GENERAL INTRODUCTION
Agriculture is the main industry of our nation. Often, we import food materials from other countries. Such heavy imports enormously burden the exchequer paralysing all our development plans. Our people and the Government have launched a 'green revolution' to combat against this threat to the nation and to achieve self-sufficiency in food. The increase in food grain production alone may not be sufficient and so we have to change our food habits which should include a suitable proportion of fruits and vegetables in our daily diet. There is a need to increase the area under fruits and vegetables cultivation to provide a balanced diet with proper vitamins and minerals.

Fresh fruits and vegetables are quite perishable because of their high moisture content which makes them vulnerable to microbial decay as well as to physiological deterioration. Actual losses vary from season to season in all production areas. Overall losses are more in developing countries of the tropics where transportation and refrigeration facilities are likely to be minimal.

Microorganisms destroy perishable food materials in the store. It will not be an exaggeration to say that more food is sown than is grown, more food is grown than actually reaped, more food is reaped than is gathered and more food is gathered than stored. There is no doubt that a big
portion of this stored food does not reach the mouth of hungry millions.

The production of fruits and vegetables is often hampered to a large extent due to diseases, which are normally incited by different microorganisms. There has been a considerable difference in the qualities of gross production and the net available production for consumers. It is due to various reasons, like inadequate transport facilities, packing and storage. In India, the yield figures of per unit area of any agricultural commodity is unfortunately still low when compared to other countries inspite of rapid progress made in agricultural sciences. One of the reasons of this low yield is due to the damage caused to our crops by various types of diseases. Plant pathologists and mycologists have devoted and still continue to devote their attention towards the control of these crop diseases. Fruits and vegetables provide quite suitable substrate for many microorganisms to thrive well. The diseases destroy the tissues and also reduce the quality and nourishment of the fruits.

In India, adequate transit, storage and marketing facilities are generally not available. It leads to the great destruction of fruits and vegetables. In view of this, more attention is required towards this aspect of plant protection. The data collected from some studies carried out in India on postharvest diseases of fruits and
vegetables, put the average loss approximately 20-30%. All fruits in India occupy an area of about 1.5 million hectares and the total production of fruits is approximately 8 million tons. A sample survey of Jabalpur market has shown a loss ranging from 13.9 to 26.6 per cent for tomato, 10 to 15% for brinjal and 8 to 15% for some cucurbits (Choudhary, 1968). Loss inflicted by infectious diseases on certain fruits in Delhi was estimated by Chenulu and Thakur (1968). They reported the loss for apples (10.6%), banana (31.4%), mango (17.7%), tomato (19.3%) and potato (24%). Thus these samples indicate the seriousness of the problem of postharvest diseases. Eckert and Sommer (1967) have indicated that economic losses caused by postharvest diseases were heavier than generally realized, because fresh fruits and vegetables increase several folds in value while passing from the field at harvest to consumer.

Huge losses are incurred in various parts of our country on account of spoilage of fruits during transit and storage. The magnitude of the problem can be gauged by the fact that in USA in spite of the rapid scientific advancement made in the schedule of control measures which in most cases are scrupulously followed, the losses of this nature run into several million dollars. In India, very little attention has been paid to this phase of the problem and such diseases are sources of continuous drain on our already acute food situation. The potentiality of methods
of preserving what is harvested needs our most careful attention. A number of treatments are being used in USA, Britain, Australia and other countries to reduce the incidence of such losses. The object of most of these treatments is to kill or inhibit the growth of rot inciting microorganisms which otherwise would be able to cause infection on the fruits through the minute bruises sustained during harvesting, grading, packing and transporting the product. "Over the last twenty to thirty years, the agricultural production has increased dramatically, and yet interest in the protection of crops against postharvest losses has never gained the same momentum. Some wastage of crops or animal produce is, by the very nature of the harvesting processes, inevitable, but the avoidable losses 'between the farm gate and the consumer' give cause for real concern" (Robinson, 1983).

In the past few decades we have acquired much knowledge in the control of postharvest diseases of fruits and vegetables but either due to the lesser popularity of the control methods or on account of unawareness of our farmers, we still suffer substantially. A good amount of work has also been carried out in India and other countries on postharvest diseases of fruits and vegetables occurring during transit and storage (Saha, 1945; Sinha, 1946; Agrawal, 1949; Walker, 1952; Bhargava and Gupta, 1957; Hingorani et al., 1960; Friedman, 1960; Sommer, 1982; Mehta,

It has now been well understood that disease manifestation is not only the play of pathogen but is the result of complex interactions between host and the pathogen. In recent years, plant pathologists and mycologists have undertaken studies on physiological and biochemical aspects of the disease so as to understand its causation and to apply suitable control measures. Biochemical studies give an insight to the host-parasite relationship as well as to the interaction caused by therapeutic or fungicidal agents. Adequate information about the mechanism for different host-parasite interaction is essential for devising suitable methods for disease control.

There may be no more compelling reasons to study cell wall degrading enzymes than the observations that every microbial plant pathogen examined has shown the ability to produce such enzymes (Albersheim et al., 1969). Diseases of plants mainly 'rots' are generally caused by certain enzymes secreted by the pathogen into the host or host-pathogen interactions. The cell wall is decomposed by the enzymes and the pathogen gets nutrition from host cells by killing them. The exact role of cell wall degrading enzymes is not fully understood. Many non-pathogenic and less virulent strains of microorganisms also found to produce considerable amount of these cell wall degrading enzymes which may or may
not show any correlation between pathogenic potentiality of the organisms and their ability to produce cell wall degrading enzymes in vitro or in vivo.

In enzymological studies the concept of regulation by controlling the production and activity of enzymes involved in the pathogenesis with the help of various chemicals has acquired a great deal of fundamental and applied importance. Besides induction of resistance of the host against the action of various enzymes of the pathogen can also be a good approach for the control of various plant diseases.

Considering the commercial importance, perishable nature and extent of losses during transportation and storage, it was thought desirable to work on the fungi responsible for causing postharvest diseases of fruits. With the above ideas and background in mind, the present investigation was undertaken to select the soft rot pathogens of more economically valuable fruits. During the survey of local markets and cold storages, diseased fruits of alubukhara, grape, mango, guava, cheeku, pear, orange, pomegranate were collected and their causal organisms were isolated and identified.

Prunus domestica (alubukhara) is an important fruit cultivars grown in Himachal Pradesh and Nilgiris in South India. It has to be transported after harvest to distant places. During transit and storage, fruits are often attacked by different microorganisms. This generally owes
to the carelessness of the growers during plucking, packing and mishandling of the fruits with the result that the fruits often get small injuries on the surface which helps the pathogen to invade directly into the host tissues. Amongst other diseases of alubukhara, a new soft rot disease caused by *C. granati* was found to be very serious and common.

*Vitis vinifera* (grape) is also one of the major fruits grown in many parts of India. A new and serious fruit rot disease of grapes caused by *Geotrichum candidum* was noticed in local markets and cold storages of Sagar. This disease is of severe nature and renders the fruit unfit for consumption and lowering down its nutritional value, soon.

On looking to the importance of alubukhara and grape fruits in the market and their huge spoilage due to *Coniella granati* and *Geotrichum candidum*, respectively, the present problem was selected. These fungal forms have also not been recorded on their respective hosts so far, therefore, they are the new additions to our records. The present investigation has been taken to evaluate the pathogenic nature of the test organisms, role of environmental conditions, biochemical changes and various cell wall degrading enzymes during pathogenesis of these fruit rot diseases. Finally, a trial has also been made to control the disease development *in vitro* and *in vivo* conditions, using various chemicals and other substances.
The present investigation has been planned on the following lines:

PART I : General

This part deals with the description of the host, the pathogen and the common diseases.

PART II : Pathogenicity

This part includes isolation of the pathogen, pathogenicity tests, different inoculation experiments and effect of various factors, like temperature and age of culture on disease development.

PART III : Study of metabolites

In this part, investigations have been carried out to analyse amino acids, sugars, organic acids and phenols of both healthy and diseased alubukhara and grape fruits.

PART IV : Enzymological studies

This part consists of detailed investigations of pectolytic and cellulolytic enzymes produced in vivo and in vitro conditions. Effect of different culture media and native carbon sources has also been studied.

PART V : Control measures

This part deals with the effects of various antibiotics, trace elements, homoeopathic drugs, leaf extracts and stem extracts on the radial growth, fruit rot
development and on the production of pectolytic and cellulolytic enzymes in vivo. Effect of some edible oils and volatile compounds has also been studied against the rot development and mycelial growth, respectively, in both the cases.
PART - I

GENERAL
PRUNUS DOMESTICA LINN. SYN. P. COMMUNIS HUDS.
(ALUBUKHARA SYN. PLUM)

A small tree, with twigs pubescent when young; flowers white, usually in clusters; fruits firm in texture, varying in colour from green and golden yellow to red and dark purple; stones large, rough and pitted. Prunus domestica is thought to be a native of the Caucasus and trans-Caucasus regions. The plums are cultivated largely in Europe. The area under the plums in Himachal Pradesh is about 750 hectares. The plums are cultivated (60-80 ha.) in the Nilgiris in South India.

Plums contain appreciable amounts of sugars and carotene (Vitamin A). Analysis of the edible portion (90-93% of the fruit) of the red plums contains: moisture, 86.3; protein, 0.7; fat, 0.4; other carbohydrates, 11.7% and minerals, 0.5%; calcium, 10; phosphorus, 20; iron, 1.4; potassium, 190; copper, 0.05; nicotinic acid, 0.1; ascorbic acid, 0 mg/100 gm; vitamin A value, 166 I.U./100 gm. The presence of citric, tartaric and malic acids have been reported in plums. Glucose (3.0-6.2%), fructose (2.7-6.1%) and sucrose (0.7-4.8%) are also found to be present in plum fruits. The average pectin content (calcium pectate) ranged from 0.8 to 1.3 per cent (Wealth of India, 1969).

Plum pits (2.3-6.0% of the fruit) yield up to 26.7 per
cent of kernels which are bitter and contain: water, 9.6; protein, 20.2; fat, 39.5; lecithin, 0.15; carbohydrates, 15.0; fibre, 12.2; ash, 3.4; and hydrocyanic acid (free), 0.06%. The kernels also contain amygdalin and phosphatides (0.3% in the seed).

The various types of plums come to harvest during the months of July and August. The fruits are harvested when they have developed good colour, but are still firm enough to withstand transport to distant markets.

Plums are used as dessert. They are cooked and eaten, canned and dried, and sometimes also made into jams. In Uttar Pradesh certain types of plums are dried successfully without the removal of the pit and are distinguished as Prunes. In the Pacific coast area of America and in some areas of central and Southern Europe, large quantities of the fruit are dried and made into prunes.

Prunes are canned and used for the preparation of prune pulp and prune beverage. The pulp finds some use in ice-cream mix, in fountain drinks, in bread making, candy, jelly, breakfast cereals, custards, fancy pastries and meat sauces. Pitted prunes are excellent for fruit cakes, plum pudding and pies, and can be used as a substitute for raisins. Alubukhara gives a fairly good canned product and the juice of alubukhara can be made into a squash.
Plum kernels yield about 39-42 per cent of a fatty oil which resembles expressed almond oil and can be used for the same general purposes. Plum kernel oil possesses good keeping qualities and can be used as a substitute for almond oil. It is suitable for lubricating finer machinery after admixing with light mineral lubricating oil. The oil is extracted in the plum-growing hilly areas in India to a limited extent and used for lubricating, cooking and hair dressing purposes and as illuminant.

Common diseases of *Prunus domestica* Linn. (Alubukhara)

A large number of fungi are known to damage this fruit in fields and many times during harvest, storage and transportation. Hasija and Agrawal (1977) observed the fruit rot of plum infected by *Trichotheccium roseum*. *Cercospora prunicola*, *Mucor circinelloides*, *Polystigmina rubra*, *Ucinula prunastri* and *Verticillium albo-atrum* are known to cause diseases on *Prunus domestica* fruits (Bilgrami et al., 1981). Chopra (1982) studied fruit rot of alubukhara caused by *Aspergillus niger*. Pusey and Wilson (1984) noticed fruit rot of plums caused by *Monilinia fructicola*. Michailides et al. (1987) studied storage rot of *Prunus domestica* due to *Rhizopus stolonifer*, *Monilinia laxa*, *Botrytis cinerea*, *Cladosporium herbarum*, *Penicillium* sp., *Alternaria alternata* and *Aspergillus ochraceous*. Krishnaiah and Thirupathaiah (1990) described the fruit rot of alubukhara due to *Aspergillus niger*, *Monilinia fructicola*...
and *Trichoderma viride*. A new fruit rot disease of alubukhara caused by *Coniella granati* has been reported for the first time in the present studies. The infection starts in mid region and spreads throughout the fruit soon. Small circular, light brown, water soaked spots can be noticed on ripened fruits due to which internal tissues disintegrate soon and turn dark brown and later the whole fruit becomes very pulpy (Plate 1).
PLATE-1. Healthy and diseased fruit of alubukhara

H = Healthy
D = Diseased

PLATE-2. A culture of Coniella granati
**VITIS VINIFERA LINN. (GRAPE)**

*Vitis vinifera* is the most important and universally cultivated grape-vine. A large deciduous climber, leaf-opposed, long, often bifid tendrils, cultivated in many parts of India. Berries are variable in size, ovoid to globose, greenish, purplish or bluish black, edible and generally sweet. The seeds are 2-4, pear shaped with a discoidal tubercle at the back.

The culture of *vinifera* grapes is extensive and most successful in the warm-temperate regions of the Northern Hemisphere. In India, grapes are grown on a commercial scale in two comparatively different climatic areas, viz. in the States of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu in the Deccan Peninsula, and in the plains of Punjab, Haryana, and Delhi in the North-West. The cultivation of grapes has also been undertaken in parts of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh and Rajasthan.

The fruit pulp contains: moisture, 85.0%; total sugars, 14.6%; acids, 0.41%; tannins, 0.31%; protein, 0.9%; ash, 0.57%; Ca, 14.2%; P, 32.0% and Fe, 1.5% (Wealth of India, 1976). Grapes are a good source of biflavonoides (vitamin P) which are known to be useful in such conditions as purpura, capillary bleeding in diabetes, oedema and
inflammation from injury, radiation damage, and atherosclerosis.

Out of the total world production of grapes, 80 per cent is crushed for wine-making and seven per cent is dried into raisins. Some quantity is consumed as fresh fruit or processed juice. Grapes have a pleasant flavour. Large size, thin skin and brilliant colour are appreciated in table grapes. A large varieties (Anab-e-shahi, Bangalore Blue, Cheema-7, Cheema-94, Kali Sahebi, Muscat Hamburg, Perlette and Thompson seedless) of grapes are grown in India.

Grapes, both fresh and dried, have varied uses in Ayurvedic and Unani system of medicine. Fresh grapes are considered laxative, stomachic, diuretic, demulcent and cooling; raisins are also demulcent, laxative, cooling and expectorant. Grapes are extensively used in various medicinal preparations. The popular tonic Drakshasava is made from grape-juice. Similarly, grapes have entered into the preparation of Chyavanaprasa. The juice of the unripe berries is used as an astringent in throat infections. The leaves are astringent and are sometimes used in diarrhoea. The sap of the young branches is reported to be used for skin diseases and ophthalmia.
Common diseases of *Vitis vinifera* Linn. (Grape)

Bitter rot diseases of grapes caused by *Melanconium fuligineum* and *Greeneria fuliginea* have been reported by Ridings and Clayton (1970) and Prakash *et al.* (1974), respectively. Major decay pathogens of cold-stored grapes are *Botrytis cinerea*, *Cladosporium herbarum*, *Alternaria* sp. and *Stemphylium* sp. (Hewitt, 1974; Nelson, 1985). Bilgrami *et al.* (1981) reported a number of fungi (*Alternaria alternata*, *Alternaria longipes*, *Alternaria vitis*, *Cladosporium cladosporioides*, *Coniella diplodiella*, *Fusarium solani*, *Gloeosporium ampelophagum*, *Greenaria fuliginosa*, *Penicillium chrysogenum*, *Phoma glomerata*, *Phoma vitis*, *Pestalotia viticola*, *Plasmopara viticola*, *Rhizopus arrhizus* and *Uncinula necator* on *Vitis vinifera* fruits. Reddy and Reddy (1983) noticed fruit rot of grape caused by *Greeneria uvicola*. Pscheidt and Pearson (1989) studied the fruit rot of grape caused by *Phomopsis viticola*.

In the present studies, a new post-harvest disease of grapes incited by *Geotrichum candidum* has been recorded. The first symptom of the disease appeared on matured fruits as small light-brown spots. Maximum infection was noticed at the stalk end region of the fruit. The diseased area gradually increased in size and fruits become soft very soon (Plate 3).
PLATE-3. Healthy and diseased fruit of grape

$H = \text{Healthy}$

$D = \text{Diseased}$

PLATE-4. Culture of Geotrichum candidum
THE PATHOGENS

Coniella granati (Sacc.) Petrak and H. Sydow

The young colony of the fungus in culture was whitish brown, ringed pattern and somewhat aggregated. Mycelium immersed as hyaline, branched and septate. Conidiomata are pycnidial type and average size 121.88 μm diam., separate, globose to subglobose, thin-walled and pale brown; ostiole simple, circular, central and not protruding; conidiophores absent; pycniospore average size 13.45 x 2.85 μm, aseptate, slightly curved, fusiform, pale brown, smooth and thick walled (Fig. 1). The fungus was identified as Coniella granati (Plate 2) which has not been reported on Prunus domestica, so far. A viable culture of this fungus has been deposited in I.M.I., Kew (IMI No. 345208).

Geotrichum candidum Link.

Colony was white, mycelium septate, conidiophores absent, conidia (arthrosposes) hyaline, one-celled, short, cylindrical with truncate ends, formed by segmentation of hyphae having average size 5.7 μm (Fig. 2). The fungus (Plate 4) was identified as Geotrichum candidum (IMI No. 345227). This is a new host record as this fungus has not been recorded on grapes so far.
Fig. 1. *Coniella graniti*
A... pycnidia,  B... pycniospores.

Fig. 2. *Geotrichum candidum*
(mycelium with arthrospores)