomless seeds) form of the disease quite often occurs so that one or two generations are grown before infection becomes evident (Sackston, 1981). The fungus usually invades the ovary and the pericarp, but fails to grow into the embryo (Novotel'nova, 1966; Döken, 1989). The molecular techniques are also tried and found good technique to detect even a very small quantity of fungal biomass in the host or incipient infection (Tourvieille *et al*., 1996).

The deleterious effects of seed-borne fungi including biodeterioration of seeds when used as feed, reduced seed viability, germination, sedling vigour, poor stand of the crop in the field and low yields. The

management of seed-borne fungi is an important task and the deleterious effects can be alleviated through integrated approaches (Vaidehi, 2002).

Afzal *et al.*, (2010) isolated fungi a total of 13 phytopathogenic fungal species associated with seeds of seven cultivars of sunflower by using agar and blotter paper methods. These fungi were found to reduce seed germination by 10-20% and seedling mortality by 10-12%. Two systemic fungicides *viz.* Topsin and Bayleton were found to be significantly effective in the elimination of seed-borne fungi. The extracts of *Azadirachta indica* (Neem) and *Allium sativum* (garlic) at the concentration of 0.015% were found best antifungal activity against these fungi.

Chohan and Jasmit (1975) reported the efficacy of Bavistin and Benlate seed treatment at 0.3 per cent, in controlling pre- and post-emergence death of seedlings due to seed-borne mycoflora of sunflower.

Anilkumar and Urs (1976) reported the efficacy of mancozeb, difolatan and thiram eradicating the seed-borne fungi of sunflower. The leaf spot caused by *Alternaria helianthi* disease is controlled by spraying 0.2% Dithane M-45, Thiovit or any copper fungicide, on the 30th, 40th and 50th days (Rangaswami and Mahadevan, 2008). Amaresh (2000) reported that among plant extracts, neem leaf extract (5%), *Ocimum canum* L. leaf extracts (5%) and *Bougainivillea* sp. leaf extracts were found to be effective in controlling both Alternaria blight and rust. Seedling blight caused by *A. helianthi*, was controlled in the field by treatment of seeds with iprodione, benomyl, captan, chlorothalonil, mancozeb or triadimenol (Jeffrey *et al.*, 1985). Prasad and Das (1986) found agrosan GN and ceresan wet to be the most effective fungicides in eliminating the seed-borne infection of *Alternaria* sp. in sunflower seeds. Prasad and Das (1986) stated that brassicol (quintozene) at a rate of 3 g/kg of seed gave the best control in overcoming seed borne infection of sunflower. Treatment with seed dressing fungicides of four fungicides *viz.* Bayleton, Topsin, Vitavax and Captan, was assessed against 7 fungi viz., *Alternaria alternata, Aspergillus flavus, A. niger*, *Dreschlera tetramera, Rhizopus* spp., isolated from the seeds.

Head rot diseases caused by *Rhizopus* spp. significant showed yield loss. The loss of seeds can be controlled by spraying diathion (0.1%) plus Thiovit (0.2%) at the time of head initiation which reduces the disease severity and increase the yield the crop (Rangaswami and Mahadevan, 2008).

Rust is caused by the eu-autoecious fungus *Puccinia helianthi* is also one of the most common, widespread and most severe diseases of sunflower. The disease can be identified by small reddish brown spots, covered with "rusty" coloured dust, appear on the lower leaves. The disease can spread to all the leaves and even the green parts of the head finally and the leaves turn yellow but rarely fall from the plant (Jamaluddin *et al.*, 2004; Rangaswami and Mahadevan, 2008). Rust can be controlled by using resistant varieties like Admiral and Advent, sanitation practices, crop rotation, destruction of volunteer seedlings, removal the previous crop and debris are important. The disease could be effectively checked by spraying with chemicals like 0.1% nickel chloride or Thiovit or Dithane M-45 (Amaresh *et al.*, 1998; Rangaswami and Mahadevan, 2008).

For the controlling of charcoal rot or improved seedling emergence resulting from fungicide seed treatment has been reported for many crops. Fungicides most commonly used are carbendazim (Theradimani and Marimuthu, 1993), captafol, mancozeb (Singh and Kaiser, 1995), thiram, chlorothalonil, iprodione, captan (Raut and Somani, 1987), thiophanate-methyl, thiabendazole, benomyl and carboxin (Abawi and Pastor-Corrales, 1990) also found effective against various diseases. Benlate treatment at the rate of 0.3 per cent was found most effective against seed-borne infection of *Macrophomina phaseolina* in sunflower as compared to hot water treatment at 52^{o}C for 10 min (Raut and Bhombe, 1983).

The increasing use of potentially hazardous fungicides that are mostly chemicals in agriculture has been the subject of growing concern of both environmentalists and public health authorities. Eco-friendly management by integration of chemicals, plant extracts, biotic agents along with resistance for managing plant diseases has been considered as a novel approach, as it requires low amount of chemicals, by reducing the cost of control as well as pollution hazards, with minimum interference of biological equilibrium (Papavizas, 1973). The use of fungicides, seed dressing chemicals, bioagents or botanicals with priming agents has become an inevitable method of controlling the diseases particularly in sunflower

in the absence of resistance cultivars. Amaresh (2000) reported that among fungi *Trichoderma viride* and *T. harzianum* overgrew and inhibited the growth of *A. helianthi* while the bacterium *Pseudomonas fluorescens* produced maximum inhibition zone. Treatment of seeds with plant extracts can be used as alternative sources for controlling of various pathogens due of presence of some bioactive compounds which are known to control seed mycoflora.

Efficacy of Datura, Ginger, Garlic and Neem was determined at different concentrations against seven isolated fungi viz. *Alternaria alternata, Aspergillus flavus, A. niger, Drechslera tetramera, Rhizopus* spp., *Curvularia lunata* and *Penicillium* spp. *Azadiracthta indica* and *Allium sativum* showed the best antifungal property against all the fungi tested and found useful substitutes for the control of pathogen and protect from hazardous to the society (Afzal *et al.,* 2010).

Bhutta *et al.,* (2001a, b) also reported the effectiveness of seed diffusates of neem in controlling of *Alternaria alternata, Cochliobolus specifer, Emericellopsis terricola, Gibberella fujikuroi, Fusarium semitectum, Macrophomina phaseolina* and *Phoma oleracea, Leptosphaeria maculans* found a significant increase in seed germination after elimination of fungi. Hussain *et al.,* (2000) found that Neem was more effective in controlling *C. lunata* and *Rhizoctonia bataticola* with inhibition rate 98.87 and 88.83%. The efficacy of Neem has recently been reported and reviewed by Rao *et al.,* (2007) and similar results were found by Ravishankar and Mamatha (2005) on forest seeds.

Arun Kishore and Gupta (1997) studied the different organic solvents for enhanced efficiency of carbendazim against slecrotinia rot of sunflower. Translocation of carbendazim in sunflower was higher when seeds were treated in acetone at a dosage of 0.05 per cent only. Prasad and Kulshrestha (1999) observed the efficacy of acetone in infusing the seed dressing chemicals against seed-borne infection of *A. helianthi*.

Seed treatment with bio-control agents along with priming agents may serve as an important means of managing many of the soil and seed-borne diseases called bio-priming (Taylor and Harman, 1990). Biopriming involves coating seed with a bacterial biocontrol agent such as *Pseudomonas aureofaciens* Kluyver AB254 and hydrating for 20 h under warm (23^{o}C) conditions in moist vermiculite or on moist germination blotters in a self-sealing plastic bag. The bacterial biocontrol agent may multiply substantially on seed during biopriming (Callan *et al.,* 1990).

Venkata Ratnam *et al.,* (2001) investigated the effectiveness of seed treatment with inducer chemicals like salicylic acid and bion on the systemic resistance against *A. helianthi*. It is also reported that seed treatment with salicylic acid and bion, increased the phenolic compounds synthesis in sunflower leaves which increase the defense mechanism in host.

Conclusion

Sunflower (*Helianthus annuus* L.) of Asteraceae is major oil seed crop grown for edible oil in the world. Seed contain 40-50% oil and 23% protein and constitute excellent source of unsaturated fats, crude protein, fiber and important nutrients like vitamin E, selenium, copper, zinc and B-complex vitamin as well. The crop is attacked by numerous seed mycoflora and these pathogens may affect the crop resulting in a reduction of the seed quantity and quality. Due to attack of numerous diseases caused by fungi, bacteria, viruses the biochemical constituents of edible oil as well as quality and quantity of seeds are severely affected.

ACKNOWLEDGEMENT

Author is grateful to Prof. Ashok Sharma, hon'ble vice-chancellor, VMOU, Kota, Prof. Kailash Agrawal Head, Department of Botany, University of Rajasthan, Jaipur, Prof. RS Khangrot, Principal, Agrawal P.G. College, Jaipur and faculty members of P.G. Department of Botany for valuable support and academic guidance.

REFERENCES

Abawi GS and Pastor Corrales MA (1990). Seed transmission and effect of fungicide seed treatments against *Macrophomina phaseolina* in dry edible beans. *Turrialba* **40** 334-339.

Abdel-Mallek AY, El-Maraghy SSM and Hasan HAH (1994). Mycotoxin-producing potentialities of some isolates of *Aspergillus*, *Penicillium* and *Fusarium* from corn grains and sunflower seeds. *Assiut Journal of Agricultural Sciences* **25**(2) 133-141.

Afzal R, Mughal SM, Munir M, Sultana K, Qureshi R, Arshad M and Laghari MK (2010). Mycoflora associated with seeds of different sunflower cultivars and its management. *Pakistan Journal of Botany* **42**(1) 435-445.

Ahmad KGM, El-Said SIA, Fawzy RN, Badr AE and Abd-Allah MA (1994). Pathological study on sunflower plant, chemical and biological control and seed oil content. *Annals of Agricultural Science Moshtohor* **3**(3) 1529-1543.

Ahmed I, Iftikhar S and Bhutta AR (1993). Seed-borne microorganisms in Pakistan. A checklist 1991. *Pakistan Agricultural Research Council, Islamabad, Pakistan* 32.

Allen SJ, Brown JF and Kochman JK (1983). Effects of temperature dew period and light on the growth and development of *Alternaria helianthi*. *Phytopathology* **73** 30.

Amaresh YS (2000). Epidemiology and management of Alternaria leaf blight and rust of sunflower. Ph.D. Thesis, University of Agricultural Sciences, Dharwad 321.

Amaresh YS, Nargund VB, Anahosur KH and Kulkarni S (1998). *In vitro* and *in vivo* evaluation of fungitoxicants for the control of sunflower rust caused by *Puccinia helianthi*. *Journal of Maharashtra Agricultural Universities* **23** 256-259.

Anilkumar TB and Urs SD (1976). Seed microflora of sunflower and its control. *Mysore Journal of Agricultural Sciences* **10** 424-427.

Anonymous (2010). *Iopepc-Indian Oil Seed Production*. Available: http//www.iopepc.org/oilseed%2020.

Arun Kishore M and Gupta JP (1997). Organic solvents for enhanced efficacy of carbendazim against sclerotinia rot of sunflower. *Indian Phytopathology* **50** 246- 249.

Balasubrahmanyam N and Kolte SJ (1980). Effect of Alternaria blight on yield components, oil content and seed quality of sunflower. *Indian Journal of Agricultural Sciences* **50** 701-706.

Bhaskaran R and Kandaswamy TK (1980). Epidemiology of leaf spot disease of sunflower. *East African Agricultural and Forestry Journal* **43** 5-8.

Bhutta AR, Bhatti MHR and Ahmad I (2001 b). Chemical control of seed-borne fungal pathogens of sunflower. *Helia* **24**(35) 67-72.

Bhutta AR, Rahber Bhatti MH and Ahmad I (2001 a). Effect of seed diffusates on fungal population and germination of sunflower seeds. *Helia* **24**(34) 77-81.

Bradbury JF (1986). *Guide to Plant Pathogenic Bacteria*, (CAB International Mycological Institute (CMI), UK) 332.

Butt AM and Ali M (2005). Implications of increased oil-seed productions on cropping patterns. *Proceedings of the National Conference of Pakistan* 31-38.

Chohan JS and Kaur J (1975). Seed borne mycoflora of sunflower and control of seed borne pathogens. *Indian Journal of Mycology and Plant Pathology* **6** 210-211.

Döken MT (1989). *Plasmopara halstedii* (Farl.) Berlese et de Toni in sunflower seeds and the role of infected seeds in producing plants with systemic symptoms. *Journal of Phytopathology* **124** 23-26.

El-Deeb AA, Abdallah SM, Mosa AA and Ibrahim MM (2000). *Sclerotinia* diseases of sunflower in Egypt, Arab Universities. *Journal of Agricultural Science* **8** 779-798.

El-Wakil DA (2014). Seed-Borne Fungi of Sunflower (*Helianthus annuus* L.) and their Impact on Oil Quality. *IOSR Journal of Agriculture and Veterinary Science* **6**(6) 38-44.

Godika S (1995). Microorganisms of sunflower seeds and their pathological effects. Ph.D. Thesis, University of Rajasthan, Jaipur 238.

Godika S, Agrawal K and Singh T (1999). Incidence of *Rhizoctonia bataticola* in sunflower seeds grown in Rajasthan. *Journal of Mycology and Plant Pathology* **29**(2) 255-266.

Gonzalez M, Figlas D, Devalis R, Delmostro S and Carretto N (2002). Sunflower seed hull as a main nutrient source for cultivating *Ganoderm lucidum*. *Micologia Aplicada International* **14**(2) 19- 24.

Gowdar H, Rameshbabu N, Reddy NA, Rajeshwari N and Krishnappa M (2007). Seed-borne mycoflora associated with sunflower seeds. *Research on Crops* **8**(2) 469-473.
Hatim M and Abassi GQ (1994). *Oil Seed Crop Production*, (National Book Foundation, Islamabad, Pakistan) 330-383.
Hiremath PC, Lokesh MS and Kulkarni MS (1993). Seed borne nature of *Alternaria helianthi* and its effect on seed germination of sunflower. *Karnataka Journal of Agricultural Sciences* **6** 68-69.
Hussain SZ, Anandam RJ and Rao AS (2000). Effect of different fungicides and homeopathic drugs on seed borne fungi of sunflower (*Helianthus annuus* L.). *Indian Journal of Plant Protection* **28**(2) 148- 151.
Jamaluddin, Goswami MG and Ojha BM (2004). *Fungi of India (1989-01)* (Scientific Publishers (India) Jodhpur, India) 326.
Jeffrey KK, Lipps PE and Herr LJ (1985). Seed-treatment fungicides for control of seed- borne *Alternaria helianthi* on sunflower. *Plant Disease* **69** 124-126.
Jhamaria SL, Sharma KB and Gupta RB (1975). Fungi intercepted from sunflower seeds and their control. *Indian Journal of Mycology and Plant Pathology* **5** 212.
Kaur J, Chahal SS and Aulakh KS (1990). Differential efficiency of different methods in detection and location of seed borne fungi in sunflower. *Plant Disease Research* **5**(1) 53-58.
Kochhar SL (2004). *Economic Botany in the Tropics*, (Macmillan India Limited, Daryaganj, New Delhi, India) 604.
Krishnappa M and Shetty HS (1990). Location of *Alternaria* species in sunflower seeds. *Plant Disease Research* **5** 203-204.
Kumar K, Singh J and Yadav MD (1997). Fungi associated with linseed seeds, their effect and chemical control. *Annals of Plant Protection Sciences* **5**(2) 179-183.
Kumar V and Dwivedi RS (1981). Mycoflora associated with floral parts of sunflower. *Indian Phytopathology* **34**(30) 314-317.
Laxminarayana RMS (2006). Studies on seed-borne fungal diseases of sunflower and their management with special reference to the Alternaria blight. University of Agricultural Sciences, Dharwad 134.
Lipps PE and Herr LJ (1986). Reaction of *Helianthus annuus* and *Helianthus tuberosus* plant introductions to *Alternaria helianthi*. *Plant Disease* **70** 831-835.
Lodha S and Kothari DV (1988). *Indian Phytopathlogy: A Classified Index with New Host Records (1948-1985)*, (Nidhi Publisher, Jodhpur (Rajasthan), India) 236.
Masirevic S and Jasnic S (2006 b). Wilt of sunflower. *Biljni- Lekar- Plant- Doctor* **34**(4/5) 333-335.
Mishra RP, Kushwaha US, Khare MN and Chand JN (1972). Rhizopus rot of sunflower, in India. *Indian Phytopathology* **25** 236-239.
Morar MV, Dancea Z, Bele C, Salegean D, Beke A and Baonca I (2004). An approach upon the qualities of the raw material and raw oil from sunflower seeds resulting in process of low capacities. *Buletinul-Universitatii-de-Stiinte- Agricole-si-Medicina-Veterinara-Cluj-Napoca- Seria-Agricultura* **60** 381-384.
Morris JB, Yang SM and Wilson L (1983). Reaction of *Helianthus* species to *Alternaria helianthi*. *Plant Disease* **67** 539-540.
Mukherji KG and Bhasin J (1986). *Plant Diseases of India,* (Tata Mc Graw Hill Publishing Company Limited, New Delhi, India) 133-34.
Nahar S, Mushtaq M and Hashmi MH (2005). Seed-borne mycoflora of sunflower (*Helianthus annuus* L.). *Pakistan Journal of Botany* **37**(2) 451-457.
Neergaard P (1956). Arsbertzing vadrende trapatologisk Kontrol. St Plantetilsya, *Statens*
Neergaard P (1977). *Seed Pathology*, **I and II**, (MacMillan Press, London, U.K) 1187.
Novotel'nova NS (1966). *Downy Mildew of Sunflower*, (Russia, Moscow, USSR: Nauka) 112.
Papavizas GC (1973). Status of biological control of soil borne plant pathogens. *Soil Biology and Biochemistry* **5** 709.
Prasad RD and Kulshreshta DD (1999). Acetone infusion of fungicides in sunflower seed for the control of *Alternaria helianthi*. *Seed Research* **27** 217-219.

Prasad RK and Das SR (1986). Effect of methoxy-ethyl mercury chloride on control of seed-borne Alternaria leaf blight of sunflower. *Seed Research* **14** 248-249.

Ramegowda (1980). Studies on seed viability in relation to storage in sunflower. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore 120.

Rangaswami G and Mahadevan A (2008). *Diseases of Crop Plants in India*, (PHI Learning Private ltd, New Delhi, India) 339.

Rao MSL, Kulkarni S, Kulkarni VR and Mesta RK (2007). Efficacy of seed dressing fungicides, bio-agents and storage containers against seed-borne infections of sunflower in storage. *Annals of Biology* **23**(1) 57-63.

Rauf Bhutta A, Rahber Bhatti MH, Nizamani SM and Ahmad I (1997). Studies on effect of seed-borne fungi on germination of sunflower. *Helia* **20** 35-42.

Raut BT and Somani RB (1987). Efficacy of different fungicides. IV. Field trials on root rot of chickpea. *PKV Research Journal* **11** 182-184.

Raut JG (1985). Location of *Alternaria helianthi* in sunflower seed and its transmission from seed to plant. *Indian Phytopathology* **38** 522.

Raut JG 1987. Detection of *Macrophomina phaseolina* in sunflower seeds. *Seed Research* **15** 102-103.

Raut JG and Bhombe BB (1983). Efficacy of some fungicides and hot water in the control of seed-borne infection of *Macrophomina phaseolina* in sunflower. *Indian Phytopathology* **36** 294-296.

Ravishankar V and Mamatha T (2005). Seedling disease of some important forest tree species and their management. *Working Papers of Finish Forest Research Institute 11*, Mysore, Karnataka 51-63.

Reddy MJ (1993). Varietal differences in seed mycoflora of sunflower. *Seeds and Farms* **15** 17-20.

Reddy PC and Gupta BM (1977). Disease loss appraisal due to leaf blight of sunflower incited by *Alternaria helianthi*. *Indian Phytopathology* **30** 569-570.

Richardson MJ (1979). *An Annotated List of Seed-Borne Diseases*, (International Seed Testing Association, Zurich, Switzerland) 320.

Richardson MJ (1981). *An Annotated List of Seed-borne Diseases*, Supplement 1, (International Seed Testing Association, Zurich, Switzerland) 78.

Richardson MJ (1983). *An Annotated List of Seed-Borne Diseases*, Supplement 2, (International Seed Testing Association, Zurich, Switzerland) 108.

Sackston WE (1981). The sunflower crop and disease: Progress, Problems and Prospects. *Plant Disease* **65** 643-648.

Sadashivaiah AS, Ranganathaiah KG and Nanje Gowda D (1986). Seed health testing of *Helianthus annuus* with special reference to *Macrophomina phaseolina*. *Indian Phytopathology* **39** 445-447.

Sahu BK, Ghemawat MS and Agrawat JM (1991). Survival of *Alternaria helianthi*, the leaf-spot and blight pathogen of sunflower in Kota, India. *Acta Phytopathologica et Entomologica Hungarica* **26** 321-326.

Salustiano ME, Machado J daC and Pittis JE (2006). Comparison of two health methods in the detection of *Alternaria helianthi* in sunflower seeds. *Fitopatologia-Brasileira* **31**(3) 322- 324.

Sexena N and Karan D (1991). Effect of seed-borne fungi on protein and carbohydrate contents of sesame and sunflower seeds. *Indian Phytopathology* **44**(1) 134-136.

Shahnaz D and Ghaffar A (1990). Location of fungi in sunflower seed. *Pakistan Journal of Botany* **22**(2) 117- 120.

Shahnaz D and Ghaffar A (1991 a). Detection of seed-borne mycoflora of sunflower. *Pakistan Journal of Botany* **23**(2) 173-178.

Shahnaz D and Ghaffar A (1991 b). Detection of Aflatoxin in Sunflower seed. *Pakistan Journal of Botany* **23**(1) 123-126.

Sharfun-Nahar, Mushtaq M and Hashmi MH (2005). Seed-borne mycoflora of sunflower (*Helianthus annuus* L.). *Pakistan Journal of Botany* **37**(2) 451-457.

Sharma OP (2006). *Hill's Economic Botany* (Tata Mc Graw - Hill Publishing Company ltd. 252.

Singh BK and Prasad T (1977). Effect of seedborne fungi on the Physico-chemical properties of sunflower oil. *Phytopathologische Zeitschrift* **90** 337-341.
Singh BK and Prasad T (1986). Changes in cholesterol content in sunflower seeds due to fungal infestation. *Indian Phytopathology* **38**(4) 666-667.
Singh RD and Kaiser SA (1995). Evaluation of some systemic and non-systemic fungicides against the charcoal rot pathogen *Macrophomina phaseolina* (Tassi) Goid. of maize. *Journal of Tropical Agriculture* **33** 54-58.
Straser N (1985). Mycopopulation of sunflower seed from a 1984 large plot trial treated with fungicides. *Savremena Poljopriverda* **33**(3/4) 179-184.
Svetov VG (1975). *Alternaria* blight of sunflower along the Kuban River. *Miklogiya Fitopatologia* **9** 418-421.
Taylor AG and Harman GE (1990). Concepts and technologies of selected seed treatments. *Annual Review of Phytopathology* **28** 321-339.
Theradimani M and Marimuthu T (1993). Effect of decomposed coconut coirpith on damping-off of chillies and root rot of blackgram. *Plant Disease Research* **8** 1-5.
Tourvieille J, Roeckel Drevet P, Nicolas P and De Labrouhe D (1996). Characterization of sunflower downy mildew (*Plasmopara halstedii*) races by RAPD. In: *Proceedings of the 14th International Sunflower Conference*, Beijing 781-785.
Vaidehi BK (2002). Seed mycoflora of sunflower - a perspective. *Frontiers in Microbiology, Biotechnology and Plant Pathology* **23** 25-40.
Venkataramana, Nagaraju, Jagadish GV and Jayaramegowda (1995). Severity of rust and Alternaria leaf spot in relation to different sowing dates in parental lines of sunflower hybrids. *Journal of Oilseeds Research* **12** 146-148.
Vidhyasekaran P, Rabindran R, Muthamilan M, Kamala N, Rajappan K, Kumar V and Dwivedi RS (1981). Mycoflora associated with floral parts of sunflower. *Indian Phytopathology* **34** 314-317.
Vijayalakshmi M and Rao AS (1986). Mycoflora invading sunflower seeds during development. *Acta Botanica Indica* **14**(1) 1-7.
Wadhwani K (1982). Thermophilous and thermo-tolerant fungi associated with sunflower seeds. *Indian Phytopathology* **35** 162-164.
Wagan KH, Pathan MA and Jiskani MM (2006). Effect of *Alternaria helianthi* on disease development, germination and seed quality in sunflower. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences* **22**(1) 26-29.
Zad J (1978). Transmission of sunflower downy mildew by seed. *Iranian Journal of Plant Pathology* **14** 1-2.
Zad J (1979). A note on the mycoflora of sunflower seeds in Iran. *Iranian Journal of Plant Pathology* **15** 953-956.