**Sustainable Biological Management of Important Temperate Fruit Diseases for Quality Fruit Production**

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**Introduction**

Agro-climatic conditions in hilly states offer immense natural potential for increasing area and production under temperature fruits, especially apple. The production of these fruits is influenced to a great deal due to various diseases caused by fungi, bacteria and viruses. These diseases result in heavy losses to the farmers. To minimize the losses due to the diseases, farmers employ chemical control measures in fruit production system. Chemical fungicides which are used on fruit crops are posing threat in the form of environment and health hazards. In modern era of organic farming the use of chemicals is being discouraged. Also the development of resistant pathogen populations against the chemicals has stimulated interest in the formulation of integrated disease control system. Biological control would appear to have significant potential in terms of both environmental and economic issues for incorporation into organic and conventional temperate fruit production systems. Perennial cropping systems such as temperate fruits production provide unique opportunities and impediments to the use of biological control (Anwar et al.2008) measures especially during the process of plant establishment. Several opportunities will exist in the nursery environment for the application of microbial inoculants such as biocontrol agents or mycorrhizal fungi. An additional opportunity for introduction of biocontrol agents exists at the time of orchard establishment.

**Soil-borne diseases**

**Replant Problem**

Cultivation of fruit trees is rapidly changing, with growers planting high density orchards of trees on dwarfing rootstocks instead of low density orchards with vigorous trees. Because of the limited land available to plant new orchards, growers are compelled to lay out new plantation on the old orchard site. Due to this replant problem has become major concern of growers. The problem of establishing fruit trees in old nurseries or orchard sites is generally known as replant problem or replant disease. Replant problem includes biotic and abiotic factors that cause poor growth and delayed fruit production. Replant disease is caused by biotic factors and is one of the components of the replant problem. Replant problem is a complex malady of temperate fruit crops. It is caused by abiotic and biotic factors. Abiotic factors including phytotoxins, imbalance nutrition, poor soil structure, poor drainage, cold or draught stress and excess or lack of soil moisture contribute to the occurrence of replant problem. Among biotic factors various fungi, bacteria, nematodes and actinomycetes have been reported to be associated with replant disease. Various species of fungi like *Fusariumequiseti, F. oxysporum, F. solani, Rhizoctonia*spp., *Cylindrocladium spp., Rosellinianecatrix, Penicilliumclaviforme, P. janthinellum, Phytophthora*spp., *Puthium*spp*., Cylindrocarpon*spp*.,* of bacteria like *Pseudomonas* spp. and *Bacillus* spp., and of nematodes like *Pratylenchuspenetrans*and X*iphinema*spp. have been found associated with replant disease by various workers (Utkhede, 1996). The cause of the replant problem varies from region to region. Depending upon the causal factor involved in the replant problem different control measures including cultural practices, chemicals, bioagents and host resistance have been suggested to control this. Chemical control with soil fumigants is the most adopted method of controlling replant disease all over the world. But it is not an attractive approach as the effectiveness of volatile fumigants is influenced by temperature and moisture. Also the application of fumigants is difficult, expensive and hazardous. Moreover, soil fumigation is believed to destroy the natural equilibrium between pathogens and antagonistic microorganisms in soil. In this regards attempts have been made to develop a biological control of replant problem. A number of studies have demonstrated benefits resulting from application of plant growth promoting and disease suppressive rhizobacteria to subsequent growth of apple in replant soil (Caesar and Burr, 1987; Utkhede and Li, 1989b; Janisiewicz and Covey, 1983). A diversity of bacterial species has been identified that suppress individual causal elements and enhance growth of plants in replant soil. Biological control of *Phytophthoracactorum*which contributes to replant disease (Mazzola, 1998) has been reported in response to application of *Enterobacteraerogenes*(Utkhede and Smith, 1991). Application of strain B8 of *E. Aerogenes*alone was found increasing growth of apple seedlings in replant soil (Utkhede and Li, 1989a). Similarly, BACT-1, EBW and B10 strains of *Bacillus subtilis*and B8 strain of *E. Aerogenes*applied as soil drench increased plant growth over and above that of formalin fumigation (Utkhede and Li, 1989b). The inoculation of roots of young apple plants with *Agrobacterium radiobacter*has eliminated replant problems in greenhouse and nursery experiments (Catska and Hudska, 1990). This biocontrol agent reduced the number of colonies of phytotoxic micromycetes which contribute towards replant disease. *Pseudomonas putida*strain 2 CB isolated from apple roots was found to inhibit growth of each element of the fungal complex reported to incite replant disease and enhanced growth of M-26 root stock in multiple apple replant soil (Mazzola*et al*., 2002). Casear and Burr (1987) identified two fluorescent pseudomonads and an enteric bacterium possessing the ability to promote growth of apple in replant soils. Enhanced growth by these rhizobacteria was associated with a reduction in root infection of *Cylindrocarpondestructans*, a fungal pathogen known to contribute apple replant disease (Jaffe *et al*., 1982; Mazzola, 1998). Application of *Bacillus subtilis*and *Enterobacteraerogenes*has also been found effective in promoting growth of apple plants even under filed condition in British Columbia, Canada (Utkhede and Smith, 1994). These results indicate that these species of rhizobacteria have a potential for biological control of replant disease. Various studies have indicated that phosphorus is an essential nutrient for early growth of young plants in replant soil. Mycorrhizae symbiosis can improve nutrient uptake, particularly for immobile ions such as phosphate (Mosse, 1973). As a result of increased uptake of mineral nutrients from soil, mycorrihizal plants grow more vigorously and appear healthier than non mycorrhizal plants. However, these beneficial fungi are eliminated when replant disease is controlled by soil fumigation (Nemec, 1980). Inoculation of apple seedlings with arbuscularmycorrhizal fungi (AMF) was increased their growth is replant disease soil (Catska and Taube-Baab, 1994). Inoculation of apple seedlings with AMF *Glomusfasciculatum*and *G. Macrocarpus*suppressed the population of phytotoxic micromycetes, responsible for replant disease and increased plant biomass (Catska, 1994). Two AMF, *Glomusintraradices*and *G. Mosseae*significantly increased total shoot length and number of shoots per rootstock in replant soil. The seedlings inoculated with *G. Mosseae*showed increased growth in replant soil which was neither pasteurized nor fertilized (Utkhede*et al*., 1992). Preplant sterilization of soil and subsequent inoculation with AMF, *Glomusepigaeum*significantly controlled the replant problem of apple and peach. It was observed that the growth promotion by inoculation with AMF was more in autoclaved replant soil (Bingye and Shengrui, 1998).

**Root rot**

Root rot is a very serious soil-borne disease infecting temperate fruits especially apple. It is caused by *Rosellinianecatrix*Berl. exPrill. (Anam.*Dematophoranecatrix*Hartig).The perfect stage of the fungus is not known to occur in India. The fungus has a wide host range of about 158 plant species belonging to over 45 families (Ito and Nakamura, 1984) comprising of fruit plants, forest trees and vegetable and field crops. In India the disease was first observed by Singh in 1939. Agarwala (1961) observed the disease on apple trees in Himachal Pradesh. The annual losses estimated due to this disease are about Rs. 1.3 million (Agarwala and Sharma, 1966) which are expected to be much more as the disease is reported to occur in all apple growing regions of the country. The pathogen affects the underground parts of the trees. The lateral roots turn dark brown and are covered with greenish gray or white mycelial mat and with the progress of disease all the roots are attacked and fibrous root system disappears. Whitish mycelial mat like fungal growth is visible during monsoon on the affected parts. The affected plants show bronzing of the leaves and progressive decline and ultimately die within 2-3 years of infection. The pathogen survives in the form of mycelium or sclerotia in the infected roots. The infection of new roots takes place by the fungal mycelium present in the soil on debris or by the contact of new plant roots with the old dead roots. The disease is more serious in water logged acidic soils. Management of root rot is very difficult because of deep seated infection. It is very difficult to make the reach ofremedial measures up to the point of infection. It can be managed by practicing preventive as well as curative measures consisting of cultural, biological and chemical methods and resistant root stocks. Biocontrol of soil borne pathogens with antagonistic fungi and bacteria has been under intensive investigations for the last many years. This method has gained considerable attention and appears to be promising as a viable supplement or alternative to chemical control. Ieki*et al*. (1969) have reported the inhibition of *R. Necatrix*by different isolates of *Trichoderma* spp. Species of *Trichoderma* viz., *T. harzianum* and *T. Hamatum*isolated from naturally roots rot infected root inhibited the growth of the fungus *R. Necatrix*(Freeman *et al*., 1986.) The use of antagonistic *Trichoderma* spp. against the disease has also been explored along with soil solarization (Sztejnberg*et al*., 1987). Reduction of root rot by using the antagonists like *T. harzianum, T. Koningii*and *T. viride* has also been noticed under pot culture studies (Sharma, 1993). Fungal antagonists *T. harzianum* and *T. viride* and bacterial antagonists *Pseudomonas fluorescens*and *Bacillus* spp. have proved effective in controlling root rot under pot culture studies (Sharma, 2000). Other bacterial antagonists *Enterobacteraerogenes*have been found to protect the plants from *D. Necatrix*(Gupta and Jindal, 1989). Repeated application of these antagonists enhanced their efficacy against the pathogen and the effect persisted for longer period. Besides antagonistic fungi and bacteria the arbuscularmycorrhizal fungi (AMF) have also been used against soil borne diseases. Bharat and Bhardwaj (2001) while studying the interactions between AMF and root rot pathogens *D. Necatrix*on apple seedlings under pot culture found that the apple seedlings previously inoculated with local AMF isolate of *Glomus*spp. showed less root rot severity as compared to the seedlings which were not inoculated with *Glomus*spp. The mycorrhizal seedlings also exhibited increased growth.

**Crown rot**

Crown rot, also known as collar rot is prevalent in all apple growing regions of the world. It is caused by a fungus *Phytophthoracactorum*(Lebert- Cohn) Schroeter. The disease causes extensive losses sometimes resulting in death of trees. The infection starts from the collar region and spread mostly to underground parts and the above ground stem. Bark at the soil level becomes slimy and rots resulting in cankered area. The attacked trees show chlorotic foliage with red colouration of veins and margins. The causal fungus in known to survive in the orchard soils as chlamydospores in plant debris or soil. The fungus produces oospores which serve as the source of primary inoculum. Moderate temperature and high soil moisture favour the disease. For the management of this disease attempts have been made by using chemicals, cultural practices and through host resistance. But the use of biological agents for controlling *P. cactroum*has also been tested by various workers. Roiger and Jeffer (1991) evaluated *Trichoderma* spp. against *Phytophthora*crown rot of apple and found that *T. virens*, *T. koningii*and *T. harzianum* were effective in controlling the disease. Other species of *Trichoderma*, *T. longibrachiatum*, *T. viride* also proved effective in controlling *P. cactorum*in apple (Kumar, 2002). Some bacterial antagonists have also been found effective in checking the disease. Utkhede (1983) showed that bacterium *Enterobacteraerogenes*was antagonistic to *P. cactorum*. When this antagonistic bacterial cells were applied as soil drench, reduced the infection of *P. Cactorum*in McIntosh apple seedlings. Other bacterial antagonists such as *Pseudomonas* spp., *Bacillus subtilis*were also found affective against *Phytophthora*crown rot (Janisiewicz and Covey, 1983; Utkhede, 1984). Antifungal activity of *E. aerogenes*and *Bacillus* spp. against *P. cactorum*was also observed by Gupta and Utkhede (1986) and with the treatments of apple plants with these antagonists even managed the crown rot infection under field conditions (Utkhede, 1987). Effect of soil drenching of apple trees with *E. aerogenes*was evaluated for three years by Utkhede and Smith (1991) in British Columbia with god control of the disease. Apple trees treated with strain B8 of *E. Aerogenes*for two consecutive years not only reduced *P. Cactorum*infection but also increased the plant height (Levesque *et al*., 1993). It has also been demonstrated that antibiotics produced by *E. Aerogenes*provide protection to apple trees from infection by other soil borne pathogens (Marchi and Utkhede, 1994). Another species of antagonistic bacterium *Enterobacter*, *E. agglomerans*have also been reported to reduce disease severity and increase the trunk girth and fruit yield in McSpur apple on MM 106 rootstock which is otherwise susceptible rootstock for crown rot (Utkhede and Smith, 1997). Lyophilized dry formulation of strain B8 of this antagonist proved effective. Another product Binab-1 formulated from antagonist *Trichoderma viride* have proved successful in controlling *P. cactorum*infection in apple seedlings (Orlikowski and Schmidle, 1985). Application of bacterial antagonistic *E. agglomerans*and *B. subtilis*along with arbuscularmycorrhizal fungus *Glomusintraradices*in a six year experiment significantly reduced the infection of apple plants with *P. cactorum*and increased fruit yield and tree trunk growth (Utkhede and Smith, 2000). The application of this antagonist has also been tried in combination with fungicide metalaxyl as soil trunk drench twice in a year for three years and once in spring for seven years. The combined application reduced disease ratings of *P. Cactorum*(Utkhede and Smith, 1993). Similarly the same combination (each 1g/tree) when applied once in a year resulted higher annual increase in trunk diameter of effected apple plants (Levesque *et al*., 1993). Kumar (2002) has observed that pre inoculation of apple seedlings with *Trichodermalongibrachiatum*along with simultaneous inoculation with *Bacillus subtilis*effectively controlled *P. Cactorum*infection in apple seedlings under pot cultures.

**Foliar and fruit diseases**

**Apple scab**

Apple scab occurs worldwide and is the most important disease of apples. Its primary effect is reduction of the quality of fruits. It also reduces size and results in premature fruits drop, defoliation and poor fruit bud development for the next year, and it reduces the length of time infected fruit can be kept in storage. In India the disease was first noticed in Kashmir in 1930 (Nath, 1935). This disease appeared in epidemic form in 1973 and caused large scale damage to apple crop in Kashmir. In Himachal Pradesh the disease was noticed in 1977 (Gupta, 1978) and spread to epidemic form in 1983 (Gupta, 1989). The disease destroyed most of the apple crop in the state. The disease was declared as one of the five main plant diseases of national importance of Government of India. The disease symptoms are observed on leaves, petioles, blossoms, fruits and pedicels. On emerging leaves velvety brown to olive green lesions appear first on lower surface and later on the both the surfaces. As the infected leaf ages, the tissue adjacent to the lesion thicken resulting in deformed leaves. The number of lesions may range from one to many and sometimes the entire surfaces become covered with scab and the term sheet scab is used to refer this type of symptoms. Infection of petioles and pedicels result in premature defoliation of leaves and fruits. On fruit similar lesions appear as the infected fruit enlarge the lesions become brown and corky. The disease is caused by a fungus *Venturiainaequalis*(Cke.) Wint. Both the imperfect and perfect stages of the fungus are encountered in nature. The perfect stage is produced in overwintered leaves or fruits on the orchard floor. The pseudothecia formed of diseased fallen leaves in the presence of moisture continue to mature with development of asci and ascospores. The mature ascospores are discharged over a period of 5 to 9 weeks which coincides with time between pink and full bloom stages of apple bud development. Once the primary infection has taken place, the secondary infection is through the conidia produced on the primary lesions. Adequate moisture is essential for the discharge of ripe ascospores from the pseudothecia. The germination of ascospores takes place under suitable temperature and moisture (leaf wetness) condition. The conditions of temperature and leaf wetness duration for scab infection are well defined on Mills period or Tables. On the basis of weather data and amount of primary inoculum scab prediction and warning has become possible and an advantage in the monitored apple scab control programme especially in Himachal Pradesh. For the management of the disease in India a protective fungicide spray programme is being adopted. The first spray of protective fungicide must start at silver tip stage. And this way, 6-7 sprays of various fungicides are needed during the growing season which causes pollution and health hazards. Hence the work on resistance breeding and biological control of apple scab was initiated. The work on biological control is primarily focused on the control of overwintering stage of the pathogen on leaf litter. Carisse*et al*. (2000) have studied the effect of antagonistic fungi viz., *Microsphearopsis*spp. *Diplodia*spp. and *Trichoderma* spp. on ascospore production under natural conditions either as foliar postharvest sprays or as a ground application at 90% leaf fall. They found significant reduction in ascospore production. Antagonistic fungus *Microsphaeropsisochraceae*has been considered as potent bio-sanitation agent against apple scab as this fungus kills the resting structures of *V. Inaequalis*and thereby reduces disease in the subsequent crop reason by lowering the initial inoculum (Carisse*et al*., 2007). In Canada use of biocontrol agents for the management of apple scab has become popular in organic apple production (Carisse and Dewdney, 2002). Use of antagonistic fungi to control overwintering stage of scab pathogen in fallen leaves is seen as an alternative to chemical control measures (Bengtson*et al*., 2001). Yeasts isolated from apple leaves have also been evaluated against *V. inaequalis*for their antagonistic activity (Fiss*et al*. 2003). Three strains H 10, H 15 and H 25 were found to suppress scab severity on apple seedlings under greenhouse trials. Application of a concentration of 1.5 x 107 yeast cells per ml on 9 year old apple tree cv. Golden Delicious led to significant reduction in scab. Altinok and coworkers (2002) studied antagonistic effect of 30 different fungal isolates against apple scab on three cultivars of apple viz. granny Smith, Stark spur Golden and Starkrimson. Some isolates such as C*ryptococcus* spp. (white yeast), *Sporobolomyces*(pink yeast), *Alternaria*spp., *Epicoccum*spp. and *Popularia*spp. were found to produce volatile antibiotics and resulted 100% inhibition of colony development of scab pathogen. Some biofungicides have also been evaluated against apple scab. Pleskatsevich and Berlinchick (2004) evaluated Fruitine, a biofungicide formulation of *Bacillus subtilis*strain BIMV 262 under integrated disease control system against scab and observed reduction in the disease. Other biofungicide formulations viz., Dizofungin, Biostat and Narciss of fungal and bacterial species were found to induce resistance in apple plants against scab in Russia (Nadykta, 2004).

**Apple powdery mildew**

Powdery mildew of apple is a major foliar disease prevalent in all apple growing countries of the world. The disease was first noticed on apple seedlings in Iova, USA in 1871 (Bessey, 1877). It is caused by the biotrophic fungus *Podosphaeraleucotricha*(Ell. and Ev.) Salm. It can be a significant commercial problem in every stage of apple development, from reducing the growth of nursery stock to causing fruit russetting (Jones and Aldwinckle, 1990). In apple the pathogen overwinters in dormant buds, and infected buds may fail to develop new shoots during the subsequent growing season. Conidia developing from overwintering mycelium serve as the primary source of inoculum, and secondary spread of the pathogen is incited by inoculum that develops from infection of young leaves, blossoms and young fruits. Perfect stage of the pathogen is also reported in nature (Bharat and Bhardwaj, 2000) but is not believed to have a major role in the disease cycle. For biological control of powdery mildew all agents that have been reported to provide biocontrol have been fungal in nature. As powdery mildews are biotrophs and typically do not require exogenous nutrients for germination and initial penetration, control through competition for nutrients is not a viable strategy. Likewise as exposure of the pathogen on the leaf surface after spore germination is limited, control through antibiosis is not likely to be a suitable mechanism for disease control. As such the greatest attention has been focused on the use of mycoparasites for the control of powdery mildews. These include *Ampelomycesquisqualis*(Novitskaya and Puzanova, 1992). The mechanism of biocontrol by the fungus has been established as hyper-parasitism as this fungus possess the ability to colonize the mycelium of powdery mildew and produce reproductive structures. This fungus is naturally occurring hyper-parasite of both sexual and asexual structures of powdery mildew pathogen. It parasitizes and form pycnidia within powdery mildews hyphae, conidiophores and cleistothecia. The parasitized colonies of powdery mildew are dull in appearance, flattened off-white to gray in colour with reduced spore production (Falk *et al*., 1995). Vaidya and Thakur (2005) have also isolated *A. quisqualis*from affected apple plants and other plant species belonging to rosaceae family. It showed the natural occurrence of this hyper-parasite in western Himalayan region for managing powdery mildew disease. Use of plant extracts along with hyper-parasite especially walnut extract has also been found to reduce the primary infection of apple foliar diseases including powdery mildew and (Meszka and Bielenin, 2006). The mycoparasite*A. quisqualis*isolate A-10 has been released as a commercial product AQ 10 TM for biological control of powdery mildew (Grove and Boal, 1997). Another formulation Ampelomitsin form *Ampelomyces*spp. has been observed achieve 70-80 percent control of powdery mildew of temperate fruits (Smol-Yokova*et al*., 2004).

**Postharvest diseases**

Amongst temperate fruits stone fruits are comparatively more perishable and prone to postharvest diseases. Postharvest diseases result in 10-50 per cent losses to temperate fruits (Steppe, 1976). Many fungi and bacteria can cause postharvest spoilage and the major pathogens are species of *Alternaria, Aspergillus, Botyosphaeria, Botrytis, Colletotrichum, Monilinia, Mucor, Penicillium, Rhizopus and Trichothecium.* In most instances the postharvest pathogens gain entry to susceptible fruit tissues and cause infection via entry through fruits surface wounds that are generated through fruits surface wounds that are generated through the process of harvesting and postharvest handling. Some pathogens can also enter through natural opening like lenticels or decay may be initiated in the sinus between the calyx and core cavity (Spotts*et al*, 1988). Attention to fruits handling practices in the field and during storage to reduce mechanical and physical injuries and management of controlled atmospheric condition can be effective techniques in reducing postharvest diseases. However, these methods do not ensure effective protection of stored fruits. Hence postharvest disease control has been reliant on the use of fungicides (Eckert and Ogawa, 1988). But the use of fungicides is being avoided in modern era of organic farming due to perceived or actual hazards to human health as well as environment. As the consumption of fruits can be sources of direct ingestion of fungicides, the use of biological methodologies for control of postharvest diseases has enjoyed significant attention and even a modicum of success over the past two decades. The primary sources of biological agents for thecontrol of postharvest pathogens have been the microbial community resident to the phyllosphere and fruit surface (Janisiewicz, 1987). Bacteria and yeasts or yeast like organisms have been the most commonly employed agents for the biological control of postharvest diseases of temperate fruits (Sharma and Kaul, 1999). Several studies have identified bacterial agents for control of postharvest diseases of apple pear and peaches. A saprophytic strain of *Pseudomonas syringe* provided biological control of gray mould, blue mould and mucor rot on pear and also on apple (Janisiewicz and Marchi, 1992; Jeffers and Wright, 1994). The strain *P. syringe* ESC-11 is currently registered for postharvest application to apples and marketed as the product Bio-save 110. An isolate of *Burkholderiacepacia*provided biological control of blue mould and gray mould of Golden delicious apples (Jamisiewicz and Roitman 1988). *Bacillus subtilis*applied to wounded apple reduced fruit rot caused by *Botrytis cineria, Penicilliumexpansum and P. Malicorticis*(Leibinger*et al*., 1997). Biological control of postharvest brown rot of stone fruits has been reported by the application of *Bacillus subtilis, Epicoccumnigrum*and *Pseudomonas* spp. (Pusey and Wilson, 1984; Smilarick*et al*., 1993; Madrigal *et al*., 1994; Foschi*et al*., 1995). *B. Subtilis*can also be incorporated into wax which is normally used for the control of brown rot of peaches (Pusey *et al*., 1986). Successful biological control of postharvest diseases of fruits has been obtained through application of yeasts. In apple diversity of yeasts have been studies for biological controls of postharvest decays. Control of *Penicilliumexpansum, Botrytis cineria and Mucor spp.* has been reported using yeasts *Condidaguilliermondii*(McLaughlin *et al*., 1992), *C. oleophila*(Mercier and Wilson, 1994), *Cryptococcus laurentii*(Roberts, 1990), *Kloeckeraapiculata*(McLaughlin *et al.,* 1992) and *Sporobolomycesroseus*(Janisiewicz*et al*., 1994). The yeast *Candida oleophila*strain 182 has been commercialized as postharvest fungicide Aspire for conduct of *Botrytis* spp. and *Penicillium* spp. However, Biological control of postharvest diseases has been obtained through the use of individual isolates; the application of strain mixtures has been promoted through the application of multiple agents, which in concert expand the range of biocontrol activity. Janisiewicz (1988) found that combination of *Pseudomonas* spp. and *Acremoniumbreve*gave complete control of *B. Cineria*and *P. Expansum*on apple. A co-application involving the bacterial antagonist *P. syringe* and the yeast *S. Roseus*applied in equal biomass provided control of blue mould that was superior to that obtained by treatment with the individual agents applied separately using a biomass equivalent to that of the mixture (Janisiewicz and Bors, 1995). Mixture of two *Aureobasidiumpullulans*strains and an isolate of *Rhodotorulaglutinis*were superior to any of the strains applied individually in controlling decay caused by *B. cineria, P. expansum and P. malicorticis*(Leibinger*et al*., 1997). Mechanisms reported to contribute to biological control of postharvest diseases include antibiosis competitive exclusion, induced resistance in the host and production of hydrolytic enzymes suppression of *B. Cinerea*and *P. expansum*by *Burkholderiacepacia*is reported to involve impart the production of antibiotic pyrrolnitrin (Janisiewicz*et al*., 1991). *Bacillus subtilis*produced antifungal substance i.e. iturin peptides which possess a wide spectrum of antifungal activity. This substance was determined to be primary mode of action of this antagonistic bacterium to *Moniliniafructicola*causing brown rot of stone fruits (McKeen*et al*., 1986). Utilization of carbon or nitrogen sources, nutrient competition and physical exclusion of pathogen are considered the possible mechanism in control of postharvest diseases of fruits by yeasts (Roberts, 1990). Droby and Chalutz (1994) suggested that application of yeasts to wounds on different fruit resulted in enhanced ethylene production. As ethylene is reported to have a role in induction of the resistance process, it was proposed that induction of the host resistance may operate in the disease suppression resulting from yeast application.

There has been increasing interest in determining the practicality of applying bio-control agents in the fields prior to harvest as a mean to control postharvest pathogens. This interest emanates from the fact that the infection of fruit by postharvest pathogens may occur in the field prior to harvest or as result of wound created during harvesting and handling but preceding the movement of fruit into dump tanks where bio-control agents have been applied. Biological control of postharvest diseases of fruit in a preharvest setting does appear in option on the basis of limited studies. Application of *Trichoderma harzianum* to apple in field significantly reduced symptoms of bulls eye rot in storage. Leibinger*et al*. (1997) applied antagonists to Golden Delicious apple in field to control postharvest disease and application of a combination containing two antagonists *Aurobasidiumpullans*and *Rhodotorulaglutinis*was as effective as chemical fungicides used against these diseases. These findings suggest that application of certain biocontrol agents that are a characteristic element of the resident microflora of fruits may be useful in reducing infection in the field and subsequent infections during fruit storage.

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