CHAPTER TWO

REVIEW OF LITERATURE

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Soil harbours a plethora of microorganisms. Number of groups and types of microorganisms are present in soil as dominant and others as subdominant forms. These organisms derive a major part of the organic nutrients required for their growth from decomposition of dead organic remains of plants and animals in soil. Moreover, in recent past, it has been well established that living plants liberate organic nutrients through their active roots in soil. This makes the root surface and the soil in the vicinity of the root system, a site of intense microbial activity. This phenomenon of enhanced activity of microorganisms immediately around living root systems of higher plants is referred to as 'Rhizosphere effect'. It is difficult to find out the exact origin of rhizosphere but the change in the soil is obvious. When a root grows through the soil, the various activities of organisms are stimulated and normally there is an increase in population of microorganisms in this localized region of soil.

The term 'rhizosphere' was first used by Hiltner (1904) when he noticed an enhanced microbial activity in close vicinity of plant roots. According to him it is the zone of enhanced microbiological activity immediately around the root. Relatively little attention was paid to the rhizosphere for a quarter of a century, apart from scattered investigations which supported Hiltner's observations. However, the classical researches of

Starkey (1929a, 1929b, 1929c, 1931a and 1931b) once again aroused the interest among many workers to probe the relationships between soil microbes and plants. Since then rhizosphere has been studied with an increasing awareness because it has been amply indicated that microbiology of this region concerns not only the growth but also health of plants and that full implication of what is called 'rhizosphere effect' embraces triple interaction involving : soil microbes, soil-borne pathogens and plant.

The work done by Starkey is an excellent and pioneering in the field of rhizosphere study. He was the first to work out rhizosphere microflora in detail and unearthed several microbiological problems regarding rhizosphere. He worked out qualitative and quantitative effects of different plant species, increase in number of microorganisms in rhizosphere with age of the plant and also the seasonal variation in number of the rhizosphere microflora. Later Starkey (1958) found that the number of microorganisms on the root surface (rhizoplane) is greater than in the rhizosphere. He also made a very significant contribution to rhizosphere study when he stated that the intense microbial activity in the rhizosphere was due to interaction of organic nutrients secreted by roots and put new dimensions to the phenomena of antagonism and symbiosis of microorganisms in the root zone especially mycorrhizae and nodulation in legumes.

Increase in numbers of microorganisms is most pronounced with bacteria. For bacteria the rhizosphere - soil ratio may

reach as high as 100 or even more, particularly in case of legumes. More modest increases are usually recorded in the case of Actinomycetes and Fungi and even Algae and Protozoa, where the environmental conditions may be significant in determining the degree of rhizosphere effect.

It has been observed that rhizosphere effect is discernible in early stages of growth. Timonin (1940) noted the establishment of rhizosphere microflora within 3 days of seed germination more noticeable with bacteria than fungi. Further development of rhizosphere population depends on normal growth of plant. The rhizosphere effect increases with age of the plant and normally reaches its maximum at the stage of greatest vegetative growth.

Timonin and Lochhead (1948) reported that, not all parts of the root system support similar rhizosphere populations. The microflora is most abundent for the central or crown portion of the root and decreases with increasing distance in horizontal and more particularly in vertical direction from the base of stem. There are evidences which indicate that legumes support higher rhizosphere populations than nonlegumes but conflicting evidence has so far made it impossible to arrange even our commonest crop plants in order of their stimulative effects on soil microorganisms.

It has been noted that, within a moisture range suited

to plant growth, numbers of rhizosphere microorganisms are greater at lower than at higher soil moisture levels, whereas reverse is true in case of non-rhizosphere soil microorganisms. Subsequently Katznelson et al., (1955) observed that there exists a relationship between drying of soil and liberation of amino acids from roots which may increase the number of microorganisms in rhizosphere soil. They further stated that the amino acids containing secretions by plant root stimulated growth of those bacteria which require these amino acids as growth factors.

Garretsen (1948) reported that insoluble phosphates were brought into solution through the action of microorganisms about the plant roots. Brian (1957) and Winter (1951) while studying effects of some microbial products on plant growth reported production of a number of organic substances by microorganisms, including antibiotics, vitamins and auxins. It is also reported that the increased CO_2 concentration in rhizosphere arising from microbial and plant tissue respiration results in greater solubilization of soil minerals. Hildebrand and West (1941) and Rouaft and Atkinson (1950) reported that the pathological conditions resulting in root lesioning usually increase the micropopulation, probably by qualitative and quantitative changes in the root exudations and by providing decomposable dead tissue. Soil amendments resulting in amelioration of disease may also affect both the soil and rhizosphere microflora, increasing the former and decreasing the latter and so narrowing R/S ratio (R = Rhizosphere and S = Soil).

It is reported by many worker that due to denser micropopulation in the rhizosphere than in non-rhizosphere soil and even more significant, the higher level of microbial activity, the antagonistic and associative interactions between groups of microorganisms in soil at or near roots are found to be intensified (Lochhead and Landerkin, 1949; Hervey, 1958).

The enhanced microbial activity in the rhizosphere region has attracted attention of microbiologists, agronomists and soil chemists all over the world. Many workers like Clark (1949), Harley and Waid (1955), Thornton (1956), Peterson (1958, 1959, 1961), Parkinson and Clarke (1961), Ordin (1961) studied various aspects of rhizosphere such as role of rhizosphere microflora in relation to development of crop plant, relation of rhizosphere organisms to the formation of stable soil structure, seasonal variation in rhizosphere soil fungi associated with plant roots, influence of plant illumination on the fungal flora of roots, mycoflora of rhizosphere and roots of cultivated plants etc. The saprophytic microflora of rhizosphere has been extensively studied by Thom and Humfield (1932), West and Lochhead (1940) and Tyner (1948). They have also tried to find out its relationship with resistance of plant to soil-borne plant pathogens.

The workers like Timonin (1940), Lochhead et al., (1949) Rovira (1956, 1965), Buxton (1957), Katznelson (1965) etc. concentrated their studies on rhizosphere microflora in relation to age, root habit, soil condition and physiological set up of

plants. Halleck and Cochrane (1950) studied interrelationship between soil microbes and plant roots by foliar application of certain chemicals.

Several Indian workers also have made significant contributions to the knowledge of rhizosphere microbiology. Notable Indian Workers in this field are Agnihotrudu (1955), Sadasivan (1955, 1960), Bhuvaneswari and Rao (1957), Bāgyaraj and Rangaswami (1966), Gujarathi (1965), Gadgil (1965), Mujumdar (1968), Mishra and Srivastava (1969, 1971), Mishra and Kamal (1970), Ranga Rao (1972), Khanna and Singh (1974), Wajidkhan et al., (1974), Ursekar (1975), Mishra (1978), Mall (1979), Prakash et al., (1979), Arya and Mathew (1993) etc.

Agnihotrudu (1955) worked on incidence of fungistatic organisms in the rhizosphere of pigeon pea (Cajanus cajan L.) in relation to resistance and susceptibility to Fusarium wilt caused by F.udum Butler. While Bhuvaneswari and Rao (1957) made some useful observations regarding root exudates in relation to rhizosphere effect. Many workers have studied different problems such as studies of rhizosphere microflora and their significance in plant disease control, root and shoot growth etc. Mishra and Kamal (1970) studied rhizosphere mycoflora of virus infected plants and found that Fusarium was found occurring through out the period of investigation. Gupta (1974) has studied effect of foliar application of subamycin on rhizosphere and rhizoplane mycoflora. Wajidkhan et al., (1974) and Khanna and

Singh (1974) have studied rhizosphere microflora in amended soils, Mishra (1978) has worked out rhizoplane mycoflora of fibre-yielding plants while Prakash et al., (1979) have studied rhizosphere mycoflora of cauliflower as influenced by different levels of carbon to nitrogen. Arya and Mathew (1993) have studied qualitative and quantitative incidence of microrganisms after solarization and reported that Fusarium udum, the incitant of wilt disease of pigeon pea could not be recovered from non-rhizosphere soil after mulching with coloured sheets for 45 days.

Definition and Cirumscription of Rhizosphere :

Hiltner (1904) defined rhizosphere as "the soil adhering and close to the roots". He, however, did not specifically mention the boundries of the rhizosphere. Naturally this created certain ambiguity in circumscribing the rhizosphere zone. This has led many workers to putforth their views regarding the delimitation of rhizosphere and use of appropriate terminology. Perotti (1926) in attempting to establish delimitation for rhizosphere, considered it to be limited on one side by general soil region or 'edaphosphere' and on the other by the root tissue or 'histosphere'. Graf (1930) and Poschenreider (1930) used the terms 'outer rhizosphere' and 'inner rhizosphere' for rhizosphere soil and the soil on root surface respectively. The term 'root region' was used by Katznelson, Lochhead, and Timonin (1948) and Harley (1948) to describe the root surface zone and rhizosphere zone together. The use of these terms,

however, has not solved the riddle of circumscription of rhizosphere and a well defined line cannot be drawn in the field of the 'rhizosphere effect' as it extends right form the root surface to a few millimeters away from it. It is observed that the rhizosphere effect is maximum near the root and goes on decreasing on the outer side. The numbers of microorganisms is more on the root surface than in the soil around the root. Clark (1949) suggested the term 'rhizoplane' for external root surface and closely adhering particles of soil and debris. However, the term 'rhizosphere' is widely accepted and preferred by most of the workers all over the world and it is not necessary to seperate the zone of plant root since most of the workers consider it under the term 'rhizosphere effect'.

Technique for the study of Rhizosphere Microflora :

Rhizosphere microflora is generally studied by employing three different methods viz., 1) Culture method 2) Microscopic method and 3) Manometric method. Most of the workers commonly use the first two methods. In the recent past the advent of modern, sophisticated techniques has tremendously helped the workers to study rhizosphere microflora in depth. In recent past fluorescence (Zvyagintsev, 1962) and Electron microscopy (Ivenvy and Garsenbacher, 1962) have been used for study of rhizosphere microflora.

1. Culture Method :

This method consists of the dilution plate method and

the soil-plate method. The dilution plate method is widely used for detailed study of morphological, nutritional, physiological and taxonomic characterisation of rhizosphere microflora. The detailed procedure of dilution plate method is described in the Chapter : Materials and Methods. The number of organisms in rhizosphere as well as non-rhizosphere soil is determined. The extent to which the roots influence the microflora of soil or change in the rhizosphere effect may then be expressed by means of rhizosphere - soil ratio, R : S. It is obtained by dividing the total number of organisms present in rhizosphere by the total number of organisms present in the non-rhizosphere soil.

Chesters (1940, 1948) introduced immersion tube method for isolation of fungi from soil, which consists of introduction into soil of a glass tube with 4 to 6 invaginated capillaries filled with nutrient agar. Mueller and Durrell (1957) have described a modification of Chester's immersion tubes. In 1955 Warcup reported a simple method for isolation of hyphae from soil. Harley and Waid (1955) recommended serial washing technique, which consists of washing root segments and placing them on agar plates.

Many workers have made appraisal of rhizosphere microflora obtained by culture method. Timonin (1941) suggested that only soil adhering to roots should be used for expressing the rhizosphere population. This suggestion, however, met with scepticism from other workers especially because they did not

believe in making any distinction betwen rhizosphere and rhizoplane. Katznelson et al., (1948) initially referred to the total weight of the soil adjacent to roots as rhizosphere without making any distinction between rhizosphere and rhizoplane.

Attempts to improve the media used in plating procedure for enumerating microorganisms in soil have been made by Rovira (1956a and 1956b) and Low and Webley (1959), however, they did not find much difference; only 10 to 20% of bacteria in the soil develop. Warcup (1960) reported that plating favours development of rapidly growing and spore forming types of microorganisms.

In the soil-plate method, instead of preparing dilutions, a small quantity of soil is dispersed through out the medium in the isolation plate. This method was devised after it was observed that in the preparation of dilution plates many fungi are discarded with the residue; it was considered that the use of soil would allow growth of fungi embedded in humus or attached to mineral particles. Comparative studies, showing that usually more species were recorded by soil than dilution plates, seemed to substantiate this view (Warcup, 1950).

Notwithstanding the limitations, the plating method gives good information on distribution, relative proportion and activity of microbial population.

2. Microscopic Method :

Direct microscopic examination method involves buried slide technique developed by Rossi (1928) and Cholodny (1930). This method enables study of microorganisms in situ. This technique is well known as "Rossi-Cholodny buried slide technique". This method gives more natural information about the activity of fungal mycelium in soil than dilution plate methood. But it does not give qualitative data. A modification of Rossi-Cholodny buried slide technique has been described by Jones and Millison (1948). Linford (1942) noted that direct observation of the organisms associated with the root growing in soil are possible when the roots are grown in contact with glass coverslips. Thom and Humfield (1932) observed the roots directly under microscope. Thornton (1952) devised screened immersion plates as an innovation of Rossi-Cholodny buried slide method which permits isolation of microorganisms capable of growing from soil into water-agar. The rhizosphere microorganisms have also been studied by using fluorescence microscopy and electron microscopy (Zvyagintsev, 1962).

Fungi in Rhizosphere :

Since the excellent work done by Starkey (1929), the knowledge of rhizosphere fungi has increased manifold. The investigations are primarily done by means of standard techniques used for soil fungi. The information accumulated over the years is mostly of floristic type and very scant attention has been given to physiology and nutrition of these forms.

Earlier, many workers were apprehensive and circumspect to accept the view that, certain species of fungi were preferentially encouraged by plant roots. Timonin (1940) studied the rhizosphere microorganisms of wheat, alfalfa and peas and compared it with population of non-rhizosphere soil. He found that bacteria and actinomycetes, together, were 7 to 71 times and fungi 0.75 to 3.1 times greater in rhizosphere soil than non-rhizosphere soil. In general, an increasing effect was observed with advancing age of seedling. Zukovskaya (1941) working on potatoes, flax and clover found that the microbial population was 100 times more in the rhizosphere soil which was showing a concomitant rise with the age of plant. There was a long-standing controversy regarding the forms in which the fungi existed in the rhizosphere soil. Most workers believed that fungi may exist in soil either as mycelium or as spores and while direct observation methods give little information as to the identity of the fungi observed, cultural methods usually fail to discriminate between active mycelium and resting bodies (Garett, 1938). Chesters and Thornton, 1956; Garett, 1938; Harley and Waid, 1955; Warcup, 1957; have worked on this aspect and believed that only in active mycelial condition fungi take part in decomposition and other soil processes. Agnithotrudu (1955) showed that fungi occurred in the mycelial forms in the rhizosphere and in sporulated forms in non-rhizosphere soil.

Harley and Waid (1955) claimed that exact mycoflora of rhizosphere is obtained by careful washing of roots and then

scraping the surface layer off and transferring them to agar or by plating out washed root segments. Williams et al., (1965) used this technique for study of slow growing fungi. Gadgil (1965) used a slight modification of Harley and Waid's procedure by cutting the entire root into 1 mm segments in sequence and plating them on agar observed mycelial growth on each piece. A qualitative difference in the fungi between the rhizosphere of tomato and soil has been obtained by Katznelson and Richardson (1943); however, the results varied with the age of the plant and soil treatment. Vagherova et al., (1960) and Lugauska (1961) have found that the antagonistic fungus Trichoderma viride is encouraged in rhizosphere of many plants. Workers like Stenton, 1958; Parkinson and Williams, 1961; Parkinson and Clarke, 1961; Katznelson et al., 1962; have reported occurrence of Fusarium spp. and Cylindrocarpon spp. from roots of many plants.

Chesters and Parkinson (1959) reported definite fungal succession on the roots as the plant matures. They isolated Mucorales and sterile forms in the early stage of oat plant. After maturity, the cellulose degrading forms like Chaetomium globosum dominated the rhizosphere. Peterson (1959) reported that fungi are slow colonizers of root system as only a small number could be detected during the early stage of plant growth. He also mentioned that fungi associated with seed coat take little part in the colonization and the soil was the primary source of fungi colonizing the roots.

Mishra and Kamal (1974) have investigated mycoflora of virus infected plants like Croton bonplandianum, Capsicum annuum L., Lycopersicum esculentum Mill. etc. From the rhizosphere of virus infected tomato they isolated 22 organisms.

Association of microorganisms with different regions of root growing at various soil depths has been studied by Iverson and Katznelson, (1960); Venkateshan, (1964); Mishra and Srivastava, (1971) etc. They concluded that fungal population decreased with the increase in soil depth. They also found that the maximum population was found at flowering stage. According to Rovira (1956) and many others the rhizosphere microorganisms grow more rapidly in culture than the general soil organisms, probably because they are fully matured at the root surface.

The fruits and vegetables are indispensible items in the nutrition of human beings and a great chunk of global commerce also revolves around these two important categories of agricultural products. Fungi are known to inflict severe damages to fruits and vegetables in storage. In India, until recently, the importance of a systematic probe in the various aspects of market pathology with an intention of stemming the rot was underestimated vis-a-vis the enormous losses incurred due to the rots and other diseases. However, now many workers are studying different facets of market diseases all over India. As a result of these extensive studies a great amount of information about causal organisms, their prevalence, the extent of damage caused, pathogenesis, biochemical changes brought about by fungi

in infected fruits as a result of pathogenesis and possible preventive and control measures of post-harvest diseases has accumulated.

In India, the early work in market pathology has been done by many renowned workers. Dastur (1915 and 1916) worked on rots of bananas; Mann and Nagpurkar (1920) and Ajarekar and Kamat (1923) on dry rot of potatoes caused by Fusarium from W. India; Mitter and Tandon (1929) on rots of pears and apples; Chona (1933) on diseases of banana; Pushkarnath (1935) on diseases of apples in Kashmir; Ghatak (1938) on rots of oranges; Mehta (1939) on Rhizopus rot of apples; Kanitkar and Uppal (1939) on mango rots; Singh (1941, 1942) on certain disease of Kumaun region; Choudhury (1945) on diseases of pineapple; Sinha (1946) on market pathology of several fruits; Chowdhury (1950) on Ascochyta rot of papaya; Venkatarayan and Dalvi (1951) on black mould rots of onion; Tandon and Agarwal (1956) on dry rot of Colocasia antiquorum; Bhargava and Gupta (1957) on Rhizopus rots of plums from Kumaun; Tandon and Bhatnagar (1958) on the storage rot of apples caused by Aspergillus terreus; Mathur and Mathur (1958) on Fusarium rot of tinda fruits from Kota markets, Rajasthan.

Recently workers like Sridhana and Jain (1962) worked on Botryodiplodia rot of papaya from Gwalior (M.P.); Grover (1965) on Cunninghamella rot of pumpkins; Tandon et al., (1965) on various fruits from U.P.; Chattopadhyaya and Mustafee (1967) on various fruits from W. Bengal; Rao, V.G. (1968) on various

diseases of fruits and vegetables from Maharashtra; Dhingra et al., (1970) on cigar end rot of banana from M.P.; Singh and Chohan (1972) on Glomerella fruit rot of pomegranate from Punjab; Tandon (1972) on rot of apples incited by Gliocephalotrichum bulbiferum Ellis and Hasseltin; Panwar and Vyas (1973) on rot of Citrus reticulata; Sreekantiah et al., (1974) on Trichothecium rot of apples in storage; Mishra et al., (1974) on Pestalotia menezesiana rots of grape berries; Joshi et al., (1975) on post-harvest fungal diseases of Cyclanthera pedata; Vyas et al., (1976) on Post-harvest diseases of apple; Laxminarayan and Reddy (1976) on post-harvest diseases of tomato; Jamaludin and Tandon (1976) on market diseases of fruits and vegetables; Thind et al., (1976) on post-harvest decay of apple incited by Aspergillus candidus; Gupta and Madan (1977) on fruit rot diseases of ber from Haryana; Sohi (1977) on storage rots of onion; Singh et al., (1978) on fruit rot of guava due to Phytophthora nicotianae var. parasitica; Sharma and Jain (1978) on pomegranate fruit disease; Lal and Arya (1980) on Fusarial rots of papaya; Rajak and Gautam (1980) on Citrus fruit disease; Miss Sawant (1984) on market diseases of fruits of Kolhapur; Roy et al., (1989) on some rot diseases of banana; Majumdar and Pathak (1989) on some new post-harvest diseases of guava fruits; Madhukar and Reddy (1989) on guava fruit diseases; Sharma and Majumdar (1993) on some new post-harvest diseases of ber fruits in India.

The U.S. Department of Agriculture has published a series

of reports on pathological aspects, economics and control of post-harvest diseases (Harvey and Pentser, 1960; McColloch and others, 1968; Smith and others, 1966; Ramsey and Smith, 1961; Ramsey and others, 1949, 1959; Rose and others, 1943, 1950, 1951; Friedman, 1960; Wiant and Brately, 1948; Eckert, 1967; Pryer, 1950; Eckert and Sommer, 1967; Tandon, 1967b; Tandon et al., 1974).

Dastur (1916) has recommended the removal and destruction of infected fruits for the control of rots of banana fruits. Chona (1933) has studied the incidence of stem end rot of bananas incited by speices of Gloeosporium and Botryodiplodia in relation to environmental factors such as temperature and humidity. Dey and Nigam (1933) reported the soft rot of apples caused by Aspergillus niger and recommended the wrapping of fruits in tissue paper before packing. Keshwalla (1936) carried out investigations on fruit diseases and described the symptoms of blue mould of apple (Penicillium expansum Link) and for effective control of such diseases he recommended careful handling of fruits to avoid the bruises or injury to skin. He also studied pink rot of apple incited by Trichothecium roseum Link. Mehta (1939) studied the effect of temperature and pH on the growth of Rhizopus arrhisus Fischer., causing apple rot. Grewal (1954) made detailed investigations on the incidence of diseases with respect to the effect of temperature, humidity, light, age of fruit and variety. Srivastava et al., (1964) found

that some pathogens causing diseases in transit and storage were also found associated with other parts of the host in the field.

The workers from M.A.C.S. now Agharkar Research Institute, Pune have recorded several hitherto unknown post-harvest diseases such as waxy rot of potatoes caused by Geotrichum candidum, fruit rot of squashes (Cucurbita moschata) by Drechslera halodes, soft rot of tomato by Syncephalastrum racemosum, grape rot by Pseudostemphylium radicium, cucumber rot caused by Myrothecium roridium, black scurf of sweet potato caused by Pellionella indica, rot of muskmelon and woodapple by Thielaviopsis paradoxa, pink rot of persimon (Diosphyros tomentosa) incited by Trichothecium roseum, blemish of apple due to Calothyriopsis mali and rot of Kamrakh (Averrhoa carambola) caused by Phoma averrhoiae. Sohi (1977) studied storage rot of onion bulbs and its control and recommended 10 minutes treatment of 0.2% Captan and Thiram and 10 ppm aureofungin. Roy et al., (1989) recorded some new fruit rot diseases of banana incited by Drechslera spicifera Bainair., Acremonium strictum Walter Gams., Chalara Paradoxa (Deseynes) Sacc., Pestalotiopsis disseminata (Thum.) Stey., Drechslera musae-sapientum (Hansford) M.B. Ellis., Altemaria alternata (Fr.) Keis., Sharma and Majumdar (1993) made some new records of post harvest diseases of ber fruit caused by Alternaria alternata (Fr.) Keis., Cladosporium tenuissimum Cooke., Rhizopus stolonifer (Ehrenb.) Vuill., Fusarium pallidoroseum (Cooke) Sacc., Aspergillus niger Van Tieghem., Pythium aphanidermatum (Edson) Fitz., Rhizoctonia solani Kuhn. and Phoma nebulosa.

Many workers have studied the effect of temperature and humidity on the disease development. Jamaluddin et al.,(1974) reported maximum rotting of Citrus fruits at 25°C incited by Geotrichum candidum, while no rot occurred at 10°C. Khanna and Chandra (1977) observed maximum rotting of tomato fruits by 12 pathogenic fungi at 20-25°C (over 50%) with relative humidity of 90-100 percent. Heavy rotting of papaya fruits caused by Botryodiplodia theobromae at 90-100% relative humidity and between 25 to 30°C is observed (Gupta and Nema, 1979). Similar reports are made by Singh and Khanna (1966), Singh (1977), Narain and Reddy (1978), Rao and Subramaniam (1974), Lal and Arya (1982). Besides, temperature also indirectly affects fungal advancement by increasing or minimising host resistance. Temperature determines the type of decay.

According to Bhargava et al., (1965) low temperatures minimise losses due to fungal invasions in two ways. Firstly, it delays the advent of senescence and consequently increases resistance in fruits. Secondly, it slows down the rate of growth of the pathogens.

Study of pectolytic and cellulolytic enzymes secreted by rot fungi during invasion and subsequent colonization has been done by many workers. Microbes break down pectic and cellulosic materials of the host cell walls and macerate the tissue, thereby, resulting in rot. Agarwal and Hasija (1978) have worked on pectolytic enzymes of Alternaria citri inciting storage

rot of Citrus fruits. Thind et al., (1980) studied cell wall degrading enzymes of Clathridium cotricola causing apple rot, Garg and Gupta (1980) worked on pectolytic and cellulolytic enzymes of Aspergillus niger, Aspergillus awamori responsible for storage decay of Carissa fruits and Hasija and Batra (1982) on cellulolytic enzyme of Phoma destructiva, a well known pathogen on tomato. Chandra and Khanna (1977) have reviewed this aspect of rot fungi.

Investigations pertaining to changes in sugars, amino acids, organic acids and ascorbic acid (Vitamin C) have been carried out by many workers recently (Agarwal and Ghosh, 1979; Bhargava, 1977; Chaudhary et al.,1980 Ghosh et al., 1964; Ghosh et al.,1966; Ghosh et al., 1965 and many others) in different fruits under pathogensis by a variety of fungi. New oligosaccharides synthesized during pathogenesis have been reported by a few workers. Prasad and Bilgrami (1977) reported synthesis of an unknown amino acid in litchi fruits infected with Aspergillus variecolor and A. nidulans.

Sumbali and Mehrotra (1981) have collected some valuable aerobiological data of fruit and vegetable shops which will be of much aid in controlling post-harvest diseases at market yards and also in maintaining market sanitation.

Studies on control of post-harvest diseases have met encouraging results using fungicides and antibiotics either as

post-harvest dips or treatments in case of many diseases of fruits and vegetables of economic significance (Dharam Vir et al., 1971; Ogawa et al., 1976; Thirumalachar, 1973). Some antibiotics and fungicides like Ferbam, Benlate (Benomyl), Plantvax, Captan, Bavistin, Aureofungin, Difoltan, Dithane M-45 etc. have been screened with encouraging results (Jamaluddin et al., 1972; Jamaluddin and Tandon, 1975; Khanna and Chandra, 1977a, 1977b; Prasad and Bilgrami, 1977; Rai et al., 1982). Besides, the chemical treatment of fruits and vegetables in cold storage at a temperature between 5 to 15^{o}C has been found to be of much advantage and economical on a large scale in many cases (Smith et al., 1964).

The rots and other maladies of fruits and vegetables incited by pathogens either in field or storage are made more complex due to secondary invadors and make it difficult to study the actual primary pathogens.