

**STUDIES ON FUNGAL DISEASES OF OPIUM POPPY
(*Papaver somniferum L.*) IN EASTERN UTTAR
PRADESH AND THEIR CONTROL THROUGH
NATURAL (PLANT) PRODUCTS**

THESIS

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“ If thou shoudst say, “ It is enough,
I have reached perfection, all is lost,
for, it is the function of perfection to
make one know one’s imperfection.”

-Augustine

“अगर तू यह दावा करता है कि बस
जानने के लिए कुछ शेष नहीं रहा,
ज्ञान की पूर्णता मैंने प्राप्त कर ली है।
तो समझ ते तूने सब कुछ गंवा दिया,
क्योंकि पूर्णता की मूल प्रक्रिया ही
यह जताने के लिए है कि तूने अभी
तक कुछ भी नहीं प्राप्त किया है।”

—आगस्टीन

CERTIFICATE

Certified that:

- (i) The thesis entitled, “STUDIES ON FUNGAL DISEASES OF OPIUM POPPY (*PAP~~A~~VER SOMNIF~~E~~RUM* L.) IN EASTERN UTTAR PRADESH AND THEIR CONTROL THROUGH NATURAL (PLANT) PRODUCTS”, embodies the original work of Mr. Raj Kishore himself.
- (ii) The candidate worked under my guidance and supervision for the period required under the Ph.D. Ordinance IX.
- (iii) He has put in the required attendance in the Department of Botany, M.L.K. Post-Graduate College, Balrampur, during that period.

signed

(Dr. D.S. Shukla)

Supervisor

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INTRODUCTION

The opium poppy (*Papaver somniferum* L.) is a dicotyledonous plant belonging to the group – Polypetalae, series – Thalamiflorae and family – Papaveraceae. A native of Asia Minor, it is indigenous to mediterranean coastal region and is distributed across the world extending up to 60° N in northwest Soviet Union with the southern limit reaching almost the tropics (Veselovskaya, 1976). It has been legitimately cultivated in India, Iran, China, Egypt, France, Holland, Hungary, Greece, Spain, Portugal, Italy, Turkey, U.S.S.R., Yugoslavia, Japan, Bulgaria and Pakistan (Ramanathan and Ramachandran, 1977; INCB, 1981). It was identified as a useful plant perhaps, right in the neolithic era (nearly 8,000 years ago). Its sleep inducing property was well known to the Greeks since 6th century BC when Hypnos (Morpheus), the Greek God of Sleep, was depicted holding a poppy stem in his hand (Veselovskaya, 1976). However, the oldest reference to this plant is found from Mesopotamia, where, it is mentioned in the “Assyrian Herbal” list. The people of Mesopotamia used it as a medicine about 4,000 years ago (Jurgan, 1962). Opium poppy is one of the few medicinal plants grown over thousands of years (Neligan, 1927) for opium alkaloids which are frequently used as analgesic, antitussive, antispasmodic and as a sedative in modern medicines. Besides, opium poppy seeds, as such, are edible and find considerable usage in culinary and food industries in India and a small part of the seed finds export market, mainly in the countries of Asia and Africa.

In India, the cultivation of opium poppy was established by early 13th century (Anonymous, 1966; Veselovskaya, 1976). It became a considerable source of revenue to the successive governments.

The seeds are a rich source of fatty oil and protein. Many European countries grow it as a source of opium seed oil, which is used for

comestible and industrial purposes. However, in India it is a dual purpose crop, grown for, opium and seeds both.

The opium poppy plant is also important in apiculture (bee-keeping) as its flowers produce large quantity of pollens which is used by bees to feed their young ones.

The genus *Papaver* consists of many species, six of these widely available in India are: *P. rhoeas*, *P. nudicaule*, *P. orientale*, *P. argemone*, *P. dubium* and *P. somniferum* (Anonymous, 1966). While majority of these are renowned for their exquisite flower colour, only the *P. somniferum* is of great medicinal importance. It is economically most viable as it contains such therapeutically important opium alkaloids, viz., morphine, codeine, narcotine and papaverine etc. which manifest sedative, antispasmodic, antitusive and analgesic activities.

The opium poppy (*P. somniferum*) is an annual herb with thick pithy stem. It grows erect, rarely branched, usually glaucous, 60-120 cm in height. Leaves are sessile, oval ovate or obvate oblong, irregularly lobed with cordate amplexicaule base enveloping the stem, dentate or serrate. Flowers are solitary on long peduncle, bisexual, regular and hypogynous usually white with a blue tint, sometimes purple or variegated. They contain no honey. Fruit is a capsule, large up to 2.5 cm in diameter, globose to spherical, stalked, when immature covered with a waxy coating which imparts greyish blue tint to the capsule, pale brown when mature. Seeds are numerous, reniform, generally white but grey in some 'malwa' forms. Seeds contain fixed oils. The plant is cultivated as Rabi (winter) crop.

India is gross producer of opium and responsible for more than seventy per cent of the world output of opium and eighty per cent of it is exported

annually. A substantial part of this produce comes from eastern Uttar Pradesh.

The crop is a host to several pathogens. Although poppy is cultivated in eastern Uttar Pradesh since long time, very little attempt has been made to investigate the diseases occurring in this region. Ways open to produce more opium are, either to put a larger acreage under poppy cultivation or to control the various diseases of the crop. The first aspect is, however, not possible due to increasing pressure of population. Therefore, the systematic survey of the diseases of opium poppy and their effective, economical and safe control is a great necessity.

The crop is infected by a number of phytopathogenic fungi, bacteria and viruses. Besides, as the crop is raised only from the seeds, any factor affecting seed vigour and viability assumes vital importance. However, majority of the diseases are caused by fungi belonging to various groups. As such, fungal diseases are of paramount importance. The diseases caused by such phytopathogenic microbes can be categorised as follows:

- (i) Fungal diseases of major importance
 - (A) Seed borne fungal diseases
 - (B) Other fungal diseases
- (ii) Fungal diseases of minor importance

A perusal of literature reveals that much of the work on disease management and control has been done with the help of usual synthetic commercial fungicides. During recent years, several of these are being used with caution due to their undesirable side – effects, such as phytotoxicity, carcinogenicity, teratogenicity, residual and pollutive effects. In recent years, several workers have controlled plant diseases through the use of various

natural (plant) products providing less phytotoxic, more systemic, easily biodegradable with stimulatory host metabolism activities (Tripathi, 1981; Beye, 1978 ; Tereziz, 1978; Dixit *et al* .,1978)

So far, no work has been done to evolve an effective and safe control measure to control the fungal diseases of opium poppy through the use of natural (plant) products either in India or in any other part of the world.

As such, the present project was undertaken with a view:

- (i) To record the incidence of various fungal diseases (mentioned above) through a systematic survey of major opium growing areas of eastern Uttar Pradesh.
- (ii) To screen various available natural (plant) products against fungal pathogens of opium poppy, both *in vitro* and *in vivo* conditions.
- (iii) To establish the most effective natural (plant) product (s) as found effective in *in vivo* screening as economical and safe control tool against major fungal diseases of opium in conditions prevailing in eastern Uttar Pradesh.

REVIEW OF LITERATURE

As the opium poppy (*Papaver somniferum* L.) crop has a worldwide distribution, it has attracted the attention of plant pathologists all over the world. A critical review of literature revealed that majority of the diseases are caused by fungi belonging to various groups. The fungal diseases recorded so far in India and abroad can be categorised as follows:

- (i) Fungal diseases of major importance
 - (A) Seed borne fungal diseases

- (B) Other fungal diseases
- (ii) Fungal diseases of minor importance
- (iii) Fungi recorded from dead plant parts

The literature available regarding these categories are discussed as follows:

(i) Fungal diseases of major importance

(A) SEED BORNE FUNGAL DISEASES

Investigation on seed mycoflora of the opium poppy have been carried- out by several workers in different parts of the world . The literature on the fungi inciting various seedborne diseases is discussed here.

Pleospora calvescens was found to be the most destructive pathogen in Bulgaria (Christoff, 1930). Most of the seeds contained in infected capsules were found infected by the fungus. Such seeds either have a very low viability or do not germinate at all. *Fusarium scirpi* var. *caudatum* was observed as a semi- parasite capable of attacking the seeds in Bulgaria (Christoff. 1934). Neergaard (1937) reported severe infection of opium poppy seeds by *Helminthosporium papaveris* in Denmark. Disorganisation of the seed – embryos due to the infection of *Pleospora calvescens* was reported by Ekstrand (1941) from Sweden. Christoff (1943) observed that in Bulgaria seed infections are usually caused by *Peronospora arborescens*, *Pleospora calvescens*, *Alternaria brassica* var. *somniferum*, *Fusarium scirpi* var. *caudatam*, *Mycosphaerella tulasnei* and *Ophiobolus sativus*. Simultaneously, *Macrosporium bresadolae*, *Fusarium* sp., *Penicillium* sp. and *Mucor mucedo* were also, though, rarely found associated with opium poppy seeds.

Pleospora calvescens was often detected in samples of opium poppy seeds in Denmark (Neergaard, 1949, 1950 and 1951). Ballarin (1950)

observed that on diseased poppy seeds, the conidiophores of *H. papaveris* were abundantly branched and when such contaminated seeds germinate, more diseased seedlings were found on acid medium than on alkaline medium. *Pleospora papaveracea* and *Peronospora arborescens* were found to contaminate the seeds and cause appreciable degree of damage in Turkey (Gobelet, 1956). Kutova and Bankova (1975) reported the infection of opium poppy seeds by *P. calvescens*. *Dendryphion penicillatum* was isolated from opium poppy seeds in Denmark (Neergaard, 1956). Seed infection due to *Dendryphion papaveris* (*P. papaveracea*) was found high in samples from infested areas in Turkey (Karahan and Maden, 1978). Seed transmission to seedlings occurred at nearly the same rate as seed infection.

Peronospora arborescens was found to cause extensive damage in all important opium growing regions of Poland as seed-borne pathogen (Pietkiewicz, 1958). Detailed investigations concerning the control of downy mildew confirms the positive role of the seed in transmitting the causal organism, *P. arborescens* (Alavi, 1975).

Zarzyca (1958) isolated *Mucor* spp., *Rhizopus nigricans*, Yeasts, *Pleospora calvescens* (conidial state of *H. papaveris*), *Gloeosporium* sp., *Alternaria* spp., *Fusarium scirpi* var. *caudatum*, *Fusarium concolor*, *Cladosporium herbarum*, *Penicillium* spp., *Trichothecium roseum*, *Aspergillus* spp., *Trichoderma* sp. and *Pullularia pullulans* from opium seeds collected from different regions of Poland. But in pathogenicity tests only *Helminthosporium papaveris*, *Fusarium scirpi* var. *caudatum* and *Alternaria* spp. were found to be injurious for seeds and seedlings and these occurred as internal pathogens. Out of these three, she observed that the fungus *Helminthosporium papaveris* is the most noxious for seeds and seedlings of the opium poppy. Czyżewska and Zarzyca (1967) also reported the infection of opium poppy seeds by the fungus

Helminthosporium papaveris (perfect state *Pleospora papaveracea*). Reinmuth (1943) reported the infection of opium poppy seeds by *Helminthosporium papaveris*. The fungus apparently was found as a permanent element of seed mycoflora in samples taken at various locations and in various harvest years (Blotnicka, 1976) . Seedlings which develop from such seeds, were found infected up to 90 per cent . Anatomical investigations of heavily infected seeds revealed that no mycelium was present in embryo or endosperm but in seedling stage, the fungus infects the primary cortex.

The control measures recommended by Christoff (1930) were strict sanitation of seed beds and fields including incineration of the plant debris and stubble, use of disease free seed and appropriate crop rotation. Some measures of control was also obtained by steeping seeds from diseased plants for one hour in 0.25 to 1 per cent Upsulum-Universal, 0.25 to 0.5 per cent Germisan, 0.05 per cent Mercuric Chloride , or 0.5 per cent Chigosan. Satisfactory results could also be obtained by spraying the diseased plants with 3 to 5 per cent Bordeaux mixture, or with 2 per cent Tutokilla or else by dusting with Nosperit. He further recommended the disinfection of the seeds by 0.25 per cent formaldehyde for 15 minutes and spraying of bolls with one per cent Bordeaux mixture and resin soap (Christoff, 1943).

Kutova and Bankova (1975) reported that seed treatment with 0.02 per cent of Zinc Sulphate and 0.2 per cent of Copper sulphate for six hours eliminates the seed infection by *P. calvescens*. Karahan and Maden (1978) found that in seed treatment trials, out of Benlate (Benomyl), Captan and Thiram + Vitavax (Carboxin), the last gave the best result. Out of five chemicals tested by Alavi (1975) Bisdithane was significant at 1 per cent and Benlate was the next most effective chemical.

(B) OTHER FUNGAL DISEASES

The various other fungal diseases recorded so far, are reviewed as follows:

SEEDLING INFECTION AND DAMPING – OFF

Severe infection of opium poppy seedlings caused by *Helminthosporium papaveris* was reported for the first time from Denmark (Neergaard, 1937). Opium poppy seedlings sustain heavy damage in Switzerland caused by *Pyrenophora (Pleospora) calvescens* (Zogg, 1995). *Helminthosporium papaveris* (*P. calvescens*) was also found responsible of ‘abstriction’ of the seedlings in Germany (Gassner, 1949). Ballarin (1950) observed that when the seeds were contaminated with *H. papaveris*, more diseased seedlings were found. Seedlings developed from the seeds which were infected up to 90 per cent with the fungus *H. papaveris*, showed narrowing of hypocotyl (Blotnicka, 1976). Anatomical investigations of the diseased seedlings revealed the presence of fungus in the primary cortex.

Barbacka (1936) reported that *H.papaveris* causes a serious damping – off of cultivated poppy (*Papaver* spp.). Damping–off disease of opium poppy seedlings caused by *Rhizoctonia solani* has been reported from Pakistan in mild form (Zaman and Khan, 1969) . *Dendryphion pencillatum* (conidial state of *Pleospora papaveracea*) was found responsible to cause damping–off of opium poppy seedlings in Tasmania (Munro. 1978). Control measure recommended was seed dressing with Captan @2 g/kg of seeds.

SEEDLING BLIGHT

Christoff (1934) reported that the opium poppy seedlings raised from the seeds infected with *Fusarium scirpi* var. *caudatum*, suffers severely from a blight caused by the fungus. A root blight of oil poppy seedlings, caused by *Pleospora calvescens* was reported to assume serious proportions by Bergstrom (1942). Dipping the seeds in 1.5--3 per cent aqueous solution of the usual disinfectants checked the disease without impairing germination whereas dry infectants gave less effective control.

Seedling blight of opium poppy has been reported to be a serious disease in Australia. Angell (1950, 1951) found that *Pythium ultimum* and *Pythium mamillatum* were responsible for this disease. Several pathogenic isolates of *P. ultimum* and *P. mamillatum* were investigated for their role on crop stand. Experiments conducted using different seedling blight potential

soils showed that seedling blight was physiogenic as well as pathogenic. Studies also revealed that both *Pythium* species, with four isolates were found pathogenic to opium poppy and were well distributed throughout Australia (Angell, 1952). He also observed that both *Pythium* spp. invade the roots of the dying seedlings and cause them to succumb more quickly. The character of the experimental soils also pre-disposes poppies to attack by *Pythium* spp.

Angell and Hills (1957) observed that fungicidal seed dressing failed entirely to control seedling blight in sterilized soil, though there was a fall stand of healthy seedlings in limed soil sown at the same time. Besides, farmyard manure or complete nutrient solution did not reduce seedling blight in potted soil. However, both in greenhouse and in the field adequate control was found by addition of lime to the soil. In the field experiments, lime distributed along the rows at the rate of 56 lb / acre or worked into the soil before seeding at 1.0 60 lb/ acre gave, respectively, 17.5 and 26.5 seedling per foot of row after six weeks, as against 13.3 in unlimed rows.

A seedling blight of opium poppy was also observed in Netherland, caused by *Pleospora papaveracea* (*Pyrenophora calvescens*) but the fungus attacks only dying tissues and should not be considered as a parasite (Mass Geesteranus, 1960). Seed treatment with Thiram or Captan can partly suppress the disease.

DOWNY MILDEW

Out of other fungal diseases , downy mildew is one of the serious and widespread disease of opium poppy (*Papaver somniferum* L). It is caused by *Peronospora arborescens* and acts as a limiting factor in opium poppy cultivation.

Work done abroad

Severe attack of *P. arborescens* was reported by Gaumann (1923) and Van Poeteren (1923). Gaumann considered *P. arborescens*, a biologically specialized form on *P. somniferum*. Prochaska (1928) and Proshikina (1928) observed that opium poppy crop was heavily damaged by downy mildew in Lower Austria and Ukraine respectively. Prochaska (1928) reported that the disease was most conspicuous on *Esterhaza* variety showing 60-70 per cent and least so (15 per cent) on a Burgenland variety . Other varieties also showed more or less heavy infection (30-70 per cent). Seeds from abnormally small and malformed capsules failed to germinate in laboratory tests. Fokin (1922) reported that *P. arborescens* caused hypertrophy and curvature of the stem and flower stalks.

Yossiflovitch (1928) observed that the pathogen caused enormous damage to the opium poppy cultivation by reducing the crop by one-half or

two-third in some districts of southern Serbia and in some cases, totally destroyed it . He found that the disease appeared early in May in sheltered localities while a little later in exposed regions. The infection spread upwards from the lower leaves and entire leaf surface was covered by the downy mildew coating. The lower leaves were completely dry by the beginning of June, while the middle ones were covered with numerous brown patches. The stems and even the capsules were also attacked, the stem bases often being girdled resulting in premature death of the plant . It was also observed by the author that the disease continued to spread even in very dry weather during the May, showing that humidity was not essential to the development of the pathogen.

Besides, the author observed that the seedlings may be infected by the pathogen at the time of their germination and new infections occurred during the whole period of growth. All the aerial parts being equally susceptible to the disease. Plants that were infected in the cotyledonary stage were mostly killed outrightly. When infection occurred in young established plants, the growing point was almost diseased. All the new leaves becoming infected from the very start and being rapidly killed while in older plants (from six leaves onwards) the disease may assume two forms (Yossiflovitch, 1929). He also observed that fragments of diseased capsules were dangerous source of infection when mixed with seed. Symptomatology, mode of mycelial

entrance at inter cellular level of the host and morphology was also described by him.

Severe outbreaks of *P. arborescens* were observed in opium poppy in England, Scotland and Ireland (Cotton, 1929). Skoric (1930) reported that *P.arborescens*, a serious parasite of the opium poppy in Yugoslavia, was a specialized form of the fungus. Lindquist (1939) and Petrak and Esfandiari (1941) reported the presence of *P. arborescens* for the first time in Argentina and Iran, respectively. *P.arborescens* was found restricted to certain districts in U.S.S.R. (Kratichvil and Zakopal, 1948).

Christoff (1943) reported that *P. arborescens* caused spotting of bolls and moulding of seeds with several other fungal pathogens. Darpoux (1945) observed that *P. arborescens* causes slight damage to the crop in Versailles . Schmidt (1949) observed that opium poppies were severely attacked by *P. arborescens* in Austria. Pietkiewicz (1958) found that seed-borne *P._arborescens* was found in all the important opium poppy growing regions in Poland, causing extensive damage to the crop. Behr (1956) and Scharif (1970) carried out comprehensive studies on the biology of downy mildew , especially on the symptomatology, disease development and control. Leiteritz and Roder (1980) also carried out studies on symptomatology of *P._arborescens* whereas Ikata and Yamauti (1941) studied on haustoria of *P._arborescens*. They found that haustoria of the pathogen were complicated in shape and the young

haustoria were sac-shaped, bending and dividing into a few branches at maturity, and development being sparse measuring 30-70 or upward of 200 x 2-5 μ .

The disease was observed to be epiphytotic in Hungary and Germany (Moesz, 1938 ; Masurat and Stephan, 1963). Infection of *P. arborescens* in a mild form was also reported from England, Ajarbaijan , Bucharest, Denmark and Poland (Beaumont ,1953 ; Dzhaifrov, 1960 ; Elaide ,1960 ; Stapel, 1960 and Wronska , 1980). Zyubin (1963) observed that the plants which were infected with the local form of *Peronospora* reduced the yield of opium by 5-20 per cent and the yield of seeds by 50-70 per cent.

Alavi (1974, 1975) observed the disease in most of the opium poppy cultivating regions of Iran and sometimes with heavy loss. He found that the disease was seed transmitted. Rundy (1976) found *P. arborescens* as the main pathogen of opium poppy attacking poppy heads up to 14.65 per cent while causes losses in seed yield from 7-37 per cent .

Work done in India

Very little work has been done in India so far on this disease. Cunningham (1897) and Sydow and Butler (1911) reported the occurrence of *P. arborescens* as a new pathogen record. Butler (1918) reported that downy mildew causes 20-30 per cent loss in yield of opium poppy.

Kothari and Prasad (1970) reported the occurrence of downy mildew disease in Rajasthan and found it to be of epiphytotic nature. The crop suffers heavy loss in Rajasthan due to this disease. The severely infected plants were present throughout the crop period but incidence was highest at seedling level. After first appearance of the disease on lowermost leaves, all leaves were covered by leaf spots within 60-80 days. They further reported that heavy incidence (severely infected plants) occurred in those fields where poppy was regularly cultivated in consecutive years. The authors found that the disease manifests itself in two forms i.e. (i) systemic infection and (ii) local infection. Histopathology, pathogenicity with conidia and oospores, host range, infective period of oospore, role of seeds in perpetuation of the fungus, biology of the pathogen and control of the disease through synthetic fungicides has been discussed in detail by the authors.

Sekhawat and Kothari (1971) studied the biochemical changes, especially changes in the composition of the healthy and downy mildewed plants and found that the concentration of a number of amino acids were either reduced or remains unchanged except for tyrosine, which was absent in samples of diseased plants with an increase in an unknown amino acid.

Ramanathan and Ramachandran (1977) found that cloudy weather and high humidity in the atmosphere were favourable conditions for the infection and spread of the diseases. Thakore *et al.*, (1983) observed that the

secondary infection of downy mildew was found to reduce latex yield from 17-22.8 per cent and its morphine content and seed yield from 12.9-14.8 per cent .

Prochaska (1928) suggested crop **rotation**, wide- spacing , avoidance of seeds from abnormally small and malformed capsules for sowing purpose and the avoidance of low-lying damp sites for poppy cultivation. He also suggested control **of** the downy mildew caused by *P. arborescens* in fresh and infected fields by immediate destruction of infected plants. Yossiflovitch (1929) recommended a proper crop rotation (at least of three years), the removal of diseased plants and debris from the field either destroying them by fire or by deeply dug in, the incineration of the stubbles after harvest and the use of pure seed from healthy plants for control of the downy mildew.

Christoff (1943) also recommended the destruction of the stubbles of the poppy crop, use of disease free seeds and **disinfection of the seed by 0.05 per cent Mercuric chloride for one hour or 0.25 per cent** Formaldehyde for 15 minutes and spraying the plants especially the bolls with one per cent Bordeaux mixture with resin soap for control of the disease.

Darpoux (1945) suggested seed disinfection while Beaumont (1953) recommended spraying of seed beds with 0.5 per cent Bordeaux mixture or other copper fungicides for control of the disease. **Seed treatment with Granosan @10 g/kg of seed for 7 days before planting, 5 g/kg of seed for 1**

month before planting was recommended by Zyubin (1963) as control measure . Treatment of the soil, especially selective treatment was reported to improve the yield. High yield was also reported to obtained by a crop rotation of 4 years. Removal of plant debris and ploughing the field at the same time was recommended as prophylatic measure.

Kothari and Verma (1967) reported the control of downy mildew by root application of fungicides. Out of 5 fungicides tested , 75 per cent Zineb (Dithane Z-78), Ferbam and Bisdithane (Bis-D) (a manganese and zinc salt of dithiocarbamate) gave 51 per cent control. Kothari and Prasad (1970) reported the control of primary infection of *P. arborescens* oospore infection by application of Dithane Z-78 (0.4 per cent) as a drench treatment of soil . However, Captan treatment was not recommended as this fungicide inhibited seed germination of opium poppy .They also reported the control of secondary infection by foliar application of 12 chemicals including two systemic fungicides and antibiotic. Although the 12 chemicals were found effective in controlling the disease but Bisdithane proved the best fungicide showing 85.62 per cent disease control. They also recommended a three year gap in cultivation of two consecutive crops in the same field and destruction of infected plants by burning in the field as prophylatic measure.

Alavi (1975) tested five fungicides to control the downy mildew disease and found that 3 sprays of Bisdithane at 0.15 per cent gave significant result

followed by Benlate at 0.05 per cent. Crop rotation of 4 to 5 years with one year follow was also recommended. Incineration of diseased plants was also found advantageous. Seed dressing with Zaprwa Nasienna T and spaying the plants with Cynkotox, and Dithane M- 45 (mancozeb) were found to be the best protective measures (Rundy, 1976) . Ramanathan and Ramachandran (1977) found that spraying of Dithane Z-78 and Dithane M-45 or Cosan or Copper oxychloride (blue copper) at early stages of growth of the poppy prevents the attack and spreading of the disease. Leiteritz and Roder (1980) suggested spraying of Dithane M-45 @1.8 kg /ha for the control of the disease.

Out of 7 fungicides tested ,Thakore *et al.*, (1983) found Dithane M-45, @4 gm/kg of seeds , best in reducing the primary infection of the disease, Agrosan GN , Difolatan and Bangtan also reduced the primary infection of the disease. Among the 9 fungicides tested for control of the secondary infection, only Dithane M-45 at 0.4 and 0.3 per cent concentrations was found to control the disease severity and increase the latex and seed yields and as well as morphine contents . Gupta (1984) recommended the treatment of seeds with 4-6 g/kg of Apron -35 to control the downy mildew infection .

Three sprayings of 0.2 per cent Ridomil WP at the interval of 15 days from the appearance of first symptoms of infection provide better control (85 per cent PEDC) than any other known fungicide (Gupta, 1984). In the

absence of this chemical, he found that 4 spraying of Dithane M-45 at 0.3 per cent at an interval of 10-15 days protects the crop (55 per cent PEDC) from the disease. Crop rotation and avoidance to grow poppy crop in already infested fields was also recommended by the author.

WILT DISEASE

Wilt of opium poppy caused by *Verticillium* sp. was reported for the first time from Holland (Vander Meer, 1925). Reinmuth (1942) reported a wilt of oil poppy plants caused by *Pleospora calvescens* (*Helminthosporium papaveris*), which was found to be a dangerous parasite causing severe decrease in yield. The disease, generally first attacked the younger plants at the base of stem which they generally survived while on older plants, leaves beginning from the base, faded and dry up. Infection and necrosis of the stem, especially in vicinity of the vascular bundles, diminishes the supply of water to the leaves, resulting in wilting of the whole plant. The disease was more severe in dense fields than those with a more open stand. Another poppy wilt attributed to *H. papaveris* has been reported from Versailles (Anonymous, 1945). *H. papaveris* (*P. calvescens*) causes abstriction of the seedlings and more generalized infection of the fungus has been found to cause death of the plants before flowering (Gassner, 1949).

Outbreak of *Fusarium* wilt was observed in several parts of Spain (Navarro De Palencia, 1954). The disease occurred during the advanced stage of growth causing rapid foliar wilt and total desiccation of the plants. The causal organism was identified as *Fusarium martii* or *F. oxysporum* var. *cubense*. The preventive measures recommended were avoidance of planting sites with an acid reaction, application of lime to the soil at the rate of 1,500 to 2,000 kg/ha, crop rotation and cultivation of resistant varieties.

ROOT ROT DISEASE

Work done abroad

A root rot of opium poppy caused by *Sclerotinia sclerotiorum* was reported by Masalab (1938). Opium poppy stands were severely attacked by *Helminthosporium papaveris* (*Pleospora papaveracea*) causing decay of the collar of young plants. Seed disinfection was recommended as control measure (Darpoux, 1945). *Pyrenophora* (*Pleospora*) *calvescens* was found to cause dry root rot of opium poppy (Zogg, 1945). He also observed that the fungus caused girdling of the older plants resulting into collapse of the plants. *P. calvescens* was reported to cause abstriction of root collar (Anonymous, 1947). The root rot observed in Pakistan was found to cause by *Rhizoctonia solani* which appear to be a most damaging disease of opium poppy (Zaman and Khan, 1969).

Dendryphion papaveris (*Pleospora papaveracea*) was reported to inflict considerable damage to opium poppy stands by causing root and collar rot. In control trials, out of three fungicides tested Thiram + Vitavax gave the significant result (Karahan and Maden, 1978). *D. penicillatum* was also reported to affect opium poppy plants by producing dark lesions encircling the roots of mature plants (Munro, 1978). Seed dressing with Captan @ 2 g/kg was recommended as control measure.

Work done in India

A root-rot of opium poppy caused by *Rhizoctonia* sp. was reported by Butler(1918). He found that the disease appears chiefly in badly drained fields and the affected plants begin to wither and dry up from the base. Later *Rhizoctonia bataticola* was found to be responsible for causing root-rot of opium poppy in Rajasthan (Deshpande *et al.*, 1969).

The symptoms of the disease were generally characterized by withering and drying of leaves, early maturity and very little or no opium yield. Discolouration and rotting of roots and the development of abundant dark sclerotial bodies takes place on the outer surface of roots. A *Fusarium* root-rot caused by *F. semitectum* proving serious damage, especially in seedling stage, was also observed in Uttar Pradesh (Janardhanan and Husain, 1983).

LEAF BLIGHT DISEASE

Work done abroad

Leaf blight disease of opium poppy caused by *Helminthosporium* species was reported to be one of the most destructive disease in Bulgaria, Switzerland, Germany, U.S.S.R, Poland, Sweden, England, France, Romania and Yugoslavia.

Girzitska (1928) showed that when slightly scratched leaves of opium poppy were artificially inoculated with the conidia of *Pleospora papaveracea*, infection ensued following formation of diffuse yellow spots followed by the premature dying of the infected tissues. The mycelium from infected leaves advanced to the stem, on which the pathogen produced the perithecia. Christoff (1930, 1948) observed the leaf blight caused by *Pleospora calvescens* and its imperfect state, *H. papaveris* to be the most destructive disease of the opium poppy. He found that the disease developed rapidly under favourable conditions and destroyed entire crop. Although *H. papaveris* was stated to be of common occurrence on cultivated poppy, marked variations were observed in response of different varieties of the cultivated poppy to attack by the fungus in Poland (Barabacka, 1936). Ekstrand (1941) reported the foliar discolouration in opium plants in Sweden due to infection by *P. calvescens*. The crop sustained much less damage in the relatively cool season than in exceptionally warm one, however, when cooler and moisten conditions

developed, the place of *P. calvescens* being largely taken by various combined infections including *Fusarium* spp., *Sclerotium* and *Botrytis* sp. (Reinmuth, 1943).

Pyrenophora (Pleospora) calvescens was found to be the agent of a destructive opium poppy leaf blight, in Switzerland, affecting the plants at all stages of its growth (Zogg, 1945). Leaf shrivelling was also found at the same time. The extension of lesions at optimum temperature was 2-3 mm in the first 48 hours. Later the growth was found more rapid. Continuing his studies on reaction of opium poppies to infection by leaf blight, the author reported that the pathogen penetrates the foliar tissue and ramifies through the intercellular spaces. During this process, toxins were released by the parasite enabling it to assimilate the requisite nutrients. Further, it was found that the host can react to infiltration of the nutrient by forming a gummous demarcation zone extending through 10 to 30 cell layers (Zogg, 1946). Gassner (1949) and Ballarin (1950) observed that in opium poppy stands border plants (two outermost rows) were more severely attacked than those in the interior of plots, and infection gradually increases with dilution of number of plants per unit area. Further the conditions that favour abundant and prolonged vegetation also increase the severity of the disease. He also found that late sowing also contributed to an increase in infection. Meffert (1949,1950) provides informations in the symptomatology of leaf blight of opium poppy caused by

Pleospora papaveracea and the taxonomy of the causal organism. The author argued that as *P. calvescens* was found only on chenopodiaceae and has hairy perithecia, the poppy fungus should be considered to be *Pleospora papaveracea*, as it was confirmed to the genus *Papaver* and has naked perithecia. He further observed that the blight perpetuated through the seeds, to which both mycelium and conidia adhere externally. The development of the pathogen, the course of the disease, and the incidence of infection were dependent on the prevailing weather conditions.

Severe attacks by *Pleospora* and *Helminthosporium papaveris* (*Pleospora papaveracea*) were reported on opium poppy stands in various parts of Yugoslavia and the England, respectively (Milatovic, 1952; Beaumont, 1953). Zambettakis (1952) in a detailed study of poppy leaf blight, covers the history and geographical distribution of the disease, synonymy of the perfect and imperfect states of the causal fungus, its morphology, the development, liberation and germination of the ascospores, host-parasite relationship and control. The author uses the name *Pleospora calvescens* (*H. papaveris*), relegating *P. papaveracea* to synonymy. He further observed that in artificial inoculation experiments with conidia, infection ensued in 4-5 days while when a spore suspension was sprinkled on young and adult plants kept under cloches, lesions developed in 3 hours and the infected leaves withered. The fungal

mycelium spread to the stalk of some plants kept in glass house, and perithecia develops in following autumn.

Incidence of *H. papaveris* on opium poppy varied from 2.48 to 98.7 per cent according to the locality (Marz, 1960). The infection was favoured by high temperature and heavy rainfall particularly in July. Bogarada *et al.*, (1971) reported that *H. papaveris* appears on opium poppy in June and mass infection follows in July, usually at bud stage. The authors also found that higher rainfall and relative humidity in June or July favoured infection. Stapel (1960), Louvet (1961) and Misko (1963) reported the occurrence of *H. papaveris* from Denmark, Versailles and some Ukrainian districts, respectively, while Masurat and Staphen (1961, 1963) observed that the disease reached 9 per cent in Leipzig and 14 per cent in Halle in Germany. Radulescu *et al.*, (1961) and Radulescu and Perseca (1964) reported that the poppy stand was impaired most seriously by the *P. papaveracea* in Romania. The authors observed that high plant density and poor nutrition favoured infection, while early sowing reduced it. They found a direct link between the intensity of attack with density of sowing. Rundy (1976) observed *H. papaveris* (*P. papaveracea*) as the main pathogen during an investigation. He further observed that the early sowing decreased the infection.

The control measures recommended were strict sanitation of seed beds and field, including the removal and incineration of all plant debris. Some measure of control was also obtained by steeping seed from diseased plants for one hour in 0.25 to 1 per cent Upsulum-Universal, 0.25 to 5 per cent of

Germisan, 0.05 per cent of Mercuric chloride, or 0.5 per cent Chigosan. Spraying the diseased plants with 3-5 per cent Bordeaux mixture or with 2 per cent Tutokilla or dusting with Nosperit, all gave satisfactory results. However, the time of application and frequency of these treatments was entirely dependent of the seasonal conditions and severity of the disease (Christoff, 1930). Barbacka (1936) observed that seed disinfection with 0.25 per cent Formalin solution greatly reduced seedling infection. Spraying with Bordeaux mixture also gave a good measure of control but was considered to be uneconomical. Reinmuth (1948) found satisfactory control by seed disinfection, early sowing, wide spacing and by hygienic measures in poppy fields. Darpoux and Faivre (1949) and Dolle (1954) showed the inhibition of *H.papaveris* (*Pleospora calvescens* or *P.papaveracea*) by some actinomycetes isolated from opium poppy fields.

Ballarin (1950) recommended early and denser sowing in infected areas. Out of ten types of fungicides tested, the best control was given by dusting with Copper o-oxyquinolate (18 per cent copper) @ 600 gm/hl seed as it completely inhibited germination of the spores and has no adverse effect on seed germination even after one year (Zambettakis, 1952). Iron dithiocarbamate, because of its tenacity, also gave good results @ 700 gm/hl, though it was less effective than the copper compound, while the best liquid treatment was given by 0.02 per cent Unalcoylthydroxymercury, with least

toxicity to seed germination of all the organo-mercury compounds. Beaumont (1953) suggested spraying of seed beds with 0.5 per cent Bordeaux mixture or other copper fungicides for the control of the disease. Matzner (1958) observed that incorporation of lime and CaCO_3 @ 285 mg/ha appreciably reduced the losses caused by *H. papaveris*. But soil amendments with KCl resulted in heavy infection in the absence of lime. Fungicidal spraying with Systox before flowering reduced infection and increased the yield (Mass Geesteranus, 1960). Marz (1960,1963) found that out of 7 seed disinfectants tested against *H. papaveris* Agronol @ 50 g/10 kg of seed and 0.5 and 1 kg/100 kg of seed respectively, significantly reduced the infection caused by *H. papaveris* (*P. calvescens*). Louvet (1961) also recommended seed disinfection to control the infection of *H.papaveris*.

Early sowing was observed to reduce the infection caused by *H.papaveris* (*P.calvescens*) (Radulescu *et al.*, 1961 ; Radulescu and Perseca, 1964). Spraying with Germisan (1 per cent), Gramisan (0.1 per cent) and dusting with Thiram, Gramisan, Germisan or Agrosan were found to be the most effective control measures of the disease (Radulescu *et al.*,1961; Radulescu and Perseca, 1964). Misko (1963) observed that soil treatment with Borate and Manganese superphosphate (30 kg/ha) reduced the infection significantly. Flanderikova (1972) observed that treatment with Fungicidin + Actidione (0.05 g/l) gave some control to the disease while the others were found phytotoxic to poppy.

However, in field trials of 28 fungicides (applied before and after flowering) against *H. papaveris* (*Pleospora calvescens*) on poppy, 19 were found phytotoxic which includes organic Sn compounds, Cuprosan and Morestn, while Polyram combi and Polyram ultra were most fungitoxic (Flanderkova, 1973). Misko (1973) reported that the direction of metabolic reactions between the pathogen and infected plants can be regulated by means of inorganic fertilizers with micronutrients (B⁻ and Mn⁻ containing superphosphate). Macias and Stopa (1974) reported that in field and glass house trials, 0.3 per cent Cynkotox, 0.4 per cent Miedzian-50, 0.2 per cent Sadoplan-75, 0.2 per cent Dithane M-45 and 0.1 cent Terrafun 75 gave best results against *H. papaveris*. Rudy (1976) found seed dressing with Zaprawa and Nasienna-T and spraying plants with Cynkotox and Dithane M-45 (Mancozeb) as best protective measures against *H. papaveris*. Leiteritz and Roder (1980) also reported the control of *H. papaveris* by Dithane M-45 (Mancozeb) @ 0.8 kg/ha.

LEAF SPOT DISEASE

Work done abroad

Van Poeteren (1929, 1933) reported that the opium poppy was attacked by the fungus *Dendryphium penicillatum* producing black spots on mid rib of the leaves and only 15 per cent of the plants remained free from the infection.

-----Savulescu (1932) reported that the opium poppy was severely attacked and damaged by a leaf spot caused by *Entyloma fuscum*. A considerable extension of the greyish-brown spotting and premature shedding of opium poppy leaves caused by *E. fuscum* has been reported by Mehlich (1935) from Germany. The chlorotic aspect of the foliage sometimes accompanied by curling. Similar reports are there by Kochman (1936), Kovacevski (1936) and Brundza (1937) from Poland, Bulgaria and Lithuania, respectively. *E. fuscum* was also found to infect the opium poppy leaves in Cyprus (Nattrass, 1937). Saville (1946) describes the symptoms of the smut (*E. fuscum*) and reported the production of conidia on host for the first time. Bremer *et al.*, (1947) also reported the occurrence of *E. fuscum* on opium poppy in Turkey.

Another leaf spot disease caused by *Cercospora papaveri* was also reported from Brazil and U.S.A. (Muller and Chupp, 1936; Stevenson, 1942). Muller and Chupp observed that the lesions formed on poppy (*Papaver* sp.) were circular to irregular, 3 to 8 mm in diam. and sometimes with an ashen centre bordered by a dark line. Chupp (1954) reported the occurrence of *C. papavericola* nom. nov. (Syn. *C. papveri*) on opium poppy as new combination from New York. *C. papaveri* was also found to cause leaf spot on opium poppy in Pakistan (Zaman and Khan, 1969).

Work done in India

So far only one report of leaf spot is available in India. Pavgi and Upadhyay (1964) reported leaf spot disease of opium poppy caused by *C. papaveri*.

DISEASES OF STEM

Work done abroad

Girzitska (1928) observed that the mycelium of *Pleospora papaveracea* spread to the stem after causing leaf infection and perithecia of the fungus were found on them in following autumn. Ekstrand (1941) reported the occurrence of black stem spots caused due to the infection of *P. calvescens* whereas Reinmuth (1942) observed that the disease first attacks the base of the stem resulting in necrosis of the stem. Stem spots caused by *Pyrenophora (Pleospora) calvescens* was also reported by Zogg (1945). Meffert (1950) observed that when the opium poppy plants were attacked by *P. papaveracea*, within the stems, its growth was predominantly intracellular causing tracheomycosis. Mass Geesteranus (1960) reported that the fungus attacks only dying tissues and enters the base of the stem at ripening time. The perithecia were found to be confined mainly to the stem base. Development and ripening of perithecia of the fungus *P. papaveracea* on stem pieces was

studied by Radulescu and Perseca (1964). Drozdovskaya (1977) also found perithecia of the fungus on the stem only. *Rhizoctonia solani* was reported to cause stem rot in Pakistan (Zamand and Khan, 1969).

Laughlin and Munro (1983) reported the occurrence of *Sclerotinia sclerotiorum* inflicting stem infection. They found that in field tests N fertilizer (100kg N/ha) had no effect on incidence of *S. sclerotiorum* while P fertilizer (100 kg P/ha) increased infection from 19 per cent to 39 per cent. They further observed that morphine concentration in stem and leaves of infected plants was 75 per cent greater than that of uninfected plants. The distribution pattern was interpreted as the result of the restrictive influence of *S. sclerotiorum* infection on the vascular system which disrupted the normal translocation of morphine.

CAPSULE INFECTION

Work done abroad

Parisi Rosa (1921) found that *Macrosporium papaveris* caused large velvety black spots especially on the green capsules. Garbowski and Juraszkowna (1933) reported that *Alternaria brassicae* var. *somniferum* infects the capsules of opium poppy. Christoff (1934) observed that *Fusarium scirpi*

var. *caudatum* was capable of infecting capsules of opium poppy. Christoff (1943) further showed that spotting of opium poppy bolls (and moulding of seeds) were usually caused by *Peronospora arborescens*, *Pleospora calvescens*, *A. brassicae* var. *somniferum*, *F. scirpi* var. *caudatum*, *Mycospharella tulasnei* and *Ophiobolus sativus*. Besides, *Macrosporium bresadolae*, *Fusarium* sp., *Penicillium* sp., *Mucor mucedo* were also rarely found. Spraying of bolls with 1 per cent Bordeaux mixture and resin was recommended as control tool.

Darpoux (1945) found that *H. papveris* causes deformity of opium poppy capsules. *Pyrenophora* (*Pleospora*) *calvescens* was reported as the agent to cause spots on opium poppy capsules (Zogg, 1945). Reinmuth (1948) observed that capsules which were infected by *H. papaveris* grow one sided and stunted and seed formation of these capsules became defective and sometimes suppressed. Control measures recommended were seed disinfection, early sowing, wide spacing and adoption of hygienic measures in poppy fields. A similar report of capsule infection is there by Ballarin (1950) and Marz (1979).

Gassner (1949) observed the invasion of the capsules by *H. papveris* (*Pleospora calvescens*) in Germany. He found that some of the diseased capsules were normal in size and show no external symptoms but the seeds within them adhere to the pericarp while in cases of severe infection seeds may be matted together by the mycelium. Other infected capsules bore dark

colouration or the conidia on the exterior surface or they may be undersize and stunted on one side.

Grummer (1953) reported that *Alternaria brassicae* var. *somniferum* infected capsules of the opium poppy. The fungus causes a typical infection symptom of precocious germination of the unripe to semi-ripe seeds within the capsules. Miczulska (1967) observed that the increased infestation of the poppy heads with *A. alternata* and *Cladosporium herbarum* resulted in decline of morphine content in the heads. Felklova (1976) indicated significant decrease in codeine and thebaine content in opium poppy capsule infected with *A. alternata*. Rudy (1976) reported the incidence of fungal infection (*Alternaria* sp. and *H.papaveris*) on poppy heads upto 14.65 per cent.

Dendryphion penicillatum was found to cause capsule spots in Australia (Munro, 1978). Control measure recommended was seed dressing with Captan @ 2g/kg. *D. penicillatum* and *A. alternata* were two of the major fungi isolated from opium poppy capsules from Australia (Laughlin and Munro, 1982). The authors observed that the abnormally low concentrations of morphine content in poppy capsules was associated with heavy fungal colonization. Colonization was generally localized in the top half of the capsules and increased with successive harvests.

Laughlin and Munro (1983) further reported that when stem of opium poppy plants were infected by *S. sclerotiorum*, the morphine concentration of terminal capsules was lowered by 13 per cent while that of the lateral capsules increased by a similar amount. The distribution pattern was interpreted as the result of the restrictive influence of *Sclerotinia* infection on the vascular system which disrupted the normal translocation of morphine.

Work done in India

A *Dendryphon* capsule rot of opium poppy caused by *D. penicillatum* incurring severe damage was prevalent in Rajasthan (Sehgal *et al.*, 1971). Another serious capsule rot caused by *Botrytis cineria* was also observed in opium poppy stands grown at Lucknow (Janardhanan and Husain, 1983.).

POWDERY MILDEW

Work done abroad

Zaprometoff (1925) reported that opium poppy was frequently attacked by *Erysiphe cichoracearum*. Sawada (1933) recorded *Oidiopsis papaveri* from Japan. *E. cichoracearum* (*Oidium*) was observed in France also by Darpoux (1945). Schuepp and Blumer (1963) found that *E. polygoni*, isolated from another host, also infected the opium poppy. Zaman and Khan (1969)

observed the powdery mildew as a minor disease in Pakistan and identified the causal organism as *E. polygoni*.

Work done in India

Patel *et al.*, (1949) reported the occurrence of *E. cichoracearum* from Bombay. Kothari (1968) reported the occurrence of another powdery mildew of opium poppy in Rajasthan caused by *Oidiopsis* sp. Kothari and Prasad (1972) reported that powdery mildew caused by *E. polygoni* has been found as a serious parasite of the opium poppy crop in Rajasthan. The authors found that poppy cultivars suffer heavy losses on account of this disease. Germination of conidia of *E. polygoni* in *in vitro* conditions has been studied by Kothari and Verma (1972). Ramanathan and Ramachandran (1977) reported that powdery mildew infects opium poppy, when the capsules became ready for lancing.

Kothari and Prasad (1972) tested 7 sulfur fungicides, 3 copper fungicides and two organic fungicides in order to control the infection of powdery mildew caused by *E. polygoni*. They found that all the fungicides except Fungimar had remarkable effect in controlling the disease while Spersul proved most effective by one spray at 0.5 per cent. Ramanathan and Ramachandran (1977) recommended the spraying of Guman-L mixed with wettable sulfur (Sultaf) as a control measure.

Gupta (1984) suggested that the diseased plants in the early stage should be uprooted and burnt while at later stages, the crop should be dusted with 5kg/ha of Sulfex or Microsulf (5 litres in 500 litres of water) to control the infection of powdery mildew. Besides, spray of Karathane (250 mg/ha), Dithane Z-78 or Dithane M-45 beginning at flower stage and repeating it 2-3 times at an interval of 15 days also prevents the spread of the disease.

(ii) Fungal diseases of minor importance

The various other diseases of minor importance recorded so far are reviewed as follows :

SPOT DISEASES OF STALK

Van Poeteren (1929) observed that *Dendryphion pencillatum* produces black spots on the stalk whereas, Barbacka (1936) reported that stalk were rarely attacked by the fungus *Helminthosporium papaveris*. Zambettakis (1952) reported that the mycellium of the fungus *Pleospora calvescens*, during the course of infection spread to the stalks of some plants which were kept in the green house and perithecia were developed in the following autumn.

ANTHRACNOSE DISEASE

Hemmi and Nojima (1927) reported anthracnose disease of poppy (*Papver* sp.) from Japan. The causal organism was identified as *Glomerulla cingulata*.

LEAF SHEATH DISEASE

Munro (1978) reported the occurrence of blue-black lesions at the point of leaf attachment which was found to be caused by *Dendryphion penicillatum*.

(iii) Fungi recorded from dead plant parts

Ascospores of the fungus *P. calvescens* were reported from dead stems and stubble of the opium poppy plants (Christoff, 1930). Similarly, species of *Fusarium*, *Alternaria* and *Cladosporium* were frequently isolated from the blackened stumps of opium poppy plants abstricted at root collar (Anonymous, 1947).

MATERIALS AND METHOD**S**

MATERIALS AND METHODS

I. SEED-BORNE DISEASES

Seed sample collection

The opium poppy seeds were collected from different opium growing areas of eastern Uttar Pradesh during 1982-83. The samples collected from field, market and stores of commercial growers, were kept separately in fresh and sterilized polythene bags and immediately sealed to avoid any further contamination during transit and storage. The capsules (both healthy and deteriorated) bearing seeds were also collected from standing crop in the field. The seeds and other parts of both type of capsules were gently separated in laboratory under aseptic conditions and stored in sterilized glass bottles in refrigerator. 100 gms of seed from each type of seed sample (except *in situ* seed sample) were taken separately and mixed to form a composite sample for further studies. The seed germination as and when needed was studied in sterilized and unsterilized standard soil and by 'Standard Blotter Technique'. 'Standard International Rules for Seed Testing' (Neergard, 1977) were followed throughout the entire studies. The study was made in following ways:

Inspection of dry seed sample

The composite sample was examined for (i) impurities classified partly as 'inert matter' in the International Rules for Seed Testing (ii) for discolouration of the seeds and (iii) for the weight lost due to fungal infections.

(i) Inspection of inert matters

-----The main sources of the spread of plant diseases are remains of diseased plants, infected soil and infected seeds which were frequently found mixed with stored seed lots. These seed materials can be a source of disease for the crop if disinfection measures had not been carried out. As such, it was worthwhile like other methods, to examine the seed samples for:

- (i) Impurities, classified partly as 'inert matter' such as plant debris, sclerotia, galls, soil particles and other grain particles, if any,
- (ii) for symptoms such as, discoloration and malformation etc. and,
- (iii) For mechanical damages (as mycoorganisms with weaker parasitic and saprophytic nature may infect only those seeds which were mechanically damaged).

-----The encountered inert matters were tested by Standard Blotter Technique and Agar Plate Method. The Inert matters were seeded and the plates were incubated at $20(\pm 2)^{\circ}\text{C}$. The plates were examined from 5th day and then after an alternate days up to 15 days for the growth and isolation of the encamping fungi.

(ii) Seed Discoloration

-----Discolouration of seeds is an important degrading factor. In seeds for sowing, such disorders may indicate that seed transmitted parasites are present and in seeds for consumption and for industrial purposes, it may be indication of poor quality. There are at least three categories of seed discoloration when causes and effects are considered:

- (i) Superficial necrotic lesions
- (ii) Fungus coatings and
- (iii) Pigmentation (Neergaard, 1977).

For the purpose, 1000 infected (mild to heavily infected) seeds were picked out randomly and studied.

(iv) Weight loss

-----To find out the weight loss due to fungal deterioration, 1000 each of infected (mild to heavily infected) and healthy

seeds were picked-out from composite sample and were weighed separately on Mettler AE 160.

Detection of moisture content

Moisture content of the seed is an important factor for the deterioration of seeds by seed loving fungi during storage. Higher moisture level of the seeds leads to servere destruction of seed embryos (Christensen and Kaufman, 1964; Follstad and Christensen, 1965). Keeping the fact in view, percentage moisture of the experimental opium poppy seeds was determined.

For the purpose, 10 gm of seeds were taken separately from samples collected from field, stores of commercial growers and market and dried in hot air oven at 50°C for 6 hours. The dried seeds were allowed to cool down at room temperature for 15 minutes and then reweighed.

Examination of suspensions obtained from washings of seed

This technique is used for (i) quantitative determination of seed mycoflora and (ii) for detection of obligate parasitic fungi harbouring on them externally.

For the study, 1000 seeds were picked-out randomly from composite sample and were dropped in 50 ml of distilled and sterilized water in a test tube. The plugged test tube containing the seeds was shaken for 15 minutes on a mechanical shaker. After allowing the seeds for 5 minutes to stand, the

suspended fungal material was concentrated by centrifuging the supernatant liquid at 1000 r.p.m. for 15 minutes. The sediment thus obtained was examined under the microscope both at low and high magnifications.

Detection of seed mycoflora

To detect the spermaphile~~ein~~ fungi, 100 seeds were tested each by 'Standard Blotter Technique', 'Agar Plate Method', and 'Moist Sand Method'(Neergaard, 1977).

Isolation of external spermaphile~~ein~~ mycoflora

To isolate the external spermaphile~~ein~~ mycoflora associated with the seeds, 100 seeds were picked-out randomly from the composite sample and were seeded on sterilized moist blotter and on agar media (both Potato-Dextrose-Agar (P.D.A.) and Malt-Extract-Agar (M.E.A.) media. In order to detect the presence of *Aspergillus restricts* (a rare storage fungi), agar media of high salt concentration (prepared by using Sodium chloride at 15 and 18 per cent range) has been used. The seeded plates were incubated at $27 (\pm 2)^{\circ}\text{C}$. A similar set of seeded plates was also incubated at two different temperatures viz., $20 (\pm 2)^{\circ}\text{C}$ and $27 (\pm 2)^{\circ}\text{C}$ to know the effect of temperature on the incidence of seed mycoflora. The plates were examined from 5th day onwards on alternate days up to 30th day for growth and isolation of the encamping spermaphile~~ein~~ fungi under stereoscopic binocular microscope.

Isolated fungi were further purified by hyphal tip method. Purified fungal cultures were maintained on P.D.A. slants for further studies. To facilitate recording of fungal colonies germination of the tested seeds was precluded by using 0.2 per cent aqueous solution of sodium salt of 2, 4 -dichlorophenoxy acetic acid instead of sterilized water (Neegaard, 1969). In some sets, to prevent profuse development of fast growing saprophytic fungi, seeds were pretreated by soaking them for three to five minutes in one per cent aqueous solution of Sodium hypochlorite. The treated seeds were seeded immediately on respective media without washing the treated seeds.

Isolation of internal spermapileein mycoflora

To detect the endophytically carried spermaphileein fungi, 100 seeds were picked-out randomly from composite sample. All the seeds were first surface sterilized with 0.1 per cent aqueous solution of mercuric chloride for 1 to 2 minutes, to eliminate the external seed mycoflora. The treated seeds were washed in four changes of distilled and sterilized water before planting them on different media. Seeded plates were incubated at $27 (\pm 2)^{\circ}\text{C}$. The plates were examined on 5th day onwards on alternate days up to 30th day for growth and isolation of the encamping fungi under stereoscopic binocular microscope. Isolated fungi were further purified by hyphal tip method and purified cultures were maintained on P.D.A. slants for further studies.

Percentage abundance of the spermaphile~~ee~~in fungi was calculated as per following formula:

$$\% A = \frac{Tp}{TP} \times 100$$

Where, A = Abundance of fungi

Tp = Total population of any individual fungi

TP = Total population of all isolated fungi

II. OTHER DISEASES AND DISEASES OF MINOR IMPORTANCE

Survey

With a view to study the (i) effect of different sowing times on disease appearance, (ii) disease intensity at different growth stages of the crop and (iii) the effect of previous opium poppy cultivation on disease intensity, systematic surveys were conducted intermittently during 1982-83 and 1983-84. Alongwith this, to explore the co-relation between the environmental conditions, terrain, other surrounding vegetation and fungal pathogens infecting opium poppy crop prevailing under different climatic condtions, three commercial opium poppy fields under three different climatic condition were chosen in three major opium growing areas viz., (i) Mughalsi, (ii) Barabanki and (iii) Kumarganj of easter~~n~~ Uttar Pradesh.

Systematic surveys of these three fields were made intermittently for the incidence of various types of fungal diseases of the crop. The survey was started right from the seedling stage and continued up to harvesting of the seeds. The disease intensity observations were recorded by rating on 0-5 rating scale basis.

Besides the survey, informations on following points were also collected: the variety cultivated, adaptation of plant protection measures, the know-how of modern agro-techniques and the rainfall. Some interesting observations, experience-n-orthodox beliefs etc. were also recorded. The local names of the disease (s) given by the farmers were recorded at the same time.

Disease sample collection

The disease sample collection was done following Blanchard and Tattar (1981).

(A) Collection – The living host part (s) showing symptoms of other than normal) were collected aseptically and kept in fresh and sterilized polythene bags and sealed immediately. Possible at the spot diagnosis of the disease was also made for each disease sample and was accompanied with the respective samples. Different diseased samples were kept under separate bags.

(B) Identification – Primary identification of the causal agent of each sample was done by ‘Zoom approach’ method as follows:

- (i) Macroscopic close-up view** – This is the animal’s eye view from 20 cm distance. In this approach, abnormal parts of the host with naked eye and with magnifying lens of 20 X were examined.
- (ii) Microscopic view** – Microscopic studies were carried out under the following sub- headings :
 - (a) Isolation, purification and maintenance of the culture.
 - (b) Morphological studies of the pathogens.

a) Isolation, purification and maintenance of the cultures

Isolation of the pathogenic fungal agents, their purification and maintenance of the isolated cultures were done following Blanchard and Tattar (1981).

Separate isolations were made from each type of disease sample. The isolates were established in pure culture. The pure cultures thus obtained, were maintained by transferring them to tube-slants of P.D.A. and M.E.A. media. All stock cultures were further maintained by transferring them periodically for future studies. The stock cultures were generally stored in a refrigerator (at approximately 5°C).

b) Morphological studies of the pathogens

Morphological studies of the fungal pathogen were carried out under following sub-headings:

- (i) **Colony characteristics-** Colour and nature of the growth of each fungus were observed with naked eye.
- (ii) **Mycelial characteristics -** Septation, branching, colour and width of the hyphae were studied microscopically.
- (iii) **Conidiophore characteristic-** Colour, shape, length and width , septation and geniculation of the conidiophores were studied microscopically.
- (iv) **Conidial Characteristics-** Colour, shape, size (length and breadth), septation and point of attachment of the conidia were studied microscopically.
- (v) **Sporangium and sporangiophore characteristics –** Colour, shape, length and width, texture, arrangement of sporangium and sporangiophores were studied microscopically.
- (vi) **Spore and zygospor characteristics –** Colour, shape, and size (length and breadth) were studied microscopically.
- (vii) **Azygospor and chlamydospore characteristic –** Colour, shape and size (length and breadth) were studied microscopically.

(viii) **Sclerotial characteristics** – colour, shape and breadth were studied microscopically.

Scan Electron Microscopic (SEM) studies of the isolated fungi

The experimental fungal cultures for SEM study have been taken either from agar culture or directly from infected plant parts. A small piece of the fungus was fixed for 4 hours in 2-5 per cent glutaraldehyde in 0.1 m phosphate buffer of 7 pH. The fixed materials were thoroughly washed with buffer solution and subsequently with distilled water. Materials were dehydrated with upgrading ethanol series starting from 30%, 50%, 70%, 90% and two washings of absolute alcohol. Materials were left for 10-15 minutes in each grade. Dehydrated samples were dried in critical point drier (TOUSIMIS SAMDRI Pvt. U.S.A.) with liquid carbon dioxide at critical pressure of 1070 psi and temperature of 31°C.

Dried samples were mounted on SEM stubs with double sided sticky tape and were coated with 200 Å thick coating of gold. Materials were studied and photographed with JEOL JSM- 35 C.

Identification of the causative agents

Identification of some of the isolated seed borne fungi (external and internal both) were made with the aid of standard monographs on

various groups of fungi and some of the cultures were also got identified from Commonwealth Mycological Institute, Ferry Lane, Kew, Surrey, England TW9 3AF .

However, tentative identification (at least up to genus level) of the various causative agents of other diseases were made on the basis of morphological charactersitics and the identity of the pathogens was got confirmed by C. M.I. Kew , England.

PATHOGENICITY TEST

To establish the Koch's postulates, various isolates were tested to establish their pathogenic ability which was done as follow:

A) Pathogenicity test with seed borne fungi

The test was carried out, with some of the isolates appearing very frequently. For the study, healthy and surface sterilized seeds were used at the rate of 100 seeds per test fungus. The study was made by inoculating the seeds with the test fungus. For incoulation, contact inoculation method was employed. Inoculated seeds were tested by (i) blotter test and (ii) standard soil test. One hundred contact inoculated seeds were used each for blotter test and seedling symptom test.

Blotter test

Surface sterilized healthy seeds were rolled on the surface of 7 & 10 days old, actively sporulating desired culture of test fungus for 30 minutes. After rolling, the seeds were left to dry on a sterilized blotting paper in aseptic condition for 60 minutes. The plates were seeded as usual with the inoculated seeds and incubated. The observations were made for proliferation of the inoculated fungi and for pre - and post - emergence of seedling rots on 7th, 14th, 21st and 28th days. The pre- emergence observations were meant especially for those seeds which germinated but could not grow more and ultimately rotted. One hundred surface sterilized healthy and uninoculated seeds were maintained to serve as control. Isolations were made from the diseased seedlings or their parts and from ungerminated seeds to recover the fungus used in the inoculation.

Seedling symptom test

In the blotter test method, the medium used was entirely artificial. An approach to establish more natural conditions were obtained by sowing the seeds in sterilized soil or similar materials as under standard conditions of temperature and moisture, artificially infected seeds and seedlings may develop symptoms comparable with those developed under field conditions. For the purpose, following two methods were employed:

- i) Standard soil method

ii) Test tube agar method

(i) Standard soil method

The medium for the test was prepared by mixing 3 parts of garden soil and 1 part of coarse sand. The soil was filled in earthen pots and got sterilized. Contact inoculated seeds (at the rate of 100 seeds per test fungus) were sown in pots containing sterilized and unsterilized soil. The pots were watered with sterilized water as and when found necessary. Separate trays were used to keep the pots for each test fungus so as to avoid the risk of contact infection among the seedlings. 100 surface sterilized healthy seeds were sown uninoculated to serve as control.

(ii) Test tube agar method

The test tubes of 16 mm diameter were filled with 1.5 per cent of water agar medium at a rate of 10 ml per tube. The medium was got sterilized and tubes were kept in slant position to solidify. The inoculated seeds were sown in the tubes and incubated. To retain moisture, the tubes were covered, in groups, by aluminium foil. The foils were removed when seedlings have reached to cover. 100 surface sterilized seeds were seeded uninoculated to serve as control.

In both the tests, observations were made on 7th, 14th, 21st and 28th days categorising them in the following five groups :

- (a) **Normal seedlings:** Seedlings of normal height, normal vigour and unblemished.
- (b) **Delayed seedlings:** Seedlings of below normal height, below normal vigour but unblemished.
- (c) **Distorted seedlings:** Seedlings showing underdeveloped conditions and blemished.
- (d) **Blighted seedlings:** Seedlings died due to post-emergence blighting.
- (e) **Ungerminated seeds :** Seeds which could not germinate.

Isolation were made from the diseased seedlings or their parts and from ungerminated seeds to recover the fungus used in the inoculation .

(B) Pathogenicity test with isolates of other diseases

For the purpose, both intact and detached plant parts, as according to the need, were artificially inoculated with the spore/conidial and mycelial suspension of one week old, actively sprouting culture of each isolates. In case of obligate parasites host was inoculated with freshly collected pathogen herbaria. When needed, procedure of direct inoculation with an active culture through the injury was also employed.

Assessment of the losses caused by downy mildew and powdery mildew diseases

To find out the losses, in terms of latex (opium) and seed yields, due to (i) secondary infection of downy mildew and (ii) powdery mildew infection, experiments were carried out on local susceptible cultivar, 'kalidanthi' following randomised block design with three replications in the commercial field of N.D. University of Agriculture and Technology, Kumarganj, Faizabad, U.P., India where disease has been found to occur in severe form under natural conditions. 100 plants having mild to severe infection and 100 healthy plants, for each set, were selected at random and labelled during 1982-83, 1983-84 and 1984-85. The losses for different intensities of the disease were estimated on the basis of 0-5 rating scale as described earlier. Latex and seed yields were collected from diseased and healthy plants separately and percentage reduction in yield was calculated.

During the assessment of losses due to downy mildew, all experimental plants were protected from powdery mildew by spraying sulfex (0.2 per cent), whenever needed.

CHEMICAL CONTROL OF THE DISEASES

Evaluation of natural (plant) products vis-a-vis spermathaleen fungi

In the present investigation, eight natural (plant) products, viz, (i) Lawsone, (ii) Menadione, (iii) Eugenol, (iv) Clove oil, (v) Lemongrass oil, (vi) Cedar wood oil, (vii) Terpinyl acetate, and (viii) Opium poppy seed

oil , were selected to evaluate their efficacy to control the biodeterioration of opium poppy seeds by spermathileein fungi. To compare the efficacy of all the natural (plant) products , three synthetic commercial fungicides, viz, Dithane M-45 , Agrosan GN and Bavistin-50 were also evaluated *in vogue* .

During the evaluation of the natural (plant) products, following two points were also kept in view (i) the natural (plant) product (s) should not retard the percentage seed germination after their application, otherwise the seed lot would become useless for growing purpose and (ii) the natural (plant) product (s) should control the infestation of spermathileein fungi during storage and should not impart any toxicity in the seeds. The natural (plant) product (s) which fulfil these conditions would be considered as a suitable and safe tool to protect the seeds from fungal deterioration .

Procedure

The aqueous solution of all the natural (plant) products were made in sterilized water in a range of four concentrations viz., (i) 250 ppm , (ii) 500 ppm, (iii) 1000 ppm, and (iv) 2000 ppm. Aqueous solution of synthetic commercial fungicides were also prepared in the same range.

Seeds were picked-out randomly from the composite sample at the rate of 100 seeds per concentration of each natural (plant) product and synthetic commercial fungicide. Seeds were treated in 50 ml of different concentrations

of each test chemical in Erlenmeyer flasks by shaking well for 15 minutes, on a mechanical shaker. After treatment, seeds were taken out from the respective solutions and allowed to dry on sterilized blotting paper at room temperature in aseptic conditions for 3 hours. Alongwith this ,100 healthy seeds were treated with sterilized water and 100 surface sterilized seeds were maintained to serve as control-1 and control-2, respectively in order to differentiate the effect of natural (plant) product (s) on the establishment and proliferation of seed mycoflora and on the seed germination. Pre-soaking of seeds before the treatment for 14-16 hours as recommended by Mittal and Sharma (1982) and Rahalkar and Neergaard (1969) was avoided as water soaking trials were found to retard seed germination.

The treated and untreated seeds were tested by standard blotter method as usual. The observations were made from 5th day onwards on alternate days up to 30th day for the mycoflora developed on the seeds and for seed germination percentage. The observations were also made for nature and vigour of seedlings by taking average length of cameout part and the average weight of the germinated seedlings.

Evaluation of natural (plant) products against other diseases

During the present investigation, the natural (plant) products selected, were first evaluated during *in vitro* conditions against all isolated fungal

pathogens. However , only two major diseases i.e. (i) downy mildew caused by *Peronospora arborescens* and (ii) powdery mildew caused by *Erysiphe polygoni* were selected for *in vivo* evaluation of all the natural (plant) products. The procedures were as follows:

***In vitro* evaluation of natural (plant) products**

The effect of eight natural (plant) products viz., (i) Lawson, (ii) Menadione, (iii) Eugenol , (iv) Clove oil, (v) Cedarwood oil, (vi) Lemongrass oil, (vii) Terpinyl acetate and (viii) Opium poppy seed oil were evaluated against nine pathogenic fungi viz., *A. alternata*, *D. spicifera* , *F. oxysporum* , *F. solani* , *R. bataticola*, *S. rolfii* , *Alternaria* state of *P. infectoria* , *M. racemosus* and *R. microsporus* using conventional poisoned food technique (Grover and More, 1962) separately.

For the purpose, stock solution of the natural (plant) products were prepared in acetone or sterilized distilled water, as according to the need and incorporated in luke-warm melted and sterilized potato–dextrose-agar medium so as to give the concentrations of 250 ppm, 500 ppm, 1000 ppm, and 2000 ppm. After mixing the natural (plant) products solution, 5 ml of each concentration was poured into sterilized petriplates. The medium having no test chemical but having the same amount of solvent (acetone or sterilized distilled water) was served as control . The petriplates with

medium, were left in aseptic conditions for 24 hours so as to observe the growth of contaminant, if any, and then inoculated with actively growing regions of 5 to 7 days old actively sprouting test fungus. The discs were kept upside downwards. The inoculated plates were incubated at suitable temperature ($27 \pm 1^\circ\text{C}$) for 5 to 7 days . Three replications were kept for each treatment.

Fungitoxicity values were recorded following Mishra and Dixit (1977). Percentage of mycelial inhibition (PMI) was calculated as per following formula :

$$\% \text{ mycelial inhibition (I)} = \frac{dc-dt}{dc} \times 100$$

Where, dc =colony diameter in control.

dt = colony diameter in treatment.

The candidate fungitoxic natural (plant) product (s) were then tested for their fungistatic/fungicidal activity following Garber and Houston (1959). Efficacy of the natural (plant) products was compared with three synthetic commercial fungicides viz., Dithane M-45, Dithane Z-78 and Bavistin -50 following Singh *et. al.*, (1980) .

***In vivo* evaluation of natural (plant) products**

Trials were made to evaluate the efficacy of all the eight natural (plant) products to control the downy mildew and powdery mildew diseases in glass house and under field conditions as per need. The procedures were as follows:

(i) Evaluation of natural (plant) products for control of downy mildew disease

Seeds of local susceptible cultivar ‘ Kalidanthi’ and the plants raised from them were used throughout the study. Experiments were conducted in glass house (in pots) as well as in commercial fields where opium poppy has been grown for the last three years and disease has been found to occur in severe form under natural conditions. In the present study, all the eight natural (plant) products were evaluated for their efficacy to control the disease with four synthetic commercial fungicides (two non-systemic and two systemic) viz., Dithane M-45, Blitox-50, Bavistin and Calixin serving as standard check. Solutions of all the text chemicals were prepared in distilled and sterilized water in a range of two concentrations viz., 500 ppm and 2000 ppm except in the experiments of seed treatment where 500 ppm and 1000 ppm concentrations were used.

Control of primary infection by seed treatment

150 seeds of susceptible cultivar 'Kalidanthi' were picked-out randomly from the seed sample and were treated in 100 ml of 500 ppm and 1000 ppm concentrations of aqueous solution of all the natural (plant) products and two commercial fungicides (Dithane M-45 and Blitox -50) separately as described earlier. The treated seeds were sown in a randomized block design in three replications. Plot size being $2.5 \times 1.5 \text{ m}^2$. Untreated seeds were sown in the control plot. After germination, Only 100 plants were maintained by thinning out the rest. Effect of treatments on the appearance of systemic infection was evaluated by counting healthy and systemically infected plants.

Control of primary infection by soil drenching

The experiment was conducted in pots in three replications with a control set. Three days before sowing of seeds of the susceptible cultivar, 100 ml aqueous solution of each concentration of each natural (plant) product and synthetic commercial fungicide were applied as soil drench in the pots carrying oospore layer at one inch depth. Simultaneously distilled and sterilized water was added to control set pots which also had the oospore layer. Seeds were sown after 12 hours of last

application of test chemicals. After germination 30 plants were maintained by thinning out the rest. Observations were made on the appearance of disease till maturity.

Control of secondary infection by foliar application

To evaluate the efficacy of foliar application on secondary (local) infection, experiments were conducted in pots (in glass house) as well as in the field under natural conditions.

(A) Control of the disease in glass house

Each treatment was replicated thrice having two healthy plants in each pot. Aqueous solution of each concentration of test chemicals were uniformly sprayed 4 times at 15 days interval. Twenty four hours after the last spray, the plants were inoculated with fresh and virulent conidial suspension of the fungus and incubated for 24 hours in humidity chamber with 100 per cent humidity. After incubation, the pots were shifted to the glass house. Observations were made 7 days after inoculation for secondary infection and disease intensity was recorded by rating on 0-5 rating scale basis.

(B) Control of the disease in field

Field experiments were conducted during 1982-83, 1983-84 and 1984-85 cropping season at a commercial field where primary infection as well as secondary infection appears every year. The trials were conducted in 3.0 x 1.5

m² size plot in a randomized block design with three replications. Aqueous solution of test chemicals were sprayed 4 times at 15 days interval. First spray was given just after the appearance of initial symptoms of secondary infection. In 1983-84 cropping season, the natural (plant) product(s) found effective in preceding year were again tested for their efficacy. The period of spray interval was reduced from 15 days to 10 days. In 1984-85 cropping season, trials were conducted to confirm the efficacy of best found natural (plant) product(s) at the most effective concentration. The spraying was done 4 times at 10 days interval. Spraying operations were done with a hand compression (Maruti) sprayer. Observations on secondary infection were recorded by rating on 0-5 rating scale basis. Thirty plants per plot being randomly selected for the observations.

Disease index and the percentage efficiency of disease control was calculated by the following formula:

$$\text{Percent disease index} = \frac{\text{Sum of all numerical ratings}}{\text{number of plants assessed} \times \text{rating given}} \times 100$$

$$\text{Percent efficiency} = \frac{\text{Score of disease index in control} - \text{Score of disease index in treatment}}{\text{score of disease index in control}} \times 100$$

Control of secondary infection by root application of natural plant products

To find out the possibilities to control the secondary infection of downy mildew through root application, all the eight natural (plant) products, mentioned earlier alongwith two systemic synthetic commercial fungicides viz., Bavistin-50 and Calixin serving as standard check, were evaluated following Taylor (1953).

About 2 months old potted plants were selected for the tests. Three pots having 3 plants in each were taken for each treatment. Concentrations used were 500 ppm and 2000 ppm. 100 ml aqueous solution of each concentration were applied daily in each pot as drench for 7 consecutive days. Care was taken to avoid foliar contact of test chemicals. Similarly in control set pots (12 plants), 100 ml distilled and sterilized water was applied to each pot. During this period no extra water was given for irrigation purposes to the experimental pots.

After 24 hours of the last application, all experimental plants were inoculated with a heavy suspension of freshly collected conidial material from highly virulent *Peronospora arborescens*. Leaves of individual plants were counted before inoculation. Out of twelve control set plants, six were inoculated with the same inoculum serving as control-1 and the rest six plants were sprayed with distilled and sterilized water serving as control-2. The pots after inoculation were immediately shifted to humidity chamber

having 100 per cent humidity and incubated for 24 hours. Later, the pots were shifted to the glass house and watered as and when needed.

Initial symptoms of the disease (leaf spots) started to appear three days after inoculation. Infection manifested itself only on leaves as it appeared under natural conditions. Observations were made 7 days after inoculation when the disease reached to its maximum stage. For assessing the effect of test chemicals every individual leaf was scored on 0-5 rating scale basis.

Average score per treatment was worked out taking all the leaves of three plants per treatments (48-63) into account .

Evaluation of natural (plant) products for control of powdery mildew

Plants raised from the seeds of local susceptible cultivar 'Kalidanthi' were used throughout the study. *Erysiphe polygoni* isolates were maintained on the same cultivar in pots under controlled conditions. Plants were shaken daily to remove older conidia because *E. polygoni* releases a single conidium per day (Yarwood, 1936). As such, fresh conidia formed after 6-8 hours following shaking were used for the *in vitro* experiments. Experiments were conducted *in vitro* as well as in commercial fields where opium poppy has been grown for the last 3 years and disease has been found to occur in severe form under natural conditions. In the present study, all the eight natural (plant) products were selected to evaluate their efficacy to control the disease. Efficacy of natural (plant) products with synthetic commercial fungicides

viz., Sulfex (80% elemental sulfur), Dithane M-45 and Blitox-50 was compared as standard check. Solution of all the natural (plant) products and synthetic commercial fungicides were prepared in distilled and sterilized water in a range of 250 ppm, 500 ppm, 1000 ppm and 2000 ppm concentrations.

***In vitro* evaluation of natural (plant) products against the pathogen**

For *in vitro* tests, all the four concentrations of test chemicals were maintained in 2 per cent agar. Agar with various concentrations of the test chemicals was coated on fresh glass slides using the technique of Zaracovitis (1964). Young conidia from diseased leaves of opium poppy were dusted uniformly on the agar coated slides. Seeded glass slides were kept in petridishes and 20 (+2)⁰C. After 6, 12, 24 and 48 hours of incubation, the slides were taken out and examined under light microscope for per cent conidial germination.

Three replications were kept under each treatment. Glass slides with submerged conidia in water and glass slides coated with pure agar were maintained to serve as control-1 and control-2, respectively. Per cent efficiency of conidial inhibition was calculated as per following formula:

$$\% \text{ spore inhibition (I)} = \frac{SC - ST}{SC} \times 100$$

where, SC = spore germination in control.

ST = spore germination in treatment.

Control of the disease in field

Field experiments were conducted during 1982-83, 1983-84 and 1984-85 cropping season at a commercial field where the powdery mildew appeared every year. The trials were conducted in 3.0 x 1.5 m size plots in a randomized block design. The plants were observed regularly for mildew appearance. Aqueous solution of test chemicals were sprayed after 80-100 days of sowing since powdery mildew appears around flowering stage only. First spray was given at the initiation of the symptoms. The diseased plants were sprayed thrice at fortnightly interval. Similarly, the control plants were sprayed with sterilized distilled water. Yarwood (1939) has suggested control of powdery mildews by spraying with water, hence one more set, which was unsprayed, serve as an additional control. Three replications were maintained for each treatment. A hand compression (Maruti) sprayer was used for spraying operations.

In 1983-84 cropping season, the natural (plant) product(s) found effective in proceeding year were retested for their efficacy. The spray interval was reduced from 15 days to 10 days. In 1984-85 cropping season, trials were conducted to confirm the efficacy of most effective natural (plant) product(s) at the most effective concentration. The spraying was done 4 times at 10 days interval. Disease intensity was recorded one week after the last spray. Observations on powdery mildew infection was recorded by rating on 0-9 rating scale basis. Ten plants per plot being randomly selected for the observations. Per cent disease intensity and per cent efficiency of disease control was calculated as described earlier.

Phytotoxicity studies on the natural (plant) products

The toxic effect of all the eight natural (plant) products on *Papaver somniferum* L. var. "Kalidanthi" (the host plant) was studied following the procedure described by Tripathi (1980) with slight modifications. Opium poppy (*P. somniferum* var. "Kalidanthi") plants, grown in earthen pots, were sprayed fortnightly with aqueous solution of all the natural (plant) products separately at 250 ppm, 500 ppm, 1000 ppm and 2000 ppm for 3 months and the symptoms of visual toxicity on leaf, stem, floral parts and capsules were recorded, whenever seen.

EXPERIMENTAL FINDINGS

SEED PATHOLOGICAL STUDIES

The results obtained during the present studies are summarised below:

Inert matters associated with the seeds

The inert matters, that were found associated with the seeds are as follows:

- i) Plant debris viz., outer and inner capsular parts, bits of peduncle, stem and often leaf fragments.
- ii) Bits of soil were observed from the samples collected from field (during threshing of seeds and stores of commercial growers).
- iii) Other inert matters, viz., fragments of rice, pulse and sometimes, mustard seeds were observed from the samples collected from the market.

Mycoflora of inert matters

In all, 9 and 7 fungal species from capsule fragments, 5 and 3 fungal species from stem fragments and 7 and 6 fungal species from leaf fragments, 10 and 8 fungal species from soil particles and 9 and 5 fungal species from other inert matters were intercepted from Blotter and P.D.A., respectively (Table 1).

Table 1: Showing mycoflora associated with inert matters of *Papaver somniferum* seeds

Fungi isolated		Inert matters									
		Capsule		Stem		Leaf		Soil			
		fragments		fragments		fragments		particles			
		BT	PDA	BT	PDA	BT	PDA	BT	PDA	BT	PDA
1.	<i>Aspergillus niger</i>	+	+	+	+	+	+	+	+	+	+
2.	<i>A. flavus</i>	+	+	-	-	+	-	+	+	-	-
3.	<i>A. fumigatus</i>	+	+	-	+	+	+	+	-	+	+
4.	<i>Rhizopus microsporus</i>	+	+	-	-	-	-	+	+	+	+
5.	<i>Mucor racemosus</i>	-	-	+	+	-	-	+	+	+	-
6.	<i>Rhizoctonia bataticola</i>	-	-	-	-	-	-	+	+	-	-
7.	<i>Penicillium canadense</i>	+	-	+	-	+	+	+	-	+	+
8.	<i>Fusarium oxysporum</i>	-	-	-	-	-	-	+	+	+	-
9.	<i>F. solani</i>	-	-	-	-	-	-	+	+	+	-
10.	<i>Trichoderma viride</i>	+	+	+	-	-	-	+	+	-	-
11.	<i>Alternaria alternata</i>	+	+	+	-	+	+	-	-	+	+
12.	<i>Cladosporium oxysporum</i>	+	+	-	-	+	+	-	-	+	-
13.	<i>Dechslera spicifera</i> v. Arx state of <i>Cochliobolus spicifera</i>	+	-	-	-	+	+	-	-	-	-
Total number of species		9	7	5	3	7	6	10	8	9	5

- = Absence, + = Presence, PDA = Potato-dextrose-agar method, BT = Blotter technique

Out of these *A. niger* was found to be associated universally with all the inert matters. The highest incidence of fungal species was observed from oil particles.

Seed discoloration

The various discoloration symptoms that were observed on the infected seeds are – light brown to dark brown, dark brown to black, black to olivaceous black , grey, creamish brown, olive brown to clove brown and pink.

Besides, shrinkage of the seeds, seed rot and hypertrophy of the seeds were also observed. It was observed that the size of heavily infected seeds gets reduced in comparison to the healthy seeds. The seed coat of the heavily infected seeds got deteriorated due to harbouring of spermaphilein fungi. The reticulation walls of the heavily infected seeds also got deteriorated and ruptured (Plate 1). Mechanically damaged (by insects, birds and threshing) seeds were also observed but in lesser number.

Weight loss

A significant decrease in the weight of infected (mild to heavily infected) seeds has been observed which is shown in Table 2.

Moisture content

The percentage moisture content of opium poppy seeds has been shown in Table 3. As revealed from the table, higher moisture percentage was observed in seeds collected from market whereas the lower moisture percentage was observed in seeds collected from field.

Mycoflora from the seed washings

In total 10 fungal species viz., *Aspergillus niger*, *A. fumigatus*, *A. terreus*, *Alternaria alternata*, *Fusarium oxysporum*, *Drechslera spicifera* v. *Arx* state of *Cochliobolus spicifer*, *Rhizopus microsporus*, *Cladosporium oxysporum*, *Curvularia lunata*, *Peronospora arborescens*, and *Erysiphe polygoni* were observed. Out of these, *P. arborescens* and *E. polygoni* belongs to obligate fungi.

***In situ* mycoflora**

The fungi that came up in *in situ* test, include 15 and 19 fungal species from external surface, and 2 and 10 fungal species from internal surface of healthy and deteriorated capsules, respectively. Similarly, healthy and deteriorated seeds showed 4 and 12 fungal species from external surface whereas, zero and 10 fungal species from internal surface respectively (Table 4). However, no fungal species was obtained internally from healthy seeds taken from healthy capsules.

Table 2 : Showing weight loss of seeds due to fungal deterioration

Weight of 1000 seeds				Weight lost	
Lot	Healthy seeds	Infected seeds		(a-b)	(gm)
	(a)	(gm)	(b)	(gm)	
1.		0.3890		0.2580	0.1310
2.		0.3972		0.2674	0.1298
3.		0.3873		0.2598	0.1275
Average		0.3911		0.2617	0.1294

Table 3: Showing moisture content of *Papaver somniferum* seeds

Initial		Duration	Source of	Wt.	Wt. lost	Per cent
Wt. (gm)		of drying	seed	after	(gm)	moisture
		(hrs)	sample	drying		lost
				(gm)		
1.	10.00	6	Field	9.6786	0.3214	3.2140
2.	10.00	6	Stores of commercial growers	9.6612	0.3388	3.3880
3.	10.00	6	Market	9.6600	0.3400	3.4000
Wt = Weight				hrs = Hours		

Table 4: Showing presence of mycoflora *in situ* in *Papaver somniferum* (*capsule and seeds)

Fungi isolated		Healthy				<u>Deteriorated</u>			
		Capsule	Seed		Capsule	Seed		Int.	Int.
		Ext.	Int.	Ext.		Ext.	Int.		
1.	<i>Aspergillus niger</i>	++	-	+	-	+++	+	++	++
2.	<i>A.flavus</i>	++	+	+	-	++	+	++	+
3.	<i>A.fumigatus</i>	+	-	-	-	++	+	+	+
4.	<i>A.terreus</i>	+	-	-	-	+	-	-	-
5.	<i>Penicillium canadense</i>	+	-	-	-	+++	+	-	-
6.	<i>P. expansum</i>	+	-	-	-	+	-	-	+
7.	<i>P. chrysogenum</i>	+	+	-	-	++	+	++	+
8.	<i>Fusarium moniliformae</i>	+	-	-	-	+	+	+	+
9.	<i>F. oxysporum</i>	+	-	-	-	+	-	+	+
10.	<i>Cladosporium oxysporum</i>	+	-	-	-	+	+	+	+
11.	<i>Alternaria alternata</i>	++	-	+	-	++	-	++	-
12.	<i>Alternaria state of Pleospora infectoria</i>	-	-	-	-	+	+	+	-
13.	<i>Drechslera spicifera</i> v. <i>Arx</i> state of <i>Cochliobolus spicifer</i>	+	-	-	-	++	+	++	+
14.	<i>Mucor racemosus</i>	+	-	-	-	++	-	+	-

15.	<i>Rhizopus microsporus</i>	++	-	+	-	+++	+	+++	+++
16.	<i>Curvularia lunata</i>	+	-	-	-	+	-	-	-
17*.	<i>Peromospora arborescens</i>	-	-	-	-	+	-	-	-
18*.	<i>Erysiphe polygoni</i>	-	-	-	-	+	-	-	-
19*.	<i>E.cichoracearum</i>	-	-	-	-	+	-	-	-
Total number of species		15	2	4	-	19	10	12	10

- =Absence

+ = Presence

++ = Sub-dominance

+++ =Dominance

* =

Ext. =

Int. =

Observed by 'washing technique'

External

Internal

Out of these *A. niger*, *P. candense* and *R. microsporus* were found to be most dominating whereas, *A. flavus*, *A. fumigatus*, *P. chrysogenum*, *A. alternata* and *D. spicifera* appeared sub-dominating in *in situ* conditions. However, *A. niger* and *R. microsporus* appeared in higher proportion with higher number of colonies from deteriorated capsule and seeds.

Besides, three obligate parasitic fungal species viz., *P. arborescens*, *E. polygoni* and *E. cichoracearum* were also encountered from external surface of deteriorated capsules. These three fungal species were observed by the washing technique.

External spermatophyte mycoflora

The total fungi that came up on seeds tested include 26 fungal species belonging to 12 genera together with one sterile mycelia (Table 5). Out of these, 24 fungal species were encountered from moist blotter, 17 fungal species from potato-dextrose –agar whereas 11 fungal species were, encountered from malt-extract-agar and moist-sand, respectively.

Out of 4 methods used in the present study, moist blotter yielded maximum number of fungal species and also fungal colonies. However, the colonies of *R. microsporus*, *C. lunata*, *A. alternata* and *D. spicifera* v. Arx state of *C. spicifer* were in higher number in potato – dextrose- agar than in the blotter, whereas the colonies of *F. oxysporum* and *F. solani* were in much higher number in moist-sand. *A. niger*, *R. microsporus*, *R. nigricans*, *F. oxysporum*, *F. solani*, *C. lunata*, *A. alternata* and *D. spicifera* v. Arx state of *C. spicifer* were found of universal occurrence as these were encountered from all the methods. Interestingly, a rare storage fungi, *A. restrictus* was also observed on 5 per cent of seeds.

The fungi showing higher percentage (11-100 per cent) of infections were *A. niger*, *A. flavus*, *A. ustus*, *A. funiculosus*, *A. fumigatus*, *A. sydowii* , *R. Microspores* , *R. nigricans*, *M. racemosus*, *P. canadense*, *F. solani*, *A. alternata* and *D. spicifera* v. arx state of *C. spicifer* whereas the others were showing up to 10 per cent infection only (Table 5).

In all the tests, *A. niger* and *R. microsporus* were found to be most dominating fungi whereas, *A. flavus* , *A. ustus*, *A. funiculosus*, *A. fumigates*, *A. sydowii*, *R. nigricans*, *M. racemosus* , *P. canadense* , *F. oxysporum*, *F. solani*, *A. alternata* and *D. spicifera* v. Arx state of *C. spicifer* were found to be sub-dominating. The fungi of these two categories were found to be the most commonly occurring deleterious and deteriorating fungi to opium poppy seeds.

Endophytic spermatophyte mycoflora

The total fungi that came up on seeds tested include 11 fungal species belonging to 9 genera. Out of these, 11 fungal species were encountered from moist blotter and 7 fungal species from potato- dextrose– agar, whereas , 4 and 7 fungal species were encountered from malt-extract –agar, and moist- sand, respectively.

Out of four methods used in the present study, moist blotter yielded maximum number of fungal species and also fungal colonies. However, the colonies of *A. alternata*, *R. microsporus*, *C. lunata*, *D. spicifera* v. Arx state of *C. spicifera* were in higher number in potato- dextrose- agar plates than in blotter plates, whereas the colonies of *F. oxysporum* and *M. phaseolina* were in higher number in moist - sand plates.

A. niger, *A. alternata* and *D. spicifera* v. Arx state of *Cochliobolus spicifer*, were found of universal occurrence as they were encountered in all the four methods tested. The fungi showing higher percentage (21- 100 per cent of infections were *A. niger* (in PDA, MEA and MST) , *A. alternata* (in BT, PDA and MEA) whereas others were seen causing 10 per cent infection only (Table 6).

In all the tests, *A. niger*, *A. alternata*, *D. spicifera* v. Arx state of *C. spicifer* and *R. microsporus*

(except in MST) were found as the most dominating fungi whereas *P. canadense*, *F. oxysporum*, *M. phaseolina* and *C. capsici* were found as the sub-dominating fungi.

As revealed by Table 5 and Table 6, *A. niger*, *A. alternata*, *P. canadense*, *F. oxysporum*, *C. lunata*, *D. spicifera* v. Arx stare of *C. spicifer*, *R. microsporus* were of common occurrence in both the tests which shows their wide occurrence and adaptability.

Surface disinfection of seeds with mercuric chloride wiped out the infestation of fungi viz., *A. flavus*, *A. ustus*, *A. funiculosus*, *A. fumigatus*, *A. terricola*, *A. restrictus*, *C. globosum*, *P. chrysogenum*, *C. herbarum*, *C. oxysporum*, *F. solani*, *Alternaria zinniae* and white sterile mycelia. Pre-treatment of seeds with sodium hypochlorite, provides better development of several slow growing and late coming fungal species by restricting the growth of fast growing fungal species like *A. niger* and *R. microsporus*.

The percentage of saprophytic fungi isolated from discolored seeds were much more than those that were obtained from normal coloured seeds. Discoloured seeds also showed higher percentage of *A. niger* and *R. microrosporus*.

Effect of temperature on the incidence of spermaphileic fungi

Incubation of opium poppy seeds at two different temperatures by blotter and PDA methods revealed a total of 12 fungal species in both the methods at low ($20 \pm 2^\circ \text{C}$) temperature whereas 19 and 18 fungal species were recovered at high ($27 \pm 2^\circ \text{C}$) temperature in blotter and PDA methods, respectively (Table 7).

Out of these, *A.niger*, *A. flavus*, *P. canadense*, *A. alternata*, *F. solani*, *C.lunata*, *R.microsporus* and *R. nigricans* were encountered at both the temperature but their population was higher at higher ($27 \pm 2^{\circ}\text{C}$) temperature. As revealed by both the methods of study, incidence varied with variation in the temperature.

G. virens appeared at low temperature only whereas, fungal species like *A. sydowii* , *D. spicifera* v. Arx state of *C. spicifer* , *M. racemosus*, *Drechslera* state of *C. bicolour*, *C. capsici* and a species of *Phoma* were encountered at high temperature (Table 7).

Table 7: Incidence of different spermeophilein mycoflora on the *Papaver somniferum* seeds incubated at 20 (+2)⁰ C and 27 (+2)⁰ C

Per cent incidence of fungi at													
20 (+2) ⁰ C : 27(+2) ⁰ C													
BT : BT : PDA													
Oc c-urr-enc e Tp %A Occ -urr-enc e Tp %A Occ -urr-enc e Tp %A													
1.	<i>Aspergillus niger</i>	++	21.0	15.0	++	15.0	12.0	+++	43.0	11.87	++	48.0	13.91
2.	<i>A. flavus</i>	+	13.0	9.28	+	12.0	9.6	+++	36.0	9.94	++	33.0	9.56
3.	<i>A. sydowii</i>	-	-	-	-	-	-	+	5.0	1.38	+	6.0	1.73
4.	<i>A. versicolor</i>	-+	-	-	+	8.0	6.4	+	10.0	2.76	++	13.0	3.76
5.	<i>A. fumigatus</i>	+	8.0	5.71	-	-	-	++	15.0	4.14	++	14.0	4.05
6.	<i>Penicillium canadense</i>	++	13.0	9.28	++	13.0	10.4	++	23.0	6.35	++	15.0	4.34
7.	<i>Alternaria alternata</i>	++	12.0	8.57	+	10.0	8.0	+++	52.0	14.36	++	49.0	14.20
8.	<i>Fusarium solani</i>	++	18.0	12.85	++	12.0	9.6	++	18.0	4.97	++	16.0	4.63
9.	<i>F. oxysporum</i>	+	5.0	3.57	-	-	-	++	23.0	6.35	+	21.0	6.08
10.	<i>Curvularia lunata</i>	+	5.0	3.57	+	7.0	5.6	+	4.0	1.10	++	6.0	1.73

[illegible]

Total number of species 12
TP=362

TP= 140

12

TP=125

19

=	=	Absence	I		BT	=	Blotter
+	=	Presence	I		PDA	=	Potato-
++	=	Sub-dominance	I	Occurrence	% A	=	Percentage
+++	=	Dominance	I		TP	=	Total
					TP	=	Total

Population of any individual fungi

population of all isolated fungi

Survey of opium poppy diseases

Survey of opium poppy diseases was carried out in three commercial opium poppy fields under three different climatic conditions in three major opium poppy growing areas of eastern Uttar Pradesh

viz., (i) Mughalsi, (ii) Barabanki and (iii) Kumarganj

In eastern Uttar Pradesh, The growers used local cultivar ' Kalidanthi ' for sowing purposes. Farmers of all the three areas did not adopt any major plant protection measures during the season. Side by side, they were least aware of modern agrotechniques. The crop was sown by broadcast method. In all the three localities, the crop was sown within the first fortnight of November. The crop sown after this period was found more vulnerable to various diseases. The plant stubbles of opium poppy crop of previous cropping season (both healthy and diseased), except the poppy straw, was not removed from the field which serves as source of various diseases for the next cropping year. It was also found that the crop was sown in the same fields from last 4 to 5 years as a result of which various pathogens were carried over from year to year resulting in increase of inoculum and severe lossess to the crop. The opium poppy crop, in all the three areas under survey was found to be surrounded by other crops and vegetation (orchards etc.) as described below:

Plot A: The opium poppy field 'A' was surrounded by other crops from three sides. On north, there was a narrow irrigation channel. At the left side in eastern direction there was a field of mustard (*Brassica nigra*) crop and at the right side, a field of mixed crop of wheat (*Triticum aestivum*) and mustard. A narrow path lied in between the poppy crop and the fields in eastern direction. On the south, there was a narrow strip of garlic (*Allium sativum*) and broad bean (*Vicia faba*) crop followed by vast fields of wheat. On the west , there was another narrow path then there was a 'sanwan' (*Echinochloa frumentacea* ,small millet) field . There was a 'pigeon pea' (*Cajanus cajan*) field on the right side of sanwan field , and was on southern–western corner of the opium poppy field . The soil type was of sandy loam nature.

Plot B: The opium poppy field 'B' was surrounded by other crops from all the four directions. On north, there was a narrow path followed by a mixed crop of potato (*Solanum tuberosum*) and pea (*Pisum sativum*). On the east to south part , there was a narrow irrigation channel, followed by a wheat crop in the left part and on the right part there was a chilli (*Capsicum annuum*) crop. On the south, there was a vast wheat crop field extending up to western corner. On the west , there was a mustard field followed by the pigeon pea crop. The whole poppy crop field was surrounded from three sides i.e. west, south and north directions

by huge mango (*Mangifera indica*) orchards. The soil type was of silty loam nature.

Plot C: The opium poppy field 'C' was surrounded by other crops and vegetation from three directions . On the north, there was a field of broad bean crop which was followed by a vast river bank and then the river . On the eastern part, there was a mixed orchard of mango, guava (*Psidium guajava*) and mahuwa (*Madhuca indica*) at the right angle wheat and mustard fields . On the southern part, opium poppy field was followed by a huge mango orchard . On the west, there was a narrow path and then there was a mixed field of mustard and pea crop. The soil type was of loamy nature.

Procedure followed for the estimation of losses caused by various diseases is given below. Survey of opium poppy diseases was conducted right from the seedling stage and continued up to maturity of the capsules.

The survey was done in a random way choosing twenty spots per field randomly. The spots for the survey were selected randomly every time the selected fields were visited. Number of diseased and healthy plants were counted by placing a quadrangular object of one sq.m. size. Observations were recorded on the per cent mortality of the plants due to particular disease or number of leaves or plant parts infected per one thousand opium poppy plants

. The diseased plants or plant parts were collected in sterilized polythene bags and brought to the laboratory for further studies and identification of the causal organism(s).

The data from different survey trips were collected and pooled. The comparative incidence of various opium poppy diseases was analysed and is presented in Table 8. Following were the diseases and their causal organisms recorded so far.

1. Damping – off (DO) caused by *Fusarium solani*.
2. Downy mildew (DM) caused by *Peronospora arborescens*.
3. Wilt disease (WD) caused by *Fusarium oxysporum*.
4. Root – rot (RR) caused by *Rhizoctonia bataticola* Briton -Jones state of *Macrophomina phaseolina*.
5. Leaf spot (LS) caused by *Alternaria alternata*.
6. Leaf spot (LS) caused by *Drechslera spicifera*_v. Arx state of *Cochliobolus spicifer*.
7. Sclerotial wilt (SW) caused by *Sclerotium rolfsii*.
8. Stem rot (SR) caused by *Mucor racemosus*.
9. Sepal blight (SB) caused by *Alternaria alternata*.
10. Petal blight (PB) caused by *Alternaria alternata*.

11. **S**tamen blight (St **B**) caused by *Alternaria* state of *Pleospora infectoria*.
12. **C**apsule rot (CR) caused by *Rhizopus microsporus*.
13. **P**owdery mildew (PM) caused by *Erysiphe polygoni* and *Oidium* state of *Erysiphe cichoracearum*.

Results presented in Table 8 clearly indicate that the most destructive diseases were powdery mildew (*E.polygoni*) (96.44 per cent incidence) , leaf blight (81.0 per cent incidence) , leaf spot (67.22 per cent incidence) and downy mildew (66.38 per cent incidence) followed by capsule rot (25.94 per cent incidence) , damping – off (25.22 per cent incidence) , wilt disease (19.33 per cent incidence) , petal blight (16.38 per cent incidence) , root rot (12.25 per cent incidence) , stamen blight (11.55 per cent incidence),

**Table 8: Incidence of various opium poppy diseases in eastern utter pradesh
during 1982-83**

Distric ts	Diseases (per cent)												
	Do	D	W	RR	LS	LB	S	S	PM	SB	PB	ST	CR
		M	D				W	R				B	
Mugha	28.	74.	22.	8.7	65.	90.	9.	7.	96.0	19.	18.	15.	36.
lsi	33	50	50	5	00	00	66	00	0	33	33	36	00
Baraba	27.	66.	17.	17.	66.	78.	3.	-	100.	17.	12.	10.	23.
nki	33	66	66	00	66	50	30		00	66	50	66	50
Kumar	20.	58.	18.	11.	70.	74.	6.	-	93.3	21.	18.	9.0	18.
ganj	00	00	33	00	00	50	00		3	00	33	0	33
Mean	25.	66.	19.	12.	67.	81.	6.	7.	96.4	19.	16.	11.	25.
	22	38	49	25	22	00	32	00	4	33	38	55	94

DO =Damping-off

LS= Leaf spot

SB=Sepal blight

DM= Downy mildew

LB= Leaf blight

PB=Petal blight

WD=Wilt disease

SW= Sclerotial wilt

StB =Stamen blight

RR=Root-rot

SR=Stem rot

CR=Capsule rot

PM= Powdery mildew

sclerotial wilt (6.32 per cent incidences). Stem rot caused by *M. racemosus* was observed only in Mughalsi with 7.00 per cent incidence.

Data presented in Table 8 indicate that the intensity of DO ranged from 20.00 to 28.33 per cent, DM from 58.00 to 74.50 per cent, WD from 17.66 to 22.50 per cent, RR from 8.75 to 17.00 per cent, LS from 65.00 to 70.00 per cent, LB from 74.50 to 90.00 per cent, SW from 3.30 to 9.66 per cent, SR 7.00 per cent, PM from 93.33 to 100.00 per cent, SB from 17.66 to 21.00 per cent, PB from 12.50 to 18.33 per cent, StB from 9.00 to 15.00 per cent and CR from 18.33 to 36.00 per cent.

Observations recorded in Table 8 show that the highest incidence of PM (100.00 and 96.00 per cent) was recorded in Barabanki and Mughalsi, respectively followed by LB (90.00 per cent) and DM (74.50 per cent in Mughalsi and Barabanki, respectively i. e. all these diseases were found in lethal scale, whereas the highest incidence of LS (70.00 per cent) was found in Kumarganj. Highest incidence of CR (36.00 per cent), DO (28.33 per cent) and WD (22.50 per cent) was recorded in Mughalsi. Incidence of SB was found highest (21.00 per cent) in Kumarganj, whereas highest incidence of PB (18.33 per cent) was recorded in Mughali and Kumarganj and that of StB (15.00 per cent was found in Mughalsi). Maximum RR incidence of 17.00 per cent was recorded in Barabanki. Highest incidence of SW and SR was found to be 9.66 and 7.00 per cent in Mughalsi.

Results presented in Table 8 reveal that at the time of survey, incidence of powdery mildew, leaf blight, leaf spot and downy mildew diseases were in alarming stage in all the three areas under survey followed by capsule rot and damping - off diseases but the productivity of the crop (quality and quantity of the latex and seeds) was lowered significantly only by downy mildew and powdery mildew diseases.

As the downy mildew appeared as a devastating disease especially during the primary growth stages of the crop, another survey was conducted in the next cropping season (1983-84) to study (i) the effect of sowing time on disease appearance, (ii) disease intensity at different stages of growth of the crop and (iii) the effect of previous cultivation on disease. The findings were as follows:

Three commercial opium poppy fields which were sown on different dates (i.e. on October 22, 1983, November 3, 1983 and November 25, 1983) were selected for the survey:

- i) Severely infected plants (primary/systemic infection) appeared 3 to 4 weeks after sowing irrespective of sowing time, while leaf spots (secondary (local) infection appeared after 6 to 10 weeks of sowing. It was observed that the crop sown earlier (i.e. on October 22 and November 3, 1983) escaped leaf spot infection for a longer period while the crop sown later (November 25, 1983) suffered severely from the disease.

- ii) Intensity of disease was recorded intermittently from 1st December, 1983 to 1st April, 1984. Severely infected plants were found throughout the cropping period but the incidence was higher at seedling to 10 leaved stage and between 80-140 days period nearly all leaves were covered by leaf spots (Table 9).

The data presented in Table 10 indicate that when the crop was cultivated for the first time or after a gap of 3 years or more, only spots (secondary infection) appeared and not the severely infected (primary infection) plants. Such plants appeared in large numbers in plots in which opium poppy was cultivated during previous years or before a gap of one or two years. Heavy incidence (severely infected plants were found where the crop was regularly cultivated in consecutive years. Preceding crops, other than poppy, did not have any stimulatory or inhibitory effect on the disease appearance in the subsequent poppy crop.

Number of fields observed	Dates of observation								
	Dec. 1 1983	Dec. 6 1983	Jan. 2 1984	Jan. 6 1984	Feb. 2 1984	Feb. 6 1984	Marc h 2 1984	Marc h 16 1984	Apri 11 1984
	Crop age in days								
A	48	63	78	93	108	123	138	153	168
B	33	48	63	78	93	108	123	138	153
C	22	37	52	67	82	97	112	127	142
	Degree of secondary infection[‡]								
A	+	++	+++	++	+++	+++	++	++	+
B	++	++	+++	++	+++	+++	++	++	+
C	++	+++	+++	+++	+++	+++	+++	++	+
	Incidence of leaf spots (primary infection)^{‡#}								
A	3	2.5	7	13	16.4	*	17.5	*	*
B	5	**	8	17	12.3	*	*	*	20.2
C	6	**	2.8	9.7	11.5	*	17.2	*	21.7
#	=	Such plants were removed from the field especially during thinning.							
##	=	Figure showing average number of spotted leaves per plant.							
*	=	Leaf spots covering almost all leaves of the of the plants.							
**	=	Disease just appeared on few plants. + = Infected plants upto 10% in the field.							
++	=	Infected plants upto 11 to 28% in the field.							
+++	=	Infected plants upto 26 to 50% in the field.							
++++	=	Infected plants upto 51 or more in the field.							

Table 10: The effect of previous poppy cultivation on the incidence of downy mildew in subsequent crop

Previous poppy cultivation in the plot	No. of fields observed	Appearance of disease	
		Severely diseased plants*	Leaf spots
Preceding 3 years or more	10	++++	≠
Preceding 2 years	10	++++	≠
Preceding year only	10	+++	≠
Alternate years	7	++	≠
Two years earlier	8	++	≠
Three years earlier	5	+	≠
Five years earlier	2	-	≠
Freshly cultivated	15	-	≠

+++++ = Very high incidence
 +++ = High incidence
 ++ = Medium incidence
 + = Low incidence
 ≠ = Disease appeared
 - = Disease did not appear
 * = Incidence of severely infected plants (both primary and secondary infected plants were found).

Symptomatology

Following are the symptomatological details of the fungal diseases found impairing opium poppy crop during the course of investigation.

Damping-off disease

The disease was caused by *Fusarium solani*. The seedlings initially developed small brown to black spots at the collar region. Infected portion became rotted and got constricted resulting in toppling of the seedlings.

Downy mildew disease

The disease was caused by *Peronospora arborescens*. The disease manifested itself in two forms:

- (i) Primary (systemic) infection and
- (ii) Secondary (local) infection

(i) Primary (systemic) infection

The primary infection was caused through the oospores, inflicting severe damage to the young plants. Such plants bore two distinct phases; lower healthy part and upper diseased part. In healthy parts, the placement and size of the leaves were normal while in the diseased part, the leaves remained small, chlorotic, curling downwards at the edges and closely placed (Plate 1a and 1b). Infection spread upwards from the lower diseased leaves. Heavy sporulation occurred on entire lower surface of the diseased leaves, which were completely covered with brownish coating of the fungus composed of mycelium, conidiophores and conidia

of the fungus (Plate 1c). The sporulation on leaves was persistent. The growing point almost fully affected and could not grow normally, the new leaves becoming infected from the very beginning and being rapidly killed (Plate 1 d). The disease sapped the plant vigour and stunted the plant . On disease being severe, heavy sporulation occurred on peduncle , flower buds and young capsules but not persistently (Plate 1 e) .

The infected buds remained under-developed, became feckless and did not open . Capsule formation did not take place and when formed it became feckless and shrivelled, got crimped and yielded little or no latex. Simultaneously, rudimentary brownish black structures developed in place of normal seeds. Such capsules ultimately dried gradually. The infected plants died prematurely (7-40 days after appearance of the disease). The disease continued to spread even during very dry weather during the March – April.

(ii) Secondary (local) infection

The secondary infection occurred through the conidia and appears as brown to black coloured spots on the leaves of more than one month old plants. The infected area became chlorotic gradually turning into localized necrosis (Plate 1F). The spots often coalesced and became large covering most of the 5 to 8 lower leaves. Sporulation occurred in the underside of spotted area but was neither heavy nor persistent. In spite of excessive spots, plants bearing infected leaves, did not die prematurely . The disease is locally called 'Chandwa',

WILT DISEASE

The disease was caused by *Fusarium oxysporum*. Symptoms of the disease first appeared when the plants were about 5 to 6 weeks old. The disease was characterized by yellowing and flagging of leaves. With aging, the disease ultimately results in foliar wilt and rapid desiccation of the whole plant (Plate 2). The examination of the main root and base of the stem, revealed that the fungus produces a brownish-black discolouration of the root and stem bases. With the aging, the infected tissues of the wilted plants were blackened, either uniformly or in dark streaks. The streaks, when present were found to arise from main and lateral roots. In a few plants, the black streaks were found extending upward to the stem part.

Histopathological studies revealed that the mycelium of the fungus obstructed the translocation of the sap through the wood vessels which in turn resulted in the above mentioned aerial symptoms. The disease is locally called 'Jalkandra',

ROOT-ROT DISEASE

The disease was caused by *Rhizoctonia bataticola* Britton-Jones state of *Macrophomina phaseolina*. The disease was characterized by gradual yellowing of the leaves and flower buds followed by drooping and withering (Plate 3). The plants having inchoate capsules, when attacked by the disease, the capsules lost their greenness, shriveled and died prematurely. The root-rot affected plants could be pulled out easily from the soil. All the infected plants died prematurely.

Infection often originated from the stem base giving them a red brown to brownish black tint and proceeds slowly downwards up to the main and lateral

roots. At the collar, the stem was blackened and cracked. The infected root portion became necrotic and disorganised. The rot is usually a dry one, at least on the above ground part. The cortex was destroyed. Numerous minute sclerotia have been produced on the rotted root parts. The disease is locally called 'Jalkandra'.

SCLEROTIAL WILT DISEASE

The disease was caused by *Sclerotium rolfsii*. Plants were found susceptible at young stage. The fungus attacked the plants at collar region and below the soil. Dark lesions started developing just below to nearly 10 cm above ground level. The leaves soon yellowed, became flaccid and droop off. Soon the entire plant wilted and died. The base of the stem was slightly discoloured. On splitting the stem, a dark greyish weft of hyphae were sometimes found within the hollow stem and small, round, black shining bodies (sclerotia) could be seen adhering all over the inner surface. The mycelium also entered the hollow of the stem and the spaces between the stem and sheath forming a grey, wooly growth. Sclerotia developed on the free mycelium lining the inner surface. The sclerotia were produced in plenty and were responsible for perpetuation and dissemination of the pathogen.

Leaf blight disease

The disease was caused by *Drechslera spicifera* v. Arx state of *Cochliobolus spicifer*. The disease started as small, irregular diffused spots both on the younger and older leaves but more frequently on older ones. Extension occurred with the aging and spots became diffused and turned to dark brown to black. The affected leaves (Plate 5) which were followed by premature dying of the infected leaves.

Leaf spot disease

The disease was caused by *Alternaria alternata*. The disease initially started as a small pin-head sized light brown spots both in the older and younger leaves but more frequently on the older ones. The spots later on became spherical to irregular. Extension occurred with the aging and spots turned dark brown to black (Plate 4). The infected regions ultimately became necrotic resulting in premature dying of the infected leaves.

Stem rot disease

The disease was caused by *Mucor recemosus*. The disease manifested itself as a ashen coloured diffused spot at the base of the stem. With the aging disease proceeded upwards encroaching much part of the stem. The ashen coloured spots later on turned black to olivaceous black. The infected portion got constricted and looked girdled resulting in wilting of the foliage before or after flowering. The infected plants toppled automatically or on getting slight jerk by any means.

Sepal blight disease

The disease was caused by *Alternaria alternata*. Infection initially started from upper half of the sepals which were in intact position covering the whole reproductive parts. The disease manifested itself as small, irregular to spherical (mostly spherical), dark brown to black coloured spots. With the advancement of the disease, spots coalesced forming long diffused spots extending downwards. The infected portion became necrotic giving a tarry appearance of the sepals (Plate 6a). The infection extended rapidly and covered 1/2 to 3/4th part of sepals and occasionally covered whole of the sepals. The buds which were ready to flower ceased to grow and fail to open perhaps due to tenacious character of the diseased

sepals, resulting in bursting of sepals from other weakened points rather than from normal opening point (Plate 6 b). Such buds either flowered late or fail to flower and withered subsequently.

Petal blight disease

The disease was caused by *Alternaria alternata*. Infection initially started from the periphery of the upper half of the petals, when they were in intact position (Plate 7b). The disease manifested itself as small light brown irregular spots which later on turns to strip form running through the periphery. Extensions occurred with the aging and the infection extended downwards, more preferably in form of diffused strips covering more than 90 per cent area of the petals (Plate 7a). This results in failure of pollination and the covered ovary either could not develop into capsule or if develops, the growth becomes rudimentary. Such capsules were found unproductive for the latex and the seeds.

Stamen blight disease

The disease was caused by *Alternaria* state of *Pleospora infectoria*. It initially appeared on the anther of the inchoate stamen as brown to black coloured, dot shaped, spots. Number of spots increases with the growth of the stamen and gradually spread all over the stamen making them blurred. With the aging, spots coalesces giving a tarry appearance to the stamens. On severity of the disease, crumpling of the anther takes place which incapacitate the stamens for reproductive purpose. The diseased stamens die later on.

Capsule rot disease

The disease was caused by *Rhizopus microsporus*. The disease attacked the capsules when they are grown to full size and ready for lancing. But it infected the immature capsules, occasionally. Initially, the disease manifested itself as small, ashen coloured rounded spots on middle portion of green capsules. With the aging, the spots increased in size in a diffused form covering a large area of the capsule (Plate 8). Infected area became bulged and tarnished. In severe condition of the disease whole capsule became floppy resulting in total rotting of the capsule.

Powdery mildew disease

A. Powdery mildew caused by *Erysiphe polygoni*

Powdery mildew appears in the field after 90-112 days of sowing i.e. nearly at and after flowering stage. Late sown crop (after second week of November) develops heavy powdery mildew while crop sown before last week of October almost escaped the disease. The disease made its first appearance in the last week of February or in the first week of March. Disease first attacked the base of the stem where it manifested as small, circular spots consisting of radially arranged white mycelium. Extensions occurred with the aging and spots coalesced with each other resulting in formation of larger patches of white powdery mass. Sporulation occurred soon. Several new colonies continued to appear covering larger part of the stem. After 10 to 15 days of the appearance of the disease, affected parts, became black. When mildew reached to its maximum, 1/2 to 3/4th of stem appeared black interspersed with green patches (Plate 9 a). Simultaneously, but more frequently after luxurious growth of the fungus on the

stem, it started to make its appearance on lower side of the leaves. Extensions occurred with the aging and soon the disease covered both lower and upper surfaces of the leaves forming powdery coating all over the leaf surface (Plate 9b). The mildew growth was luxuriant in shady part of the field. Floral parts and peduncle of younger (late appearing) branches also got severely attacked by the mildew due to which capsule formation did not take place. Whenever, capsule formed on such branches, they got attacked in inchoate stage by the mildew, resulting in crumpling and withering. The disease is locally called 'Dahia'.

Powdery mildew caused by *Oidium* state of *Erysiphe cichoracearum*

The disease was observed during the middle of March, first at the base of the stem. Initially patches were small and isolated but soon they coalesced with each other covering a good part of the stem making the mildew colonies effuse, indeterminate and subpulverulent. The mildew forms a fine white or pale whitish web which became powdery when sporulation occurred. After 10-15 days of the appearance of the disease, blackening developed in the affected parts. Simultaneously, but more frequently after luxurious growth of the fungus on the stem, lower leaves, chiefly on their undersurface, were infected by the mildew, covering all or a considerable part. At first patches were small and isolated (Plate 9 c), later becoming effuse. Extensions occur with the aging and soon both lower and upper surfaces were arrogated by the disease and covered with a floury coating. The mildew growth was luxuriant on shaded parts of the plant and their growth was rapid in shady parts of the field. Heavily infected leaves loose their greenness in the densely covered parts turns brown followed by withering.

Morphological studies on the pathogens

Fusarium solani (Mart.) Sacc

Colony : Under laboratory conditions, colonies were usually white

to pale white(Plate 10 a).

Mycelium : Aerial mycelium striate, sparse to dense and floccose, greyish white.

Conidiophore : Microconidiophores elongated and sparsely branched,

reaching up to 400 μ long. Each branch usually terminates

in a single cylindrical to barely subulate phialide which

measures 45-80 x 2.5-3 μ .

Conidia : Microconidia (Plate 10 b) develop after 4-7 days from initially simple but later formed short multi-branched conidiophores, abundant, measuring 8-16 x 2-4 μ , mostly one septate, small,

oval to oblong, straight or sometimes slightly curved, hyaline.

Macroconidia (Plate b & c) are inequilaterally fusoid with many of the spores having the widest diameter in penultimate cell, dorsiventral, apical call is pointed and sometimes beaked, curved towards the end where they are narrower, blunt and smoothly rounded at the tip, mostly 0-5 septate, sometimes more or less septe, hyaline. Macroconidia with no septation measures 5-12 x 2-5 μ , with one septation 14-30 x 3-5 μ , with three septation 19-63x3.5-7 μ , with five septation 22-77x 4-8 μ and rarely with seven septation measures 60-89 x 5-8 μ .

Chlamydospoe: Chlamydospores (Plate 10 c) globose to oval, smooth to rough walled, 9-12 x 8-10 μ and formed terminally on short lateral branches or are intercalary, only occasionally do they form chains, one celled or two celled, one celled chlamydospores measures 8-22 x 1-12 μ .

Asci and : Asci cylindrical, becoming clavate rounded
apex with

Ascospore a central pore, measuring 60-80 x 8-12 μ .
Ascospores were ellipsoid to obovate, hyaline
but become light brown, measuring 11-18 x 4-
7 μ (Plate 10 c).

Fusarium oxysporum Schlecht

Colony : Under laboratory conditions, colonies were
usually pale (Plate 11 a).

Mycelium : Mycelium delicate, white or peachy but usually
with a purple tinge, sparse to abundant then floccose, wrinkled
in older cultures.

Peronospora arborescens (Berk.) Casp

My~~celium~~celium : The mycelium consist of hyaline, septate
branching hyphae measuring 6-22 μ in
thickness.

Conidiophore : Conidiophores arise directly from the internal
hyphae . They were robust, erect,
sometimes nearly 1 mm in length x 10-12 μ

thick, 5 to 10 times dichotomously branched towards the tip, the ultimate branches being very fine, curved, short and diverging nearly at right angles (Plate 12 b).

Conidia : Conidia were borne single on ultimate pointed branchlets of conidiophores (Plate 12a). They were rounded-oval, smooth, hyaline or very pale, turning brown with age, measuring 20-25 x 18-22 μ in diameter.

Oospore : In the older withered spots, oospores were developed within tissues. They were rounded and pale yellow in colour measuring 30-54 μ in diameter.

Rhizoctonia bataticola (Taub) Britton-Jones state of

Macrophomina phaseolina (Tassi) Goid

Colony : Under laboratory conditions, colonies at first ashy, turning later to greyish black to black, with fluffy mycelium (Plate 13 a). The culture was atypical of the fungus forming

few sclerotia in sub – cultures. (Mordue, J. E.M. (C. M. I. England).

Mycelium : Mycelium branched and sparsely septate.

Conidiophore : Conidiophores hyaline, short obpyriform to
(Phialides) cylindrical, measuring 5-13 x 4-6 μ .

Conidia : Hyaline, ellipsoid to obovoid, measuring 14-
30 x 5-10 μ in diameter
(Plate 13 b).

Sclerotia : Sclerotia minute black, rough walled, hard,
measuring 50-300 μ in
diameter (Plate 13 c).

Sclerotium rolfsii Sacc

Colony : In culture, colonies were at first white but on
aging may turn to light brown especially at the
edges and on the surface of the medium (Plate 14
a).

Mycelium : Mycelium composed of a layer of thick hyphae,
not much septate or branched at first. In culture,
the mycelium, at first was white but later turned

brown, very floccose, not ropy, producing numerous sclerotia.

Sclerotia : Sclerotia were roughly circular, rough walled (Plate 14 b), pinkish buff to olive- brown to clove brown, globose, occasionally irregular, measuring 150-500 μ in diameter.

Alternaria alternata (Fr.) Keissler

Colony : Under laboratory conditions, colonies were usually black to olivaceous black but sometimes grey (Plate 15 a).

Mycelium : Aerial mycelium usually fairly abundant in cultures, varying from loose, open and cottony to close, tufted and wooly in appearance. Whitish to greyish, greenish to olivaceous or brownish to almost black. Hyphae hyaline, septate profusely branched measuring 3-6 μ wide.

Colony : Colonies were usually greenish black to olivaceous black and black on aging (Plate 16 a).

Mycelium : Aerial mycelium abundant in culture, greyish yellow to olivaceous, composed of brownish septate, branched hyphae (Plate 16 b).

Conidiophore : Conidiophores solitary or in small groups, flexuous, repeatedly geniculate with numerous well defined conidial scars (Plate 16 b,c,d), often torsive, mid to dark brown, up to 300 μ long or sometimes longer, 4 μ thick.

Conidia : Conidia straight, oblong or cylindrical rounded at the ends. (Plate 16 b,c,e), when mature golden brown except for a small area just above the dark scar which remains hyaline or very pale, smooth, constantly 3- pseudoseptate, measuring 20 - 40 x 9-14 (mostly 30-36 x 11-13) μ , hilum 2-3 μ , wide .

Mucor recemosus Fres

Colony : Colonies at first white to ashy white, turning later to yellowish brown (Plate 17 a).

Mycelium : Mycelium glistening white. Hyphae long slender , much branched, coenocytic, septate and bifurcate when bears sporangophores.

Sporangiophore: Sporangiphores erect, close, forming a yellow-turf of very variable height, measuring 5-40 mm high x 8-20 μ wide, branched irregularly in groups. All branches terminates in sporangia.

Sporangia : Sporangia very unequal in size, small globose, pale yellow, later wax-yellow or yellowish brown, measures 20-70 μ in diam, erect or occasionally incurved, hyaline.

Collumella : Columella free, globose to ovoid or broadly cruciform, campanulate, measure 17- 60 μ long x 7-30 μ at the base and 9-42 μ in greatest diam.

Spore : Spores hyaline, smooth, yellow in mass, globose and ovoid measuring 5-8 μ x 4-3 μ , more often elliptical measures 6-10 μ x 3-6 μ .

Gemmae : Gemmae in sporangiophores cylindrical to barrel shaped, measures 8-12.8 μ in diam.

Zygospore : Zygospore globose, slightly *striate*, measures 70-85 μ in diam, brown with conic warts.

Azygospore and

Chlamydospore: Azygospores and chlamydospores always numerous, chlamydospores formed either on the mycelium, or on the sporangiophores and even on the columellae. Colourless or yellow with a smooth membrane, shapes various, measures 20-30 μ long and 11-20 μ in *diam.*

Alternaria state of Pleospora infectoria Fuckel

Colony : Under laboratory conditions, colonies were effuse, grey, dark brown to black.

Mycelium : Mycelium immersed or partly superficial, olivaceous brown to brown.

Conidiophore : Conidiophores arising singly or in fascicles, simple or branched, straight or flexuous, sometimes geniculate, pale to mid golden brown,

smooth, measures up to 80 μ long and 3-6 μ thick with one or several conidial scars.

Conidia : Conidia formed in long, often branched chains, conical, obpyriform or obclavate, tapering gradually to a beak which is up to half the total length of the conidium and often swollen at its tips, pale to mid golden brown, distinctly verrucose and rather thick walled with up to 8 transverse septa usually close together and several longitudinal or oblique septa, overall length measures 20-70 (50) μ and 9-18 (14) μ thick in the broadest part, beak measures 3-5 μ wide.

Rhizopus microsporus v. Tieghem

Colony : Under laboratory conditions, colonies were fast growing, 5-8 mm high, from greyish white to very pale olivaceous grey to mouse grey to black depending on amount of sporulation (Plate 18 a).

Mycelium : Mycelium coenocytic, multinucleate and non-septate, septa were, however, formed in the older hyphae and at the time of formation of

reproductive structure. Rhizoids and stolons hyaline to light brown. Rhizoids branched.

Sporangiophore: Sporangiphores smooth-walled, non-septate (Plate 18 b), light brown, simple, sometimes united in a group of 2 or 3 arising from stolons usually opposite rhizoids. Measures up to 10 μ in diam, and 150-850 μ in length.

Sporangia : Sporangia globose, white at first then black, many spored (Plate 18 b, c). Measures 30-85 μ

Columella : Columellae sub globose to somewhat dorsiventrally flattened, light brown to grey. Measures 80-70 x 25-55 μ .

Erysiphe polygoni DC

Mycelium : Mycelium purely superficial, creeping over the host, generally delicate, fine and persistent, rarely thick.

Conidiophore : Conidiophores arise vertically from the surface and each bears several conidia (Plate 19 a).

Conidia : Conidia were borne on short, erect conidiophores and usually formed singly (rarely in chains). The production of conidia was so copious as to give the surface of the mycelium a characteristic powdery appearance. Conidia thin walled, elliptical, barrel-shaped, or sometimes cylindrical, measuring 25 -38 x 13-21 μ , colourless and unicellular (Plate 19 a).

Cleistothecia : Cleistothecia appears as sharp black specks, scattered on the surface of the white mycelium. Globose or rounded, small, 85-126 μ (usually about 90 μ) in diameter with a variable number of appendages, dark coloured or colourless and free or inter-woven with one another or with the mycelial hyphae. Septate when coloured and were often angularly bent or flexed but usually unbranched (Plate 19 c).

Asci and

Ascospore : Asci 3-10, usually 4-8, sometimes more, ovate to broadly-ovate or subglobose, sometimes short stalked, measuring $46-72 \times 30 - 45 \mu$, each containing from 3 to 8 ascospores. Ascospores elliptical, non-septate, colourless, measuring $19-25 \times 9-14 \mu$ (Plate 19 b).

Oidium state of *Erysiphe cichoracearum* DC

Colony : Under natural conditions, colonies broadly effuse, indeterminate, arachnoid to sub-pulverulent, white or pale white.

Mycelium : Mycelium usually well developed, superficial, evanescent but sometimes persistent and effuse. The mycelium forms a fine or dense network according to the vigour of its development, composed of branching hyphae.

Conidiophore : Conidiophores arise from the recumbent hyphae, arise more or less at right angles to the surface from which upright chains of conidia of the customary oidium type found in the mildew arise (Plate 20 c).

Conidia : Upright chains of conidia of the customary oidium type, arise from the ultimate part of the conidiophores. The chains consists conidia, very variable in size, measuring 25-45 x 14 - 26 μ , rounded at the ends, hyaline. (Plate 20 c).

Cleistothecia : Cleistothecia gregarious or scattered, globose becoming depressed or irregular measuring 90-135 μ in diam. Appendages numerous, basally inserted, myceloid, interwoven with mycelium, hyaline to dark brown (Plate 20 a).

Asci : Asci numerous, ovate, measuring 58-90 x 30-50 μ in diam. Each contain two spores (Pate 20 b) .

Ascospore : Ascospes hyaline, oval and continuous measuing about 24x 14 μ in diam (Plate 20 b).

Pathogens isolated and their identification

During the course of survey of disease vis –a- vis their isolation studies, a number of phytopathogenic fungi were isolated from different parts of the plant at various growth stages. The diseases recorded, their causative organisms and the plant part (s) affected are listed in Table 11. The identity of the causal fungal

species was got confirmed by Commonwealth Mycological Institute, Kew, England, (IMI numbers are given against each pathogen).

PATHOGENICITY TESTS

Pathogenicity test with seed borne fungi

Out of total fungal species isolated during the study, nine frequently occurring fungal species viz., *A. niger*, *R. microsporus*, *R. nigricans*, *P. canadense*, *F. oxysporum*, *F. solani*, *A. alternata*, *D. spicifera* and *M. phaseolina*, were tested for their pathogenic ability for seed deterioration and seedling rots by different methods.

A. niger, *R. nigricans*, *R. microsporus* and *P. canadense* were highly pathogenic reducing seed germination by 72 to 95 per cent and 78 to 100 per cent by causing seed rot in unsterilized and sterilized soils, respectively. *D. spicifera*, *F. solani*, *F. oxysporum*, *A. alternata* and *M. phaseolina*, appeared to be 'severe' pathogens reducing 62 to 74 per cent and 68 to 90 per cent of seed germination in similar conditions (Table 12).

Table 11: Showing various opium poppy diseases and their causal organisms

Sl. No.	Disease recorded	Plant part (s) affected	Causative fungal species indentified	IMI No.
1.	Damping-off	Seedling	<i>Fusarium solani</i> (Mart.) Sacc	287175
2.	Wilt disease	Root	<i>Fusarium oxysporum</i> schlecht.	287170
3.	Root-rot	Root	<i>Rhizoctonia bataticola</i> (Taub.) Briton-Jones state of <i>Macrophomina Phaseolina</i> (Tassi) Goid	287171
4.	Downy mildew	Leaf, flower bud & capsule	<i>Peronospora arborescens</i> (Berk) Casp	287187
5.	Leaf spot	Leaf	<i>Alternaria alternata</i> (Fr.) Keissler	287167
6.	Leaf blight	Leaf	<i>Drechslera spicifera</i> (Bainier) v. Arx state Of <i>Cochliobolus spicifer</i> Nelson.	287169
7.	Sclerotial wilt	Foot part of stem	<i>Sclerotium rolfsii</i> Sacc	
8.	Stem rot	Stem	<i>Mucor racemosus</i> Fres	287177

9.	Sepal blight	Sepal	<i>Alternaria alternata</i> (Fr.) Keissler	287179
10.	Petal blight	Petal	<i>Alternaria alternata</i> (Fr.) Keissler	287166
11.	Stemen blight	Stamen	<i>Alternaria state of</i> <i>Pleospora</i> <i>infectoria</i> Fuckel	287172
12.	Capsule rot	Capsule	<i>Rhizpus microsporus</i> v. Tieghem	287168
13.	Powdery mildew	Leaf, stem & flower bud	<i>Erysiphe polygoni</i> DC	
14.	Powdery mildew	Leaf, stem & flower bud	<i>Oidium</i> state of <i>Erysiphe</i> <i>cichoracearum</i> DC	287182

Table 12: Effect of some frequently occurring fungal pathogens of *Papaver somniferum* seeds on germination and emergence of seedlings

Fungi inoculated	Nature of soil*	No. of germinated seedlings	Effect on emergence and appearance of seedlings**				No. of ungerminated seeds**
			Normal	Delayed	Distorted	Blighted	
<i>Aspergillus niger</i>	(U.S.)	100	12	4	10	2	72
	(S)	100	4	5	9	4	78
<i>Rhizopus microsporus</i>	(U.S.)	100	5	2	2	3	88
	(S)	100	-	-	-	-	100
<i>R. nigricans</i>	(U.S.)	100	4	3	3	4	86
	(S)	100	-	6	-	-	94
<i>Penicillium canadense</i>	(U.S.)	100	-	5	-	-	95
	(S)	100	-	-	-	-	100
<i>Fusarium oxysporum</i>	(U.S.)	100	8	12	-	8	72
	(S)	100	-	16	-	4	80
<i>F. Solani</i>	(U.S.)	100	7	13	-	10	70
	(S)	100	-	15	2	3	80
<i>Alternaria alternata</i>	(U.S.)	100	10	12	3	3	72
	(S)	100	2	9	-	8	81
<i>Drechslera spicifera</i> v. <i>Arx</i> state of <i>Cochliobolus spicifer</i>	(U.S)	100	12	5	3	18	62
	(S)	100	5	-	5	22	68
<i>Macrophomin a phaseolina</i>	(U.S.)	100	4	5	12	5	74
	(S)	100	-	-	8	2	90
Control	(U.S.)	100	91	-	-	2	7
	(S)	100	95	-	-	-	5

* = Standard Soil Method. **=Based on 100 seeds. (-) = Absence. (US) = Unsterilized
(S) = Sterilized.

Pathogenicity test with isolates of fungi causing other diseases

Pathogenicity test of isolates of other fungal diseases were done as follows:

Fusarium solani (Mart.) Sacc (Damping-Off)

For pathogenicity test, seedlings were raised from healthy and surface sterilized seeds in sterilized pots containing sterilized standard soil. Seeds were sown in furrows and covered with the soil. The fungus was grown on soil-oat medium and 5-7 days old actively sporulating inoculums was applied into the soil simultaneously with the sowing of seeds in first set while after germination of the seeds in the second set. The pots were incubated for 24 hours in humidity chamber and then kept in glass house. Typical symptoms of the disease appeared in both the sets 5 to 7 days of the inoculation. Reisolation from infected seedlings yielded the same fungal species, thus proving the pathogenicity of the fungus.

Peronospora arborescens (Berk) Casp (Downy mildew)

Nearly 2-3 months old potted plants were selected for testing pathogenicity. The plants were inoculated with water suspension of fresh conidia and incubated in humidity chamber for 4-5 hours. Initial symptoms of leaf spots appeared with 5-7 days and typical symptoms of the disease appeared after 15 to 20 days of the inoculation. When spotted leaves detached and kept in moist chamber, typical sporulation developed in 12-24 hours. All inoculations made from December to March were found successful.

Plants at all stages were found susceptible to the disease. Older (lower) leaves were found more susceptible than younger (upper) ones. However,

disease did not manifest itself when detached leaves from 2-3 months old potted plants and uprooted plants were inoculated with water suspension of conidia followed by continuous incubation in humid chamber for 4 to 24 hours. Only fresh conidia were found infective. They lost their viability soon after collection of diseased plants unless kept at low temperature. Viability of the conidia could be prolonged up to 15-17 days by storing freshly collected diseased plant parts at 5-7°C. Free water for 4 hours was found necessary in the infection court.

Oospore infection

Experiments were conducted to study the pathogenicity of oospores of *P.arborsecens*. The test was carried out in pots in glass-house. Oospore inoculum consisted of powdered leaf debris of severely downy mildewed plants. Inoculum was mixed in sterilized soil surface filled in pots before sowing the poppy seeds at a depth of 1-2". Another set without oospores was maintained to serve as control. The pots were incubated at 10 to 15°C for 3 to 5 hours and then shifted to glass-house. Severely infected plants started appearing within 20 to 22 days in inoculated pots, whereas plants in the control set remained healthy (Table 15).

In another trial, two years old downy mildewed leaf material stored under laboratory conditions was also tested for pathogenic ability of the oospores. It was found that the stored oospores retained their pathogenic ability during storage but to a lesser extent as compared to the fresh ones.

Infective period and pathogenic ability of oospores

Following experiments were conducted (i) to determine whether oospores of downy mildew pathogen *P. arborescens* require any resting period before they start new infection, (ii) to study the disease incidence at different growth stages of the plant. The experiment was conducted during 1983-84 in a microplot of 3x1.5m size.

Heavily downy mildewed leaves were collected in January, 1983 and presence of oospores in them was ascertained microscopically. These leaves were dried under shade, crushed to small pieces and mixed with sterilized farmyard manure and mixed in the experimental plots up to half an inch depth. A control plot of same size was maintained without adding any oospore debris. Seeds from healthy capsule were surface sterilized and sown in second week of February, 1983. Observations for appearance of the disease were made periodically

Table 15: Showing pathogenic behaviour of oospores in initiating primary infection (systemic infection of downy mildew).

Experiment Number	Treatment	No. of plants grown ⁺	No. of plants infected	% infected plants
1	Debris *mixed in 2" top of soil**	30	6	2.00
2	(a) Debris mixed in 1 $\frac{1}{2}$ " top of soil	30	10	33.33
	(b) Control	30	0	0.00
3	(a) Debris mixed in a thin layer at 1" depth of soil	30	13	43.33
	(b) Debris in a thin layers at 1" depth of soil	30	18	60.00
	(c) Control	30	0	0.00
4	(a) Debris mixed at 1" depth (sterilized soil with sterilized farmyard manure)	30	17	56.66
	(b) Control	30	0	0.00
5	Debris mixed at 1" depth in unsterilized soil with unsterilized farmyard manure	30	4	13.33
6	Two years old debris mixed at 1" depth (sterilized soil with sterilized farmyard manure)	30	6	20.00

+ = Seeds sown were surface sterilized.

* = Debris contained heavily infected leaf material of previous crop containing abundant oospores.

** = Soil used was sterilized except mentioned otherwise.

≠ = Control set contained sterilized soil but no debris.

but the disease did not appear in either of the plots even up to maturity of plants. At the end of crop period, the dried plants were uprooted and the plots were left fallow during summer and following rains. In next sowing season, the same plots were prepared again and sown with healthy and surface sterilized seeds. Three weeks after sowing, severely infected plants appeared in artificially infested plot only. The diseased plants were counted and removed daily for the first two weeks and later at weekly intervals. At the end of the season all remaining plants were uprooted and plant debris was completely removed.

Results (Table 16) show that (i) fresh oospores were non-pathogenic, (ii) oospores became pathogenic in the season next to their formation i.e., they require some resting period before they became pathogenic, (iii) plants may contract infection at any of their growth stages but the largest number of plants get infected in young stages only, i.e., from seedling to 10 leaf stage after which the number of newly appearing diseased plants decreased gradually. Sowing was done again in the same plot in the third season to determine whether sick soil (already infested soil carrying oospores) had any residual infectivity. After germination of the opium poppy crop, few severely infected plants appeared in

the plot at the seedling stage showing that the soil retains the pathogenic ability to some extent during the third cropping season as well.

Table 16: Frequency of systemic infection of opium poppy by *P. arborescence* in artificially oospore infested plot*

Sowing date	Date of observation	Days after sowing	Number of infected plants appear**
Feb. 16, 1983	Feb. 26, 1983 to April 30, 1983	10-74	0
Nov. 25, 1983	Dec. 5, 1983 to Dec. 16, 1983	10-21	0
	Dec. 17, 1983	22	2
	Dec. 18, 1983	23	5
	Dec. 19, 1983	24	8
	Dec. 20, 1983	25	7
	Dec. 21, 1983	26	15
	Dec. 22, 1983	27	17
	Dec. 23, 1983	28	21
	Dec. 24, 1983	29	18
	Dec. 25, 1983	30	22
	Dec. 26, 1983	31	16
	Dec. 27, 1983	32	31
	Dec. 28, 1983	33	34
	Dec. 29, 1983	34	47
	Dec. 30, 1983	35	50

	Dec. 31, 1983	36	55
	Jan. 1, 1984	37	21
	Jan. 2, 1984	38	32
	Jan. 3, 1984	39	27
	Jan. 4, 1984	40	13
	Jan. 5, 1984	41	19
	Jan. 6, 1984	42	17
	Jan. 7, 1984	43	23
	Jan. 14, 1984	50	18
	Jan. 21, 1984	57	17
	Jan. 28, 1984	64	14
	Feb. 4, 1984	71	13
	Feb. 11, 1984	78	8
	Feb. 18, 1984	85	7
	Feb. 25, 1984	92	4
	March. 3, 1984	99	9
	March. 10, 1984	106	6
	March 17, 1984	113	7
	March 24, 1984	120	3
	March 31, 1984	127	5

* = Plot size 3x1.5m. Heavily downy mildewed leaf material collected on Feb. 1, 1983 and dried crushed material was added to the plot in Feb. 10, 1983. The plot was left as such from May 1, 1983 to November 24, 1983.

** = Diseased plants were removed from the plot after the observation.

***Fusarium oxysporum* Schlecht (Wilt disease)**

For Pathogenicity test, the fungus was grown on soil - oat medium and the inoculum was applied into 7 to 15 cm deep holes made around 5 to 6 weeks old opium poppy plants grown in pots containing sterilized soil. After inoculation, pots were kept in glass-house. Typical symptoms of the disease appear after 3 to 5 weeks of inoculation. Reisolation from diseased plants yielded the same fungal species thus proving the pathogenicity of the fungus.

***Rhizoctonia bataticola* (Taub) Briton-Jones state of *Macrophomina phaseolina* (Tassi) Goid (Root-rot)**

For pathogenicity test, the fungus was grown on soil- oat medium and the inoculum was applied into 7 to 15 cm deep holes made around 10 to 14 weeks old plants grown in sterilized standard soil filled in sterilized pots. The pots were kept in glass-house after inoculation. Typical symptoms of the disease developed 3 to 5 weeks after inoculation. Reisolation from diseased plant part yielded *R. bataticola* Briton-Jones state of *M.phaseolina*, thus proving the pathogenicity of the fungus.

***Sclerotium rolfsii* Sacc (Wilt (foot rot) disease)**

For pathogenicity test the fungus was grown on soil - oat medium and the inoculum (mycelium and sclerotia both) was applied in bands on both sides of 5-8 weeks old plants grown in pots. The pots were kept in glass-house after inoculation. Inoculation through artificial wounds was also attempted in few plants. Typical symptoms of the disease developed within 7-15 days of the inoculation. However, symptoms of the disease appeared earlier on the

wounded plants than on unwounded ones. Reisolation from infected (wilted) plants yielded *S. rolfsii*, thus proving the pathogenicity of the fungus.

***Alternaria alternata* (Fr) Keissler (Leaf spot disease)**

Plants for testing pathogenicity were raised in pots containing sterilized standard soil. Nearly 90-100 days old plants were selected for testing pathogenicity. The conidia of *A. alternata*, had been grown as described by Allen *et al.*, (1983). Before inoculation, the leaves were wiped with cotton wool dipped in sterilized distilled water. The plants were inoculated uniformly in a inoculation chamber, with conidial suspension (20 mg of freshly produced conidia per 100 ml of sterilized distilled water) using an atomizer. The inoculated plants were immediately covered with sterilized polythene bags for 48 hours to maintain high humidity around them. Typical symptoms of the disease developed within 7 to 10 days of the inoculation. Reisolation from infected leaves yielded *A. alternata*, thus proving the pathogenicity of the fungus.

***Drechslera spicifera* (Bainier) v. Arx state of *Cochliobolus spicifer* Nelson (Leaf blight)**

Plants for testing pathogenicity were raised in pots containing sterilized soil. Ninety to hundred days old plants were used for testing pathogenicity. Before inoculation the leaves were wiped with cotton wool dipped in sterilized distilled water. The plants were inoculated uniformly in a inoculation chamber with conidial suspension using an atomizer. The inoculated plants were covered with sterilized polythene bags for 48 hours to maintain high humidity around them. Typical symptoms of the disease

developed within 10 days of the inoculation. Reisolation from infected leaves yielded *D. Spicifera* v. Arx state of *C._spicifer* Nelson, thus proving the pathogenicity of the fungus.

***Mucor racemosus* Fres (Stem rot)**

Plants for testing pathogenicity were raised in pots. The plants in three sets at their 30, 60 and 75 days growth were inoculated by making 1 cm vertical incision on bark of the stem at 2-15 cm above ground level. The inoculum from 4 day old PDA culture was rubbed on the incision with a spatula, covered with a piece of moist cotton and finally with a piece of polythene which were removed after 48 hours. Typical symptoms of the disease appeared 4-7 days of the inoculation. Reisolation from infected plants yielded *M. racemosus*, thus proving the pathogenicity of the fungus.

***Alternaria alternata* (Fr.) Keissler (Sepal blight)**

Young and developing flower buds, with intact sepals were selected for the pathogenicity test. Before inoculation, the sepals were wiped with cotton wool dipped in sterilized distilled water. The sepals were inoculated uniformly with conidial suspension of *A. alternata*, using an atomizer. Inoculation through superficial wounds was also attempted in a few sets. The inoculated buds were immediately covered with sterilized polythene bags for 24 hours to maintain humidity around them. Typical symptoms of the disease developed within 3 to 5 days of the inoculation. However, symptoms of the disease appeared earlier on the wounded sepals than on unwounded ones. Reisolation from infected sepals of both the sets yielded *A. alternata*, thus proving the pathogenicity of the fungus.

***Alternaria alternata* (Fr.) Keissler (Petal blight)**

Young and developing flower buds were selected for the pathogenicity test. For the test, sepals were gently separated with the help of sterilized scalpel and forceps. Petals were inoculated uniformly with conidial suspension of *A. alternata*, using an atomizer. The inoculated petals were immediately covered with sterilized polythene bags for 24 hours to maintain humidity around them. Typical symptoms of the disease developed within 3 to 5 days of the inoculation. Reisolation from infected petals yielded *A. alternata*, thus proving the pathogenicity of the fungus.

***Alternaria state of Pleospora infectoria* Fucklel (Stamen blight)**

For pathogenicity test young flower buds were gently opened with the help of sterilized scalpel and forceps avoiding damage to the floral parts. The stamens were inoculated with a conidial suspension using an atomizer. The inoculated stamens with whole bud were covered immediately with sterilized polythene bags for 24 hours to maintain humidity around them. Typical symptoms of the disease developed within 3 to 5 days of the inoculation. Reisolation from infected stamens yielded *Alternaria* state of *P. infectoria*, thus proving the pathogenicity of the fungus.

***Rhizopus microsporus* v. Tieghem (Capsule rot)**

Full grown capsules were selected for the pathogenicity test. Before inoculation, the capsules were wiped with cotton wool dipped in sterilized distilled water. The inoculum was placed over superficial wounds made in the centre of the capsule by sterilized scalpel. The inoculated capsules were immediately enclosed in sterilized polythene bags for 48 hours to maintain

humidity around them. Typical symptoms of the disease developed within 3 to 5 days of the inoculation. Reisolation from infected capsules yielded *R. microsporus*, thus proving the pathogenicity of the fungus.

***Erysiphe polygoni* DC and *Oidium* state of *E. cichoracearum* DC (Powdery mildew)**

Plants for testing pathogenicity were raised in pots under a special spore proof thick cloth house (30' x 8' x 8') for each fungus. Nearly three months old plants were used for testing pathogenicity. The inoculations were made by shaking naturally infected plants with young sporulating mildew colonies over them. The inoculated plants were immediately covered with sterilized polythene bags for 48 hours to maintain humidity around them. Typical mildew colonies of both the fungus appeared on leaves after 15-20 days of inoculation.

Assessment of the losses caused by downy mildew and powdery mildew diseases

I. Losses caused by downy mildew

Three year's (1982-83, 1983-84 and 1984-85) data from field experiments, under conditions of natural infection, revealed that secondary infection of downy mildew could give a loss of 16.7 to 33.8 per cent in latex (opium) yield and 13.5 to 16.5 per cent in seed yield when infection index ranged from 58.6 to 78.4 per cent.

II. Losses caused by powdery mildew

Three year's (1982-83, 1983-84, 1984-85) data from field experiments, under conditions of natural infection, revealed that powdery mildew could give

a loss of 9.37 to 29.33 per cent in latex yield and 7.85 to 13.75 per cent in seed yield when infection index ranged from 65.20 to 89.63 per cent .

Chemical control of spermathilein fungi

The effect of different natural (plant) products on seed germination, on number and intensity of establishment and proliferation of fungal species on seeds and on the development of seedlings have been shown in Table 17-19.

Out of eight natural (plant) products evaluated, five were found effective in reducing the incidence of fungal infections, most effective of them being Eugenol, Lawsone, and Clocimum oil. Out of these three, Eugenol has been the best, as the seeds treated with Eugenol, even at its lowest concentration (250 ppm), were found to be completely free from fungal infections. Lawsone and Clocimum oil, on the other hand checked the spermathilein mycoflora completely at 500 ppm concentration. Menadione was able to check the entire mycoflora only at the concentration of 2000 ppm yet very little fungal population was recorded in seeds treated at 1000 ppm, 500 ppm and 250 ppm concentrations. Very little fungal population was recorded on seeds treated with Lemongrass oil at 500 ppm, 1000 ppm and 2000 ppm concentrations, whereas, same result was found at 1000 ppm and 2000 ppm concentrations of Cedarwood oil. However, Lemongrass oil and Cedarwood oil at 250 ppm and 500 ppm concentrations, Terpinyl acetate and opium poppy oil at all four concentrations could not check the fungal infections (Table 17).

Out of three synthetic fungitoxicants tested, Dithane M-45 and Agrosan GN were found effective only at 2000 ppm concentration , where only 2 and 5 fungal species have been recorded, whereas 6, 16 and 18 fungal species were recorded at 1000 ppm, 500 ppm and 250 ppm concentrations of Dithane M-45 and 12 fungal species with Agrosan GN at 1000 ppm concentration. However, Agrosan GN at 500 ppm and 1000 ppm and Bavistin SD at all four concentrations could not reduce the fungal flora of the seeds (Table 18).

Above results clearly established the superiority of Eugenol, Lawsone, Clocimum oil, Menadione and Lemongrass oil over all the synthetic fungitoxicants tested. Cedarwood oil was found superior to Bavistin SD only at the concentrations of 1000 ppm and 2000 ppm whereas, Cedarwood oil, Terpinyl acetate and opium poppy oil were found ineffective in reducing seed borne fungi at 250 ppm, 500 ppm and 250 ppm to 2000 ppm concentrations, respectively.

Germination of seeds treated with the natural (plant) products was higher than in untreated seeds except those treated with Menadione and Lawsone. A marked reduction in seed germination was found with Menadione at 500 ppm, 1000 ppm

Table 18: Influence of different commercial fungicide on occurrence of spermaphileein mycoflora associated with the seeds of p. somniferum

Treatments / Fungi recorded	Number of seeds giving fungal growth after treatments													
	Contro l		Agrosan Gn				Bavistin SD				Dithane M_45			
	C1	C2	.25 *	.5 *	1* 2 *		.2 5	.5	1	2	.2 5	.5	1	2
Aspergillus niger	48	19	26	18	1 3	9	77	6 3	5 1	3 7	19	1 3	9	-
A. Flavus	21	8	19	9	6	3	70	5 1	3 7	2 1	17	6	-	-
A. Fumigatu s	15	7	19	15	9	4	53	3 5	2 1	1 1	13	9	5	-
A. ustus	9	-	13	9	4	-	39	2 7	1 9	8	19	7	-	-
A. Variecolo r	-	9	19	13	6	-	48	2 1	1 3	6	18	7	4	1
A. Terricola	7	-	15	9	-	-	27	1 4	9	5	13	6	3	-
A. Penicilliu m canadens e	38	23	13	8	-	-	37	1 6	5	2	17	5	-	-
P. Chrysogenum	9	-	11	8	-	-	21	1 3	9	6	12	5	-	-
P. Frequentans	-	19	9	3	-	-	28	1 3	4	3	9	3	-	-
Fusarium oxysporum	35	11	18	10	5	-	41	2 9	1 7	9	6	2	-	-
F. Solani	13	-	10	6	3	-	35	2 7	1 7	8	7	3	-	-
Rhizopus microsporus	78	38	20	11	7	-	63	4 8	3 9	1 3	18	1 1	7	-
R. nigricans	21	6	19	11	5	-	39	3 1	2 1	1 1	13	7	-	-
Cladosporium oxysporum	3	-	7	-	-	-	17	1 1	5	-	-	-	-	-

Mucor racemosus	11	9	11	4	-	-	28	21	13	7	6	2	-	-
Colletotrichum capsici	7	5	19	13	9	2	27	19	11	8	7	-	-	-
Chaetomium globosum	3	-	5	-	-	-	13	10	7	-	-	-	-	-
Alternaria alternata	78	35	7	2	-	-	19	14	8	5	5	-	-	-
Macrophomina phaseeolina	17	-	6	3	-	-	16	10	7	4	-	-	-	-
Drechslera spicifera v.ArX state of	61	43	28	17	10	7	48	37	25	19	19	10	5	2
Cochliobolus spicifera														
Gliocladium virens	7	-	6	3	-	-	13	7	6	3	-	-	-	-
Botrytis cinerea	8	2	13	9	3	-	23	17	9	4	9	3	-	-
Total incidenc of fungal species	20	14	22	20	12	5	22	22	22	20	18	16	6	2

** = Concentration (ppm)

C1 = Control-1 (Seeds without any treatment)

C2 = Control-2 (Surface sterilized seeds)

and 2000 ppm concentrations whereas with Lawsone only at 2000 ppm concentration. The best germination of 95 per cent was recorded in Eugenol and Lawsone followed by 92 per cent with Clocimum oil at 250 ppm concentration. Germination percentage was good at other concentrations, of these natural (plant) products. Lemograss oil, Cedarwood oil, Terpinyl acetate and opium poppy oil also favoured good germination as compared with synthetic fungitoxicants and control set (Table 19). But as the Cedarwood oil at 250 ppm and 500 ppm concentrations, Terpinyl acetate and opium poppy oil at all four concentrations were unable to control the fungal infections, due to which germinated seedlings could not survive much.

Excellent seedling vigour was recorded at 250 ppm to 2000 ppm concentrations of Eugenol, 250 ppm to 1000 ppm concentrations of Lawsone, 250 ppm and 500 ppm concentration of Clocimum oil, 250 ppm concentration of Menadione and 1000 ppm and 2000 ppm concentrations of Lemograss oil. Poor seedling vigour was recorded only at 250 ppm and 500 ppm concentrations of opium poppy oil. In rest of the treatments, normal to good seedling vigour was recorded. However, in case of synthetic fungitoxicants seedling vigour was ordinary. Poor seedling vigour was recorded at 250 ppm to 1000 ppm concentrations of Bavistin SD and 250 ppm concentrations of Dithane M-45 and Agrosan GN whereas, in rest of the treatments, normal to good seedling vigour was recorded. Hence, natural (plant) products again proved their superiority over synthetic fungitoxicants. The order of activity of various tested natural (plant) products and synthetic fungitoxicants are shown in Table 20.

Table 19: Influence of different natural (plant) products and commercial fungicides treatments over seed germination and seedling development in *P. somniferum* out of 100 seeds

Treatments	Seed germination (%)								Vigour of the germinated seedlings			
	250*		500*		1000*		2000*					
	TG	DG	TG	DG	TG	DG	TG	DG	250	500	1000	2000
Eugenol	95	-	91	-	84	3	78	5	++++	++++	++++	++++
Lawsone	95	-	89	-	70	7	26	17	++++	++++	++++	++++
Clocimum oil	92	-	88	-	85	3	80	4	++++	++++	+++	+++
Menadione	77	4	28	10	12	3	10	3	++++	++	++	++
Lemograss oil	80	-	75	4	80	2	85	3	+++	+++	++++	++++
Cedarwood oil	73	-	76	2	82	6	74	8	+++	+++	+++	+++
Terpinyl acetate	72	-	73	2	75	2	78	3	++	++	+++	+++
Opium poppy oil	57	-	63	3	71	2	73	3	+	+	++	++
Dithane M-45	68	-	70	3	71	4	75	2	+	++	+++	+++
Agrosan GN	67	-	66	5	68	5	71	5	+	++	++	+++
Bavistin-50	42	-	44	5	48	3	51	4	+	+	+	++
Control-1	55	-	-	-	-	-	-	-	+	-	-	-
Control-2	77	-	--	-	-	-	-	-	++	-	-	-

Control-1 = With out any treatment

++ = Normal

Control-2 = Surface sterilized - = Absence

+++ = Good

TG = Timely germination + = Poor

++++ = Excellent

(within 48 hours)

DG= Delayed germination (after 48 hours)

Table 20: Showing order of activity of different natural (Plant) products and commercial fungicides

Treatments	Total number of fungal species developed after treatment			
	250*	500*	1000*	2000*
Eugenol	0	0	0	0
Lawson	4	0	0	0
Clocimum oil	8	0	0	0
Menadione	15	10	4	0
Lemongrass oil	19	17	10	2
Cedarwood oil	22	20	19	12
Terpinyl acetate	22	22	20	20
Opium poppy oil	22	22	22	22
Dithane M-45	18	16	6	2
Agrosan GN	22	20	12	5
Bavistin SD	22	22	22	20

* = Concentration (ppm)

Laboratory bioassay of natural (plant) products against the pathogens of other diseases

The results presented in Table 21 reveal that amongst the eight natural (plant) products (NPPs) tested, four viz., Eugenol, Lawsone, Menadione and Clove oil completely (100.00 per cent) inhibited the mycelial growth of 6, 5 , 3, and 2 fungi, respectively , at all four concentrations (i.e. 250 ppm, 500 ppm, 1000 ppm and 2000 ppm) *in vitro* with a minimum inhibitory concentration (MIC) of 250 ppm whereas at 500 ppm, 100 ppm and 2000 ppm concentrations, mycelial growth of 7, 4, 3, 3, and 1 fungi were completely inhibited by Clove oil, Lawsone, Eugenol, Lemongrass oil and Menadione, respectively, showing MIC of 500 ppm. Similarly at 1000 ppm and 2000 ppm concentrations, mycelial growth of 4, 3 and 1 fungi were completely inhibited by Lemongrass oil , Menadione and Terpinyl acetate, respectively, showing MIC of 1000 ppm, while at 2000 ppm concentrations, mycelial growth of 2 , 1 and 1 fungi were completely inhibited by Menadione, Lemongrass oil and Terpinyl acetate, respectively.

The MIC of Lawsone was found to be 250 ppm against *A. alternata*, *Alternaria* state of *P. infectoria*, *F. solani*, *M. racemosus* and *S. rolfsii*, while 500 ppm against *D. Spicifera*, *F. oxysporum*, *R. bataticola* and *R. microsporus* ; MIC of Menadione was found to be 250 ppm against *D. Spicifera*, *R. bataticola* and *S. rolfsii*, while 500 ppm against *F. oxysporum* ; 1000 ppm against *A. alternata*, *F. solani* and

Table 21: Per cent mycelial inhibition of different fungal pathogens of *P. somniferum* with natural (Plant) products

Treatments	Fungal Pathogens	Percent mycelial inhibition at different concentrations (ppm)				Toxicity index
		250	500	1000	2000	
Lawson	A. Alternata	100.00**	100.00**	100.00**	100.00**	400.00
	Alternaria state of <i>P. infectoria</i>	100.00**	100.00**	100.00*	100.00*	400.00
	D. Spicifera	87.50	100.00*	100.00*	100.00*	387.50
	F.oxysporum	87.00	100.00*	100.00*	100.00	387.00
	F. Solani	100.00**	100.00*	100.00*	100.00*	400.00
	M. racemosus	100.00**	100.00**	100.00	100.00*	400.00
	R. Bataticola	58.00	100.00**	100.00*	100.00*	358.00
	R. microsporus	61.00	100.00*	100.00*	100.00*	361.00
	S. rolfsii	100.00**	100.00**	100.00*	100.00*	400.00
Menadione	A. Alternata	67.50	71.50	100.00*	100.00*	339.00
	Alternaria state of <i>P. infectoria</i>	72.00	72.50	85.00	100.00*	329.50
	D. Spicifera	100.00**	100.00**	100.00*	100.00*	400.00
	F. oxysporum	75.50	100.00	100.00*	100.00*	375.50
	F. Solani	76.00	84.50	100.00*	100.00*	360.50
	M. racemosus	60.00	65.00	68.00	100.00*	293.00
	R. Bataticola	100.00*	100.00*	100.00*	100.00*	400.00
	R. microsporus	70.50	80.50	100.00**	100.00**	351.00
	S. Rolfsii	100.00*	100.00*	100.00*	100.00	400.00

Rerpinyl acetate	A. Alternata	00.00	00.00	0.00	36.00	36.00
	Alternaria state of P. infectoria	63.50	67.00	77.00	100.00	307.50
	D. Spicifera	20.50	30.50	46.00	51.50	148.50
	F.oxysporum	45.50	49.50	56.50	63.00	214.50
	F. Solani	46.00	54.50	58.00	68.00	226.50
	M. racemosus	48.00	51.50	54.00	57.00	210.50
	R. Bataticola	72.50	86.50	100.00*	100.00*	359.00
	R. microsporus	0.00	0.00	0.00	6.75	6.75
	S. rolfsii	00.00	0.00	0.00	0.00	0.00
Eugenol	Alternata	100.00*	100.00*	100.00*	100.00*	400.00
	Alternaria state of P. infectoria	100.00**	100.00*	100.00*	100.00	400.00
	D. Spicifera	100.00**	100.00*	100.00*	100.00*	400.00
	F.oxysporum	82.50	100.00*	100.00*	100.00*	382.50
	F. Solani	83.00	100.00*	100.00*	100.00*	383.00
	M. racemosus	100.00**	100.00**	100.00*	100.00*	400.00
	R. Bataticola	75.00	100.00*	100.00*	100.00*	375.00
	R. microsporus	100.00**	100.00**	100.00*	100.00*	400.00
	S. rolfsii	100.00*	100.00*	100.00*	100.00*	400.00
Clocimum oil	A. Alternata	69.00	100.00**	100.00**	100.00**	369.00
	Alternaria state of P. infectoria	100.00*	100.00*	100.00*	100.00*	400.00
	D. Spicifera	80.00	100.00*	100.00*	100.00*	380.00
	F.oxysporum	84.00	100.00**	100.00**	100.00*	384.00

	F. Solani	83.50	100.00**	100.00**	100.00*	383.50
	M. racemosus	80.00	100.00**	100.00*	100.00*	380.00
	R. Bataticola	85.50	100.00**	100.00**	100.00**	385.50
	R. microsporus	76.00	100.00**	100.00**	100.00*	376.00
	S. rolfsii	100.00**	100.00*	100.00*	100.00*	400.00
Cedarwood oil	A. Alternata	49.50	57.50	65.00	71.00	243.00
	Alternaria state of P. infectoria	44.00	57.00	62.50	70.00	233.50
	D. Spicifera	34.50	53.00	55.50	62.00	205.00
	F.oxysporum	33.50	51.00	57.00	66.50	208.00
	F. Solani	33.00	47.00	53.50	66.00	199.50
	M. racemosus	15.00	29.50	40.00	45.50	130.00
	R. Bataticola	17.50	21.00	28.50	58.50	125.50
	R. microsporus	10.00	22.50	238.00	42.00	112.50
	S. rolfsii	57.00	71.50	79.50	88.50	296.50
Lemongrass oil	A. Alternata	80.00	100.00**	100.00**	100.00*	380.00
	Alternaria state of P. infectoria	73.00	100.00**	100.00*	100.00*	373.00
	D. Spicifera	68.50	75.50	83.50	100.00**	327.50
	F.oxysporum	69.00	82.00	100.00*	100.00*	351.00
	F. Solani	55.00	70.50	100.00*	100.00*	325.50
	M. racemosus	61.50	74.50	100.00*	100.00*	336.00
	R. Bataticola	58.00	6400	100.00*	100.00*	322.00
	R. microsporus	0.00	0.00	0.00	0.00	0.00
	S. rolfsii	28.00	100.00*	100.00*	100.00*	328.00

Opium poppy	Alternata	12.50	38.50	46.50	53.00	150.50
	Alternaria state of P. infectoria	12.50	23.50	46.50	50.00	132.50
	D. Spicifera	32.00	37.50	38.50	46.50	154.50
	F.oxysporum	50.00	54.50	60.00	66.50	231.00
	F. Solani	38.00	47.00	61.00	71.00	217.00
	M. racemosus	0.00	0.00	47.00	58.00	106.00
	R. Bataticola	0.00	0.0	0.00	0.00	0.00
	R. microsporus	0.0	0.0	0.0	0.0	0.0
	S. rolfsii	0.	0.0	0.0	3.50	3.50
Control	A. Alternata	-	-	-	-	-
	Alternaria state of P. infectoria	-	-	-	-	-
	D. Spicifera	-	-	-	-	-
	F.oxysporum	-	-	-	-	-
	F. Solani	-	-	-	-	-
	M. racemosus	-	-	-	-	-
	R. Bataticola	-	-	-	-	-
	R. microsporus	-	-	-	-	-
	S. rolfsii	-	-	-	-	-

* Fungicidal

** Fungistatic

0 No inhibition

(-) Growth occurs

R. microsporus and 2000 ppm against *Alternaria* state of *P. infectoria* and *M. Racemosus* ; MIC of Terpinyl acetate was found to be 1000 ppm against *R. bataticola* and 2000 ppm against *Alternaria* state of *P. infectoria* ; MIC of Eugenol was found to be 250 ppm against *A. alternata*, *Alternaria* state of *P. infectoria* , *D. spicifera* , *M. racemosus*, *R. microsporus* and *S. rolfsii*, while 500 ppm against *F. oxysporum*, *F. solani* and *R. bataticola* ; MIC of Clove oil was found to be 250 ppm against *Alternaria* state of *P. infectoria* and *S. rolfsii*, while 500 ppm against *A. alternata*, *D. spicifera*, *F. oxysporum*, *F. solani*, *M. racemosus*, *R. bataticola* and *R. microsporus* ; MIC of Lemongrass oil was found to be 500 ppm against *A. alternata*, *Alternaria* state of *P. infectoria* and *S. rolfsii* followed by 1000 ppm against *F. oxysporum* , *F. solani*, *M. racemosus* and *R. bataticola* , while 2000 ppm against *D. spicifera*.

Observations presented in Table 22 reveal that the Lawsone was found to be fungistatic in action at 250 ppm against *A. alternata*, *F. solani*, *M. racemosus* and *S. rolfsii* while at 500 ppm it was fungistatic against *M. racemosus*, *R. bataticola* and *S. rolfsii*. It was found to be fungicidal in action at 250 ppm , 500 ppm , 1000 ppm and 2000 ppm against *Alternaria* state of *P. infectoria*, while at 500 ppm, 1000 ppm, and 2000 ppm, it was fungicidal against *A. alternata*, *D. spicifera*, *F. oxysporum*, *F. solani* and *R. microsporus* and at 1000 ppm and 2000 ppm, it was fungicidal against *M. racemosus* , *R. bataticola* and *S. rolfsii*.

Menadione was found to be fungistatic in action at 250 ppm and 500 ppm against *D. spicifera*, while at 1000 ppm and 2000 ppm, it was fungistatic against *R. microsporus*. It was found to be fungicidal in action at 250 ppm, 500 ppm, 1000 ppm and 2000 ppm against *R. bataticola* and *S. rolfsii*, while at 500 ppm, 1000 ppm and 2000 ppm, it was fungicidal against *F. oxysporum* only. At 1000 ppm and 2000 ppm, it was found to be fungicidal against *D. spicifera* and *F. solani*, while at 2000 ppm, it was fungicidal against *Alternaria* state of *P. infectoria* and *M. racemosus*.

Terpinyl acetate was found to be fungistatic in action in 2000 ppm against *Alternaria* state of *P. infectoria*, while it was fungicidal in action at 1000 ppm and 2000 ppm against *R. bataticola*.

Eugenol was found to be fungistatic in action at 250 ppm against *Alternaria* state of *P. infectoria*, *D. spicifera*, *M. racemosus* and *R. microsporus*, while at 500 ppm it was fungistatic against *M. racemosus* and *R. microsporus*. It was found to be fungicidal in action at 250 ppm, 500 ppm, 1000 ppm and 2000 ppm against *A. alternata* and *S. rolfii* while at 500 ppm, 1000 ppm, 2000 ppm, it was fungicidal in action against *Alternaria* state of *P. infectoria*, *D. spicifera*, *F. oxysporum*, *F. solani* and *R. bataticola*, while at 1000 ppm and 2000 ppm, it was fungicidal in action against *M. racemosus* and *R. microsporus*.

Clocimum oil was found to be fungistatic in action at 250 ppm against *S. rolfii*, while at 500 ppm, it was fungistatic against *A. alternata*, *F. oxysporum*, *F. solani*, *M. racemosus*, *R. bataticola* and *R. microsporus*. At 1000 ppm, it was fungistatic against *A. alternata*, and *F. oxysporum*, while at 2000 ppm, it was fungistatic against *A. alternata* only. It was found to be fungicidal in action at 250 ppm, 500 ppm, 1000 ppm and 2000 ppm against *Alternaria* state of *P. infectoria*, while at 500 ppm, 1000 ppm and 2000 ppm, it was fungicidal against *D. spicifera* and *S. rolfii*. At 1000 ppm and 2000 ppm, it was fungicidal against *F. solani*, *M. racemosus*, *R. bataticola* and *R. microsporus*, while at 2000 ppm, it was fungicidal against *F. oxysporum* only.

Lemongrass oil was found to be fungistatic in action at 500 ppm, and 1000 ppm against *A. alternata*, while at 500 ppm and 2000 ppm, it was fungistatic against *Alternaria* state of *P. infectoria* and *D. spicifera*, respectively. It was found to be fungicidal in action at 500 ppm, 1000 ppm and 2000 ppm against *S. rolfii*, while at 1000 ppm and 2000 ppm, it was fungicidal against *Alternaria* state of *P. infectoria*, *F. oxysporum*, *F. solani*, *M. racemosus* and *R. bataticola*, while it was fungicidal to *A. alternata* only at 2000 ppm.

The fungitoxicity of other concentrations of various natural (plant) products, in order of their decreasing inhibitory effect on mycelial growth of different fungal pathogens, were Eugenol (83.00-75.00 per cent), Lawsone (87.50-58.00 per cent),

Table 22: Showing fungistatic and fungicidal nature of minimum inhibitory concentrations of different natural (plant) products

Treatments	Fungal pathogens	Minimum inhibitory concentrations (ppm)							
		Fungistatic*				Fungicidal*			
Lawsonia	A. Alternata	250				250	500	1000, 2000	
	Alternaria state of P. infectoria					250	500	1000, 2000	
	D. Spicifera					-	500	1000	2000
	F.oxysporum					-	500	1000	2000
	F. Solani					-	500	1000	2000
	M. racemosus					-	-	1000	2000
	R. Bataticola					-	-	1000	2000
	R. microsporus					-	500	1000	2000
	S. rolfsii					-	-	1000	2000
Menadione	A. Alternata					-	-	1000	2000
	Alternaria state of P. infectoria					-	-	-	2000
	D. Spicifera					-		1000	2000
	F.oxysporum					-	500	1000	2000
	F. Solani					-		1000	2000
	M. racemosus					-		-	2000
	R. Bataticola					-			2000
	R. microsporus					-			2000
	S. rolfsii					-			2000
Terpinyl acetate	A. Alternata	-				250	500	1000	2000
	Alternaria state of P. infectoria			1000	2000	-		-	-
	D. Spicifera					250-	500	1000	2000
	F.oxysporum					-			

	F. Solani				2000	--	-	-	-
	M. racemosus					-			
	R. Bataticola					-		10000	2000
	R. microsporus					-			
	S. rolfsii					-			
Eugenol	A. Alternata					250	500	1000	2000
	Alternaria state of P. infectoria	250	-	-	-	-	500	1000	2000
	D. Spicifera	250	-	-	-	-	500	1000	2000
	F.oxysporum		-	-	-	-	500	1000	2000
	F. Solani		-	-	-	-	500	1000	2000
	M. racemosus	250	500	-	-	-	-	1000	2000
	R. Bataticola	-	-	-	-	-	500	1000	2000
	R. microsporus	250	500		-	-	-	1000	2000
	S. rolfsii	-	-			250	500	1000	2000
Clocimum oil	A. Alternata	-	500	1000	2000	+-	-	-	-
	Alternaria state of P. infectoria	-	-	-	-	250	500	1000	2000
	D. Spicifera						500	1000	2000
	F.oxysporum	-	500	1000	-	-	-	-	2000
	F. Solani	-	500	-	-	-	-	1000	2000
	M. racemosus	-	500	-	-	-	-	1000	2000
	R. Bataticola	-	500	-	-	-	-	1000	2000
	R. microsporus	-	500	-	-	-	-	1000	2000
	S. rolfsii	250	-	-	-	-	500	1000	2000
Cedarwood oil	A. Alternata	-	-	-	-	-	-	-	-
	Alternaria state of	-	-	-	-	-	-	-	-

	P. infectoria								
	D. Spicifera	-	-	-	-	-	-	-	-
	F.oxysporum	-	-	-	-	-	-	-	-
	F. Solani	-	-	-	-	-	-	-	-
	M. racemosus	-	-	-	-	-	-	-	-
	R. Bataticola	-	-	-	-	-	-	-	-
	R. microsporus	-	-	-	-	-	-	-	-
	S. rolfsii	-	-	-	-	-	-	-	-
Lemongrass oil	A. Alternata	-	500	1000					2000
	Alternaria state of P. infectoria		500	-				1000	2000
	D. Spicifera	-	-	-	2000			-	-
	F.oxysporum							1000	2000
	F. Solani							1000	2000
	M. racemosus							1000	2000
	R. Bataticola							1000	2000
	R. microsporus								
	S. rolfsii						500	1000	2000
Opium poppy oil	A. Alternata								
	Alternaria state of P. infectoria								

-
- Property Studied at 100 per cent inhibition (-) Growth occurs

Clocimum oil (85.50-69.00 per cent), Menadione (85.00-60.00 per cent),
Lemongrass oil (83.50-28.00 per cent), Cedarwood oil (88.50-10.00 per cent),

Terpinyl acetate (86.50-6.75 per cent) and opium poppy oil (71.00- 3.50 per cent). However, no inhibition of mycelial growth was observed, with Lemongrass oil at any of the four concentrations (i.e. 250 ppm, 500 ppm, 1000 ppm and 2000 ppm) against *R. microsporus*, with Terpinyl acetate at 250 ppm, 500 ppm and 1000 ppm against *A. alternata* and *R. microporus* and no inhibition of mycelial growth at 250 ppm, 500 ppm, 1000 ppm and 2000 ppm against *S. rolfsii*. This was followed by opium poppy oil, where no inhibition of mycelial growth was found at 250 ppm, 500 ppm and 1000 ppm against *S. rolfsii*, while no inhibition of mycelial growth was found at 250 ppm, 500 ppm and 1000 ppm against *S. rolfsii*, while no inhibition of mycelial growth was found at any of the four concentrations (250 ppm, 500 ppm, 1000 ppm and 2000 ppm) against *R. bataicola* and *R. microsporus* (Table 21). The toxicity grades of all the natural (plant) products is shown in Table 23.

Out of the three synthetic commercial fungicides, only Dithane M-45 was found to inhibit the mycelial growth of four test fungi completely (100.00 per cent) at 250 ppm, 500ppm, 1000 ppm and 2000 ppm concentrations wheareas the mycelial growth of one pathogenic fungus could be inhibited at 2000 ppm only. No complete inhibition of mycelial growth was found with Dithane Z-78 and Bavistin -50 at any of the tested concentrations against any of the test fungi.

The fungitoxicity of other concentrations of all the three synthetic commercial fungicides in order of their decreasing inhibitory effect on mycelial growth of different fungal pathogens, were Dithane M-45 (34.50-74.50 per cent), Dithane Z-78 (9.00-73.00 per cent) and Bavistin-50 (4.50-90.00 per cent). However, no inhibition of mycelial growth was found at any of the four concentrations of Dithane M-45 and Dithane Z-78 against *R. microsporus*. Similarly, Bavistin-50 was also found ineffective to inhibit the mycelial growth of *R. microsporus* and *S. rolfii* at all the tested concentrations.

On comparing the fungitoxicity of various natural (plant) products with synthetic commercial fungicides, five natural (plant) products viz., Eugenol, Lawsone, Clove oil, Menadione and Lemongrass oil were found superior to all the three synthetic commercial fungicides whereas Cedarwood oil was found superior to Dithane Z-78 and Bavistin -50. Terpinyl acetate was found superior only to Bavistin -50. Thus the results presented in Table 21, 22 and 23 show the superiority of natural (plant) products over the synthetic natural (plant) products (except in few cases) were found superior over control in inhibiting the mycelial growth of different fungal pathogens.

Table 24: Per cent mycelial inhibition of different fungal pathogens of *P. somniferum* with synthetic commercial fungicides

Treatment	Fungal Pathogens	Percent mycelial inhibition at different concentration (ppm)				Toxicity index
		250	500	1000	2000	
Dithane Z-78	A. Alternata	30.50	44.00	63.00	70.50	208.00
	Alternaria state of P. infectoria	43.50	49.00	53.00	60.50	206.00
	D. Spicifera	40.50	50.00	60.50	64.00	215.00
	F.oxysporum	9.00	20.50	29.50	41.50	100.50
	F. Solani	10.00	21.50	30.50	43.00	73.50
	M. racemosus	35.50	44.00	47.50	51.50	178.50
	R. Bataticola	22.50	24.00	34.50	43.50	124.50
	R. microsporus	00.00	.00	.00	0.0	0.0
	S. rolfsii	25.50	48.00	66.00	73.00	212.50
Dithane M-45	A. Alternata	56.50	61.50	68.50	74.00	260.50
	Alternaria state of P. infectoria	44.00	55.50	64.00	74.50	238.00
	D. Spicifera	54.00	63.50	69.50	100.00*	287.00
	F.oxysporum	100.00* *	100.00* *	100.00* *	100.00* *	400.00
	F. Solani	100.00* *	100.00* *	100.00* *	100.00* *	400.00
	M. racemosus	34.50	43.50	49.50	53.50	181.00
	R. Bataticola	100.00* *	100.00* *	100.00* *	100.00* *	400.00
	R.microsporus	0.0	0.0	0.0	0.0	0.0
	S. rolfsii	100.00* *	100.00* *	100.00* *	100.00* *	400.00

Bavistin - 50	A. Alternata	54.00	67.50	72.00	76.50	270.00
	Alternaria state of P. infectoria	53.00	65.00	73.50	80.00	271.50
	D. Spicifera	60.50	64.00	67.50	74.00	266.00
	F.oxysporum	16.00	24.00	35.50	55.50	131.00
	F. Solani	13.50	25.50	34.50	55.50	129.00
	M. racemosus	4.50	25.50	37.50	46.50	114.00
	R. Bataticola	4.50	22.00	40.00	48.50	115.00
	R. microsporus	00.00	00.0	0.0	0.0	0.0
	S. rolfsii	0.	0.	0.	0.	0.0

* Fungicidal
inhibition

** Fungistatic

00= No

Table 25: Showing fungistatic and fungicidal nature of minimum inhibitory concentration of different synthetic commercial fungicides.

Treatments	Fungal Pathogens	Minimum inhibitory concentrations (ppm)		
Dithane Z-78	A. Alternata	-	-	
	Alternaria state of P. infectoria	-	-	
	D. Spicifera	-	-	
	F.oxysporum	-	-	
	F. Solani	-	-	
	M. racemosus	-	-	
	R. Bataticola	-	-	
	R. microsporus	-	-	
	S. rolfsii	-	-	
Dithane M-45	A. Alternata	-	-	
	Alternaria state of P. infectoria		-	
	D. Spicifera	-		2000
	F.oxysporum	250, 500, 1000		2000
	F. Solani	250, 500, 1000		2000
	M. racemosus	250, 500, 1000, 2000		-
	R. Bataticola	-	--	
	R.microsporus	-	-	
	S. rolfsii	250, 500, 1000, 2000		
Bavistin-50	A. Alternata	-	-	
	Alternaria state of P. infectoria	-	-	
	D. Spicifera	-	-	
	F.oxysporum	-	-	
	F. Solani	-	-	

	M. racemosus	-	-	
	R. Bataticola	-	-	
	R. microsporus	-	-	
	S. rolfsii	-	-	

* Property was studied at 100 per cent inhibition

(-) Growth Occurs

Laboratory bioassay of natural (plant) products against the powdery mildew pathogen

Effects of various natural (plant) products on promptitude of germination of conidia are shown in Table 27. Out of eight natural (plant) products tested, five natural (plant) products viz., Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil inhibited the conidial germination completely (100.00 per cent) at all four concentrations (i.e. 250 ppm, 500 ppm, 1000 ppm and 2000 ppm). This was followed by Cedarwood oil which inhibited the conidial germination completely at 500 ppm, 1000 ppm and 2000 ppm concentrations. Nevertheless, all the above five natural (plant) products were found quite effective at their lowest concentration i.e. 250 ppm. However, of various natural (plant) products tested, Terpinyl acetate exhibited the lowest percentage of conidial inhibition which was followed by Opium poppy oil. Similarly amongst the synthetic commercial fungicides, Sulfex inhibited the conidial germination up to 100.00 per cent which was followed by Dithane M-45 and Blitox-50.

Thus, the data presented in Table 27 reveal that out of eight, five natural (plant) products viz. Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil were found as effective as Sulfex, and established synthetic fungitoxicant, for the control of powdery mildew. Simultaneously, they were found superior to the other two commercial fungicides, viz. Dithane M-45 and Blitox-50. However, Cedarwood oil was found superior only to Dithane M-45 and Blitox-50.

Table 27: Effect of different natural (plant) products on conidial germination of *E. polygoni* at different time intervals

Treatments	Conc. (ppm)	No. of conidia tested	6 hr		12 hr		24 hr		48 hr	
			Percent-germination*	Efficiency of conidial Inhibition (%)	Percent germination*	Efficiency of conidial inhibition (%)	Percent germination*	Efficiency of conidial inhibition (%)	Percent germination*	Efficiency of conidial inhibition (%)
	250	1000	0	100.00	0	100.00	0	100.00	0	100.00
Lawsone	500	1000	0	100.00	0	100.00	0	100.00	0	100.00
	1000	1000	0	100.00	0	100.00	0	100.00	0	100.00
	2000	1000	0	100.00	0	100.00	0	100.00	0	100.00
	250	1000	0	100.00	0	100.00	0	100.00	0	100.00
	500	1000	0	100.00	0	100.00	0	100.00	0	100.00
Menadiol	1000	1000	0	100.00	0	100.00	0	100.00	0	100.00
	2000	1000	0	100.00	0	100.00	0	100.00	0	100.00
	250	1000	0	100.00	0	100.00	0	100.00	0	100.00
	500	1000	0	100.00	0	100.00	0	100.00	0	100.00
Eugenol	1000	1000	0	100.00	0	100.00	0	100.00	0	100.00

	2000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	250	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	500	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
C loci mum oil	1000	10 00	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	2000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	250	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	500	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
L em ongr ass oil	1000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	2000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	250	10 0	11.5	83.57	15.5	81.4 3	18.00	88.2	22.5	76.3 1
	500	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
C eda rwoo d oil	1000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	2000	10 00	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	250	10 0	36.0	48.57	38.5	53.8 9	39.0	57.3 7	41.0	56.8 4
	500	10 0	23.5	66.42	24.5	70.6 5	26.5	71.0 3	26.5	72.1 0
T erpi nyl a ceta te	1000	10 0	18.5	73.57	20.0	76.4 0	21.5	76.5 0	24.5	74.2 1

	2000	10 0	11.5	83.57	12.5	85.0 2	13.5	85.2 4	15.5	83.6 8
	250	10 0	47.0	32.85	49.5	40.7 1	51.0	44.2 6	64.0	32.6 3
	500	10 0	29.5	57.85	31.5	62.2 7	37.5	59.0 1	53.5	43.6 8
Opium popp y oil	1000	10 0	21.0	70.00	22.5	73.0 5	24.0	73.7 7	32.5	65.7 8
	2000	10 0	17.0	75.71	19.0	77.2 4	18.5	79.7 8	22.5	76.3 1
	250	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	500	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
Sulfe x	1000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	2000	10 0	0	100.0 0	0	100. 00	0	100. 00	0	100. 00
	250	10 0	35.0	50.0	37.5	55.0 8	37.5	59.0 1	38.0	60.0 0
	500	10 0	22.0	68.57	22.5	73.0 5	25.5	72.1 3	26.5	72.1 0
Dith ane M-45	1000	10 0	19.0	72.85	20.0	76.0 4	21.0	77.0 4	23.5	75.2 6
	2000	10 0	11.0	84.28	10.0	88.0 2	11.0	87.9 7	12.0	87.3 6
	250	10 0	36.5	47.85	40.5	51.4 9	42.0	54.0 9	47.5	50.0 0
	500	10 0	29.0	58.57	31.5	62.2 9	35.0	61.7 4	37.0	61.0 5
Blito x-50	1000	10 0	21.0	70.00	22.5	73.0 5	24.0	73.7 7	25.5	73.1 5
	2000	10 0	11.0	84.28	12.5	85.0 2	15.0	83.6 0	16.5	82.6 3

Cont rol- 1**	-	10 0	61.5	12.5	73.5	11.9 7	82.0	10.3 8	83.5	12.1 0
Cont rol- 2***	-	10 0	70.0	-	83.5	-	91.5	-	95.0	-

*Average of 100 conidia in three replicates

**Glass slides with submerged conidia in water

*** Glass slides coated with pure agar

Temperature during experiment : 20 (± 2)^oC

In control sets, conidia submerged in water on glass slides (Control -1) also exhibited inhibition in conidial germination but inhibition in this case was least of all the treatments but significantly superior to the Control -2.

Chemical control of the diseases in field

Chemical control of downy mildew disease

Control of primary infection by seed treatment

The data presented in Table 28 reveal that out of eight natural (plant) products and two commercial fungicides tested during 1982-83, under natural conditions, three natural (plant) products viz., Clove oil, Eugenol and Lawsone were found to reduce the primary infection of the disease up to 97.00 per cent, 95.00 per cent and 90.00 per cent, respectively at 500 ppm concentration followed by Lemongrass oil (72.00 per cent) at the same concentration, whereas, the two commercial fungicides, Dithane M-45 and Blitox-50 were found to reduce the disease only up to 68.00 per cent and 59.00 per cent, respectively. Simultaneously, out of the above four natural (plant) products, two natural products viz., Clove oil and Eugenol were found to check the primary infection completely (100.00 per cent) and Lemongrass oil (83.00 per cent) (Table 28). Moreover, all the natural (plant) products were found effective at their lowest concentration (i.e. 500 ppm) also.

As the Menadion checked seed germination at 500 ppm and above concentrations, it was tested at 250 ppm and 400 ppm concentrations at which, it did not check the primary infection satisfactorily.

Thus, the data presented in Table 28 show the superiority of four natural (plant) products over both the commercial fungicides. However, Clocimum oil, Eugenol and Lawsone were found to be most effective natural (plant) products. The experiment was repeated with these three products and similar results were obtained suggesting that Clocimum oil, Eugenol and Lawsone can check the transmission of primary infection of *P. arborescens* through seed treatment.

Control of primary infection by soil drenching of natural (plant) products

Amongst the eight natural (plant) products tested as soil drench to control the primary infection of downy mildew, three viz., Clocimum oil, Eugenol and Lawsone reduced the disease up to 93.34 per cent, 87.00 per cent and 80.00 per cent, respectively, at 500 ppm concentration whereas, Bavistin-50 and Calixin reduced the disease only up to 50.00 per cent and 33.34 per cent, respectively. However, out of the three, only two natural (plant) products viz., Clocimum oil and Eugenol checked the disease completely (100.00 per cent) whereas, none of the commercial fungicides could check the disease completely. The Mendione checked the seed germination at the tested concentrations but when tested at lower concentration of 250 ppm and 400 ppm, it could not check the disease satisfactorily (Table 29).

The experiment was repeated with Clocimum oil, Eugenol and Lawsone and similar results were obtained suggesting that all the three natural (plant) products applied to soil can check oospore infection more effectively than have shown their fruitfulness in controlling the primary infection of downy mildew

and simultaneously show their superiority over the two commercial fungicides without imparting any visual phytotoxicity to the experimental plants.

Control Of secondary infection by foliar application

A. Control of the disease in glass-house: Out of eight natural (plant) products evaluated for the control of secondary infection of downy mildew in glass-house conditions, six natural plant products viz., Clove oil (90.26 per cent), Eugenol (90.26 per), Lawsone (87.61 per cent), Menadione (79.64 per cent), Lemongrass oil (76.99 per cent), and Cedarwood oil (63.71 per cent) were found effective in controlling the disease at 500 ppm concentration. However, Clove oil and Eugenol gave best results showing 90.26 per cent disease control whereas, out of the two commercial

Table 29: Control of primary infection of *P. arborescens* by soil drenching of natural (plant) products

Treatments	Conc. (PPM)	NO. of germinated plants	NO. of plants infected Per	per cent infection	Efficiency of disease control (%)
Clocimum oil	500	30	2	6.66	93.34
	2000	30	0	0.0	100.00
Eugenol	500	30	4	13.00	87.00
	200	30	0	0.0	100.00
Lawsone	500	30	6	20.00	80.00
	2000	30	2	6.66	93.34
Lemongrass oil	500	30	13	43.33	56.67
	2000	30	10	33.33	66.67
Cedarwood oil	500	30	17	56.66	43
	2000	30	13	43.33	56.67
Menadione	400	30	15	50.00	50.00
	500	30	25	83.33	16.67
Opium poppy oil	2000	30	20	66.66	33.34
	500	30	15	50.00	50.00
Bavisting-50	2000	30	10	33.33	66.67
	500	30	20	66.66	33.34
Calixin	2000	30	17	56.66	43.34
Control	-	30	28	93.34	-

fungicides only Dithane M-45 could check the disease only up to 56.64 per cent. All the above six natural (plant) products were found more effective at 2000 ppm concentration showing 94.69 to 64.48 per cent of disease control (Table 30). However, at the same concentration, Clove oil proved to be the best, (93.81 per cent) and Lawsone (90.26 per cent). Although, Menadione ranked fourth position, nevertheless, it gave a good control of 82.30 per cent whereas, Dithane M-45 could control the disease only up to 67.26 per cent at the same concentration.

The experiment was repeated with Clove oil, Eugenol and Lawsone at 2000 ppm concentration and similar results were obtained suggesting that Clove oil, Eugenol and Lawsone can check the secondary infection of *P. arborescens* more effectively than commercial fungicides tested. Spraying the solutions of all the natural (plant) products, neither affected the leaf number per plant, nor produced any symptoms of visual phytotoxicity to any other part of the treated plants, of *P. somniferum*.

B. Control of the disease in field : The results presented in Table 31 reveal that out of eight natural (plant) products tested during 1982-83, five reduced the disease intensity significantly over the control. Clove oil, Eugenol and Lawsone were the most effective natural (plant) products at both concentrations and were superior to all other natural (plant) products. Menadione was found next to Lawsone followed by Lemongrass oil and Cedarwood oil. However, all of these

Table 30: Effect of foliar application on the secondary infection (leaf spot) of downy mildew under glass- house conditions.

Treatments	Conc. (ppm)	No. of leaves inoculated	No. of leaves infected	Score of infection	Disease index %	Efficiency of disease control %
Lawsonia	500	30	6	14	9.33	87.61
	2000	30	4	11	7.33	90.26
Menadione	500	30	8	23	15.33	79.64
	2000	30	6	20	13.33	82.30
Eugenol	500	30	5	11	7.33	90.26
	2000	30	4	7	4.66	93.81
Cloves oil	500	30	5	11	7.33	90.26
	5000	30	3	6	4.00	94.69
Lemongrass oil	500	30	12	26	17.33	76.99
	2000	30	10	23	15.33	79.64
Cedarwood oil	500	30	17	41	27.33	63.7
	2000	30	11	39	26.00	65.48
Terpinyl acetate	500	30	21	53	35.33	53.09
	2000	30	19	48	32.00	57.52
Opium poppy oil	500	30	26	71	47.333	37.16
	2000	30	23	65	43.33	42.47
Dithane M-45	500	30	15	49	32.66	56.64
	2000	30	10	37	24.66	67.26
Blitox-50	500	30	24	69	46.00	38.93
	2000	30	19	64	42.66	43.36
Control	-	30	28	113	75.33	-

* Plants were inoculated 24 hours after the last application of natural (plant) products

Table 31: Efficacy of foilar application of natural (plant) products on intensity of downy mildew when sprayed at 15 days interval during 1982-83

Treatments	Conc. (ppm)	No. of leaves inoculated	No. of leaves infected	Score of infection	Disease index %	Efficiency of disease control %
Clocimum oil	500	30	8	32	21.33	71.93
	2000	30	6	14	9.33	87.72
Eugenol	500	30	9	35	23.33	69.30
	2000	30	6	16	10.63	86.01
Lawson	500	30	10	39	26.00	65.78
	2000	30	8	19	142.67	83.32
Menadione	500	30	14	47	31.33	58.77
	2000	30	12	30	20.00	73.68
Lemongrass oil	500	30	17	61	40.66	46.50
	2000	30	13	41	27.33	64.03
Cedarwood oil	500	30	21	73	48.66	35.97
	2000	30	18	51	34.00	55.26
Terppinyl acetate	500	30	23	88	58.66	22.81
	2000	30	20	77	51.33	32.46
Opium poppy oil	500	30	28	99	66.00	13.15
	2000	30	26	85	56.66	25.44
Dithane M-45	500	30	22	74	40.33	35.09
	2000	30	18	52	34.66	54.39
Blitox-50	500	30	23	76	50.66	33.34
	2000	30	19	58	38.66	49.13
Control	500	30	28	114	76.00	-

were found highly efficacious at 2000 ppm concentration. Terpinyl acetate and Opium poppy oil were found very poor in efficacy. Dithane M-45 was the most effective fungicide amongst the two commercial fungicides. Blitox-50 was found next to Dithane M-45.

Clocimum oil, Eugenol and Lawsone proved highly efficacious in controlling the disease at 2000 ppm concentration. However, maximum disease control of 87.72 per cent was obtained with Clocimum oil followed by 86.01 per cent with Eugenol which in turn was followed by 83.32 per cent with Lawsone. Menadione got fourth place in order of efficacy with a disease control of 73.68 per cent followed by Lemongrass oil (64.03 per cent) and Cedarwood oil (55.26 per cent). In case of commercial fungicides, maximum disease control of 54.39 per cent was obtained with Dithane M-45 followed by Blitox-50 (49.13 per cent). In addition, Clocimum oil, Eugenol and Lawsone also gave good control of the disease at their lowest concentration i.e., at 500 ppm though the performance is inferior to that of 2000 ppm concentration. Out of eight natural (plant) products, five natural (plant) products, viz., Clocimum oil, Eugenol, Lawsone, Lemongrass oil and Cedarwood oil were found superior to both the two commercial fungicides.

In 1983-84 cropping season, three natural (plant) products viz. Clocimum oil, Eugenol and Lawsone found effective in preceeding year, were again found highly efficacious in controlling the downy mildew infection considerably at 2000 ppm concentration when sprayed at 10 days interval (Table 32).

Trials were conducted again to confirm the efficacy of Clocimum oil, Eugenol and Lawsone during 1984-85 cropping season. All the three natural (plant) products were found to control the disease effectively and increase the yield of latex and seeds. Maximum disease control efficiency was found with

Clocimum oil (88.60 per cent) followed by Eugenol (86.84 per cent) and Lawsone (84.21 per cent) whereas, with Dithane M-45 maximum disease control was found to be 60.52 per cent. Maximum increase in latex and seed yield was found with Clocimum oil, the percentage increase being 19.50 and 17.00, respectively followed by Eugenol, with an increase of 19.20 and 16.30 per cent, respectively. It was followed by Lawsone, the percentage increase in case of Dithane M-45 was 7.90 and 11.35, respectively (Table 33).

Thus, the results presented in Table 32 and 33 clearly show that all the three natural (plant) products checked the secondary infection of *P. arborscens* more effectively and were significantly superior to commercial fungicides with an increase in latex and seed yield. Spraying the solutions of all the natural (plant) products, neither affected the leaf number per plant, nor produced any symptoms of visual phytotoxicity to any other part of the treated plant of *P. somniferum*.

Table 32: Efficacy of foliar application of three natural (plant) products on secondary infection of downy mildew when sprayed at 10 days interval during 1983-84

Treatments	Conc. (ppm)	No. of plants observed	No 1 of plants infected	Score of infection	Disease index %	Efficiency of disease control %
Clocimum oil	2000	30	6	13	8.66	88.60
Eugenol	2000	30	6	15	10.00	86.84
Lawsone	2000	30	7	18	12.00	84.21
Dithane M- 45	2000	30	13	45	30.00	60.52
Control	-	30	28	114	76.00	-

Table 33: Efficacy of three natural (plant) products on infection, yield of latex and seed when sprayed at 10 days interval during 1984-85

Treatm ent	Con c. (pp m)	Dise ase index %	Efficie ncy of disease control %	Yield of latex in chec k un spray ed plant s (gm)	Yiel d of latex after spra y (gm)	Incre ase in latex %	Yield of seeds in check Unspra yed) plants (gm)	Yiel d of seed s after spra y (gm)	Incre ase in seed yield %
Clocim um	200 0	8.66	88.60	26.75 2	31.9 70	19.50	583.15	682. 25	17.00
Egenol	200 0	10.00	86.84	26.75 2	31.8 67	19.20	583.15	678. 19	16.30
Lawso ne	200 0	12.00	84.21	26.75 2	31.6 79	18.39	583.15	665. 27	14.08
Dithan e M-45	200 0	30.00	60.52	26.75 2	28.8 67	7.90	583.15	649. 38	11.35
Contro l	-	76.00	-	19.63 3	-	-	425.29	-	-

Control of secondary infection of downy mildew by root application of natural (plant) products

The results presented in Table 34 reveal that the intensity of disease per leaf has been greatly affected by the treatments as compared to the control. The results clearly indicate that all the NPPs and both the fungicides were translocated in the system of the plants through roots and were capable of reducing the disease to various degree at both concentrations. However, four natural (plant) products viz., Clove oil, Lawsone, Eugenol and Menadione were found most effective showing 90.17 per cent, 85.66 per cent 85.82 per cent and 75.53 per cent of disease control, respectively, at 500 ppm concentration whereas, the commercial fungicides viz., Bavistin-50 and Calixin could control the disease only up to 62.64 per cent and 58.45 per cent, respectively.

However, at 2000 ppm concentration, out of above four, three NPPs were found even more effective showing 93.48 per cent, 90.42 per cent and 89.86 per cent of disease control, respectively. Out of these three, Clove oil was found most effective showing 93.48 per cent of disease control followed by Lawsone (90.42 per cent) and Eugenol (89.86 per cent) whereas, Bavistin-50 and Calixin could control the disease only up to 69.37 per cent and 60.47 per cent, respectively. Moreover, all the natural (plant) products were found effective at their lowest concentrations (i.e. at 500 ppm) also.

Table 34: Response of different natural (plant) products on development of secondary infection of downy mildew disease

Treatment	Conc. (ppm)	No. of leaves inoculated (A)	No. of leaves infected (B)	Total score of infection per treatment (C)	Average score of infection per leaf (D=C/A)	Efficiency of disease control %
Lawsonia	500	54	10	15	0.277	85.66
	2000	54	7	10	0.185	90.42
Menadione	500	57	15	27	0.473	75.53
	2000	60	11	21	0.35	81.89
Eugenol	500	51	9	14	0.274	85.82
	2000	51	6	10	0.196	89.86
Cloves oil	500	63	8	12	0.190	90.17
	2000	63	5	8	0.126	93.48
Lemongrass oil	500	57	21	32	0.561	70.97
	2000	57	17	23	0.403	79.15
Cedarwood oil	500	51	28	41	0.803	58.45
	2000	48	23	35	0.729	62.28
Terpinyl acetate	500	60	35	54	0.9	53.44
	2000	57	30	43	0.754	60.99
Opium poppy oil	500	51	49	78	1.529	20.90
	2000	54	47	71	1.314	32.02
Bavistin -50	500	54	26	39	0.722	62.64
	2000	54	21	32	0.592	69.37
Calixin	500	51	39	41	0.803	58.45
	2000	51	33	39	0.764	60.47
Control-1*	-	60	52	116	1.933	-
Control-2**	-	63	-	-	-	-

* inoculated

** Uninoculated

The experiment was repeated with Clove oil and Lawsone at 2000 ppm concentration and similar results were obtained suggesting that Clove oil and Lawsone can check the secondary infection of *P.arborescens* more effectively than the commercial fungicides. Spraying the solutions of all natural (plant) products neither affected the leaf number per plant, nor produced any symptoms of visual phytotoxicity to any other part of the treated plants of *P. somniferum*.

Chemical control of powdery mildew disease

Efficacy of foliar application of natural (plant) products on intensity of powdery mildew

The results presented in Table 35 reveal that out of eight natural (plant) products tested during 1982-83 cropping season, six gave significantly superior disease control over the control. Clove oil, Eugenol and Lawsone were the most effective natural (plant) products at all the four concentrations and were superior to all other treatments. Menadione was found next to Lawsone followed by Lemongrass oil and Cedarwood oil. However, all of these were found highly efficacious at 2000 ppm concentration. Terpinyl acetate and Opium poppy oil were found very poor in efficacy. Sulfex was the most effective amongst the commercial fungicides. Dithane M-45 was found next to Sulfex followed by Blitox-50. Water spray alone (Control-1) also reduced the disease intensity and was least effective of all the treatments but was superior to the opium

Table 35 : Efficacy of foliar application of natural (plant) products on the intensity of powdery mildew diseases when sprayed at 15 days interval during 1982-83

Treatment	Conc. (ppm)	No. of plants observed	Score of infection	Disease index %	Efficiency of disease control %
Clocimum oil	250	10	19	21.11	76.24
	500	10	17	18.88	78.75
	1000	10	13	14.44	83.75
	2000	10	10	11.11	87.50
Eugenol	250	10	19	21.11	76.24
	500	10	17	18.88	78.85
	1000	10	14	15.55	82.50
	2000	10	11	12.22	86.25
Lawsone	250	10	21	23.33	73.75
	500	10	19	21.11	76.24
	1000	10	15	16.66	81.25
	2000	10	12	13.33	785.00
Menadione	250	10	24	26.66	70.00
	500	10	20	22.22	75.00
	1000	10	15	16.66	81.25
	2000	10	13	14.44	83.75
Lemongrass oil	250	10	28	31.11	64.99
	500	10	25	27.77	68.75
	1000	10	22	24.44	72.50
	2000	10	19	21.11	76.24
Cedarwood oil	250	10	40	44.44	50.00
	500	10	35	38.88	56.25
	1000	10	32	35.55	60.00
	2000	10	27	30.00	66.24
Terpinyl acetate	250	10	65	72.22	18.74
	500	10	59	65.55	26.24

	1000	10	56	62.22	29.99
	2000	10	54	60.00	32.49
Opium poppy oil	250	10	79	87.77	1.24
	500	10	75	83.33	6.24
	1000	10	70	77.77	12.50
	2000	10	67	74.44	16.24
Sulfex	250	10	29	32.22	63.74
	500	10	22	24.44	72.50
	1000	10	18	20.00	77.49
	2000	10	15	16.66	81.25
Dithane M- 45	250	10	61	67.77	23.75
	500	10	56	62.22	29.99
	1000	10	54	60.00	32.49
	2000	10	52	57.77	35.00
Blitox-50	250	10	68	75.55	14.99
	500	10	64	71.11	19.99
	1000	10	61	67.77	23.75
	2000	10	58	64.44	27.49
Control-1 (with water)		10	74	82.22	7.49
Contrl-2 (No treatment)		10	80	88.88	-

poppy oil at 250 and 500 ppm concentrations and to the Control-2, i.e. no treatment. However, there was no significant difference in disease intensity between the Control-1 and Control-2.

Clocimum oil, Eugenol and Lawsone proved highly efficacious in controlling the disease at 2000 ppm concentration. However, maximum disease control of 87.50 per cent was obtained with Clocimum oil followed by 86.25 per cent with Eugenol which in turn followed by 85.00 per cent with Lawsone at 2000 ppm concentration. Menadione got fourth place in order of efficacy with a disease control of 83.75 per cent, followed by Lemngrass oil (76.24 per cent) and Cedarwood oil (66.24 per cent). Similarly, with commercial fungicides, maximum disease control of 81.25 per cent was obtained with Sulfex followed by Dithane M-45 (35.00 per cent) and Blitox-50 (27.49 per cent). In addition, Clocimum oil, Eugenol, Lawsone and Menadione also gave good control of the disease at their lowest concentration i.e. at 250 ppm though the performance was inferior to that of 2000 ppm concentration.

However, out of eight natural (plant) products, four viz, Clocimim oil, Eugenol, Lawsone and Menadione were found superior to all the three commercial fungicides whereas, Lemongrass oil and Cedarwood oil were found superior to Dithane M-45 and Blitox-50 only. Terpinyl acetate was found superior only to Blitox-50 (Table 35).

In 1983-84 cropping season, all the three natural (plant) products, found effective in preceeding year, were again found highly efficacious in controlling the powdery mildew infection at 2000 ppm concentration when sprayed at 10 days interval (Table 36).

Trials were conducted again to confirm the efficacy of Clocimum oil, Eugenol and Lawsone during 1984-85. All the three natural (plant) products were found to control the disease effectively and increase the yields of latex and seed. Maximum efficiency of disease control was found with Clocimum oil (91.25 per cent) followed by Eugenol (90.00 per cent) and Lawsone (87.25 per cent) whereas, with Sulfex , maximum disease control was 85.00 per cent. Maximum increase in latex and seed yield was found with Clocimum oil, the percentage increase being 22.90 and 15.26, respectively followed by Eugenol, with an increase of 20.15 and 14.52 per cent, respectively. It was followed by Lawsone, the percentage increase being 15.87 and 13.27, respectively whereas, the percentage increase in case of Sulfex was being 12.42 and 12.13 respectively. Water spray also gave a percentage increase of 4.09 and 2.20, respectively (Table 37).

Thus, The results presented in Table 35,36 and 37 clearly show that all the three natural (plant) products gave significantly super performance over commercial fungicides in

Table 36 : Efficacy of foliar application of three natural (plant) products on the intensity of powdery mildew disease when sprayed at 10 days interval during 1983-84

Treatment	Conc. (ppm)	No. of plants Observed	Score of infection	Disease index %	Efficiency of disease control %
Clocimum oil	2000	10	7	7.77	91.25
Eugenol	2000	10	8	8.88	90.00
Lawson	2000	10	10	11.11	87.25
Sulfex	2000	10	12	13.33	85.00
Control-1 (with water)	-	10	70	77.77	12.50
Contrl-2 (No treatment)	-	10	80	88.88	-

Table 37: Efficacy of three natural (plant) products on the infection, yield of latex and seed when sprayed at 10 days interval during 1984-85

Treatment	Conc (ppm)	Disease index %	Efficiency of disease control %	Yields of latex in Check (unsprayed plants (gm)	Yields of latex after spray (gm)	Increase in latex %	Yield of seed in check unsprayed plants (gm)	Yield of seed after spray (gm)	Increase in seed yield %
Clocimum oil	2000	7.77	91.25	25.879	31.806	22.90	627.18	722.89	15.26
Eugenol	2000	8.88	90.00	25.879	31.094	20.15	627.18	718.25	14.52
Lawsone	2000	11.11	87.25	25.879	29.987	15.87	627.18	71.45	13.27
Sulfex	2000	13.33	85.00	25.879	28.094	12.42	627.18	703.28	12.13
Control-a (with water)	-	77.77	12.50	25.879	28.094	12.42	627.18	703.28	12.13
Control-2 (No treatment)	-	88.88	-	18.582	-	-	487.37	-	-

checking the disease with an effective increase in latex and seed yield. Spraying the solutions of all the natural (plant) products, neither affected the leaf number per plant, nor produced any symptoms of visual phytotoxicity to any other part of the treated plants of *P. somniferum*.

DISCUSSION

Opium poppy *Papaver somniferum* (L), like other medicinal plants, is known to suffer from a number of fungal (Holliday, 1980; Janardhanan and Husain, 1983), bacterial (Atanasoff *et al.*, 1932; Christoff, 1932 and Singh, 1969) and viral (Anand & Summanwar, 1981; Horvath and Besada, 1975 and Smith, 1972) diseases. But fungal diseases are more numerous, frequent and devastating (Butler, 1918 ; Chattopadhyay, 1967; Horsfall and Ellis, 1977 and Schmitt, 1975). Present work revealed that the crop, in eastern parts of Uttar Pradesh is attacked by a number of phytopathogenic fungi causing seed borne diseases (caused by several spermatophyte fungi); damping-off (caused by *Fusarium solani* (Mart.) Sacc.); downy mildew (caused by *Peronospora arborescens* (Berk.) Cesp); wilt disease (caused by *Fusarium oxysporum* Schlecht.); root-rot (caused by *Rhizoctonia bataticola* (Taub.) Britton-Jones state of *Macrophomina phaseolina* (Tassi) Goid); sclerotial wilt (caused by *Sclerotium rolfsii* Sacc.) ; leaf spot disease (caused by *Alternaria alternata* (Fr.) Keissler); leaf blight disease (caused by *Drechslera spicifera* (Bainier) v. Arx state of *Cochliobolus spicifer* Nelson); stem rot (caused by *Mucor racemosus* Fres.); sepal and petal blight (caused by *Alternaria alternata* (Fr.) Keissler); stamen blight (caused by *Alternaria* state of *Pleospora infectoria* Fuckel); capsule rot (caused by *Rhizopus microsporus* v. Tieghem) and powder mildew caused by *Erysiphe polygoni* DC. and *Oidium* state of *Erysiphe cichoracearum* DC).

Seed borne diseases

Seed comes in contact with various saprophytic and parasitic fungi from the time of its formation through harvesting, threshing, transit and finally storage. Seed infection leads to a lowered germination percentage, lower seedling vigour and mortality. Such infected seeds create disease foci which initiate infection of the new harvest (Naumova, 1970). Association of a large number of fungi with economically important crop seeds has been worked out extensively (Agarwal *et al.*, 1972; Christensen and Gordon, 1948; Morey, 1976; Bagga, 1970 ; Luke and Barnett, 1979; Mishra and Kanaujia ,1973 ; Sharma and Chauhan, 1974; Suryanarayana and Bhombe, 1961 and Mittal and Sharma , 1982).

Inspection of dry seed samples revealed that opium poppy seeds collected from different growing areas and from different sources carried a good number of several inert matters viz., soil particles, different parts of the host and several other kind of grains. These inert matters on incubation on different media , yielded a varied fungal flora including both saprophytic and parasitic fungi, establishing that inert materials carry mycoflora.

Out of total fungi isolated from all inert matters, six fungi viz., *M. racemosus*, *R. bataticola*, *F. solani*, *F. oxysporum*, *A. alternata* and *D. spicifera* have already been found pathogenic to opium poppy plants. Neergaard (1977) emphasized the need of inspection of dry seed for impurities (inert matters) as the concomitant contamination occurring in plant debris leads to seed transmission of the pathogenic agents. Yossiflovitch (1929) reported that fragments of diseased opium poppy capsules act as dangerous source of *Peronospora arborescens* infection when mixed with seed.

In seed discoloration studies, discoloration were observed in varying degrees. These may be either due to necrosis, due to stains produced by the harboring fungi or may be due to fungus coatings. The results are in consonance with those of Kondo and Okamura (1927), Christensen (1957), Kilpatrick (1957), Ullstrup (1961), Ou (1963), Nath *et al.*, (1970), Neergaard (1970 b and 1977) and Laviolette and Athow (1972).

The weight lost by the experimental seeds is well documented. It may be either due to poor development of seeds or due to shrinkage and reduction in size of the seeds. The findings of Bomberg (1936), Wallin (1946 a , 1946 b) and Boosalis (1952) are in conformity with the present findings. It might be also due to consumption of the stored food material of the seed and their biodeterioration, preferably of seed coat and reticulation walls, by the toxic metabolites secreted by harbouring spermatophyte fungi. Reduction in seed weight may also happen due to poor development of the seed as a result of indirect effect of many fungi, which were not necessarily seed – transmitted. Foliage pathogens may severely impair photosynthesis with adverse consequences to seed development. The fact is supported by the example of black stem rust, *Puccinia graminis* and other rust fungi in cereals, grasses, and other crops; powdery mildews, e.g. *Erysiphe graminis* in cereals and grasses and downy mildew e.g. *Peronospora destructor* in onion (Neergaard, 1977). Naumova (1970) observed that weight of wheat ear infected by *Septoria* spot sometimes drops by 2.3-14.6 per cent while the weight of grains from one ear was reduced by 8.3 - 27.3 per cent.

The highest and lowest moisture percentages were recorded in seed samples collected from market and opium poppy fields at the time of harvesting, respectively. The lower moisture percentage in seed samples from fields might be due to the fact that opium poppy seeds were harvested during hot summer

months (April – May) of the year. The moisture content of the seeds play an important role in deterioration of seeds by spermatophyte fungi. Christensen (1964), Christensen and Kaufman (1973) and Kanaujia (1974) have shown that seeds with higher moisture content carry higher percentage of seed infection and generally with more fungal species.

Washings of seeds yielded in total 10 fungal species out of which two were obligate parasites and four facultative saprophytes. The remaining four were saprophytes. The technique was used mainly for the determination of seed infections caused by obligate parasitic fungi. The procedure has been used for similar purposes in France by Chapman (1975) and in India by Suryanaryana and Bhombe (1961).

Healthy and deteriorated capsules yielded 15 and 19 fungal species from external surface and 2 and 10 fungal species occurring internally, respectively. Similarly, seeds from such capsules yielded 4 and 12 fungal species from external surface and zero and 10 fungal species internally, respectively. However, seeds obtained from healthy capsules yielded no internally occurring fungi. Out of the fungi isolated from deteriorated and healthy capsules and seeds, *A.niger*, *P. canadense* and *R.microsporus* were dominant. Moreover, obligate parasites viz., downy mildew fungus - *P. arborescens* and two powdery mildew fungi – *E. polygoni* and *E. circhoracearum* were also found to be associated with the deteriorated capsules externally. It appears that the inoculum reached inside seed bearing parts either from atmosphere or through the insect pollinators. Many insects may enter the capsule by mechanical injury (Singh *et al.*, 1983). Similar observations were also made in case of cotton ball rot (Edgerton, 1912), microbial degradation of cotton fibre (Guthrie *et al.*, 1950) and Sesamum ,

Linum and Eruca (Agarwal, 1965). Bagga and Laster (1969) studied the role of insects in transferring the inoculum in cotton balls. Occurrence of *P. arborescens* from deteriorated capsules and seeds both, prove the fact that the fungus (causing downy mildew of opium poppy) is transmitted through the capsular fragments and seeds. The present findings are in full agreement with those of Yossiflovitch (1929) and Inaba *et al.*, (1983).

In all 27 and 18 fungal species were found to be associated externally and internally, respectively, with the tested opium poppy seeds. Out of four methods tried in the present study, moist blotter yielded maximum number of fungal species and also fungal colonies followed by potato dextrose agar. Thus, the present study also proved the superiority of blotter method over other methods of determination of spermatophyte fungi and confirmed the findings of Nath *et al.*, (1970) and Agarwal *et al.*, (1972).

Active saprophytes like *Aspergillus*, *Rhizopus* and *Penicillium* species constituted the majority in both external and internal flora. This may be due to their wide range of distribution and greater tolerance capability to various limiting factors. However, experiments on surface disinfection of seeds revealed that external contamination was most common. Out of 27 externally associated fungal species, only 11 viz., *A. niger*, *A. alternata*, *P. canadense*, *F. oxysporum*, *C. lunata*, *D. spicifera*, *R. nigricans*, *R. microsporus*, *M. phaseolina*, *C. capsici* and *B. cinerea* showed deep-seated internal infections. *Aspergillus* spp., *Penicillium* spp., *R. nigricans*, *Mucor* spp., *Alternaria* spp. and *C. herbarum* along with eight other fungi have been found to be associated with opium poppy seeds in Poland (Zarzyca, 1958) too. External contaminations were more frequent and only a small percentage of seeds bore internal pathogens viz., *Helminthosporium*

papaveris, *Fusarium scirpi* var. *caudatum* and *Alternaria* spp. These results are in agreement with the major part of the present findings.

The saprophytic fungal species isolated from discoloured seeds outnumbered those isolated from normal coloured seeds. Discoloured seeds also showed higher percentage of *A. niger* and *R. microsporus*.

On incubation of opium poppy seeds at two different temperatures (i.e at $20 \pm 2^{\circ}\text{C}$ and $27 \pm 2^{\circ}\text{C}$) by blotter and P.D.A. methods, higher number (19) of fungi were encountered at $27 \pm 2^{\circ}\text{C}$ in comparison to that of 12 fungi at $20 \pm 2^{\circ}\text{C}$. Perhaps because of this only, Neergaard (1969) recommended the incubation of seeds at $28 \pm 2^{\circ}\text{C}$ for tropical and sub-tropical crops.

In consonance to that of external and internal spermatophyte mycoflora, species of active saprophytes like *Aspergillus*, *Penicillium* and *Rhizopus* were encountered equally at both the temperatures but they were overgrowing other fungi at higher temperature.

The studies clearly revealed the succession of microorganisms from field to storage, through various stages of development and post-harvest activities with different microecological conditions and the environmental set up.

A perusal of literature reveals that some of the spermatophyte fungi viz., *P. arborescens*, *Alternaria* spp., *C. herbarum*, *Aspergillus* spp., *Penicillium* spp., *R. nigricans*, *Mucor* spp., *Aspergillus* and *Trichoderma* spp. reported here have already been reported from opium poppy seeds by different workers (Alavi, 1975; Christoff, 1943; Gobelet, 1956; Pietkiewicz, 1943; Rudy, 1976 and Zarzyca, 1958) from different parts of the world whereas the others (Table 1, 4, 5, 6, and 7)

are being reported for the first time and constitutes new world record on *P. somniferum* seeds.

In artificial inoculation experiments, all the nine frequently occurring spermatophyte fungal species have proved their pathogenic ability. However, out of these, nine fungal species, *A. niger*, *R. nigricans*, *R. microsporus* and *P. canadense* appeared as 'highly pathogenic' reducing seed germination by 72-95 per cent in unsterilized soil and 78 -100 per cent in sterilized soil, while *D. spicifera*, *F. solani*, *F. oxysporum*, *A. alternata* and *M. phaseolina* appeared as 'severe pathogens' lowering germination by 62 -74 per cent in sterilized soil. Similarly, *P. canadense*, *M. phaseolina*, *R. microsporus*, *R. nigricans* and *D. spicifera*, *A. niger*, *F. solani*, *F. oxysporum* and *A. alternata* appeared as 'very severe' and 'severe' pathogens in agar test and were found to reduce 93-100 per cent and 72- 82 per cent of seed germination, respectively. Suryanarayana and Bhombe (1961); Dwivedi and Singh (1973); Kanaujia (1974); Jain *et al.*, (1982) ; Mittal and Sharma (1982); Kumar and Singh (1983) have also reported the loss of germinability due to seed rot by many seed-borne fungi including species of *Aspergillus*, *Alternaria*, *Fusarium*, *Macrophomina* and *Rhizopus* etc. Srivastava and Gupta (1982) also reported the species of *Aspergillus*, *Alternaria*, *Drechslera* and *Fusarium* as 'very severe' pathogens causing seed and seedling rots in yellow cosmos seeds to the extent of 80 per cent. In addition, all the nine fungal species were also found to cause 19-32 and 13-31 per cent of pre- and post-emergence seed and seedling rots. Jain *et al.*, (1982) also found *Alternaria*, *Fusarium* and *Macrophomina* spp. causing pre- and post-emergence seed rots in moth bean. Out of 15 fungal species isolated from opium poppy seeds, Zarzyca (1958) found *H. papaveris* as the most noxious fungal pathogen, causing considerable loss in seed germination, and increased seedlings decay, whereas *F. scirpi* var. *caudatum*

and *Alternaria* spp. decreases seed germination and cause seedling decay to only a limited extent. These findings are in agreement with the findings of the present study.

The results of present investigation clearly show that opium poppy seeds collected from different sources can be grouped into two categories (i) apparently healthy and (ii) infected (deteriorated). Both these types have some initial mycoflora which can be isolated from external surface (external spermatophyte mycoflora) causing deterioration of seeds both qualitatively and quantitatively.

Before accession of the fungal flora, seeds have been in direct contact with fungi in field, processing yard, transit and storage. Consequently respective fungi had fair chance to contaminate the seeds and to grow and multiply there as long as food supply is adequate and environmental conditions are favourable. With the passage of time, the microecological position of the seed changes because of depletion of food and change in the environment. Now other fungi, more suited to this microenvironment take over and establish. It also appears that morphological structure of the opium poppy seed is quite important and spores of many fungi may survive on such sites (within grooves made by reticulation walls) and in suitable conditions invasion of seeds takes place.

The fungi which could ultimately establish on the seeds, proved detrimental to the seed in different ways and varying degrees. The presence of frequently occurring saprophytes like *Aspergillus*, *Rhizopus* and *Penicillium* species in higher percentage is probably one of the main reasons for the

variable and *Rhizopus* sp. produce aflatoxins in seeds. Mishra and Kanaujia (1974) reported that seed germination and seedling growth of certain oily and starchy seeds were adversely affected by the culture filtrates of *Aspergillus* spp., *R. nigricans* and *Penicillium* spp. Adverse effect of the mycotoxins has also been reported by various workers (Diener and Davis, 1966 b and Coducer *et al.*, 1963) on different hosts. It was also observed during the present investigation that besides *Aspergillus*, *Penicillium* and *Rhizopus* species, other spermatophyte fungi also cause seed and seedling rots. Even if, all the seeds infected by these spermatophyte fungi were not killed outrightly, the seedlings which emerge from such seeds were weaker and stunted resulting in ultimate reduction in crop yield.

It is also likely that survival and infestation of different mycoflora in storage is affected by the phenomenon of antagonism or synergism. The mycotoxins secreted by these fungi ultimately accumulate on and in the seeds and harm it and also the health of humans and animals consuming it (Forgacs, 1962; Spensely, 1963; Ciegeler *et al.*, 1971; Goldblatt, 1969; Kadis *et al.*, 1971, 1972; Neergaard, 1977 and Stinson *et al.*, 1980). Toxigenicity of fungi (other than *A. flavus* group) isolated from cotton seed and bolls, to brine shrimp, chick embryos and rats has also been reported by Diener *et al.*, (1976).

Damping-off disease

The opium poppy crop suffers from damping-off disease incited by several phytopathogenic fungi. The present study noted it from eastern Uttar Pradesh. It was caused by *Fusarium solani* (Mart.) Sacc. A damping-off of cultivated poppy, was reported for the first time by Barbacka (1936) from Poland and subsequently from Denmark (Neergaard, 1937; Gassner, 1949 and Stapel,

1960). Zogg (1945) reported that opium poppy seedlings sustain heavy damage from a damping-off disease caused by *Pyrenophora (Pleospora) calvescens*, in Switzerland. The disease caused by *Rhizoctonia solani*, is found to cause mild damage in Pakistan (Zaman and Khan , 1969). In Australia, the disease was caused by *D. penicillatum* (Munro, 1978).

During the present investigation, the disease was found to cause mild damage to the crop. The disease was favoured by excessive irrigation and cloudy weather. The disease surveys reveal that the disease was prevalent throughout the eastern Uttar Pradesh. Its incidence was maximum i.e. 28.33 per cent in Mughalsi followed by 27.33 per cent in Barabanki and was minimum (20.00 per cent) in Kumarganj.

The occurrence of the disease caused by *F. solani* has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

Morphological details of the fungus studied during the present investigation, were typical of *Fusarium solani* (Mart.) Sacc. (Booth , 1971).

Downy mildew disease

The opium poppy crop suffers from a downy mildew disease incited by *Peronospora arborescens* (Berk.) Casp. Its occurrence was reported as early as in 1897 from India (Cunningham, 1897) but Butler (1918) described it in detail. The disease, however, was first reported by Gaumann (1923) and Van Poetern (1923).

The disease was found to cause mild to severe damage to the crop by different workers throughout the world (Gaumann, 1923; Van Poeteren, 1923; Fokin, 1924; Prochaska, 1928; Proshkina, 1928; Cotton, 1929; Yossiflovitch,

1928,1929; Skoric, 1930; Lindquist, 1939, Ikata and Yamauti, 1941; Petrak and Esfandiari, 1941; Christoff, 1943; Darpoux, 1945; Kratichvil and Zakopal, 1948; Schimdt, 1949; Beaumont, 1953; Pietkiewicz, 1958; Elaide, 1960; Stapel 1960; Zyubin, 1963; Scharif, 1970; Alavi, 1974, 1975; Rundy, 1976; Leiteritz and Roder, 1980 and Wronska, 1980). Apart from above, downy mildew was reported from other species of *Papaver* also, viz., on *Meconopsis* spp. by Alcock (1930); on garden poppy by Pape (1933); on *P. rhoeas* by Da camara *et al.*, (1936) and Thind (1942); on *P. nudicaule* by Anonymous (1950) and Lindquist *et al.*, (1964).

Butler (1918) was first to study the yield reducing capacity of the disease. According to him downy mildew causes 20-30 per cent loss in yield. During the present investigation, disease was observed to appear year after year from seedling to maturity stage of the crop as epiphytotic throughout eastern Uttar Pradesh. Similar observations were also made by Kothari and Prasad (1970) from Rajasthan, Moesz (1938) from Hungary and by Masurat and Stephan (1963) from Germany. Gaumann (1923) and Skoric (1930) considered *P. arborescens* to be a biologically specialized form on *P. somniferum* but Cotton (1929) doubted the existence of physiological strain of the fungus.

Its incidence was maximum i.e. 74.50 per cent in Mughalsi followed by 66.66 per cent in Barabanki and was minimum (58.00 per cent) in Kumarganj. The occurrence and severity of downy mildew of opium poppy under reference happen to be the first report of its prevalence from Uttar Pradesh.

The disease symptoms in the present study are in full agreement with the findings of Butler (1918), Kothari and Prasad (1970), Ramanathan and Ramachandran (1977), Thakore *et al.*, (1983), and Gupta (1984). Moreover, it

was observed that the disease sapped the vigour and vitality of the plant and stunted it. On disease being severe, heavy infection was observed on peduncle, flower buds and even on inchoate capsule but not persistently. The infected buds remain under-developed, became feckless and did not open while, capsules became crooked. Kotahri and Prasad (1970) during histopathological studies, observed the presence of mycelium of *P.arborescens* within peduncle, stamens and developing ovules of opium poppy, which supports the present findings.

The yield loss experiments conducted during 1982-83, 1983-84 and 1984-85, showd that secondary infection of downy mildew could give a loss of 16.7-33.8 per cent in latex yield and 13.8-16.5 per cent in seed yield when infection index ranged from 58.6-78.4 per cent. Thakore *et al.*, (1983) also reported that the secondary infection of downy mildew was found to reduce 17.00-22.8 per cent of latex yield and its morphine content while 12.9-14.8 per cent of seed yield when infection index ranged from 68.7-71.2 per cent in Rajasthan. Zyubin (1963) likewise, reported the yield loss of opium and seeds by 5-20 per cent and 50-70 per cent while, Alavi (1975) observed 7-37 per cent losses in seed yield due to downy mildew disease.

The loss in terms of latex and seed yield is well documented. The infected regions of the infected leaves become brown to black (dead) due to heavy coating of the fungal material destroying the chlorophyll of the leaves. This, in turn, affects the photosynthesis as well as transmission of sap from the soil to capsules which in turn, affects the latex and seed yields. Reduction in seed yield as a result of poor development of seeds has been recorded by Neergaard (1977) also. He further reported that foliage pathogens may severely impair photosynthesis with adverse consequences for seed development. The morphological details of the fungus studied, resembled those described by Butler (1918) and Kothari and

Prasad (1970) for *Peronospora arborescens* (Berk.) Casp. The abundance of mycelium, conidiophores, conidia and oospores suggests that *P. arborescens* on opium poppy has developed remarkable adaptability to meet the challenges of nature.

Only fresh conidia were found infective and lost viability soon after the collection of the herbaria unless kept at low temperatures. It was observed that they retained their pathogenic viability up to 15 days when stored at 5-7°C of temperature. However, conidia were found incapable to produce typical symptoms of the disease in detached leaves and uprooted plants.

Results of inoculation with conidia from severely diseased plants show that conidia cause leaf spots. The occurrence of leaf spots in new fields of opium poppy can be explained. Thus, conidia from severely diseased plants from other fields are blown by wind currents to a newly sown field where they cause infection. The appearance of leaf spots in nature 2-3 weeks after the appearance of severely diseased plants also supports this contention.

Severely diseased plants appear throughout the crop period and each one of these produces a huge crop of conidia. Thus, abundant conidium inoculum is available throughout the crop period and this explains why leaf spots continue to appear till maturity of the crop.

Inoculation experiments suggest that an important requirement for conidial infection is the presence of free water at least for four hours in the infection court. Under natural conditions, this requirement might be fulfilled by heavy dewdrops. Inoculation experiments have further shown that night temperatures prevailing throughout the crop period are suitable for establishment of infection and plants are susceptible at all stages of their growth.

Thus, the three basic conditions (i) active inoculums throughout the crop period, (ii) susceptibility of the crop at all stages and, (iii) suitability of environmental factors for establishment of infection, synchronize resulting in severe leaf spotting even up to maturity of the crop.

The oospores of the pathogen were capable of producing typical symptoms of the disease within 20-22 days. The experiments conducted to workout the infective period and pathogenic ability of oospores reveal that the fresh oospores were non-pathogenic and they require some resting period to become pathogenic. Oospores were found to retain their pathogenic ability upto 3 year and to a lesser extent in consecutive years. It was also found that the soil acts as a potent reservoir of the oospores of the pathogen. That is why, the disease appears in the second year of poppy cultivation. In a new field, opium poppy plants were found susceptible to the disease at all growth stages and may contract infection at any of their growth stage. However, older leaves were found more vulnerable than younger ones. The observations made by Yossiflovitch (1928) and Kothari and Prasad (1970) are in agreement with these findings.

Root-rot disease

Root-rot disease of opium poppy is reported to be caused by several phytopathogenic fungi (Janardhanan and Husain, 1983). Its occurrence in India was reported as early as in 1918 by Butler (1918). It was caused by *Rhizoctonia* sp. However, the disease was first reported by Masalab (1938) from Crimea, where it was caused by *Sclerotinia sclerotiorum*.

Apart from the report of Butler (1918), Uppal *et al.*, (1935) reported the occurrence of *Corticium solani* (*Rhizoctonia solani*) from Karachi. Deshpande *et al.*, (1969) found root-rot of opium poppy caused by *R. solani* as a most damaging disease. During the course of present investigation, another root-rot of opium poppy caused by *R. bataticola* Britton-Jones state of *Macrophomina phaseolina* has been observed in opium poppy growing tract of eastern Uttar Pradesh. In seedling stage, root-rot was also found to be caused by *F. semitectum* (Janardhanan and Husain, 1983) from Lucknow.

The disease surveys conducted reveal that the disease was prevalent throughout eastern Uttar Pradesh. However, its incidence was maximum i.e. 17.00 per cent in Barabanki followed by 11.00 per cent in Kumarganj and was minimum (8.75 per cent) in Mughalsi.

The occurrence and severity of the disease under reference happens to be the first report of its prevalence from Uttar Pradesh.

The disease symptoms produced by different pathogens differ widely. However, the symptoms of root-rot caused by *R. bataticola* Britton-Jones state of *M. phaseolina* were more or less similar with those described by earlier workers (Butler, 1918 and Deshpande *et al.*, 1969). Moreover during present

investigations, it was observed that the disease may appear alone or in combination with *Peronospora arborescens* and the rot was usually a dry one at least on the above ground part.

Morphological details of the fungus studied during the present investigation were typical of *Rhizoctonia bataticola* (Taub.) Britton-Jones state of *Macrophomina phaseolina* (Tassi) Goid, but was atypical, forming few sclerotia in subcultures. It also differs in colony characteristics and sclerotial size as reported by Butler (1918) and Deshpande *et al.*, (1969).

Leaf spot disease

The opium poppy crop suffers from leaf spot disease caused by several phytopathogenic fungi. One of these was reported from India by Pavgi and Upadhyay (1969). It was caused by *Cercospora papavericola*. It was also reported by Muller and Chupp (1936), Stevenson (1942), Chupp (1954) and Zaman and Khan (1969) from Brazil, U.S.A, New York and Pakistan , respectively.

During the course of present investigation, a new leaf spot disease, caused by *Alternaria alternata* (Fr.) Keissler, has been observed. Leaf spot disease caused by other fungal pathogens viz., *D. penicillatum* and *E. fuscum* were reported by Van Poeteren (1929, 1933) and Savulescu (1932), Mehlich (1935), Kochman (1936), Kovacevski (1936), Brundza (1937), Nattrass (1937), Saville (1946) and Bremer *et al.*, (1947), respectively.

The disease survey conducted reveals that the disease was prevalent throughout the eastern Uttar Pradesh. However, its incidence was maximum i.e. 70.00 per cent in Kumarganj followed by 66.66 per cent in Barabanki and was minimum (65.00 per cent) in Mughalsi. Van Poeteren (1933) also observed

that 15.00 per cent of the plants remain free from the infection of *D. penicillatum* in Oudenbosch district.

The occurrence of leaf spot disease caused by *A. alternata* has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The disease symptoms were characterized by dark-brown to black coloured spherical to irregular spots. The infected regions became necrotic resulting in premature death of the infected foliage. The disease was luxuriant in shady parts of the fields and was favoured by cloudy weather.

Morphological details of the fungus studied during the present investigation were typical of *Alternaria alternata* (Fr.) Keissler (Ellis, 1971).

Leaf blight disease

The opium poppy crop suffers from serious leaf blight disease caused by several phytopathogenic fungi. This is the first report of leaf blight disease of opium poppy caused by *Drechslera spicifera* (Bainier) v. Arx state of *Cochliobolus spicifer* Nelson, from India. A leaf blight disease caused by *Pleospora papaveracea* was reported as early as in 1928 from U.S.S.R. (Girzitska, 1928).

During the course of present investigation, incidence of the disease was found equally throughout the field though it was higher in dense part of the crop and on the plants growing under shade. The disease was found to be favoured by cloudy weather and excessive irrigation. Similar observations were recorded also by Christoff (1930), Reinmuth (1935), Marz (1960), Bogarada *et al.*, (1971), Gassner (1949), Radulescu *et al.*, (1961) and Redulescu and Perseca (1964).

The disease surveys conducted reveal that the disease was prevalent throughout the eastern Uttar Pradesh. However, its incidence was maximum i.e. 90.00 per cent in Mughalsi followed by 78.50 per cent in Barabanki and was minimum (74.50 per cent) in Kumarganj. Marz (1960) reported incidence of the disease varying from 2.48 to 98.75 per cent according to locality, whereas Masurat and Stephan (1961) found 9.00 and 14.00 per cent of infection in Leippzig and Halle, respectively.

Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The symptoms observed during the present investigation, differ from the earlier findings as the causal pathogen themselves are different. The disease under investigation was characterized by dark brown to black coloured diffused spots. These infected regions became necrotic followed by premature death of the infected leaves.

Morphological details of the fungus studied during the course of present investigation, were typical of *Drechslera spicifera* v. Arx state of *Coachliobolus spicifer* Nelson (Ellis, 1971).

Wilt disease

The opium poppy crop suffers from a mild wilt disease caused by several phytopathogenic fungi.

In India, wilt disease of opium poppy, caused by *Fusarium oxysporum* Schlecht and *Sclerotium rolfsii* Sacc., has been observed for the first time from eastern Uttar Pradesh during the present investigation. A wilt of poppy caused by *Verticillium* sp. was reported as early as 1925 from Holland (Vander Meer,

1925). This disease was later reported by Donandit (1932) and Schneider (1953) on *P. bracteatum* and by Goidanich (1932) and Dimoc (1940) on *P. rhoeas* and *P. orientale*. Brittlebank and Fish (1927) found a wilt of *P. nudicaule* caused by *Phytophthora cryptogea* in Melbourne, while Wager (1931) reported another wilt of *P. rhoeas* caused by *Pythium artotrogus* from S. Africa. Navarro De Palencia (1954) reported outbreaks of a *Fusarium* wilt, caused by *F. martii* or *F. oxysporum* var. *cubense*, from Spain.

During the present investigation, the disease was found to be favoured by excessive irrigation and high plant density. In addition, intensity of the disease was found higher in shady parts of the fields. Reinmuth (1942) observed that the disease probably needs warm conditions for its optimum development whereas the infection was found to be favoured by drought (Anonymous, 1945).

The disease surveys revealed that the wilt caused by *F. oxysporum* was prevalent throughout the eastern Uttar Pradesh, however, maximum incidence of 22.50 per cent was found in Mughalsi followed by 18.33 per cent in Kumarganj. It was minimum (17.66 per cent) in Barabanki. The wilt caused by *S. rolfsii* was maximum i.e. 9.66 per cent in Mughalsi followed by 6.00 per cent in Kumarganj and was minimum (3.30 per cent) in Barabanki.

The occurrence of wilt of opium poppy caused by *F. oxysporum* has been noted for the first time and thus constitutes a new world record. Occurrence of *S. rolfsii* on *P. somniferum*, although already reported by Patel *et al.*, (1949) from the then Bombay Presidency, happens to be the first record on the foot part of the host plant.

The disease symptoms observed in case of wilts caused by different pathogens naturally differed widely. The symptoms of wilt caused by

F. oxysporum, observed during the present investigation, revealed that the disease appeared in the plants when they were 5-6 weeks old, followed by yellowing and flagging of leaves ultimately resulting foliar wilting and rapid desiccation of entire plant. In case of wilt caused by *S. rolfsii*, the disease appeared at young stage of the plants. The fungus attacked the plants at collar region and below the soil. The foliage soon yellowed, became flaccid and drooped-off. The infected region became slightly discoloured. Infected plants ultimately wilted and died.

Morphological characters of both the fungi studied during the present investigation were typical of their species.

Diseases of stem

The opium poppy crop was found to suffer from stem rot and stem infection diseases, both caused by several phytopathogenic fungi in varying degrees.

In India, stem rot disease of opium poppy was observed for the first time from eastern Uttar Pradesh during the present investigation. It was found to be caused by *Mucor racemosus* Fres. Another stem rot caused by *Rhizoctonia solani* was reported as early as 1969 from Pakistan (Zaman and Khan, 1969). The stem infection caused by *Pleospora papaveracea* was reported as early as 1928 from U.S.S.R. (Girzitska, 1928), Extrand (1941), Reinmuth (1942), Meffert (1950), Maas Geesteranus (1960), Radulescu and Perseca (1964) and Drozdovskaya (1977) also reported the stem infection of opium poppy caused by *P. papaveracea* (imperfect state of *Helminthosporium papaveris*) from Sweden, Bulgaria, Germany, Netherlands and Romania, whereas, Zogg (1945) reported

that in Switserland, stem infection was caused by *Pyrenophora (Pleospora) calvescens*.

During the present investigation, it was observed that the fungus *M. racemosus*, attacked the plants around the flowering stage and started infection from base of the stem whereas, Girzitska (1928) observed that mycelium of the fungus infect the stem after causing leaf infection. Maas Geesternus (1960), however, reported that the fungus attacks only dying tissues of the plants and confines itself to the bark while, Drozdovskaya (1977) reported that the fungus *H. papaveris* overwintered in the remains of opium poppy plants. Reinmuth (1942) reported that *P. papaveracea* first attacks the base of the stem and causes necrosis. Meffert (1950) observed that within the stem, growth of *P. papaveracea* was predominantly intercellular causing tracheomycosis. However, during the present investigation, infection resulted in constriction and girdling of the stem followed by wilting and toppling of the plants.

The disease surveys revealed that the stem rot was restricted to Mughalsi region of eastern Uttar Pradesh on a minor scale and the incidence was found only up to 7.00 per cent. The occurrence of stem rot disease has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The symptoms pertaining to stem rot and stem infection diseases were found different in each pathogen. During the present investigation, it was observed that symptoms appeared as ash coloured diffused spots, which enlarged to encroach much of the stem with the aging. The infected portion turned black to olivaceous black, got constricted and looked girdled resulting in wilting of the foliage before or after flowering. The infected plants topple down automatically or by getting a slight jerk.

Morphological characters of the fungus studied during the present investigation were typical of *Mucor racemosus* Fres. (Gilman, 1957 and Tandon, 1968). In artificial inoculation experiments, the pathogen appeared as a weak parasite and need very high inoculum load to produce typical symptoms.

Sepal blight and Petal blight diseases

The opium poppy crop was found to suffer from sepal and petal blight diseases occurring on minor scale. It was for the first time that these diseases, caused by *Alternaria alternata* (Fr.) Keissler, were observed from eastern Uttar Pradesh and constitutes first world record.

The disease surveys revealed that the sepal blight disease was prevalent throughout the area, however, its incidence ranged between 21.00 per cent in Kumarganj to 17.66 per cent in Barabanki, whereas the incidence of petal blight ranged between 18.33 per cent in Mughalsi and Kumarganj to 12.50 per cent in Barabanki.

The disease symptoms pertaining to sepal blight were characterized by long diffused spots covering $\frac{1}{2}$ or $\frac{3}{4}$ part of the sepals with a tarry appearance on aging. Infected buds fail to open from normal opening point and got open from other weakened points or could not flower at all and withered. The symptoms pertaining to petal blight were characterized by light brown diffused stripes covering about 90 per cent of the petals and became tenacious in severe cases. Infected petals neither open nor fall-off as usual resulting in failure of pollination

The incidence of both the diseases was favoured by cloudy weather. The diseases were severer in the fields with higher plant population than in those with thinner plant stands.

Morphological characters of the causal fungus were typical of the species (Ellis, 1971).

Stamen blight disease

The opium poppy crop was found to suffer from a stamen blight diseases caused by *Alternaria* state of *Pleospora infectoria* Fuckel which appears on a minor scale.

The disease surveys revealed that the stamen blight disease was prevalent throughout the area, however, its incidence was ranged between 15.00 per cent in Mughalsi to 9.00 per cent in Kumarganj. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The disease symptoms were characterized by brown to black coloured spots all over the stamens making them blurred and tarry with the aging. In severe cases, crumpling of the anthers takes place which incapacitate them for reproductive purposes. The disease was prevalent in late flowering cases and was found to be favoured by cloudy weather and winter rains.

Morphological characters of the causal fungus studied during the present investigation were typical of *Alternaria* state of *Pleospora infectoria* Fuckel (Ellis, 1971).

Diseases of capsule

The opium poppy crop was found to suffer from capsule rot and capsule infection diseases, both caused by several fungi in varying degrees.

Capsule rot disease was first reported in 1921 from Naples (Parisi Rosa, 1921) and in 1971 from India (Sehgal *et al.*, 1971).

Sehgal *et al.*, (1971) reported a capsule rot caused by *Dendryphon penicillatum* from Rajasthan whereas Janardhanan and Husain reported a serious capsule rot caused by *Botrytis cinerea* from Lucknow. However, during the present investigation, another capsule rot disease caused by *Rhizopus microsporus* v. Tieghem has been observed for the first time from eastern Uttar Pradesh. Both capsule rot and capsule infection were reported to cause mild to severe damage to the crop by different workers throughout the world (Garbowski and Juraszkowna,1933; Grummer,1953; Miczulsska,1967; Felklova,1976; Rundy,1976; Christoff,1934 and 1943; Darpoux,1945; Reinmuth,1948; Ballarin,1950; Marz,1979; Zogg,1945 and Laughlin and Munro,1982).

The disease surveys revealed the presence of capsule rot throughout eastern Uttar Pradesh , however, its incidence was a maximum of 36.00 per cent in Mughalsi to a minimum of 18.33 per cent in Kumarganj. Rundy (1976) also reported the incidence of fungal infection of poppy heads up to 14.65 per cent.

The occurrence of capsule disease caused by *R. microsporus* v. Tieghem has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

Symptoms differed depending upon the causal organism. The symptoms pertaining to capsule rot under investigation were characterized by diffused ash coloured spots which later bulged and tarnished covering much of the young capsules. On disease being severe, whole capsule became floppy and rotted. The symptoms observed by other workers differed from the present study and being characterized by large velvety black spots, especially on the green capsules (Parisi Rosa, 1921), precocious germination of the unripe to semi-ripe seeds within the capsules (Grummer, 1953), spotting of balls (Christoff, 1943), deformity of the

capsules (Darpoux, 1945). Infected capsules grow one sided and stunted (Reinmuth, 1948) and spots on capsules (Zogg, 1945).

Morphological characters of the fungus studied during the present investigation were typical of *Rhizopus microsporus* v. Tieghem (Lunn. No. 523).

Powdery mildew disease

The opium poppy crop suffers from powdery mildew disease caused by several mildew causing fungi in varying degrees.

Its occurrence in India was reported as early as 1949 by Patel *et al.*, (1949). It was caused by *Erysiphe cichoracearum*. However, it was first reported by Zaprometoff (1925) from Middle Asia. Darpoux (1945) also reported the occurrence of fungus from France. During the course of present investigation, the disease was found to be caused by *E. polygoni* DC. It inflicted severe losses to the crop. Similar observations were made by other workers (Kothari and Prasad 1972; Gupta, 1984; Schuepp and Blumer, 1963 and Zaman and Khan 1969) from Rajasthan, New Delhi, Wadenswil and Pakistan as well. However, during the present investigation powdery mildew caused by *Oidium state of E. cichoracearum* DC was also observed. This happens to be the first report of occurrence of *E. polygoni* induced powdery mildew from Uttar Pradesh and *Oidium state of E. cichoracearum* induced powdery mildew from world.

The disease surveys revealed that powdery mildew disease caused by *E. polygoni* was prevalent throughout the eastern Uttar Pradesh. Its incidence was ranging between 100.00 per cent in Barabanki to 93.33 per cent in Kumarganj.

Contrary to the findings of Kothari and Prasad (1972), it was observed that the floral parts and peduncle of younger branches also got severely attacked resulting in failure of capsule formation. Whenever capsule formed, they got attacked in inchoate stage resulting in crumpling and withering. However, the

disease symptoms produced by *Oidium* state of *E. cichoracearum* was characterized by effuse, indeterminate and subpulverulent colonies with fine white or pale whitish web with a floury coating. The mildew growth caused by both the fungi was found luxuriant in shaded parts of the plants and their growth was rapid in shady parts of the field. Powdery mildew infection resulted in a loss of 9.37 to 29.33 per cent in latex yield and 7.85 to 13.75 per cent in seed yield when infection index ranged between 65.20 to 89.63 per cent, Darpoux (1945) reported that the powdery mildew coating reduces the oozings of the latex from the capsules after lancing which in turn also accounted for low yield of latex.

Morphological characters of the fungus resembled those described by Kothari and Prasad (1972) for *Erysiphe polygoni* DC and by Kapoor (1967) for *Oidium* state of *Erysiphe cichoracearum* DC.

The efficient use of any fungicide depends largely on dispensing the active substance to the right place at right time (Evans, 1977). For evolving an effective chemical control of the disease, it is prerequisite to screen the chemicals which may be effective against causal pathogens in the laboratory. Although, such testing is not now regarded as being of sole importance and screening procedures for chemotherapeutic activity are regarded as essential. The eradication properties of compounds can also be assessed usually by applying compounds to seeds or seedlings naturally or artificially infected with pathogens of agricultural importance (Fawcett and Spencer, 1970).

However, during the course of present investigation, study was made by both above methods for (i) Chemical control of spermatophyte fungi (ii) Laboratory bioassay of NPPs against the pathogens of other diseases (iii) Laboratory bioassay of NPPs against the powdery mildew pathogen and (iv)

Chemical control of downy and powdery mildew diseases under field conditions.

Chemical control of spermathileein fungi

The present study reveals that out of eight NPPs, belonging to different chemical groups, evaluated against the spermathileein fungi, Eugenol, Lawson, Clocimum oil and Menadione check the incidence of spermathileein fungi effectively at all four (250 ppm, 500ppm, 1000ppm and 2000ppm) concentrations but most effective ones are Eugenol, Lawsons and Clocimum oil, of which Eugenol has been the best, as it completely checks the incidence of spermathileein fungi even at lowest (250ppm) concentration used followed by Lawsons and Clocimum oil, which completely check the spermathileein fungi at 500 ppm. Menadione could check the entire mycoflora only at 2000 ppm. However, Dubey *et al.*, (1982), reported complete inhibition of seed mycoflora of *Coriandrum sativum* at 2000 ppm by *Citrus medica* oil. Dixit *et al.*, (1982) also reported complete inhibition of seed mycoflora of *C. sativum* and *Foeniculum vulgare* by fumigation methods at 3 ml and 6 ml doses of Cedarwood oil (except the two fungi in each case). Thus, MIC of Eugenol was found to be 250 ppm while, it was 500 ppm for Lawsons and Clocimum oil and 2000 ppm for Menadione. None of synthetic commercial fungicides could check the spermathileein fungi completely even at highest (2000 ppm) concentration used. Although, Dithane M-45 and Agrosan GN, both were effective at highest concentration used (2000 ppm), the former inhibited more number of spermathileein fungi. No report is available so far on evaluation of NPPs against spermathileein mycoflora of opium poppy seeds. Similarly, the essential oil of *Ocimum canum* has also been reported to control the fungal deterioration of seeds of *C. sativum* and *F. vulgare* (Bhargava *et al.*, 1979 and Tripathi, 1981). Cunningham and Sharvelle (1940), Sharvelle *et al.*,

(1942), and McNew (1942) also reported the successful use of another quinone (chloranil) as a seed protectant.

The fungitoxic capability of Eugenol, Lawsone, Clocimum oil and Menadione varied against the spermaphileenin mycoflora of opium poppy seeds depicting the order of fungitoxicity as : Eugenol > Lawsone>Clocimum oil>Menadione.

All the four NPPs and two synthetic commercial fungicides found effective, were tested for their phytotoxic properties regarding seed germination and seedling vigour. Seed treated with NPPs showed higher percentage of germination as compare to untreated and fungicides treated seeds.

The best germination of 95 per cent was found with Eugenol and Lawsone followed by 92 per cent with Clocimum oil at their lowest concentration used (250 ppm). However, at the same concentration, 68 per cent and 67 per cent of seed germination could be obtained with Dithane M-45 and Agrosan GN, respectively.

Lawsone was found phytotoxic to seed germination at 2000 ppm, whereas Menadione was found phytotoxic even at 500 ppm. However, few of the treated seeds showed delayed germination at 1000 ppm of Eugenol, Lawsone and Clocimum oil and 2000 ppm of Eugenol and Clocimum oil. Contrary to the present findings, Lawsone was reported to be non-phytotoxic to seed germination of maize at 2000 ppm and 4000 ppm (Tripathi, 1977), whereas, one of its structural analogue, Juglone, was reported to be very phytotoxic to wheat (Fawcett and Spencer, 1969). The variation in phytotoxicity might be due to differences in physical characters of seeds.

Seedling vigour studies reveal that excellent seedling vigour was found with all four concentration (250 ppm, 500 ppm, 1000 ppm and 2000 ppm) of Eugenol followed by Lawsone giving excellent seedling vigour at 250 ppm to 1000 ppm . It

was followed by Clocimium oil with excellent seedling vigour at 250 ppm and 500 ppm which in turn followed by Menadione giving excellent seedling vigour at 250 ppm only. The excellent stimulation of seedling vigour might be due to the stimulation of nitrate reductase activity (NRA) in the treated seeds. NRA is an indicator of ultimate crop/grain yield (Johnson *et al.*, 1976). The stimulation of NRA in paddy seeds treated with 1000 ppm of Lawsone and 5000 ppm of Cedarwood oil has been proved experimentally by Tripathi (1981) and Dixit *et al.*, (1979), respectively. Good seedling vigour was also observed at other concentrations of Lawsone and Clocimium oil. Dithane M-45 and Agrosan GN ranked lower than these with regard to seedling vigour. The present findings are well in agreement with those of Dixit *et al.*, (1982) and Dubey *et al.*, (1982).

The findings suggest that all the four NPPs especially Eugenol, on account of their strong fungitoxicity, broad antifungal spectrum, superiority over some synthetic commercial fungicides and non-phytotoxicity to opium poppy seeds at their lower concentrations, can be exploited as potent and harmless fungitoxicants against seed borne diseases incited by several phytopathogenic fungi in opium poppy. Besides, as the NPPs are potent inhibitor of *Aspergillus*, *Penicillium*, *Rhizopus* species and other fungi, they will indirectly help in minimizing the adverse effects of mycotoxins secreted by such toxigenic fungi.

Laboratory bioassay of natural (plant) products against the pathogens of other diseases

During the recent years, several NPPs have been tested for their *in vitro* antifungal activity (Barnes, 1963; Dixit, 1980; Fawcett and Spencer, 1970; Pandey *et al.*, 1982; 1982 a; Slavenas and Razinskaite, 1962; Tripathi, 1977; Tripathi *et al.*, 1978 and Zutschi *et al.*, 1976). The NPPs have been found to exhibit narrow or wide

range of activity. The oil of *Raphanus* (Nehrash, 1961) and *Juniper* (Slavenas and Razinskaite, 1962) were reported toxic to one or two fungi. On the other hand, during the present study, fungitoxic evaluation of eight NPPs against nine test pathogens viz., *A. alternata*, *D. spicifera*, *F. oxysporum*, *R. bataticola*, *S. rolfsii*, *Alternaria state of P. infectoria*, *M. recemosus* and *R. microsporus* of opium poppy are made for the first time.

Out of eight NPPs evaluated five viz., Lawsone, Menadione (Naphthoquinones), Eugenol, Clocimum oil and Lemongrass oil (Essential oils) were found more effective. The MICs of these five effective NPPs varied against each test pathogen differently. Likewise, they also differed in their fungistatic/fungicidal nature at the MICs showed by them.

Lawsone showed MIC of 250 ppm against *A. alternata* (fungistatic), *Alternaria state of P. infectoria* (fungicidal), *S. rolfsii* (fungistatic), *M. racemosus* (fungistatic), and *S. rolfsii* (fungistatic) followed by 500 ppm against *D. spicifera* (fungicidal), *F. oxysporum* (fungicidal), *R. bataticola* (fungistatic) and *R. microsporus* (fungicidal). On the other hand, Tripathi (1977) reported that Lawsone showed MIC of 1000 ppm in solid medium against *H. oryzae*, while it was 750 ppm in liquid media. Besides, Lawsone is also reported to inhibit the growth of several fungi (Hoffman-Ostenhof and Fellner-Feldegy, 1944 and Kowalik, 1951).

Menadione showed MIC of 250 ppm against *D. spicifera* (fungistatic), *R. bataticola* (fungicidal) and *S. rolfsii* (fungicidal), while 500 ppm against *F. oxysporum* (fungicidal) while 500 ppm against *F. oxysporum* (fungicidal) followed by 1000 ppm against *A. alternata* (fungicidal), *F. solani* (fungicidal) and *R. microsporus* (fungistatic) and 2000 ppm against *M. racemosus* (fungicidal). The MIC of Lawsone and Menadione was found different against the test pathogens.

Such variation in the MICs may be due to: (a) Different sensitivity of test pathogens used (Singh *et al.*, 1984), (b) The presence of different functional groups and (c) Different strains of test pathogens. The relation of the chemical nature of the quinones to their fungitoxicity was studied by McNew and Burchfield (1951). They found that halogenation usually improves fungitoxicity and is reduced by substitution of a hydroxyl, methoxy or alkyl group or to a carbonyl. Placing any two of these groups between the carbonyls erases fungitoxicity.

Tripathi (1977, 1981) reported that Menadione was more fungitoxic to his test fungus than Lawsons, while present investigations with a different set of fungi gave reverse results. Fungitoxicity of Menadione reported by Gonzalez (1945), Guerillot-Vincet and Richter (1949) and Shibaski and Terui (1953) are in line with the present findings.

Eugenol exhibited MIC of 250 ppm against *A. alternata* (fungicidal), *Alternaria* state of *P. infectoria* (fungistatic), *D. spicifera* (fungistatic), *M. racemosus* (fungistatic), *R. microsporus* (fungistatic) and *S. rolfsii* (fungicidal), followed by 500 ppm against *F. oxysporum* (fungicidal), *F. solani* (fungicidal) and *R. bataticola* (fungicidal). Contrary to the present findings, Tripathi *et al.*, (1985) reported that Eugenol exhibited MIC of 100 ppm against *S. rolfsii* and *A. alternata*, pathogenic isolates of betelvine. However, Eugenol was reported earlier to show a narrow fungitoxic spectrum (Barnes, 1963).

Clocimum oil exhibited MIC of 250 ppm against *Alternaria* state of *P. infectoria* (fungicidal) and *S. rolfsii* (fungistatic) followed by 500 ppm against *A. alternata* (fungistatic), *D. spicifera* (fungicidal), *F. oxysporum* (fungistatic), *F. solani* (fungistatic), *M. racemosus* (fungistatic), *R. bataticola* (fungistatic) and *R.*

microsporus (fungistatic). Tripathi *et al.*, (1985) reported MIC of 50 ppm and 250 ppm against *S. rolfsii* and *A. alternata*, respectively. Such variation in the effectiveness of the oil may be due to : (a) Qualitative difference in the oil, (b) Quantitative difference of active constituents, and/or (c) Different sensitivity of test pathogens used and (d) Oils obtained from plants coming from different ecological set ups.

Lemongrass oil showed MIC of 500 ppm against *A. alternata* (fungistatic), *Alternaria state of P. infectoria* (fungistatic) and *S. rolfsii* (fungicidal) , followed by 1000 ppm against *F. oxysporum* (fungicidal) , *F.solani* (fungicidal), *M. racemosus* (fungicidal) and *R. bataticola* (fungicidal) whereas 2000 ppm against *D. spicifera* (fungistatic).

In contrast to the present findings, the oil of *Caesulia axillaris* (Pandey *et al.*, 1982 b) showed MIC of 0.1 per cent against *A. alternata* and *F. oxysporum* , the oil of *Pepromia pellucida* (Singh *et al.*, 1979) exhibited MIC of 1000 ppm against *A. alternata* and the oil of *Alpinia galanga* (Tripathi *et al.*, 1983) found MIC of 0.2 per cent against *A. alternata* and 0.4 per cent against *F. oxysporum* and *F. soilani*. The different fungicidal / fungistatic activity obtained during the present studies from the same NPPs against different pathogens may be due to the selective activity of the NPPs. The ability of fungi to detoxicate NPPs may also explain differences in susceptibility of various test pathogens to the NPPs used (Rich and Horsfall, 1954).

The MICs of certain fungitoxic oils have already been determined by various workers and found to vary considerably. MIC of *Ocimum gratissimum* (Clocimum oil) was found to be 50 ppm and 100 ppm (Tripathi *et al.* , 1985); of *Adenocalyma allicea* and *Cymbopogon oliveri* oils, 500 ppm (Chaturvedi , 1979 and

Singh *et al.* , 1980, resperctively); of *Rosa sofia* oil, 750 ppm (Singh *et al.* , 1980); of *Curcuma aromatica* oil , 1000 ppm , (Rao , 1976); of *Mentha arvensis* var. *piperascens* oil, 2000 ppm (Dixit *et al.*, 1979) ; of *Ocimum canum* and *Cedrus deodara* oils, 3000 ppm (Bhargava *et al.*, 1979 and Dixit *et al.* , 1979); of *Zingiber officinale* oil , 5000 ppm (Singh , 1977) and of ginger grass oil , 7000 ppm, (Singh *et al.* , 1980) against different test pathogens .

As against to the findings of Tripathi (1977), Lawsone was found to exhibit both fungicidal and fungistatic property at MICs as shown in the parenthesis. Menadione also exhibited both fungicidal and fungistatic property at its MICs like that of Lawsone. In line with the findings of Tirpathi *et al.*, (1985), during the present studies Clocimum oil was found to exhibit both fungistatic and fungicidal actions at MICs of 250 ppm and 500 ppm. Lemongrass oil showed fungistatic as well as fungicidal action like that of *Callistemon lanceolatus* (Panday *et al.*, 1982).

Although fungitoxicity of Lawsone and Menadione (Tripathi, 1977 ; Tripathi *et al.*, 1978 ; Gonzalez , 1945; Guerillot-Vinet and Richeter , 1949; Shibaski and Terui, 1953); Eugenol (Barnes, 1963 and Tripathi *et al.* , 1985), *Ocimum canum* (Bhargava *et al.*, 1979), *O. basilicum* (Modawi *et al.*, 1984), Clocimum oil (Tripathi *et al.* , 1985), ginger grass (*Cymbopogon martinii*) oil (Singh *et al.* , 1980) has already been reported, the fungitoxicity of Lawsone, Menadione , Eugenol , Clocimum oil and Lemongrass (*Cymbopogon flexuosus*) oil is being reported perhaps for the first time against fungal pathogens of opium poppy.

Out of tested synthetic commercial fungicide, only Dithane M-45 could completely inhibit four test pathogens viz ., *S. rolfsii*, *R. bataticola* , *Alternaria* state

of *P. infectioia* and *F. oxysporum* at MICs of 250 ppm with fungicidal action only for *S. rolfsii* and being fungistatic for rest of the three pathogens. Rest two synthetic commercial fungicides were found incapable to give complete inhibition of any of the tested pathogen.

Thus the strong fungitoxicity of Lawsone, Menadione, Eugenol, Clocimum oil and Lemongras oil against *A.alternata*, *D.spicifera*, *F. oxysporum*, *F. solani*, *R. bataticola*, *S. rolfsii*, *Alternaria* state of *P. infectoria* , *M. racemosus* and *R. microsporus* and better efficacy over some prevalent synthetic commercial fungicides suggest that all these NPPs can be exploited as effective fungitoxicants against diseases incited by these fungal pathogens in opium poppy after successful *in vivo* trials .

Laboratory bioassay of natural (plant) products against the powdery mildew pathogen

During the recent years several NPPs have been evaluated for their *in vitro* antifungal activity against facultative saprophytes (Agarwal, 1978; Appleton and Tansey, 1975; Barnes, 1963 ; Dixit , 1980; Fawcett and Spencer, 1970; Misra and Dixit , 1976 ; Murthy and Amonkar, 1974; Pandey *et al.*, 1982 a ; Singh *et al.*, 1980 ; Tripathi *et al.*, 1978 ; Tripathi *et al.*, 1985 and Zutschi *et al.*, 1976). But the antifungal efficacy of these NPPs has not been studied to far against powdery mildew fungi *in vitro*. However, the oils of garlic and neem and extracts of garlic bulb and ginger rhizome were reported earlier to control the powdery mildew of pea caused by *E. polygoni* (Singh and Singh, 1981). Juglone , another NPP, was also reported to check the infection of cucumber mildew caused by *Sphaerotheca fuliginea* completely by leaf discs method (Fawcett and Spencer,

1970). The present study, described the *in vitro* effect of eight NPPs on promptitude of conidial germination of *E. polygoni* causing powdery mildew of opium poppy.

The present study reveals that out of eight NPPs, evaluated, five viz., Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil exhibited a marked inhibitory effect on conidial germination followed by Cedarwood oil.

All the five NPPs were found to inhibit the conidial germination completely at their lowest concentration used (250 ppm) even after a minimum incubation period of 6 hours. Cedarwood oil was also found highly effective as it completely inhibited the conidial germination at 500 ppm at the same incubation period. Singh and Singh (1981) reported the complete inhibition of conidial germination at 1000 ppm, 3000 ppm, and 5000 ppm of ginger extract, garlic oil and neem oil, respectively, after incubation of 24 hours. As such, the MICs of Lawsone, Menadione, Eugenol, Clocimum oil, Lemongrass oil appeared to be 250 ppm whereas, it was 500 ppm for Cedarwood oil. On the contrary, MICs of ginger extract, garlic oil and neem oil were found to be 1000 ppm, 3000 ppm, and 5000 ppm, respectively, (Singh and Singh, 1981) which are relatively higher concentrations in comparison to the present findings. Such variation in the MICs may be due to: (a) The use of different NPPs, and (b) Different strains of test pathogen. As in the present case, the test pathogen came from different host.

Out of tested synthetic commercial fungicides, only Sulfex inhibited the conidial germination completely at a MIC of 250 ppm. Rest two, were found incapable to give complete inhibition even at their highest concentration used (2000 ppm). Ability of water treatment alone was superior only to control set.

Thus, the strong fungitoxicity of Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil at 250 ppm and Cedarwood oil at 500 ppm against *E. polygoni* gives us additional choices over and above the prevalent synthetic commercial fungicides and suggests that all these NPPs can be exploited as strong control agents (fungicides) against the powdery mildew disease of opium poppy after undergoing successful field trails.

Chemical control of downy mildew disease

Control of primary infection by seed treatment

The present study reveal that out of eight NPPs evaluated, four viz. , Clocimum oil, Eugenol, Lawsone and Lemongrass oil reduce the incidence of primary infection by downy mildew, from a maximum of 97.00 per cent to a minimum of 72.00 per cent at the lowest concentration used (500ppm). The more effective of these are Clocimum oil and Eugenol at the lowest concentration used. Out of these four, Clocimum oil and Eugenol, has been the best, as they completely check primay infection at the highest concentration used (1000 ppm) followed by Lawsone wihch gives a control of 96.00 per cent at the same concentration. Lemongrass oil could give a control of 83.00 per cent at the same concentration.

Successful control of seed borne fungi through the use of NPPs has already been reported during the present investigation. Cunnigham and Sharvelle (1940), Domsch (1958 a,b) , Mcnew (1942) and Sharvelle *et al.*, (1942) reported the successful use of a quinone,

Chloranil (tetrachloro-1,4-benzoquinone) as an excellent seed protectant. Sterindorff and Pfaff (1931) also reported 1,4-benzoquinone and phenanthrenequinone as seed protectants. Similarly, other NPPs, like *Ocimum canum* oil, *Citrus medica* oil and Cedarwood oil has also been reported to control the seed mycoflora of some spices (Bhargava *et al.*, 1969; Dubey *et al.*, 1982; Dixit *et al.*, 1982 and Tripathi, 1981).

None of the four NPPs was found to be inhibited seed germination at the highest concentration used (1000 ppm). Fawcett and Spencer (1970) also reported that antifungal substances from higher plants have been found to be generally less phototoxic than synthetic fungicides.

None of the synthetic commercial fungicides tested here could check the primary infection completely even at highest concentration used (1000 ppm) which is in accordance with the findings of Thakore *et al.*, (1983). However, Dithane M-45 could give a maximum control of 79.00 per cent. Although inhibition of primary infection of opium poppy seeds through various prevalent commercial fungicides and the control of seed borne fungi (other than *P. arborescens*) of some species through various NPPs has already been reported by various workers (Beaumont, 1953; Christoff, 1943; Darpoux, 1945; Rundy, 1976; Thakore *et al.*, 1983; Gupta, 1984; Bhargava *et al.*, 1979; Dubey *et al.*, 1982; Dixit *et al.*, 1982 and Tripathi, 1981). The control of primary infection by downy mildew by seed treatment through NPPs stands recorded for the first time.

The protectant capability of Clocimum oil, Eugenol, Lawsone and Lemongrass oil varied against the test pathogen, *P. arborescens*, depicting the order of fungitoxicity as : Clocimum oil > Eugenol > Lawsone > Lemongrass oil.

The variation in the effectiveness of the NPPs may be due to (a) Different sensitivity of the test pathogen to the NPPs, and (b) Presence of different active constituents in the NPPs. High efficacy of the Clocimum oil may be explained due to cumulative fungitoxic effect of various constituents present in it which separately or individually show higher fungitoxicity (Tripathi *et al.*, 1985).

Thus, the findings show that all the four NPPs, especially Clocimum oil and Eugenol, can completely check the seed transmission of primary infection by downy mildew. Thus, due to strong fungitoxicity, superiority over some prevalent synthetic fungicides and non- phytotoxic nature at used concentrations, they can be exploited as excellent seed protectants.

Control of primary infection by soil drenching

The observations made in the present study reveal that out of eight NPPs, three viz., Clocimum oil, Eugenol and Lawsone reduce the incidence of primary infection of downy mildew from a maximum of 93.34 per cent to a minimum of 80.00 per cent at the lowest concentration used (500 ppm). The most effective of them is Clocimum oil with a control of 93.34 per cent.

Out of **these** three NPPs, Cloocimum oil and Eugenol has been the best, as they completely check the incidence of primary infection at the highest concentration used (2000 ppm) followed by Lawsone, which gave a control of 93.34 per cent at the same concentration. Burchfield (1959 a) tested Dichlone and Chloranil (quinones) as soil fungicides but could not get positive results.

None of the synthetic commercial fungicides could check the primary infection completely even at highest concentration used (2000 ppm). Although successful control of primary infection by downy mildew through various prevalent commercial fungicides already been reported by various workers (Darpoux, 1945 and Kothari and Prasad, 1970), the control of primary infection by down mildew by soil drench of NPPs stands recorded for the first time.

During the seed treatment experiment, Lawsone was found to be phytotoxic to seed germination at 2000 ppm while in the soil treatments study, it shows no phytotoxicity to seed germination. This variation in phytotoxic effect might be due to the fact that in seed treatment experiments, **seeds were treated** directly with the Lawsone which might leads to the phytotoxicity, **whereas** in the present case, it was applied to the soil and seeds were sown after three days of last application of Lawsone. **Burchfield** (1960) reported that spinach and beet seeds, treated with chloranil, when planted in alkali soil, are injured but when the treated seeds are planted in acid soil, no damage occurs. Thus, **the** soil might play some role in minimizing the phytotoxic potentiality of the Lawsone, most probably by making some change in chemical structure. Mcnew and

Burchfield (1951) reported that halogenations usually decrease phytotoxicity and improves fungitoxicity in quinones.

The fungitoxic capability of Clocimum oil, Eugenol and Lawsone varied against the oospores of *P. arborescens* depicting the order of fungitoxicity as: Clocimum oil> Eugenol> Lawsone.

The variation in the effectiveness of the above NPPs may be due to: (a) Different sensitivity of the oospores of test pathogen to the NPPs within the soil and (b) Presence of different active constituent(s) in the NPPs. High efficacy of Clocimum oil may be explained due to cumulative fungitoxic effect of various constituents present in it which separately or individually show higher fungitoxicity (Tripathi *et al.*, 1985)

The present findings reveal that all the three NPPs applied to the soil as drench, checked the oospore infection more effectively than some prevalent commercial fungicide. Thus, their fruitfulness in controlling the primary infection by downy mildew with superiority over two commercial fungicides and non-phytotoxic nature at used concentrations suggest that they can be exploited as potent soil fungicides against downy mildew disease of opium poppy.

Control of secondary infection by root application

The observations made in the present study reveal that out of eight NPPs, four viz., Clocimum oil, Eugenol, Lawsone and Mendione were able to effectively reduce the secondary infection by downy mildew per leaf and gave a maximum of 90.17 per cent to a minimum of 75.53 per cent disease control at the lowest concentration used (500 ppm). The most

effective of them are Clocimum oil. Eugenol and Lawsone showing 90.17, 85.82 and 85.66 per cent efficiency of disease control, respectively.

Out of above four NPPs, Clocimum oil and Lawsone were found highly efficacious at the highest concentration used (2000 ppm) , as they control the disease more than ninty per cent i.e. they show 93.48 per cent and 90.42 per cent efficacy of disease control, respectively. Eugenol ranked third, nevertheless, it gave a good control of 89.86 percent. Although, Eugenol exhibited higher percentage of disease control at 500 ppm, interestingly, at 2000 ppm it was superseded by Lawsone.

None of the synthetic commercial fungicides could check the intensity of disease as effectively as the NPPs. A maximum of 69.37 per cent of disease control was found with Bavistin-50 even at the highest concentration of 2000 ppm. Control of downy mildew of opium poppy and blue mold of tabacoo by root application of some prevalent commercial fungicides has also been reported by Kothari and Verma (1967) and Taylor (1953), respectively.

All the three highly efficacious NPPs of preceeding year, proved their excellence in successive years. The results clearly indicate that the NPPs are translocated in the system of the plants through roots and are capable of controlling the disease.

Contrary to the present findings, Lawsone was reported to show non-systemic activity in maize seedlings (Tripathi, 1977). Singh *et al.*, (1984) suggested that fungitoxic substances of plant origin may be systemic because thay are obtained from biosystems similar to those of hosts. Non- systemic activity of Lawsone to maize seedlings (Tripathi, 1977) might be due to the result of any reaction of the compound with the host tissues. Quinones have been

evaluated as systemic fungicides, and a few successful trials have been reported by various workers. Akai *et al.*, (1955) soaked rice seeds and young rice plants in solutions of 2-methyl-1,4-naphthoquinone (Vitamin K₂) and found that the treatment increased the resistance of the plants to subsequent infection by *Helminthosporium oryzae*. Van Andel (1961) patented a technique for using amino acids to carry fungicide into plants and included dichlone (a quinine) as one of the fungicides that could be used in this way.

Grossmann (1962, 1963) inoculated tomato plants with *F. oxysporum* f. sp. *lycopersici*, watered the inoculated plants with rufanic acid (1,4-dioxyanthraquinone-2-sulphonic acid) and found that the treatment greatly reduced subsequent disease development. Systemic activity of Menaphthone, Dehydroacetic acid, Phloridzin, 2,6-Dimethyl-γ-pyrone, Chlorogenic acid, Pyragallol, Phloretin and several other natural products of plant origin against wheat mildew in varying degrees with or without causing phytotoxicity to host plant, has been reported by Fawcett and Spencer (1970).

Anderson and Nienow (1947) reported that streptomycin is systemic in soybean plants, but not with broad beans. However, it was systemic in cabbage and wheat under similar conditions (Crowdy and Pramer, 1966). According to Wain and Carter (1967) the extent of mobility may differ from species to species, therefore, the non-systemic activity of the Lawsone in maize plants and of *P. pellucida* oil to paddy plants (Singh *et al.*, 1984) does not indicate a non-systemic activity of the NPPs in general; they may prove systemic in other plants as was found during the present investigation. None of the NPPs was found to produce any visual phytotoxicity to the experimental plants at the concentrations used.

The fungitoxic capability of Clove oil, Lawsone and Eugenol varied against the secondary infection by downy mildew in the order depicted as Clove oil>Eugenol>Lawsone.

The present findings clearly show that all the three NPPs, applied to soil are translocated in the plant system through roots and have checked the secondary infection of downy mildew more effectively than some prevalent commercial fungicides without causing any phytotoxicity. Thus, their fruitfulness in controlling the downy mildew disease with superiority over some prevalent commercial fungicides and non-phytotoxic as potent systemic fungicides against downy mildew disease of opium poppy.

Control of secondary infection by foliar application

The observations recorded in the glass house studies reveal that out of eight NPPs, six viz., Clove oil, Eugenol, Lawsone, Menadione, Lemongrass oil and Cedarwood oil were able to effectively reduce the secondary infection by downy mildew from a maximum of 90.26 per cent to a minimum of 63.11 per cent at the lowest concentration used (500 ppm). The most effective of them are Clove oil and Eugenol with 90.26 per cent efficiency followed by 27.61 per cent efficiency of disease control with Lawsone. Menadione ranked fourth with 79.64 per cent efficiency followed by 76.99 per cent efficiency of disease control with Lemongrass oil.

Out of these six NPPs, Clove oil and Eugenol has been the best as they check the incidence of secondary infection up to 94.69 per cent and 93.81 per cent, respectively, at the highest concentration used (2000 ppm) followed by Lawsone with a control of 90.26 per cent. Although, Menadione ranked fourth in the efficacy, nevertheless, it gives a good control of 82.30 per cent at the same

concentration. Clocimum oil, Eugenol and Lawsone proved their **excellence** at the highest concentration used (2000 ppm) in the **consecutive** years also.

None of **the** synthetic commercial fungicides could check the secondary infection as effectively as the NPPs. A maximum of 67.26 per cent of disease control was recorded with Dithane M-45 even at the highest concentration used (2000 ppm). Kothari and Prasad (1970) reported a control of 85.62 per cent at 0.3 per cent concentration of Bisdithane.

The Observations recorded under the field conditions during 1982-83, reveal that out of eight NPPs, three viz., Clocimum oil, Eugenol and Lawsone reduced disease intensity effectively from a maximum of 71.93 per cent **to** a minimum of 65.78 per cent at the lowest concentration used (500 ppm). The most effective of them are Clocimum oil and Eugenol with a disease control of 71.93 per cent and 69.30 per cent, respectively. However, all the three NPPs were found highly efficacious at the highest concentration used (2000 **ppm**), as they check the incidence of secondary infection up to 87.72, 86.01 and 83.32 per cent, respectively. Although, Menadione ranked fourth in the efficacy, **n**evertheless, it gave a good control of 73.68 per cent at the same concentration.

Clocimum oil, Eugenol and Lawsone, when sprayed at the highest used concentration of 2000 ppm at 10 days interval during successive years (1983-84 and 1984-85), **p**roved their excellence by giving an increased efficiency of disease control of 88.60 per cent, 86.84 per cent and 84.21 per cent, respectively. This increase in percentage disease control was might be due to minimization of spray period from 15 to 10 days. Similar results were obtained by **Thakore *et al.***, (1983) with **s**ome prevalent commercial fungicides.

None of tested synthetic commercial fungicides could check the secondary infection as effectively as the NPPs. A maximum of 54.39 per cent of disease control in first year (1982-83), while 60.52 per cent of disease control in successive years (1983-84 and 1984-85) was recorded with Dithane M-45 even at the highest concentration used (2000 ppm). Control of secondary infection through some prevalent commercial fungicides was also reported by Alavi (1975), Christoff (1943), Gupta (1984), Kothari and Prasad (1970), Ramanathan and Ramachandran (1983) and Thakore *et al.*, (1983).

The observations recorded during third year (1984-85) reveal that all the three highly efficacious NPPs of preceding years again proved their excellence with an increase in latex and seed yields at the highest concentration used (2000 ppm). Out of these three, Clocimum oil, gave a maximum increase of 19.50 per cent and 17.00 per cent in latex and seed yields, respectively, followed by Eugenol, the percentage increase being 19.20 and 16.30 per cent, respectively. It was followed by Lawsons, the percentage increase being 18.39 and 14.08, respectively. The percentage increase of latex and seed yields in case of Dithane M-45 were 7.90 and 11.35, respectively, which is comparatively much lower than NPPs. Thakore *et al.*, (1983) also reported the increase in latex and seed yields after the application of Dithane M-45.

Chemical control of powdery mildew disease by foliar application

The observations recorded during the present study during 1982-83, reveal that out of eight NPPs, four viz., Clocimum oil, Eugenol, Lawsons and Menadione reduced disease intensity effectively at the two lower most concentrations (250 ppm and 500 ppm). All of them were found very effective in reducing the disease intensity at their higher concentrations (1000 ppm and

2000 ppm) used. The per cent efficiency of disease control ranged from maximum of 76.24 to a minimum of 70.00 at 250 ppm and 78.75 per cent to 75.00 at 500 ppm. The per cent efficiency of disease control at 1000 ppm ranged between a maximum of 83.75 and a minimum of 81.25, whereas at 2000 ppm, it ranged between a maximum of 87.50 per cent and a minimum of 81.25 per cent. Sulfex was most effective amongst the synthetic commercial fungicides. It shows a minimum disease control of 63.74 per cent at 250 ppm to a maximum of 81.25 per cent at 2000 ppm. Control of powdery mildew through various prevalent commercial fungicides has also been reported by various workers (Kothari and Prasad, 1972; Gupta, 1984 and Ramanathan and Ramachandran, 1983).

All the four NPPs when sprayed at the highest concentration of 2000 ppm at 10 days interval during successive year (1983-84) only three viz., Clocimum oil, Eugenol and Lawsone proved highly efficacious by giving an increased efficiency of disease control of 91.25 per cent, 90.00 per cent and 87.25 per cent, respectively. Sulfex also showed an increased efficiency of disease control might be due to minimization of spray period from 15 days to 10 days.

The observations recorded during third year (1984-85) reveal that all the three highly efficacious NPPs of preceding year again proved their excellence with an increase in latex and seed yields at the highest concentration used (2000 ppm). Out of these three, Clocimum oil gave a maximum increase of 22.90 per cent and 15.26 per cent in latex and seed yields, respectively, followed by Eugenol, the percentage increase being 20.15 and 14.52, respectively. It was followed by Lawsone, the percentage increase being 15.87 and 13.27, respectively. The per cent increase of latex and seed yields in case of Sulfex were 12.42 and 12.13, respectively, which is comparatively much lower than NPPs.

Strong, fungitoxicity of Clove oil and Eugenol has earlier been reported by Tripathi *et al.*, (1985) against pathogenic fungi (other than downy mildew and powdery mildew fungi) of betelvine, but it was of *in vitro* evaluation. *In vitro* antifungal activity of Eugenol has also been reported by Barnes (1963). High efficacy of Clove oil may be explained due to cumulative fungitoxic effect of various constituents present in it which separately or individually show higher fungitoxicity (Tripathi *et al.*, 1985).

Lawson was reported earlier to control the leaf spot disease of paddy caused by *H. oryzae* completely at the concentrations of 1000 ppm and 1500 ppm during *in vitro* test (Tripathi, 1981). But the fungitoxicity was tested by leaf disc technique rather than by foliar spray as in the present case. Menadione has also been tested as a fungicide by Akai *et al.*, (1955) and Akai and Oku (1956) for protecting rice plants from Gomahagra disease and *Helminthosporium* blight. In accordance with the present studies, as a foliage protectant, Chloranil (quinone) has also been used mainly for the control of downy mildew of crucifers (Eddins, 1947; Foster, 1946, 1947 and Horsfall, 1956).

Effective control of pea powdery mildew with an increase in total seed yield and its components through neem, garlic and ginger extracts along with garlic oil has earlier been reported by Singh and Singh (1981). Fawcett and Spencer (1970) reported the control of wheat and cucumber powdery mildews through various natural products of plant origin viz. Phloretin, Juglone, Menaphthone, Kojic acid and Maltol to varying degrees.

The relation of the chemical structure of the quinones to their fungitoxicity was studied by McNew and Burchfield (1951) and Tripathi (1977, 1981). Because, certain groups of vitamins are quinones, Woolley (1945) considered

that antimicrobial quinones could disrupt normal metabolism by acting as **antivitamins**. Cooper (1912), Cooper and Hains (1928) suggested that the antimicrobial action of quinones **may be** due to another mechanism of action suggested for **quinones** (Hoffmann- Ostenhof *et al.*, 1941).

The increase in latex and seed yields **might** be due to the two fold action of NPPs. NRA is an indicator of ultimate crop/ grain yield (Johnson *et al.*, 1976). On one side, the **NPPs** control the disease, thus increased the potentiality of the crop to yield more. **On** the other hand, they might increase the **NRA** of the treated plants which ultimately resulted in increased crop yield. **Stimulation** of NRA in paddy plants has already been reported by Tripathi (1977, 1981).

As the powdery mildew reduces the oozing of the latex form the capsules after lancing, spraying of NPPs, **inhibited** the fungal growth and reduced the disease intensity more than ninty per cent , which in turn also resulted in increased latex yields.

The fungitoxic potentiality of **Clocium** oil , Eugenol, Lawsone and Menadione varied against the secondary infection of downy mildew depicting the order of fungitoxicity in glass house studies as : **Clocimum** oil >Eugenol> Lawsone > **Menadione**, while under the field conditions studies, for downy mildew and powdery mildew diseases, **fungitoxic** potentiality depicted its order as : **Clocimum** oil> Eugenol > Lawsone.

The variation in effectiveness of the above NPPs may be due to: (a) **Presence** of different active principles in the NPPs and (B) **Selective** sensitivity **for** the test pathogens. **The ability of fungi to detoxicate compounds may also explain differences in susceptibility of the test fungi to these NPPs** (Rich and Horsfall, 1954).

None of the eight NPPs was found to impart any visual phytotoxicity to the treated plants either in glass house studies or in field conditions studies. This is in accordance with those of Tripathi (1977, 1981) and Tripathi *et al.*, (1985).

Thus, the present findings show the usefulness of *Clocimum* oil, Eugenol and Lawsonia in controlling the secondary infection by downy mildew and powdery mildew disease affectively, with an increase in latex and seed yields, with superiority over some prevalent commercial fungicides, and non-phytotoxic action at used concentrations. This suggests that they can be exploited as excellent foliage protectants of opium poppy against downy and powdery mildew diseases incited by *P.arborescens* and *E. polygoni*, respectively.

SUMMARY

Eastern Uttar Pradesh has been surveyed for the incidence and distribution of fungal diseases of opium poppy (*Papaver somniferum* L.). The various fungal diseases recorded in the process are: seed borne diseases (caused by several spermatophyte fungi); damping-off (*Fusarium solai* (Mart.) Sacc.); downy mildew (*Peronospora arborescens* (Berk.) Casp.); wilt disease (*Fusarium oxysporum* Schlecht); root-rot (*Rhizoctonia bataticola* (Taub.) Britton-Jones state of *Macrophomina phaseolina* (Tassi) Goid); sclerotial wilt (*Sclerotium rolfsii* Sacc.); leaf spot (*Alternaria alternata* (Fr.) Keissler); leaf blight (*Drechslera spicifera* (Bainier) v. Arx state of *Cochliobolus spicifer* Nelson); stem rot (*Mucor racemosus*

Fres.); sepal blight (*Alternaria alternata* (Fr.) Keissler); petal blight (*Alternaria alternata* (Fr.) Keissler); stamen blight (*Alternaria* state of *P. infectoria* Fuckel); capsule rot (*Rhizopus microsporus* v. Tieghem); and powdery mildew (*Erysiphe polygoni* DC. and *Oidium* state of *E. cichoracearum* DC.). These diseases were found to cause negligible to considerable loss to the crop depending upon the environmental conditions, cropping pattern, terrain and other agronomical practices.

The opium poppy seeds collected from various sources have been studied for inert matters, discolouration, weight loss, moisture content and mycoflora associated with inert matters and the seeds. Inert matters like plant parts, soil particles and other grains were found mixed with the seeds. Various grades of seed discolouration has been observed on the infected seeds. Shrinkage of the seeds, seed rot and hypertrophy of the seeds were also observed. Weight loss caused by spermatophyte fungi was found to vary from a maximum of 0.1310 gm to a minimum of 0.1275 gm. Highest moisture percentage was found in the seeds collected from market and lowest in those collected from the field. Incubation of inert matters by blotter and P.D.A. methods, revealed a total of 13 and 10 fungi, respectively. Out of these, *A. niger* was found to be associated with all the inert matters. Washings of seeds yielded in total 10 fungi, of which 2 were obligate parasites. *In situ* isolation of spermatophyte fungi yielded 15 and

4 fungi from healthy capsules and their seeds, respectively, whereas 19 and 13 fungi from deteriorated capsules and **their** seeds, respectively. Interestingly, three mildew fungi viz., *P. arborescens*, *E. polygoni* and *E. cichoracearum* were also encountered in *in situ* studies using washing technique.

Isolation of spermathilein fungi was carried out by Blotter, PDA, MEA and MST methods. A total of 26 spermathilein fungi and one represented by white sterile mycelia were isolated from external surface of the seeds constituting external spermathilein mycoflora. Out of 26, blotter method yielded a maximum of 24 fungal species followed by PDA which yielded 17. MST and MEA methods yielded only 11 fungal species. Of the total externally carried spermathilein fungi, *A. niger* and *R. microsporus* were most dominant.

The surface sterilized seeds yielded a total of 18 fungal species constituting internal mycoflora. Out of 18, blotter method yielded a maximum of 11 fungal species followed **by** PDA and MST methods yielding 7 species. MEA method **yielding** least number of fungal species i.e. only 4. Of the total internal mycoflora, *A. niger*, *A. alternata*, *D. spicifera* v. Arx state of *C. spicifer* and *R. microsporus* were most dominant. On incubation of seeds at low ($20 \pm 2^{\circ}\text{C}$) and high ($27 \pm 2^{\circ}\text{C}$) temperatures by blotter and PDA methods, low temperature yielded a total of 12 fungal species in both the methods, whereas high

temperature yielded 19 and 18 fungal species in blotter and PDA methods, respectively.

Out of four methods tested, blotter method was found the most suitable for the detection of most of the spermatophyte fungi. Pre-treatment of seeds with sodium hypochlorite, restricted the growth of fast growing fungal species like *A. niger* and *R. microsporus*. Out of total isolated spermatophyte fungi, nine frequently occurring fungi viz., *A. niger*, *R. microsporus*, *R. nigricans*, *P. canadense*, *F. oxysporum*, *F. solani*, *A. alternata*, *D. spicifera* v. Arx state of *C. spicifer* and *M. phaseolina* were found pathogenic under laboratory and glass house conditions causing various symptoms viz., distortion of seeds, pre- and post-emergence, seed and seedling rots and seedling blight. The reduced germination might be due to the mycotoxins secreted by the spermatophyte fungi.

The incidence of damping-off disease caused by *Fusarium solani* was a maximum of 28.33 per cent in Mughalsi followed by 27.33 per cent in Barabanki and a minimum of 20.00 per cent in Kumarganj. The disease appears at seedling stage and was characterized by rotting of collar part followed by toppling of the seedlings. The disease causes mild damage to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of downy mildew disease caused by *P. arborescens* was a maximum of 74.50 per cent in Mughalsi to a minimum of 58.00 per cent in Kumarganj. The disease appeared in two forms affecting the plant at any of its growth stages. The primary infection which is systemic is caused by oospores from previous crop. Infected leaves developed chlorosis and get curled. The lower leaf surface turned black destroying the chlorophyll of the leaves. The secondary infection which is local was caused by conidia emanating from the current crop. Initial symptoms usually appeared on the leaves of over a month old plants in the form of brown to black spots. The disease sapped the vigour of the plant and it got stunted. Its appearance at capsule formation stage, inhibits the development of capsule or keeps it underdeveloped. The disease inflicts severe damage to the crop. This is the first report of the occurrence of this disease from Uttar Pradesh.

The yield losses due to downy mildew depended upon intensity of the infection. At an infection range of 58.60 to 78.40 per cent, the loss varied from 16.70 to 33.80 per cent in latex yield and 13.50 to 16.50 per cent in seed yield.

The incidence of wilt disease caused by *Fusarium oxysporum* was maximum of 22.50 per cent in Mughalsi to a minimum of 17.60 per cent in Barabanki. The disease appeared at 5-6 weeks old age and characterized by

yellowing and flagging of leaves followed by foliar wilting and rapid total desiccation of entire plant. The disease causes mild damage to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of root-rot caused by *Rhizoctonia bataticola* Britton-Jones state of *Macrophomina phaseolina* was a maximum of 17.00 per cent in Barabanki to a minimum of 8.75 per cent in Mughalsi. The disease appeared near about the flowering of crop and is characterized by yellowing of leaves and flower buds followed by drooping and withering. Infected roots became necrotic and disorganised with a brownish black tint. The disease causes mild damage to the crop. This happens to be the first report of its occurrence from Uttar Pradesh.

The incidence of sclerotial wilt caused by *Sclerotium rolfsii* was a maximum of 9.66 per cent in Mughalsi to a minimum of 3.30 per cent in Barabanki. It appeared at young stage of the plants which were attacked at the collar region and below the soil by the fungus. The disease was characterized by yellowing of foliage and followed by dropping-off which resulted in total wilting and death of plants. This happens to be the first report of its occurrence from Uttar Pradesh.

The incidence of leaf spot diseased caused by *Alternaria alternata* was a maximum of 70.00 per cent in Kumarganj to a minimum of 65.00 per cent in Mughalsi. The disease appeared during the month of February and onwards and was found to interspersed with leaf blight patches. Both older and younger leaves , but frequently the older ones were attacked by the disease and was characterized by dark brown to black, spherical to irregular spots. The infected regions became necrotic followed by premature death of foliage. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of leaf blight caused by *Drechslera spicifera* v. Arx state of *Cochliobolus spicifer* disease was a maximum of 90.00 per cent in Mughalsi to a minimum of 74.50 per cent in Kumarganj. The disease appeared during the month of February and onwards and was found to interspersed with leaf spots. Both older and younger leaves, but frequently the older ones were attacked by the disease and was characterized by dark brown to black diffused spots which became necrotic lateron giving blighted appearance to the foliage. This was followed by premature death of the infected folige. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of stem rot disease caused by *Mucor racemosus* was found only in Mughalsi on a minor scale of 7.00 per cent. It appeared around the flowering. The disease attacks the plants at stem base encroaching much of the stem upwards lateron. Infected part turns black to olivaceous black, got constricted and girdled resulting wilting of the plants. The infected plants topple down auomatically or due to any jerk. The disease caused minor damage to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*. In artificial inoculation experiments, the pathogen appeared as a weak parasite.

The incidence of sepal blight disease caused by *Alternaria alternata* was a maximum of 21.00 per cent in Kumarganj to a minimum of 17.60 per cent in Barabanki. It appeared at flowering stage and attacked the sepals when they were in intact position covering whole reproductive part. The disease was characterized by long diffused spots covering $\frac{1}{2}$ to $\frac{3}{4}$ part of sepals. Infected regions became necrotic with a tarry appearance resulting in non-opening of the flower buds as usual. The diseased buds either flower late or could not flower at all. The disease caused negligible losses to the crop. Occurrence of disease happens to be the first report of its prevalence. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of petal blight caused by *Alternaria alternata* was a maximum of 18.33 per cent in Mughalsi to a minimum of 12.50 per cent in Barabanki. It appeared at flowering stage and attacked the petals when they were in intact position covering the reproductive part. The disease was characterized by diffused strips running through the periphery covering about 90 per cent area of petals, became tenacious on severity of the disease, resulting in non-opening of the petals as usual. These tenacious petals could not fall-off as usual and remains adhered to undeveloped ovary. The disease caused negligible losses to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of stamen blight caused by *Alternaria* state of *Pleospora infectoria* was a maximum of 15.00 per cent in Mughalsi to a minimum of 9.00 per cent in Kumarganj. It appeared at flowering stage and was characterized by blurred stamens with a tarry appearance. Infected stamens became crumpled as the disease being severed, incapacitating them for reproductive purposes. The disease being severed, incapacitating them for reproductive purposes. The disease cause negligible losses to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of capsule rot disease caused by *Rhizopus microsporus* was a maximum of 36.00 per cent in Mughalsi to a minimum of 18.33 per cent in Kumarganj. It appeared at capsule formation stage. The disease attacked both undeveloped and developed capsules and was characterized by bulged and tarnished capsules which became floppy on severity of the disease followed by total rotting. The disease causes mild to severe losses to the crop. Its occurrence has been noted for the first time and thus constitutes a new world record on *P. somniferum*.

The incidence of powdery mildew caused by *E. polygoni* ranged between 100.00 per cent in Barabanki to 9.33 per cent in Kumarganj. Initial symptoms of powdery mildew appeared on 90 to 100 days old crop primarily on the stem and subsequently on lower side of the leaves. The disease characterized by white powdery growth later turning into large circular patches. In advanced stages of the disease, these patches turned black. The disease was also observed on floral parts, peduncle and undeveloped capsules. The disease inflicts severe losses to the crop. This is the first report of its occurrence from Uttar Pradesh.

The yield losses due to powdery mildew caused by *E. polygoni* depended upon the intensity of the infection. At an infection range of 65.20 to 89.63 per cent, the loss varied from 9.37 to 29.33 per cent in latex yield and 7.85 to 13.75 per cent in yield.

Powdery mildew caused by *Oidium* sate of *E. cichoracearum* appeared during the middle of March at the stem bases and lower side of the leaves. The disease was characterized by diffuse, indeterminate, and subpulverulent colonies with fine white or pale white web with a floury coating. It caused mild losses to the crop. This is the first report of its occurrence and thus constitutes a new world record on *P. somniferum*.

Pathogenic ability of various fungal isolates has been proved. Typical symptoms, generally appeared within 5 to 7 days of inoculation, while those of downy and powdery mildew diseases appeared after 15 to 20 days of inoculation. Fresh conidia of *P. arborescens* were found infective. Oospores require some resting period to become pathogenic. *M. racemosus*, causing stem rot disease was found a weak parasite and needed very high inoculum load to produce typical symptoms.

Eight NPPs and three synthetic commercial fungicides were evaluted for the control of spermathileein fungi. Out of these, Eugenol > Lawsonsone>

Clocimum oil > Menadione proved to be most effective for the control of spermathileein fungi in the order depicted. Seeds treated with Eugenol even at the lowest concentration of 250 ppm were found free from fungi. None of the synthetic commercial fungicides eliminates entire mycoflora of the seeds even at the highest concentration (2000 ppm). Highest seed germination of 95 per cent was observed in case of seeds treated with Eugenol and Lawsone followed by 92 per cent in case of Clocimum oil at lowest concentration of 250 ppm. Excellent seedling vigour was recorded with all four concentrations (250 ppm to 2000 ppm) of Eugenol, 250 to 1000 ppm of Lawsone and 250 ppm to 500 ppm of Clocimum oil and 250 ppm of Menadione. These findings suggest that all the four NPPs, especially Eugenol, can be exploited as potent and harmless fungitoxicants to control the spermathileein fungi of opium poppy seeds.

Eight NPPs and three synthetic commercial fungicides were bioassayed *in vitro* against nine fungal pathogens by employing food poison technique. Out of these, Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil completely inhibited the fungal growth at different concentrations. The MIC of these five effective NPPs varied against different test pathogens. Likewise, they also differed in their fungistatic/fungicidal nature at the MICs shown by them which are parenthesized.

Lawsone showed MIC of 250 ppm against *A. alternata* (fungistatic), *Alternaria* state of *P. infectoria* (fungicidal), *F. solani* (fungistatic), *M. racemosus* (fungistatic) and *S. rolfsii* (fungistatic) followed by 500 ppm against *D. spicifera* (fungicidal), *F. oxysporum* (fungicidal), *R. bataticola* (fungistatic) and *R. microsporus* (fungicidal).

Menadione showed MIC of 250 ppm against *D. spicifera* (fungistatic), *R. bataticola* (fungicidal) and *S. rolfsii* (fungicidal) while 500 ppm against *F. oxysporum* (fungicidal) followed by 1000 ppm against *A. alternata* (fungicidal) and 200 ppm against *M. racemosus* (fungicidal).

Eugenol exhibited MIC of 250 ppm against *A. alternata* (fungicidal), *Alternaria* state of *P. infectoria* (fungistatic), *D. Spicifera* (fungistatic), *M. racemosus* (fungistatic), *R. microsporus* (fungistatic) and *S. rolfsii* (fungicidal) followed by 500 ppm against *F. oxysporum* (fungicidal), *F. Solani* (fungicidal) and *R. bataticola* (fungicidal).

Clocimum oil exhibited MIC of 250 ppm against *Alternaria* state of *P. infectoria* (fungicidal) and *S. rolfsii* (fungistatic) followed by 500 ppm against *A. alternata* (fungistatic), *D. spicifera* (fungicidal), *F. oxysporum* (fungistatic), *F. solani* (fungistatic), *M. racemosus* (fungistatic), *R. bataticola* (fungistatic) and *R. microsporus* (fungistatic).

Lemongrass oil exhibited MIC of 500 ppm against *A. alternata* (fungistatic), *Alternaria* state of *P. infectoria* (fungistatic) and *S. rolfsii* (fungicidal) followed by 1000 ppm against *F. oxysporum* (fungicidal), *F. solani* (fungicidal), *M. racemosus* (fungicidal) and *R. bataticola* (fungicidal) whereas 2000 ppm against *D. spicifera* (fungistatic). Of the tested commercial fungicides, only Dithane M-45

showed complete inhibition of *S. rolfii* (fungicidal), *R. bataicola* (fungistatic), *Alternaria* state of *P. infectoria* (fungistatic) and *F. oxysporum* (fungistatic) at MIC of 250 ppm.

Eight NPPs and three synthetic commercial fungicides were bioassayed *in vitro* against the powdery mildew pathogen by employing conidial germination technique. Out of these, Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil completely inhibited conidial germination after a minimum incubation period of 6 hours at even the lowest concentration used (250ppm). Cedarwood oil showed MIC of 500 ppm at the same incubation period. Of the tested commercial fungicides only Sulfex showed MIC of 250 ppm for complete inhibition of conidial germination. Water treatment alone also inhibited the conidial germination but was least effective of all treatments though **was** significantly superior to the check. i.e. no treatment.

Thus, these findings suggest that because of their strong fungitoxicity wide range of activity, superiority over some prevalent commercial fungicides, Lawsone, Menadione, Eugenol, Clocimum oil and Lemongrass oil can be exploited as potent fungicides against the diseases incited by above fungi in opium **poppy**, after successful field trials.

Eight NPPs and two synthetic commercial fungicides were tested for the control of primary infection, by downy mildew, by (i) seed treatment and (ii) soil drench and of secondary infection by (i) root application and (ii) foliar application.

Of the tested NPPs, Clocimum oil > Eugenol> Lawsone > Lemongrass oil proved to be most effective for the control of primary infection of the disease

through seed treatment in the order depicted at the highest concentration of 100 ppm without causing any phytotoxicity to seed germination. Clocimum oil and Eugenol have been the best as they completely check the disease incidence at the same concentration. None of the tested commercial fungicides checked the disease completely. These findings suggest that all the four NPPs, especially Clocimum oil and Eugenol can be exploited as excellent, non-phytotoxic seed protectants against the disease.

Of the tested NPPs, Clocimum oil > Eugenol > Lawsone proved to be most effective to check the incidence of primary infection through soil drench at the highest concentration used (1000 ppm) in the order depicted. Clocimum oil and Eugenol were found to be highly efficacious as they completely checked the disease at the same concentration without producing any phytotoxicity to the treated plants. None of the tested synthetic commercial fungicides were found capable of checking the disease completely at the same concentration without producing any phytotoxicity to the treated plants. None of the tested synthetic commercial fungicides were found capable of checking the disease completely at the same concentration. The findings, thus, indicate that Clocimum oil, Eugenol and Lawsone can be exploited as potent soil fungicides against the disease .

Of the tested NPPs, Clocimum oil > Lawsone > Eugenol proved to be most effective to check the secondary infection when applied through roots at the highest concentration of 2000 ppm in the order depicted. Clocimum oil and Lawsone proved highly efficacious as they gave maximum disease control of 93.48 and 90.42 per cent, respectively. None of them produced any phytotoxicity to the treated plants. Of the tested commercial fungicides, only

Bavistin-50 could give 63.37 per cent disease control at the same concentration which is comparatively much lower than NPPs. These findings reveal that the NPPs are translocated in the plant system through roots and thus, they can be exploited as potent systemic fungicides against the disease.

Of the tested NPPs under glass house conditions, Clocimum oil, Eugenol, Lawsone and Menadione were able to reduce the secondary infection of the disease most effectively from a maximum of 90.26 to minimum of 79.64 per cent at the lowest concentration used (500ppm). Of these four, Clocimum oil and Eugenol proved highly efficacious showing 94.69 and 93.81 per cent of disease control, respectively, when sprayed at 10 days interval at the highest concentration used (2000 ppm). These were followed by Lawsone and Menadione showing 90.26 and 82.30 per cent of disease control, respectively. Clocimum oil, Eugenol and Lawsone proved their excellence in the subsequent years also. Of the tested synthetic commercial fungicides, only Dithane M-45 was able to give a maximum disease control of 67.26 per cent at the highest concentration used.

Under natural conditions, Clocimum oil, Eugenol and Lawsone proved most efficacious in reducing the severity of the disease, when sprayed thrice at 15 days interval, at the highest concentration of 2000 ppm during 1982-83. The per cent disease control ranged between a maximum of 87.72 to a minimum of 83.32. All of them, when sprayed at 10 days interval, at the same concentration during successive years, proved their excellence with increased disease control and latex and seed yields efficiency. Clocimum oil gave maximum disease control of 88.60 per cent with 19.50 and 17.00 per cent increase in latex and seed yields, followed by Eugenol with 86.84 per cent of disease control and 19.20

and 16.30 per cent increased latex and seed yields, respectively. Lawsone ranked third, showing 84.21 per cent of disease control with 18.39 and 14.08 per cent increased latex and seed yield, respectively. Of the tested synthetic commercial fungicides, only Dithane M-45 could give a maximum disease control of 54.39 per cent in 1982-83 and 60.52 per cent in successive years with 7.90 and 11.35 per cent increase of latex and seed yields, respectively. None of the tested NPPs produced any phytotoxicity to the treated plants either in glass house conditions or under natural conditions .

Eight NPPs and three synthetic commercial fungicides were tested for the control of powdery mildew by foliar application under natural conditions.

All the NPPs, tested to control the diseases were superior, except opium poppy oil at 250 ppm to water spray alone, Clocimum oil, Eugenol, Lawsone and Menadione were able to reduce the disease incidence very effectively at the concentrations used (250 ppm, 500 ppm, 1000 ppm). The per cent efficiency of disease control ranged between a maximum of 76.24 to a minimum of 70.00 at 250 ppm ; 78.75 to 75.00 at 500 ppm ; 83.75 to 81.25 at 1000 ppm and 87.50 to 81.25 at 2000 ppm, when sprayed thrice at 15 days intervals. Of the four, Clocimum oil, Eugenol and Lawsone proved highly efficacious, when sprayed at 10 days interval at the highest concentration of 2000 ppm during successive years. Clocimum oil showed maximum disease control of 91.25 per cent with 22.90 and 15.26 per cent increase in latex and seed yields, respectively, whereas Eugenol showed maximum disease control of 90.00 per cent with 20.15 and 14.52 per cent increase in latex and seed yields, respectively. It was followed by Lawsone showing maximum disease control of 87.25 per cent with an increase of 15.87 and 13.27 per cent in latex and seed yields, respectively. Of the tested,

synthetic commercial fungicides, only Sulfex showed maximum disease control of 85.00 per cent with an increased latex and seed yield of 12.42 and 12.13 per cent, respectively.

None of the tested NPPs produced any phytotoxicity to the treated plants. **Thus**, the present findings suggest that Clove oil, Eugenol and Lawsone can be exploited as excellent eradicators of opium poppy downy and powdery mildew disease incited by *P. arborescens* and *E. polygoni*, respectively.

BIBLIOGRAPHY

- Agarwal, P. 1978. Effect of root and bulb extract of *Allium* spp. on fungal growth. Trans. Brit. Mycol. Sec. **70** : 439-441.
- Agarwal, U. 1965. Seed disorders of *Sesamum indicum* L. , *Linum usitatissimum* L . and *Eruca sativa* L . Ph.D. Thesis, Agra Univ., Agra.
- Agarwal, V.K. ; Mathur , S. B. and Neergaard, P. 1972 . Some aspects of seed health testing with respect to seed borne fungi of rice, wheat, black gram, green gram and soybean grown in India. Indian Phytopath. **25**: 91-100.
- Akai, S. ; Yasumori. H. ; Oku, H. and Tabuchi, T. 1955. On the influence of 2-methyl-1, 4-naphthoquinone (vitamin K₃) upon the outbreak of *Helminthosporium* blight of rice plants in Japan. Forsch. Gebiet Pflanzenkrank . **5**: 105-112.
- Akai, S. and Oku, H. 1956. On the antifungal effect of 2-methyl-1, 4-naphthoquinone (Vitamin K₃) to *Cochliobolus miyabeanus* , the causal fungus of *Gomahagare* disease of rice plants. Forsch. Gebiet Pflanzenkrank. **6** : 33-36.
- Alavi, A. 1974 . The opium poppy. 306 & iii pp, (RAM **54** : 1975).
- Alavi, A. 1975. How to prevent and control downy mildew of opium poppy. Iranian J. Plant Pathol . **11**: 25-28. (RPP **56** : 1976).

- Alcock, N.L. 1933. Downy mildew of *Meconopsis*. New Flora & Silva. **5** : 279-282 . (RAM **13** : 1934).
- Allen, S.J.; Brown, J.F. and Kochman, J.K. 1983. Production of inoculum and field assessment of *Alternaria helianthi* on sun flower. Plant Disease . **67** : 665-668.
- Anand, G.P.S. and Arvind S. Summanwar. 1981. Studies on a mosaic disease of opium poppy. Indian *Phytopath.* **34**: 262-264 .
- Andreson, H.W. and Nienow, L. 1947. Effects of streptomycin on higher plants , *Phytopathol.* **37** : 1 (abstr.).
- Angell, H.R. 1950. Seedling blight. II. Soil in relation to seedling blight of opium poppy and peas. Australian J. Agric. Res. **1**: 132-140 (Biol. Abst. **25**: 1951).
- Angell, H.R. 1951. Seedling blight. IV. Effect of source of isolates of *Pythiaceae* on percentage stands of poppies and peas on four steamed soils. Australian J. Agric. Res. **2**: 286-294 (Biol. Abst. **26**: 1952).
- Angell, H.R. 1952. Seedling Blight. **VI**. The effect of mixtures of unsterilized soils , and of reinfested steamed soils , on seedling blight of poppies and peas. Australian J. Agric. Res. **3**: 128-136 (Biol. Abst. **26** :1952) .
- Angell, H.R. and K. Loftus Hills. 1951. Seedling blight. **III**. Control of seedling blight of opium poppy by liming. J. Australian Inst. Agric Sci. **17**: 17-24 (Biol. Abst. **26**:1952).

- Anonymous. 1945. Rapport sommaire sur les travaux de pathologie végétale effectués dans les stations et laboratoires en 1944. Ann. Epiphyt., N.S. **11**: 245-247, 249-251 pp., (RAM **26**: 1947).
- Anonymous. 1947. Festschrift Zur Feier Des achtzigsten Geburtstag von Geh. Reg.-Rat. prof. dr. h.c. Otto Appel. Präsident der Biologischen Reichsanstalt in Rann 19 Mai 1947. 68 pp. Biologische Zentralanstalt für Land-und Forstwirtschaft in Berlin –Dahlem (RAM **27** : 1948).
- Anonymous .1950. Plant Diseases. Agric. Gaz. N.S.W. **61**: 465-467 (RAM **30**: 1951).
- Anonymous . 1966. The Wealth of India: Raw Materials. Vol. **7**: Ne-Pe, P. 231-248, Council of Scientific & Industrial Research, New Delhi
- Appleton, J.A. and Tausey, M.R. 1975. Inhibition of growth of zoo pathogenic fungi by garlic extract. Mycologia. **67**: 882-885.
- Asthana. A., Chandra, H; Dixit, A. and Dixit, S.N. 1982. Volatile fungitoxicants from leaves of some higher plants against *Helminthosporium oryzae* . Z. Pflanzenkrankh. Pflanzenschutz. **89**: 475-479.
- Atanasow, D.; Dodow, D.N.; Kovacevski, I.C.; Martinow, S.I.; Trifonowa, V.; Christow, A. 1932. Novi parazitni gzbi za B'lgarija , III priinos, Yearbook Univ. of Sofia. Fac. Agric. Sofia **10**: 341-366. (RAM **11**: 1932).
- Bagga, C.H. and Laster, M.L. 1968. A simple technique for evaluating the role of insects in cotton boll rot development. Phytopathol. **58**: 1323-1324.

- Bagga, H.S. 1970. Fungi associated with cotton boll rot in the Yazoo-Mississippi delta , 1966-1968. Plant Dis. Rep. **50**: 796-798.
- Ballarin, C. 1950. Untersuchungen uber *Helminthosporium papaveris*. Phytopath. Zeitschr. **16**: 399-442 (RAM **31**: 1952).
- Bamberg, R.H. 1936. Black chaff disease of wheat. J. Agric. Res. **52**: 397-417.
- Boosalis, M.G. 1952. The epidemiology of *Xanthomonas translucens* (J.J. and R.) Dowson on cereals and grasses. Phytopathol. **42**: 387-395.
- Booth, C. 1971. The Genus *Fusarium* . Commonwealth Mycological Institute, England . 237 pp.
- Bremer, H.; Ismen, H. ; Karel, G.; Ozkan, H. and Ozkan, M. 1947. Beitrage zur kenntnis der parasitischen Pilze der Turkey. II. Rev. Fac. Sci. Univ. Istanbul, Ser. B. **12**: 307-334 (RAM **27**: 1948).
- Brittlebank, C.C. and Fish, S. 1927. A garden fungus disease. A wilt of Tomatoes, Iceland Poppies and other garden plants in Victoria caused by the fungus *Phytophthora cryptogea* (Pethy and Lafferty) . Jour. Dept. Agric. Victoria . **25**: 380-381 (RAM **6**: 1927).
- Brundza, K. 1937. Report of the Phytopathological section of the plant protection station in Lithuania for the year 1935. Kaunas, **32**. (RAM **16**: 1937).

- Burchfield , H.P. 1959 a. Physical chemistry of fungicidal action: Physical properties and chemical reactivities in relation to the effectiveness of fungicides. . Plant Pathol. Probl. Progr., 1908-1958, 293-303 pp.
- Burchfield . H.P. 1960 . Performance of fungicides on plants and in soil-physical, chemical, and biological considerations. Plant Pathol. 3: 477-520.
- Butler, E.J. 1918 (Rep. 1973). Fungi and Diseases in Plants. Ch. IX. Dye, Drug and Spice Crops. 333-362 pp. M/s Bishen Singh Mahendra Pal Singh, New Connaught Place, Dehra Dun & M/s Periodical Experts, 42-D, Viveks Vihar , Delhi -32,533pp.
- Champion, R. 1975. Personal communication in Seed Pathology. Vol. I and II. Neergaard. P. 1977. The Macmillan Press Ltd. London, 839 and 940-1187 pp.
- Chattopadhyay, S. B. 1967. Diseases of plants yielding drugs, dyes and spices. Indian Council of Agricultural Research. New Delhi, 100 pp.
- Chaturvedi, R. 1979. Evaluation of higher plants for their fungitoxicity against *Helminthosporium oryzae*. Ph.D.Thesis , Gorakhpur Univ., Gorakhpur, India.
- Christensen ,C.M. 1951. Fungi on and in wheat seed. Cereal Chem. 28:408-415.
- Christensen, C.M. 1957. Biodeterioration of stored grains by fungi. Bot. Rev. 23: 108-139.

- Christensen, C.M. 1964. Effect of moisture content and length of storage period upon germination percentage of seed of corn, wheat and barley free of storage fungi. *Phytopathol.* **54**: 1464-1466.
- Christensen, C.M. 1969. Factors affecting invasion of sunflower seeds by storage fungi. *Phytopathol* **59**: 1699-1702.
- Christensen, C.M. and Gordon, D.R. 1948. The mold flora of stored wheat and corn and its relation to heating of moist grain. *Cereal Chem.* **25**:40-51.
- Christensen, C.M. and Kaufmann, H.H. 1964. Deterioration of stored grains by Fungi. *Ann. Rev. Phytopath.* **3**: 69-84.
- Christoff, A. 1930. Pleosporata po kulturnizei Mak Str. Sophia Przawna Pacatnica, iii, 99 (RAM **10**:1931).
- Christoff, A. 1933. A new bacterial blight of Opium Poppy caused by *Bacillus (Erwinia) papaveris* sp. Reprinted from Journ. Agric. Expe. Stations in Bulgaria, Sofia. **V**: 1-31 pp (RAM **13**: 1934).
- Christoff, A. 1934. Nekdko novi rastitelni polesti za B'lgarija II- I Prions. Bull. Soc. Bot. de Bulgarie VI, str. 37-48 (RAM **13**: 1934)
- Christoff, A. 1943. Gzbi pricinjavasci petnosvaneto na makovite kutijki i plesenjavaneto na Fechnite semena. Spis. Zamed. Opt. Inst. B'lgarija. **13**: 13-19 (Biol. Abst. **21**: 1947).
- Chup, C. 1954. A monograph of the fungus *Cercospora*. Published by the author, Ithaca, New York. 667 pp (RAM **33**: 1954).

Ceigler, A., Kadis, S. and Ajl, S.J. 1971. Microbial toxins .Vol.VI.563 pp. Academic Press, New York

Coducer, R. C. ; Sargeant, K. And Yeo, R. 1963. Production of aflatoxin by the culture strain of *A. flavus oryzae*, on sterilized pea-nuts. Biotech .Bioling ., **5**: 185-192 .

Cooper, E.A. 1912. On the relations of phenol and *meta*-cresol to proteins : a contribution to our knowledge of the mechanism of disinfection. Biochem. J ., **6**: 362-387.

Cooper, E.A. and Haines, R.B. 1928. The chemical action of quinones on proteins and amino acids. Biochem. J. **22**: 317-325.

Cotton, A.D. 1929. A fungus disease of *Meconopsis* . Gardner's Chron. **85**: 143-144 (RAM **8**: 1928).

Crowdy, S.H. and Pramer, D. 1955. The occurrence of translocated antibiotics in expressed plant sap. Ann. Botany: **19**: 79.

Cunningham, 8D.D. 1897. On certain diseases of fungal and algal origin affecting economic plants in India. Sci. Mem. Off. Army of India. **10**: 95-130.

Cunningham, H.S. and Sharvelle, E.G. 1940. Organic seed protectants for lima beans , Phytopathol. **30** : 4.

Czyzewska, S. and Zarzyca, H. 1961. Some data on the biology of the fungus *Helminthosporium papaveris* Hennings, perfect state *Pleospora papaveracea* (wint.) de Not. Acta agrobot. **10**: 41-51 (RAM **42**: 1963).

- Da Camara, E. Des.; De Oliveria, A.L.B. and Da Luz, C.G. 1936. Mycetes aliquot Lusitaniae. I in Laboratorio Pathologiae Vegetalis Instituti Agronmici Olisipponis Observata. Reprinted From Rev. Agron. , Lisboa, **24**: 37 (RAM **16**: 1937).
- Darpoux. H. 1945. Contribution a letude des maladies des plantes deagineuses en France. Ann. Epiphyt. N.S. **11**: 71-103.
- Darpoux, H. and Faivre-Amiot, A. 1949. Actions antagonistes de l' Actinomycete 105 sur quelques microorganisms pour la plupart Phytopathogens. Essais d' application dams la lulte contre les maladies des plantes. Ann. Inst. Pasteur, **76**: 72-74(RAM **30**: 1951).
- Deshpande, A.L.; Agarwal, J.P. and Mathur, B.N. 1960. *Rhizoctonia bataticola* causing root rot of opium in Rajasthan. Indian Phytopath. **22**: 510.
- Detroy, R.W.; Lillehoj, E.B. and Ciegler, A. 1971. Aflatoxins and related compounds in Microbial Toxins. In Fungal Toxins. Vol. 6 (eds) A. Ciegler, S. Kadis and S.J. Ajl.
- Diener, U.L. and Davis, N.D. 1966 b. Aflatoxin production by isolates of *A. flavus*. Phytopathol. **56**: 1390-1393.
- Diener, U.L.; Wagener, R.E. ; Morgan-Jones, G. and Davis, N.D. 1976. Toxigenic fungi from cotton. Phtyopathol. **66** : 514-516.
- Dimoc, A.W. 1940. Importance of *Verticillium* as a pathogen of ornamental plants. Phytopathol. **30**: 1054-1055.
- Dixit, A. 1980. Fungitoxic evaluation of some plants and the active product (*Cedrus* oil) . Ph.D. Thesis , Univ. Of Gorakhpur, Gorakhpur, India.

- Dixit, A.; Dubey, N.K.; Tripathi, N.N.; Tripathi, R.D. and Dixit, S.N. 1982. Control of fungal deterioration of some spices during storage by the essential oil of *Cedrus deodara*. Ann. Appl. Biol. **100 (suppl. 3)** : 56-57.
- Dixit, A.; Singh, A.K.; Tripathi, R.D. and Dixit, S.N. 1979. fungitoxic and phytotoxic studies of some essential oils. Bio. Bull. India. **1**: 45-51.
- Dixit, S.N.; Srivastava , H.S. and Tripathi, R.D. 1978. Effect of Lawsone, a fungitoxic nahthoquione isolated from leaves of *Lawsonia inermis* on maize . Ann. Meet. Ind. Soc. Pl. Physiol. (Abst.) 80 pp.
- Dolle, H. 1954. Uber antibiotische Wirkungen von Actinomycetan des Bodens auf *Helminthosporium papaveris* Saw.Zbl. Bakt., Abt. **108**: 127-133(RAM **34** : 1955).
- Domsch, K.H. 1958 a. Die Wirkung von Bodenfungiciden. I. Wirkstoff-spektrum. Z. Pflanzenkrankh. Pflanzenschutz. **65** : 385-405.
- Domsch, K.H. 1958 b. Die Wirkung von Bodenfungiciden. II. Wirkungsdauer . Z. Pflanzenkrankh. Pflanzenschutz. **65**: 651-657.
- Donandit, S. 1932. Untersuchungen uber die pathogenitat des Wirtelpilzes *Verticillium albobdtrum* R. u.b.-Zeitschr. fur parasitenkunde, **4** : 653-711 (RAM **12**: 1933) .
- Drozdovskaya, L.S. 1977. O biologii vzbuditelya gel' mintosporioza maka. Byulleten' Clavanogo Botanicheskogo sada. No. 103, 99-102 (RPP **57** : 1978).

- Dubey, N.k.; kishore, N.; Tripathi, N.N.; Tripathi, R.D. & Dixit, S.N. 1982. Fungitoxicity of essential oil of *Citrus medica* against storage fungi. Tests of Agrochemicals and Cultivars. *Ann. Appl. Biol.* **100(suppl. 3):** 58-59.
- Dwivedi, R.S. and Singh S.P. 1973. Effect of microfungi on seed germination and seedling growth of *Lathyrus sativus*. *Acta Botanica Indica* **1**: 41-44.
- Dzhafarov, S.A . 1960. Fungi of the order Peronosporales parasitizing agricultural crops in the Tolysh-Dokl. Akad. Nauk. Azerb. **16**: 293-297 (RAM **40**: 1961).
- Eddins, A.H. 1947. Control of downy mildew of cabbage with spergon. Florida (Univ.), Agr. Expt. Sta. (Gainesville), Press Bull. 633.
- Edgerton, C.W. 1912. The rots of cotton boll. *Agri. Exp. Sta. Bull.*, **137**: 112.
- Ekstrand, H. 1941. En sjukdom pa Vallmo. *Vaxtskyddsnotiser*. **4**: 50-53 (RAM **22**: 1943).
- Elaide, E. 1960. Contributiuni la cunoasterea bolilor plantelor din Gradina Botanica din Bucuresti. *Lucr. Grad. bot.* 1959, 115-129, (RAM **39**: 1960).
- Ellis, M.B. 1971. Dematiaceous Hyphomycetes. Kew, Surrey: Commonwealth Mycological Institute, England , 608 pp.
- Evans , E. 1977. The theory and practice of applying foliar fungicides. 89-115. In *Antifungal Compounds. I* (eds) M.R. Siegel and H.D Sisler, Marcel Dekker Inc., New York.

- Fawcett, C.H. and Spencer, D.M. 1969. Natural Antifungal Compounds. 637-663. In Fungicides Vol. 2: (ed) D.C. Torgeson, Academic Press, Inc., New York.
- Fawcett, C.H. and Spencer, D.M. 1970. Plant chemotherapy with natural products. Ann. Rev. Phytopathol. 8: 403-418.
- Felklova, M. 1976. Patofyziologická studie nekterých chrob lečivých rostlin. Acta. Inst. Bot. Acad. Sci. Slov. 1: 51-61 (RPP 57: 1978).
- Flanderková, V. 1972. Antibiotika v ochrane porostu maku proti *Helminthosporium papaveris* Hennig. Ochrana Rostlin. 8: 277-281 (RPP 52: 1973).
- Flanigen, B. 1970. Comparison of seed born mycoflora of barley, oats and wheat. Trans. Brit. Mycol. Soc. 55: 267-276.
- Fokin, A.D. 1922. Diseases and injuries of cultivated plants observed during the summer of 1922 in the Government of Vyatka. Trans. Fourth All-Russian Entomo.-Phytopath. Congress, Moscow, 8th to 14th Dec. 1922, 108-115 (RAM 4: 1925).
- Follstad M.N. and Christensen, C.N. 1965. Effect of storage for three months at 14.1% moisture content and 21°C upon the microflora of Barley kernels. Phytopathol. 55: 399-400.
- Foster, H.N. 1946. Control of downy mildew or 'rust' in cabbage seed-beds. Mississippi State Coll., Agr. Expt. Sta., Circ. 127.
- Foster, H.N. 1947. Comparison of benzene vapour with certain sprays in control of downy mildew of cauliflower. Phytopathol. 37: 428-431.
- Garber, R.H. and Houston, B.R. 1959. An inhibitor of *Verticillium albo-atrum* in cotton seed. Phytopathol. 44: 449-450.
- Garbowski, L. and Juraszkowna, Mme H. 1933. Choroby roślin użytkowych w okresie 1926-1930. Zesta wienie notowań Zakładów Ochrony Roslin.-Rocznik Ochrony Roslin, Bydgoszcz, Sect. A, 1: 97-235 (RAM 13: 1934).

- Gassner, G. 1949. Der Einfluss der standweite auf den Befall des Mohns durch *Helminthosporium papaveris* Hennig.- Nachr. Bl. dtsh. Pfl. Sch. Dienst., **1**: 119-123 (RAM **29**: 1950).
- Gumann, E. 1923. Beitrage zu einer Monographie der Gattung *Peronospora corda*-Beitage zur Kryptogamenflora der Schweiz. **5**: Helf. 4.
- Gilman, J.C. 1957. A Manual of Soil Fungi, 2nd ed. The Iowa State College Press, U.S.A., 450 pp.
- Girzitska, Mme Z.K. 1928. Konidialnaja-staclija *Pleospora papaveracea* Sacc. Abstract in w Dniewrik Wsiesojuzn. Sjezda Botanikow w Leningradie w janware 1928. goda. 172-173 (RAM **9**: 1930).
- Gobelez, H. 1956. (Research work on the varieties and areas of spread of bacterial and parasitic diseases affecting and contaminating the seeds of cultivated plants growing in certain provinces of Central Anatolia as well as the approximate degree of damage caused by such diseases). Zir Fak. Yayinl. **107**: 131.
- Goidanich, G. 1932. La Verticilliosi dell '*Acer campestre*' L. e alcuni altri casi di tracheomicosi in Italia.-Boll. R. Staz. Pat. Veg. **112**: 285-297 (RAM **12**: 1933).
- Goldblatt, L.A (ed). 1969. Aflatoxin. Scientific Background, Control, and Implications. Academic Press, New York. 12 & 472 pp.
- Gonzalez, F. 1945. Inhibiting effect of quinones on the growth of *Penicillium notatum*. Science. **101**: 494.
- Grossmann, F. 1962. Untersuchungen uber die Hemmung pektolytischer Enzyme von *Fusarium oxysporum* f. *lycopersici*. I. Hemmung durch definierte Substanzen *in vitro*. Phytopathol. Z. **44**: 361-380.
- Grossmann, F. 1963. Fungtoxic, enzyme inhibition, and therapeutic effects of rufianic acid (1,4-dihydroxy anthroquinone-2- sulfonic acid). Mededel. Landbou. Opzoek. Staat Gent. **28**: 604-610.

- Grover, R.K. and Moore, J. D. 1962. Toximetric studies of fungicides against brown rot organism, *Sclerotinia fructicola* and *S. laxa*. *Phytopathol.* **52**: 876-880.
- Grummer, G. 1952. (Contributions to the analysis of the character susceptibility to *H. papaveris* in *P. somniferum*. part III). *Zuchter.* **22** : 366.
- Grummer, G. 1953. Die wirkung von *Alternaria*-Infektionen an Mohn Kapseln auf die keimungsbereit schaft ihrer samen. *Flora, Jena*, **140**: 298-306 (RAM **33**: 1954).
- Guerillot-Vinet, A. and Richter, A. 1949. Comparative action of some quinones derivatives and of different vitamin K on growth of *Fusarium solani* . *Compt. rend. Soc. Biol.* **143**: 48-52.
- Gupta, R. 1984. Improved production methods for opium poppy. *Indian Hortic. Jan.-Mar.6* (Special no on Med. Plants), 9-11 & 26.
- Guthrie, L.R.; Bollonbachec, K. and Harrell, D.C. 1950. Observations on microbial degradation of cotton fibres during the period of boll opening in 1949. *Plant Dis. Rep.* **34**: 165-175.
- Hemmi, T. and Nojima, T. 1927. Contribution to the knowledge of anthracnoses of plants. I. Notes on the three new or little known anthracnoses of cultivated plants in Japan. *Mem.-Coll. Agric., Kyoto Imper. Univ.*, **3**: 26-39 (RAM **7**: 1928).
- Hoffmann-Ostenhof, O.; Wertheimer, P. and Gratzl, K. 1947. The action of quinones on the growth of yeast. *Experientia* **3**: 327-328.
- Hoffmann-Ostenhoff, O. and Fellner-Feldegy, H. 1949. Bacteriostatic quinones and other antibiotics XIV. The inhibition of yeast

growth by various quinines. **80**: 648-654.

- Holliday, P. 1980. Fungus Diseases of Tropical Crops. Cambridge Univ. Press, Cambridge. 606 pp.
- Holliday, P. and Punithalingam, E. 1970. C.M.I. Descriptions of Pathogenic Fungi and Bacteria No. 275. Kew, Surrey, England.
- Horsfall, J.G. 1956. Principles of Fungicidal Action. Chronica Botanica, Waltham, Massachusetts.
- Horsfall, J.G. and Cowling, E.B. (eds.). 1977-80. Plant Disease. An Advanced Treatise. Vol. **2**, 465 pp., Vol. **4**, 427pp. and Vol. **5**, 519 pp. Academic Press, New York.
- Horvath, J. and Besada, W.H. 1975. Opium poppy (*Papaver somniferum* L.) a new natural host of turnip mosaic virus in Hungary. Zeitschrift fuer pflanzenkrankheiten und pflanzeneschutz. **82**: 162-167 (RPP **55**: 1976).
- Ikata, S. and Yamauti, K. 1941. Notes on the haustoria of some species of *Peronospora*. Ann. Phytopath. Soc. Japan. **10** : 326-328. (RAM **22**: 1943).
- Inaba, T.; Takahashi, K. and Morinaka, T. 1983. Seed transmission of spinach downy mildew. Plant Disease. **67**: 1139-1141.
- INCB. 1981. Report of the International Narcotics Control Board for 1980. United Nations, Vienna.
- Johnson, C.B.; Whittington, W.J.; Blackwood, G.C. 1976. Nitrate reductase as a possible predictive test of crop yield. Nature. **262**:133-134.
- Jain, S.C.; Singh, R.C.; Sharma, R.C. and Mathur, J.R. 1982. Seed mycoflora of moth bean (*Vigna aconitifolia*) : Its pathogenicity and control. Indian J. Mycol. **12**: 137-141.
- Janardhanan, K.K. and Husain, A. 1983. Diseases and their Control. 95-106 pp. In the Opium Poppy (eds.) Akhtar Husain and J.R. Sharma, Med.

- Aromat. **Plants** Series-I, Cent. Inst. Med. Aromat. **Plants**, Lucknow, Lucknow Publ. House, Lucknow (India).
- Jurgan, T. 1962. Science and Secret of Early Medicine. Thomas and Hudson Ltd London.
- Kadis, S., Ciegler, A. and **Ajl**, S.J. 1971. Microbial toxins. Vol. **VII**, Academic **Press**, New York, 400 pp.
- Kanaujia, R.S. 1974. Studies on certain aspects of seed borne fungi IV. Seed-borne fungi of some starchy seeds. Acta Botanica Indica **2**: 129-135.
- Kapoor, J.N. 1967. C.M.I. Descriptions of **Pathogenic Fungi and Bacteria** No. 152, Kew, Surrey, England.
- Karahan, O.; Maden, S. 1978. Hashasta kok bogazi yanikligi hastaligi (*Dendryphion papveris* (Saw.) Sawada), tohumla tasimma duruma v tohum ilaclarinin bu elmene etkisi uzerinde calismalar. Bit. Kor. Bull., **18**: 1-9 (RPP **58**: 1969).
- Khan**, S.A. 1959. A new host of *Leveillula (Oidiopsis) laurica*. Biologia. **5**: 45 (RAM **39**: 1960).
- Killpatrick, R.A. 1957. Fungi associated with the flowers, pods, and seeds of soybeans. Phytopathol. **47**: 131-135.
- Kochman, J. 1936. Grazyby gtowniowe polski. **Plant Polon.** **4**: 1-161 (RAM **16**: 1937).
- Kondo, M. and Okamura, T. 1927. Untersuchungen der verschiedenen Reiskormer geringer Qualitat .I. Die braun gefarbten enthulsten Reiskorner 'Tschamai'. **Ber** Ohara Inst. Landw. Forsch. **3**: 406-419.
- Kothari, K.L. 1968. Other powdery mildew of Opium Poppy (*Papaver somniferum* L.). Indian **Phytopath.** **21**: 456.
- Kothari, K.L. and Prasad, N. 1970. Downy mildew of Opium Poppy in

- Rajasthan. Indian Phytopath. **23**:674-688.
- Kothari, K.L. and Prasad, N. 1972. Powdery mildew of Opium Poppy in Rajasthan and its control. Indian Phytopath. **25**:36-39.
- Kothari, K.L. and Verma, A.C. 1967. Control of downy mildew (*Peronospora arborescens*) of opium poppy by root application of fungicides. Plant Dis. Rep. **51**: 686-687.
- Kothari, K.L. and Verma, A.C. 1972. Germination of conidia of poppy powdery mildew (*Erysiphe polygoni* DC.) Mycopath. Mycol. Appl. **47**: 253-260
- Kovacevski, I.C. 1936. (Parasitic fungi new to Bulgaria. Fourth Contribution). Trav. Soc. bulg. Sci. nat. **17**:13-24 (RAM **16**:1937).
- Kowalik, R. 1951. The antibiotic activity of 2-substituted 1,4-naphthoquinones on a few fungi, the fungicidal effects of several dithiocarbamates. Prace Glownego. Inst. Chem. Prezemy. Stowez. No.2, 51-59.
- Kratichvil, J. and Zakopal, J. 1948. Skodlivy cinitile maku na Morave vr. 1943 Ochrana Rostlin. **21**: 2-36 (Biol. Abst. **23**:1949).
- Kumar, K. and Singh J. 1983. Seed borne Fungi of Urd Bean *Vigna mungo* (L.) Hepper, their significance and control. Indian J. Plant Pathol. **1**:178-181.
- Kutova, I and Bankova, K.H. 1975. Methodi Za povishavane na ustoichivostta na nyakoi sortove mak k'm. pleosporozata. Rostitelna Zashchita. **23**: 34-36 (RPP **5**: 1976).
- Lambat, A.K.; Ray Chaudhari, S.P.; Lele, V.C. and Nath, R.P. 1969. Fungi

intercepted on imported soybean seed. India Phytopath. **22**: 327-330.

Laviolette, F.A. and Athow, K.L. 1972. *Cercospora kikuchii* infection of soybean as affected by stage plant development, Phytopathol. **62**: 771.

Laughlin, J.C. and Munro, D. 1982. The effect of fungal colonization on the morphine production of poppy (*Papaver somniferum*) capsules. J. Agric. Sci. **98**: 679-686 (Biol. Abst. **75**:1983).

Laughlin, J.C., Munro, D. 1983. The effect of *Sclerotinia* stem infection on morphine production and distribution in poppy (*Papaver somniferum* L.) Plants. J. Agric. Sci. **100**: 299-330. (RPP **62**: 1983).

Leiteritz, R.; Roder, W. 1980. Zu wichtigen pflanzenschutz ma Bnahmen beim erweiterten Mohnanbau im Bezirk Dresden. Nachrichtenblatt fur den Pflanzenschutz in der DDR. **34**: 166-169.

Lindquist, J.C. 1939. Especies argentinas del genero *Peronospora*. Physis. B. Aires. **15**:13-20 (RAM **25**:1946).

Lindquist, J.C. and Carranza, J.M. 1964. Especies de *Peronospora* parasitas de plantas cultivadas en la Republica Argentina. Rev. Fac. Agron. La Plata. **39**:51-62 (INSDOC).

Long, P.G. and Cook, R.C. 1969. Fungal factors and density induced mortality in plant species. Trans. Brit. Mycol. Soc., **52**: 49-55 (RAM **48**:1969).

Losa, M. 1952. *Notas* micologicas. Coll. Bol., Barcinome. **3**: 147-161 (RAM **32**: 1953)

Louvet, J. 1961 . L' *Alternaria* du colza et les maladies redoutees sur

d' autres plantes **oreagineuses**. Reprinted from C.R. Journessd' Inf. Oleagineux metr. 1961, 9 pp (RAM **43**: 1964).

Luke, H.H. and Barnett, R.D. 1979. The influence of harvest conditions on the germinability and mycoflora of rye seed. **Seed Sci. & Technol.** **7**: 431-437.

Maas Geesteranus, H.P. 1960. Een geval van noodrijpheid bij Blauwmaanzaad. *Pyrenophora calvescens* Blauwmaanzaad. Tijdschr. Pl. Ziekt., **66**: 107-110. (RAM **40**: 1961).

Ma Cias, W.; Stopa, E. 1974. Zwalczenie *Helminthosporium papaveris* Sawada i *Peronospora arborescens* de by na maku. Biuletyn Instytutu Ochrony Roslin. No. 57, 191-219 (RPP **57**:1978).

Marz, F. 1960. Vliv skodliveho pusobeni houby *Helminthosporium papaveris* Hennig na vynosy maku v kraji karlovy vary v letech 1957 a 1958 . Ann. Acad. Tchecosl. Agric. **38**: 1083-1094 (RAM **40**: 1961).

Marz, F. 1963. (Study on the effectiveness of treatment compounds on the conidia of the fungus *Helmonthosporium papaveris* Hennig. Ann. Acad. Tchecosl. Agric. **36**: 51-64 (RAM **42**: 1963).

Marz, F. 1979. Dynamics of poppy flowering in relation to the infection of poppy heads with the fungus *Helminthosporium papaveris* Hennig and to the coarse of weather. Rostlinna vyroba- **UVTIZ** . **26**: 545-550.

Masurat, G. and Stephen, S. 1961. Des Auftreten der wichtigsten **krankheten** und **schadlinge** der land**wirtschaftlichen** und **gartnerischen kulturpflanzen** im **jahre 1960** im **Deutschen** Bereichder

Demokratischen Republik. Nachr Bl. dtsh. PflschDienst, Berl. **15**: 125-158 (RAM **41**: 1962) .

Masalab, N.A.1938. (Diseases of medicinal and some industrial plants caused by species of *Sclerotinia*) .Sovetsk. Bot., 67-83 pp. (RAM **18**: 1939).

Masurat, G. and Stephan, S. 1963. Das Auftren der wichtigsten

Krankheiten und gartnerischen Kulturppflanzen im Jahre 1962. im Bereich der Deutschen Demarkratischen republik . NachrBl. dtsh. PftscDienst, Berl., **17** : 185-215(RAM 43: 1964).

Matzner, F. 1985. (The influence of fertilizing with chlorides and sulphates in conjugation with calcium on the yields and seed quality of poppy (*Papaver somniferum*) in relation to infection by *Helminthosporium papaveris* according to Henning). Wiss. Z. Friedrich Schiller Univ. **7**: 295.

McNew, G.L 1942 . Growth stimulation of peas by tetrachloro- para - benzoquinone , a fungicidal seed protectant. Science . **96** : 118-119.

McNew , G,L. and Burchfield, H. P. 1951. Fungitoxicity and biological activity of quinones . Contrib. Boyce Thlompson Inst. **16**: 357-374.

Meffert, M. E. 1949. Zur geschichte der Helminthosporiose des oelmohns. Nachr Bl . dtsh. . Pflsch . Dienst , Berl ., **3**: 104-106 (RAM **29**: 1950).

- Meffert, M.E. 1950 . Ein Beitrag zur Biologie und morphologie der Erreger der parasitaren Blattiire des Mohnes. *Z. Parasitenk.* **14**: 442-498 (RAM **31**: 1952).
- Mehlisch , K. 1935. Eine Blattfleckenkran Kheit der *Dahlie* . *Blumen –u . PflBau ver. Gartenwett.* **39**: 390-391(RAM **14**: 1936).
- Miczulska, Izabela. 1967. *Observacje nad wpływem porażenia Makowek maku lekarskiego (*Papaver somniferum* L.) przez pasożytnicze na zawartosc morfiny w makawkach.* *Rocz Nauk. Roln., Ser . A. Roslinna.* **93** : 189-195 (Biol. Abst. **49**: 1968).
- Milatovic, I. 1952 . *Prilog poznavanju glazive *Pleospora calvescens* (fr.) Tulasne na maku.* *Rev. Sci. Agric. Zogreb .* , **13**: 121-133 (RAM **33**: 1954).
- Misko, L .A. 1963. Gel ‘ mintosporioz *Maka*. *Zashch Rast Moskava*, **8**: 56 (RAM **43**: 1964).
- Misko , L. A. 1973. *Izmeneniya v thanyakh rastenii maka pri porazhenii Gel ‘minotosporiozom.* *Byulleten Glavnogo Botanicheskgo Sada .* No. 87. 110-112 (RPP **52**: 1973).
- Misra, R.R. and Kanaujia , R.S. 1973. *Studies on certain aspects of seed borne fungi II. Seed –borne fungi of certain oil seeds.* *Indian Phytopath.* **26**: 284-294.

- Misra, S.B. and Dixit, S.N. 1976. Antifungal activity of plant extract I, against orange rust . Proc. Symp. Physiol. microorganism . Bhagalpur; 221-224.
- Misra, S.B. and Dixit, S.N. 1977. Screening of some medicinal plants for antifungal activity. Geobios. **4**: 129-132.
- Mittal, R.K. and Sharma , M.R. 1982. Studies on the mycoflora and its control on the seeds of some forest trees. IV. *Pinus roxborghi*. Indian J. Mycol Plant Pathol. **12**: 198-205.
- Modawi, B.M.; Duprey, R.J.H.; El Magboul , A.Z.I. and Satti. A. M. 1984. Constituents of the Essential Oil of *Ocimum basilicum* var . thrysiflorum . Fitoterapia **55**: 60.
- Moesz, G. 1938 . Fungi Hungariae. II . Archimycetes et Phycomycetes. Ann. Hist . – nat . Mus . Lung . **31**: 58 – 109 (RAM **18**: 1939).
- Morey, D. D. 1976 . The effects of storage conditions and containers on the viability of rye, wheat and oat seed. Seed Sci. & Technol. **4** : 313-323.
- Muller, A.S. and Chupp, C. 1936. Uma segunda contribuicao a S Cercesporae de Minas Geraes. Arq.Inst .Biol. Veg. iii: 91-98 (RAM **16**: 1937).
- Mundkur , B.B. 1940. A second contribution towards a knowledge of Indian Ustilagineales . Fragments **XXVI**- L. Trans. Brit. Mycol . Soc., **24**: 312- 336(RAM **20**: 1941).

- Munro, D. 1978. *Dendryphion penicillatum* (corda) Fr. on opium poppy. *APPS* newsletter **7**: 8 (RPP **57**: 1978).
- Murthy, N . B. K. and Amonkar, S. V. 1974 . Effect of natural insecticide from garlic (*Allium sativum* L.) on plant pathogenic fungi . Indian J. Exp. Biol . **12**: 208-209
- Nair, L.N. 1982. Studies on mycoflora of seeds: some cucurbitaceous vegetables. J. Indian Bot . Soc. **61**: 342-345.
- Nath, R. ; Mathur , S . B. and Neergaard , P. 1970 . Seed borne fungi of moong bean (*Phaseolus aureus* Roxb.) from India and their significance. Proc. Int. Seed . Test. Assoc. **35**: 225-244.
- Natrass, R.M.1937. Annual Report of Plant Pathology for the year book 1936. Rep. Dir. Agric. Cyprus, 1936. 50-56 pp (RAM **17**: 1938)
- Naumova, N.A. 1972. Testing of seeds for fungus and bacterial infections , 3 rd ed. (Translated from Russian). Israel Program for Scientific Translation , Jerusalem. 145 pp.
- Navarro De Palencia, J.1945 . Los ataques del *Fusarium* a la Adormidera. Bol. Inst .Invest. agron ., Madr ., **14**: 377-381 (RAM **34**: 1955).
- Neergaard, P. 1937. Aarsberetning fra J.E. Owsens Enkes plantepatologiske Laboratorium 1. April 1936-31 Marts 1937. 11 pp. (RAM **17**: 1938).
- Neergaard . P. 1938 . Aarsberetning fra J.E. Owsens Enkes plantepatologiske Laboratorium 1. April 1937-31 Marts 1938.12 pp. (RAM **17**: 1938).

Neergaard , P. 1949 . 13. Aarsberetning fra J.E. Owsens Enkes plante-
patologiske Laboratorium 1. August 1947-31 Juli 1948. 19 pp. (RAM 28: 1949).

Neergaard, P. 1950. 14 Aarsberetning fra J. E. J.B. Ohlsens Enkes plante –
patologiske Laboratorium . August 1948- 31 Juli 1949. 23 pp.
(RAM 30: 1951).

Neergaard , P. 1951 . Og. sidsta Aarsberetning fra J.E. Owsens Enkes plante –
patologiske Labortorium 1. August 1949-31 Juli 1950. 33 pp. (RAM
30: 1952).

Neergaard, P. 1956 . (Sixth and Seventh annual reports relating to the control
of seed pathology from 1st April, 1953 to 31st May, 1954 and 1st June ,1954 to
31st May ,1955).

Neergaard, P. 1969 . *Plenodomus lingam* , black leg of crucifers. Occurrence
in Danish seed lots for export , and control by Germison – hot water
treatment . Friesia. 9: 167-179.

Neergaard , P. 1969. Seed – borne diseases. Handbook for phytosanitary
Inspector in Africa , Lagos , Nigeria. 380-393 pp.

Neergaard , P. 1970 b . Seed pathology of rice . A brief review and discussion.
Plant Diseases Problems. Proc . First Int. Symp. N. Delhi . 1970.
57-68 pp .

Neergaard , P. 1977. Seed Pathology Vol. I and II. The Macmillan Press Ltd.,
London , 839 and 840-1187 pp .

- Nehra-sh, A.K. 1961. The antimicrobial properties of cultivated radish I. The antimicrobial activity of extracts and essential oil from cultivated and wild radish .J. Microbiol. **23**: 32-37.
- Neligan , A.R. .1927 . The Opium Question . Bale and Curnow , London
- Nicolas , G. and Aggery. B. 1952. Notes phytopathologiques.
Neuvieme serie . Bull. Soc. Hist. nat . Toulouse. **87**: 277-298 (RAM **33**:1954) .
- Nikitina, K.V. and Vakhrusheva , T.E. 1975. Gribnyei bakterial nye bolezni maka v Leningradskori oblasti : Trudy po Prikladnoi Botanike , Genetike Seleksii. **55**: 224-229 (RPP **55**: 1976).
- Noble, R.J. 1939. Australia: notes on plant diseases recorded in New South Wales for the year ending 30 th June, 1938 . Int. Bull . Pl. Prot. **13**: 25-26 (RAM **18**: 1939).
- Obee, D.J. 1938. Studies on the host range of *Sclerotium delphinii* Welch. Jrans. Kans. Acad. Sci., **11**: 89-93 (RAM **18**: 1939).
- Ou, S. H. 1963. Report to the government of Thailand on blast and other diseases of rice. F.A.O. (Expand. Tech . Assist. Prog.) Rep. 1673 . 4 & 28 pp.
- Pandey, D.K.; Chandra , H. and Tripathi N.N.1982.Volatile fungitoxic activity of some higher plants with special reference to that of *Callistemon lanceolatus* DC.Phytopath. Z. **105**: 175-182.

- Pandey, D.K., Tripathi , N.N.; Tripathi, R.D. and Dixit, S.N. 1982 a. Fungitoxic and phytotoxic properties of *Hyptis suaveolens*. Z. Pflanzenkrankh. Pflanzenschutz. **89**: 344-349.
- Pandey, D.K; Tripathi, N.N; Tripathi, R.D. and Dixit, S.N. 1982 b. Fungitoxic and phytotoixic properties of the essential oil of *Caesulia axillaris* Roxb. Angew.Bot. **56**: 259-267.
- Pape, H. 1933. Falscher mehltau an Moh. Gartenwelt, **27**: 289-290 (Abs. in neuheiten auf dem Geb. des. Pflanzensch. **27**: 32, 1934) (RAM **13**: 1934.
- Parisi, R. 1921. Di alcuni parassiti delle piante medicinali e da essenze. Bull. Orto. Bot . Napoli, **6**: 289-296 (RAM **1**: 1922).
- Patel, M.K.; Kamat, M.N. and Bhide, V.P. 1949. Fungi of Bombay. Supplement I. Indian Phytopath. **2**:142-155.
- Pavgi, M.S. and Upadhyay, H.P. 1964. Parasitic fungi from North India. II. Mycopath. Mycol. appl. **24**: 347-354.
- Petrak, D. and Esfandiari, E. 1941. Beitrage zur kenntnis der iranischen Pitzflora. Ann. Mycol., **39**: 204-228 (RAM **21**:1942).
- Pietkiewicz, T.A. 1958. Z. badan nad chorobami roslin *deistych* Roczn. Nauk rol., **78** (Ser. A): 199-218 (RAM **39**: 1960).
- Prochaska. M. 1928. Beobachtungen uber das Auftreten von *Peronospora arborescens* (falscher Mehltau) auf *Papaver somniferum* Fortschr. der Landw., **3**: 165-167 (RAM **7**: 1928).

Proshkina- Kobezskaya, Mme.A.I. 1928. (Diseases of cultivated plants in the Ukraine 1926-1927) . Protection of plants in Ukraine 1927-1928. 3-4, 25-32 pp. (RAM **8**:1929).

Rabbe, R.D. 1957. Perithecia of *Erysiphe polygoni* on Iceland poppy. Plant Dis. Rep. **41**: 694 -695.

Radulescu, E.; Perseca, E.and Docea, E.1961. Contributii la combaterea helminthosporizei nacului (*Pleospora papaveracea* (De not.) Sacc.) prim mijiloace agrotehnice si chimice. Lucrari stiintifice, Inst. Agronomic, N. Balcescu ser. B. **5**:33-342 (RAM **44**: 1965).

Radulscu, E.; Perseca, E.1964.Uber die Biologie des pilzes *Pleospora papaveracea* (De not.) Sacc. Rev. roum. Biol. Ser bot., **9**: 19-33 (INSDOC).

Rahalkar, P. W. and Neergaard, P. 1969. Studies on Aureofungin as seed treatment in controlling seed borne fungal diseases. Hindustan Antibiot. Bull. **11**: 163-165.

Ramanathan, V.S .and Ramachandran , C. 1977. Opium poppy : cultivation , collection of opium , improvement and utilization for purposes. 68-74 pp. In Cultivation and Utilization of Medicinal and Aromatic Plants (eds) C.K.Atal and B.M. Kapoor, CSIR, New Delhi , pp. 568.

Rao, J.T. 1976. Antifungal activity of essential oil of *Curcuma aromatica*. Indian J.Pharm . **38**: 53.

Reinmuth, E. 1942 . Die parasitare Blatdurre , eine fur den mohnbau

- Bemerkenswerte krankheit . Angew. Bot. **24**: 273-277 (Biol. Abst. **23**: 1943).
- Reinmuth, E. 1948. Weitere Beobachtungen Ueber die parasitare Blattddurre des Olmohns. Angew. Bot. **25**: 300-304. (Boil . Abst.**23**: 1949).
- Reinmuth, E. 1948. Die Helminthoseporiase des Olmohns . Zeitschr. Pflanzen ch . **55**:138-141 (Biol . Abst. **24**: 1950).
- Rich, S. and Horsfall J.G. 1954. The relation of polyphenoloxidases to fungitoxicity. Proc. Natl. Acad. Sci. U.S. **40**: 139-145.
- Rundy, R. 1976. Wplyw terminu siewu, sposabu pielegnacji ora zabiegow ochronnych na zdrowotnosc i plonwanie mak uprawnego (*Papaver somniferum* L.) Odrniana Mak miebieski KM. Pra. Nau. Inst. Och. Rosl ., **18**: 167-182 (RPP **58**:1979.
- Saville, D.B.O. 1946. *Entyloma fuscum* and related smuts attacking Papaveracea . Canadian J. Res. Sect. C. Bot. Sci. **24**: 109-114 (Biol . Abst. **21**: 1947).
- Savulescu, T. 1932. L' etat phytosanitaire en Roumanie durant tannee 1930-1931. Inst. Cerc. Agron . al Romaniei Publ. **8**: 31 (RAM **12**: 1933).
- Sawada, K. 1933. Descriptive catalogue of the Formosan fungi. Part VI. Rept. Dept. Agric. Res. Inst. Formosa, **61**: 117 (RAM **13**:1934).
- Scharif, G. 1970. Downy mildew of opium poppy in Iran, *Peronospora*

- arborescens* (Berk.) de Bary . Iranian J. Pl. Pathol. **6**: 1-16.
- Schmitt, C.G. 1975. U.S. Deptt. of Agric. Agriculture Research Service – NE – 62,186 pp.
- Schmidt, T. 1949 . Das Auftreten Wichtiger Krankheiten und Schadlinge an Kullurpflanzen in Osterreich im Jahre 1949. Pflsch . Ber ., Wien **4**: 84-94 (RAM **29**: 1950).
- Schneider, R. 1953. Untersuchungen uber fenchtigkeitsanspruche parasitischer Pilze. Phytopath. Z. **21**: 63-78 9 (RAM **33**: 1954).
- Schuepp, H. and Blumer, S. 1963. (Eidg. Versuchsanst , Obst - , Wein-und Gartenbau, Wadenswil). Uber einige Mehлтаupilze auf Zierpflanzen . Phytopath. Z. **48**: 329-336. (RAM **43**: 1964).
- Sehgal, S.P.; Gupta , I.J. and Agarwal. J.M. 1977. Capsule rot of opium poppy (*Papaver somniferum*.). Rajasthan J. Agric. Sci. **2**: 61-62.
- Sekhawat, P.S. and Kothari , K.L. 1971. Amino acid composition of healthy and downy mildewed plants of opium poppy (*Papaver somniferum*). Indian Phytopath. **2**: 403-405.
- Sharma, K.D. and Chauhan , R.K.S. 1974. Succession of mycoflora on oil seeds of Sesamum (*Sessamum indicum*) L) . J. Jiwaji Univ. **2**: 173-182.

Sharvelle, E.G.; Young, H.C. Jr., and Shema, B.F. 1942 . The value of Spergeon as a seed protectant for canning peas. *Phytopathol.* **32**: 944-952.

Shibasaki, I. and Terui, G. 1953. Antifungal substances I. Comparison of antifungal activities of synthetic drugs. *J.Ferm. Tech.* **31**: 338-342.

Shimonyan, S.A. 1959. New materials for the mycoflora of Armenia. *Izv. Akad. Nauk. Armyan. S. S. R., Biol. Sci.*, **12**: 23-31 (RAM **40**: 1961.).

Singh, A.k.; Dixit, A. and Dixit, S.N. 1984 . Antifungal studies of *Perpormia pellucida* . *Beitr. Biol. Pflanzen* . **58**: 357-368.

Singh, A.K.; Tripathi, R.D.; Sharma, M.L. and Dixit, S.N. 1980. Fungitoxic activity of some essential oils. *Eco. Bot.* **34**: 186 -190.

Singh, A.k.; Tripathi, R.D. and Dixit, S.N. 1979. Volatile fungitoxic studies of *Perperomia pellucida*. *J.Indian Bot. Soc.* **58** (suppl.): 20.

Singh, D.; Tripathi, A.K. and Ghule, B.D. 1983. Insect-pests and their control . 108- 115 pp. In the Opium Poppy (eds.) Akhtar Husain and J.R. Sharma . *Med. Aromat. Plants Series 1, Cent. Inst. Med. Arom. Plants, Lucknow, Lucknow Publ House, Lucknow (India)*

Singh, H.B. and Singh, U.P. 1981. Comparative efficey of some commercial fungicides, plant extracts and oil for the control of powdery mildew *Erysiphe polgoni* DC.) of pea (*Pisum sativum* L.) (personal communication).

- Singh, H.B. and Sing . U.P. 1981. Effect of volatiles of some plant extracts and their oils on conidia of *Erysiphe polygoni* DC. Australian Pl. Pathol. **10**: 66-67.
- Singh, R.N. 196 . A new bacterial disease of poppies in India and effect of antibiotics against its causal organism. Plant Science. **1**: 151-153 .
- Singh, Y. 1977. Antifungal activity in underground parts of higher plants. Ph. D. thesis. Gorakhpur Univ. Gorakhpur, India.
- Sivanesan, A. and Holliday. P. 1982. *Pleospora papaveracea* / *Papaver somniferum* , *Papaver* spp. , Opium poppy leaf blight distribution , transmission , morphology, CMI (Commonw. Mycol. Inst.) Descr. Pathog – Fungi Bact. **73**: No pagination (Biol . Abst. **24**: 1983).
- Skoric, V. 1930. Bolesti bilja ne falkultetskom dobru Maksimir. Rapp. Ann. Univ. de Zagreb 1929. 738-746 pp. (RAM **9**: 1930).
- Slavenas, J. and Razinskait , D. 1962 .Some studies of phytocidal substances and of Juniper oil from common juniper. Leit. TSR moks . Akad. Darbai Ser . C2, 63-64.
- Smith, K.M. 1972 . A Textbook of Virus Plant Diseases. Longman, U.K. 684 pp.
- Spencer, D.M. 1978 . The powdery Mildew (ed.) Academic Press Inc., London, 586 pp.

Spencer , D.M. 1981. The Downy Mildew (ed.) Academic Press Inc., London ,658 pp.

Spensley, P.C. 1963 . Aflatoxin , the active principle in Turkey 'X' disease. Endeavr. **22**: 75-79.

Srivastava, R.N. and Gupt , J.S. 1983 . Studies on seed mycoflora of yellow cosmos, their effect on emergence and vigour of seedlings and its control. Indian J.Mycol. Plant Pathol **12**: 148 -155.

Stapel, C. 196 . Sygdomme og stadedyr i Valmueafroder . Reprinted from Landbonyt , 1960. 3 pp. (RAM **40**: 1967).

Steindorff, A. and Pfaff, k. 1931. A seed disinfectant . German Patent 534756.

Stevenson, J.A. 1942. *Cercospora* on poppy in Albama. Plant Dis. Rept. **26**: 280. (Biol. Abst. **17**: 1943).

Stinson, E.E.; Bills, D.D.; Osman , S.F. ; Siciliano J. ; Ceponis, M.J and Heisler.1980 . Mycotoxins production by *Alternaria* species grown on Apples, Tomatoes, and Blueberries . J. Agric. Food. Chem. **28**: 960-963.

Suryanarayana, D. and Bhombe, B.B. 1961. Studies on the fungal flora of some vegetable seeds. Indian Phytopath. **14**: 30-41.

Sydow, H. and Butler, E.J. 1911. Fungi Indiae Orientalis Pars III. Ann. Mycol. **9**: 372-421.

Tandon, R.N. 1968. Mucorales of India, Indian Council of Agricultural Research, New Delhi, 117pp.

- Tasugi, H. and Siino, H. 1940. Damping-off of seedlings of China Aster and Zinnia. Ann. Phytopath. Soc. Japan, **10**: 278-293 (RAM **20**: 1941).
- Taylor, G.S. 1953. Control of tobacco blue mold by root application of Zineb and Ferbam. Phytopathol. **43**: 486.
- Thakore, B.B. Lal; Jain, J.P. ; Singh. R.B.; Khandelwal , G.L. and Mathur, S. 1983 . Loss due to downy mildew of opium poppy and its reduction by application of fungicides. Indian Phytopath. **36**: 462-464.
- Thind , K.S. 1942. The genus *Peronospora* in the Punjab. J. Indian Bot. Soc., **21**: 197-215.
- Tompkins, C.M. and Middleton, J.T.1942. Root rot of *Ranunculus asiaticus* caused by *Pythium debaryanum*. J. Agric. Res. **XIV**: 179-183 (RAM **21**: 1942).
- Tripathi, N.N.; Dubey, N.K.; Dixit, A.; Tripathi, R.D. and Dixit, S.N. 1983. Fungitoxic properties of *Alpinia galanga* oil. Trop. Plant Sci. Res. **1**: 49-52.
- Tripathi, N.N. 1980. Fungitoxicity in some higher plants. Ph. D. Thesis. Gorakhpur Univ., Gorakhpur, India.
- Tripathi, R.D. 1977. Assay of higher plants for antifungal and antibiotics and some aspects of mode of action of the active principle. Ph.D. Thesis. Gorakhpur Univ., Gorakhpur, India.

- Tripathi, R.D. 1981. Evaluation of products from some higher plants for their toxicity against fungi. Sci. Acad. Medals for Young Scientists-Lecture. Indian Nat. Sci. Acad. 307-318 pp.
- Tripathi. R.D.; Banerjee, R.; Sharma, M.L.; Balasubramanyam, V.R. and Nigam, S.K. 1985. Toxicity of essential oil from a new strain of *Ocimum gratissimum* (Clocimum) against betelvine pathogenic fungi. Agric. Biol. Chem., **49**: 2277-2282.
- Tripathi, R.D.; Srivastava, H.S. and Dixit, S.N. 1978. A fungitoxic principle from the leaves of *Lawsonia inermis* Lam. Experientia. **33**: 207.
- Tripathi, S.C. and Dixit, S.N. 1977. Fungitoxic properties of *Rosa chinensis* Jacq. Experientia. **34**: 51-52
- Uppal, B.N. ; Patel, M.K. and Kamat, M.N. 1935. The fungi of Bombay Dep. Agric. Bombay, Bull. No. **176**, 56 pp.
- Van Andel, O.M. 1961. Systemic meterial for the control of plant fungi. German Patent 1110942.
- Vander Meer, J.H.H. 1925. *Verticillium* wilt of herbaceous and wood plants. Meded.-Landbouwhoogeschool, Wageningen. **28**: 82 (RAM **4**: 1925).
- Van Poeteren, N. 1923. Verslag over de werkzaamheden van den plantenziektendundigen Dienst in hat jaar 1922. Versl. en Meded.

Plantenziektenkundigen Dienst te Wageningen. **31**: 57 pp (RAM **3**:1924)

Van Poeteren, N. 1929. Verslag over de werkzaamheden van den

Plantenziektenkundigen Dienst in het jaar Wageningen. **55**: 93 pp
(RAM **8**: 1929).

Van Poeteren, N. 1929. Verslag over de werkzaamheden van den

plantenziektenkundigen Dienst in het jaar 1932. Versl. en Meded.

Plantenziektenkundigen Dienst te Wageningen. **72**: 148 pp. (RAM
13: 1934).

Veselovskaya, M.A. 1933. The Poppy, its classification and its importance as

an oleiferous crop. Priklozherie n Trudam po Prikladnoi Botanike,
Genetike i Selektzii. **56**: 213 & XXII pp. (Biol. Abst. **9**: 1935).

Veselovskaya, M.A. 1976. The Poppy. American Publishing Co., New Delhi,

New York (translated from Russian).

Wager, V.A. 1931. Diseases of plants in South Africa due to members of

Pythiaceae. S. Africa Dept. of Agric. Sci. Bull. **105**: 43 pp. (RAM
11: 1932).

Wain, R.L. and Carter, G.A. 1967. Uptake translocation and transformations

by higher plants. 567-611 pp. In Fungicides: An Advanced
Treatise, (ed.) D.C. Torgesson, Vol. I., Academic Press, New York
and London.

- Wallin, J.R. 1946. **b**. Seed and seedling infection of barley, brome-grass, and wheat by *Xanthomonas translucens* var. *cerealis*. Phytopathol. **36**: 446-457.
- Woolley, D.W. 1945. Observations on antimicrobial action of 2,3-dichloro-1,4-naphthoquinone, and its reversal by vitamin K. Proc. Soc. Expt. Biol., Med. **60**: 225-228.
- Wronska, B. 1980. Studia biometryczno-eksperymentalne nad **grazybami** z rodzaju *Peronospora* porażającymi przedstawicieli *Papaver* L. Acta Mycol. **16**: 203-214 (**RPP 61**: 1982).
- Yarwood, C.E. 1936. The **d**iurnal cycle of the powdery mildew *Erysiphe polygoni*, J. Agric. Res. **52**: 645-657.
- Yarwood, C.E. 1936. Control of powdery mildew with water spray. Phytopathol. **29**: 288-290.
- Yossiflovitch, M. 1928. Kingdom of the Serbs, Croats and Slovenes: a **d**estructive disease of the poppy in **S**outhern Serbia. Internat. Bull. Plant. Protect. **ii** : 18-19 (**RAM 7**: 1928).
- Yassiflovitch, M. 1929. *Peronospora arborescens* (Berk) de Bary, un grave parasite due *Papaver somniferum*. Comptes. rendus. Acad. **d'** Agric. **de** France, **15**: 1010-1013 (**RAM 9**: 1930).

- Yossiflovitch, M. 1929. *Peronospora arborescens* (Berk) de Bary parasite tres important de *Papaver somniferum* en Yougoslavie. Rev. Path. Veg. et Engt. Agric. **16**: 235-270 (RAM **9**: 1930).
- Zaman, M.B. and Khan, A.S. 1969. Studies on some diseases of *Papaver somniferum* Linn. Pakistan J. Forest. **19**: 185-193.
- Zambettakis, C. 1952. Recherches sur l' Helminthosporiose de l' Oeillette et son traitement. Ann. Inst. Nat. Rech. Agron., Ser. C. (Ann. Epiphyt.) **3**: 11-59 (RAM **32**: 1953).
- Zaprometoff, N.G. 1925. (Diseases of cultivated plants in Middle Asia). Uzbekistan Plant Protec. Stat. Phytopath. Sect. Tashkent, 165 pp. (RAM **5**: 1926).
- Zaracovitis, C. 1964. Factors in testing fungicides against powdery mildews. I. A slide spore germination method of evaluating protectant fungicides. Ann. Appl. Biol., **54**:361-374.
- Zarzyca, H. 1958. Mikoflora Nasion Maku. Roczn. Nauk. rol.**78 (Ser.A)**: 309-342.
- Zimmer, D.E. and Zimmerman, D.C. 1972. Influence of some diseases on achene and oil quality of sunflower. Crop. Sci. **12**: 859-861.
- Zogg, H. 1945. Die Blattdure des Mohns. Verh. Schweiz naturf. Ges. **125**: 172 (RAM **26**:1947).
- Zogg, H. 1946. Zur Kenntnis pflanzlicher Abwehrreaktionen. Der Einfluss der temperature auf das Zustandekommen Der Gummansen

Demarkationszone. Ber. Schweiz. Bot. Ges. **56**: 507-522 (Biol. Abst. **22**:1948).

Zutschi, S.K.; Joshi, S.K. and Bokadia, M.M. 1976. The *in vitro* antimicrobial efficiency of some essential oils. Indian J. Med. Res. **64**: 854-857.

Zyubin, B. 1963. Zashita opiiinogo maka ot vreditelei i bokznei. Zel' skokhoz kirgizi i. **1**: 31-33, 1962; Referat. Zhur. Biol. 1963 (Translation), (Biol. Abst. **45**:1964).

APPENDIX-I
Natural (plant) products and their source

S1. No.	Vernacular name	Source plant	Family	Nature
1.	Cedarwood oil	<i>Cedrus deodara</i> (Royle ex. Lamb)	Pinaceae	Essential oil (Dixit <i>et al.</i> , 1979)
2.	Clocimum	A new hybrid strain of <i>Ocimum gratissimum</i> Linn. (Clocimum_leaves)	Labiatae	Essential oil (Tripathi <i>et al.</i> , 1985)
3.	Eugenol	Isolation from the oil of <i>Ocimum gratissimum</i> Linn.	Labiatae	Terpene (Tripathi <i>et al.</i> , 1985)
4.	Lawsonia	<i>Lawsonia inermis</i> Lam. (leaves)	Lythraceae	Naphthoquinone (Tripathi <i>et al.</i> , 1978)
5.	Lemongrass oil	<i>Cymbopogon flexuosus</i> (Steud.) Wats. (aerial parts)	Poacease	Essential oil
6.	Menadione	Patented by Sigma Chemical Co., St. Louis, Mo., U.S.A. 63172 (Source plant : undisclosed)	—-	Naphthoquinone
7.	Opium poppy oil	<i>Papaver somniferum</i> L. (seeds)	Papaveraceae	Fatty oil
8.	Terpinyl Acetate	Patented by Camphore & Allied Products, Bareilly (source plant : undisclosed)	—-	Terpene

APPENDIX-II

Synthetic commercial fungicides and their active ingredients

Sl. no.	Trade name	Source	Active ingredients
	Systemic fungicides		
1	Bavistin - 50wp	BASF India Limited, Bomboy – 400011	50% Carbendazim or methyl-1 H-benzemedazol-2 –Y1 carbamate
2.	Bavistin SD	BASF India Limited, Bombay – 400011	50% Carbendazim or (2-methoxycarbomy1) - benzemedazal
3.	Calixin 80 EC	BASF India Limited, Bombay – 400011	80% Tridemorph or N-tridecyl-2, 6- dimethyl morpholine
	Non – systemic fungicides		
4.	Blitox -50 wp	Rallis India Limited, Bangalore – 560025	50% Copper oxychloride
5.	Dithane M-45	Indofil Chemicals Limited, Bombay – 400025	75% Co- ordinated product of zinc ion and manganese ethylene bisdithiocarbamate (Mancozeb)
6.	Dithane Z-78	Indofil Chemicals Limited, Bombay – 400025	75% Zineb or zinc ethylene bisdithiocarbamate
7.	Sulfex-80 WP	Excel Industries Limited, Bombay – 400102	80% Elemental sulphur
8.	Agrosan GN	Imperial Chemical Industries, (I.C.I.) Calcutta	1% Mercury as phenyl mercury acetate and ethyl mercury chloride

APPENDIX- III

LIST OF RESEARCH PAPERS PUBLISHED BY THE CANDIDATE

1. A new fungal disease of *Zizyphus mauritiana* Lamk. in India. Fert. Technol. **14**: 286, (1977), (with R.S. Kanaujia).
2. A new host record of *Periconia byssoides* Pers. ex Me'rat from India. Fert. Technol. **14**: 287 (1977), (with R.S. Kanaujia).
3. Annotated list of fungi from Faizabad (U.P.) India – I. Indian J. Mycol . Plant Pathol. **8**: 183-194, (1978), (with R.S. Kanaujia).
4. Three new fungal diseases from India. Acta Botanica India. **6**: 92, (1978), (with R.S. Kanaujia and C.S. Singh).
5. A new leaf blight disease of *Tephrosia purpurea* in India. Indian J. Mycol . Plant Pathol. **9**: 100, (1979), (with R.S. Kanaujia).
6. A new fungal diseases of *Phlox drummondii* in India. Indian J. Mycol . Plant Pathol. **10**: 72, (1980), (with R.S. Kanaujia).
7. Annotated list of fungi of Faizabad . V. Indian J. Mycol. Plant Pathol. **11**: 292-293, (1981), (with R.S. Kanaujia).
8. A new wilt disease of *Brassica nigra* caused by *Fusarium oxysporum* f. *conglutinans*. Indian Phytopath. **34**: 84-85, (1981), (with R.S. Kanaujia).
9. Fungi associated with diseased floral buds of *Quisqualis indica* . Avadh Univ . Res. J. **1** : 58-61, (1982) , (with R.S. Kanaujia)
10. Some new fungal diseases of opium poppy (*Papaver somniferum* L.) Indian J. Plant Pathol. **3**: 213-217, (1985), (with R.D. Tripathi ; J.K. Johri and D.S Shukla)

APPENDIX-IV

Rating Scale

Six point (o to 5) rating scale

Rating No.

Intensity of the diseases

- 0 No infection, healthy plants free from diseases
- 1 1 to 10 per cent plants were covered
- 2 11 to 20 per cent plants were covered
- 3 21 to 50 per cent plants were covered
- 4 51 to 75 per cent plants were covered
- 5 76 to 100 per cent plants were covered

Nine point (o to 8) rating scale

- 0 No infection, healthy plants free from powdery mildew
- 1 Infection in traces , covering upto 1 per cent leaf area
- 2 Infection in small patches , covering 1to 2 per cent of leaf area
- 3 Very slight infection , covering 3 to 5 per cent of leaf area
- 4 Slight infection on leaves , covering 6 to 15 per cent of leaf area
- 5 Very moderate infection , white patches on leaves , covering 16 to 25 per cent of leaf area , stem showing slight infection
- 6 Moderate infection , white powdery growth , covering 26 to 50 per cent of leaf area, middle leaves showing heavy infection , stem moderately infected
- 7 Heavy infection, powdery growth with discoloured (brown to black) areas, covering 51 to 75 per cent of leaf area, stem heavily infected
- 8 Severe infection. powdery growth or discoloured (black) areas covering 76 to 100 per cent of leaf area. Stem severely infected showing discoloured areas, peduncle and capsule also with powdery mass