1. INTRODUCTION

1.1 THE RHIZOSPHERE AND RHIZOPLANE

The growth and development of plants are highly influenced by the interaction between their root system and the vast number of microorganisms living in the soil. The roots create a unique subterranean habitat for the microorganisms mainly through root exudation and sloughed-off tissues. The root exudates containing various organic substances, stimulate an increased microbial activity close to the plant roots, as many of these plant products serve as nutrients for the multitude of microorganisms. This unique environment under the influence of plant roots is called the 'rhizosphere' (Hiltner, 1904). The microbial population is still larger in the inner rhizosphere which essentially is the root surface and is termed 'rhizoplane' by Clark (1949). The physiological interaction between the roots and microorganisms are much more pronounced at this area than the outer rhizosphere. There is no sharp boundary between rhizosphere and neighbouring soil. The concept of rhizosphere has greatly been clarified by the study of ultrastructure and histochemistry of the rhizosphere of roots fixed *in situ* (Foster and Rovira, 1976; Foster, 1981, 1982).

Rhizosphere region is a highly favourable habitat for the proliferation and metabolic activity of numerous microbial types. Bacteria, actinomycetes, fungi, algae, protozoa and nematodes are the major groups of life forms found in the rhizosphere region. The influence of the root on the microorganisms is expressed on quantitative basis by the use of R:S relationship. The R:S ratio is defined as the ratio of microbial numbers per unit weight of rhizosphere soil (R), to the population in a unit weight of the adjacent non-rhizosphere or control soil (S). The rhizosphere effect is consistently greater, in general, for bacteria than for any other microorganism.

1.2 IMPORTANCE OF THE RHIZOSPHERE PHENOMENON

There are three factors which are important in the rhizosphere phenomenon: (i) the influence of plant roots on microorganisms, (ii) the influence of microorganisms on plant roots and (iii) interaction between the microorganisms and plant roots and its subsequent beneficial/harmful effect on plant roots. Large number of reports have appeared on the influence of plant roots on microorganisms especially through root exudates and sloughed-off tissues (Rovira, 1956b, 1956c, 1962, 1969, 1973, 1979; Bhuvaneswari and Subba Rao, 1957; Schroth and Hildebrand, 1964; Parkinson and Pearson, 1965; Vancura *et al.*, 1969; Balasubramanian and Rangaswami, 1973; Sullia, 1973a; Hale *et al.*, 1978; Prikryl and Vancura, 1980; Whipps and Lynch, 1983; Bommer *et al.*, 1986; Curl and Truelove, 1986; Lynch, 1990). Most of the substances released from roots are apparently consumed as nutrients by the soil microorganisms.

1.3 ROOT EXUDATES

Besides physical and biological characteristics of rhizosphere region, root exudation and the resultant rhizosphere effect are the two most important factors influencing root disease initiation. It has been shown since 1930 that root exudates determine what type of microorganisms occur in the rhizosphere (Rovira, 1965a). Root exudates stimulate not only pathogens but many other microorganisms also, some of which facilitate nutrient uptake by the plant and some suppress pathogens. The universality of this phenomenon suggests that it is of net benefit to the plants.

1.4 INTERACTION BETWEEN RHIZOSPHERE MICROFLORA AND PLANTS

The interaction of rhizosphere microflora among themselves and with other soil microorganisms has tremendous impact on growth of plants. Alexander (1978) considered rhizosphere as a buffer zone, in which microflora serves to protect the plant from the attack of the pathogen. In order to initiate infection, root pathogens should be able to penetrate the protective zone of the dense rhizosphere microbial population and increased microbial interaction - competitive, antagonistic or beneficial - which may eliminate or suppress the pathogen.

1.5 ANTAGONISTIC MICROFLORA AND BIOLOGICAL CONTROL OF ROOT PATHOGENS

Despite the fact that research towards biological control of pathogens started more than seven decades ago, its development was delayed for a long time due to several reasons (Baker and Cook, 1974; Schroth and Hancock, 1981). It was only during the last three decades remarkable increase of interest and research took place in the field of biological control of root pathogens as reflected by the number of books (Baker and Snyder, 1965; Baker and Cook, 1974; Bruehl, 1975; Cook and Baker, 1983; Parker *et al.*, 1985; Mukerji and

Garg, 1988a, b; Campbell, 1989) and reviews (Baker, 1968; Papavizas and Lumsden, 1980; Schroth and Hancock, 1982; Weller, 1988). Many studies on biological control of plant pathogens assumed that a single antagonist introduced into the soil should be sufficient to achieve successful biological control of root pathogens (Baker and Cook, 1974). However, it appears from current literature that individual antagonist species may be effective in partially sterile soil and that a complete microflora or multiple antagonists are best suited for non-treated soil. Baker and Cook (1974) stated that one of the reasons for the under-evaluation and neglect of biological control was that antagonistic population had often been sought in areas where both the pathogens and diseases occurred, rather than where they did not, or where the pathogen was unable to persist. Antagonistic population to a given pathogen occurs only in soils biologically suppressive to the pathogen, but individual antagonists may occur in many soils. A good source of antagonistic population will be a soil under continuous crop monoculture where the disease has declined to a low level gradually during successive years. Since the effective activity of antagonists are probably on the root surface, it will be desirable to select the antagonists from the rhizosphere soil of the crop itself.

Studies on the rhizosphere microorganisms and root exudates have opened up new vistas especially towards manipulation of rhizosphere microorganisms for biological control of root pathogens either by altering root exudates or through soil amendments. However, the main emphasis was on fungi although many of them tend to occupy a restricted area of the soil compared to bacteria and actinomycetes which are better distributed through out the soil (Jones and Griffith, 1964). Though the importance of actinomycetes in soil fungistasis and biological control of root pathogens has been stressed by several authors (Weindling *et al.*, 1950; Rangaswami and Vasantharajan, 1962c; Thirumalachar, 1968; Broadbent *et al.*, 1971; Porter, 1971; Goodfellow and Williams, 1983), no detailed study on rhizosphere actinomycetes and their unique characteristics has been carried out before.

1.6 THE ACTINOMYCETES

The actinomycetes, also known as 'ray fungi', consists of Gram-positive bacteria that are characterized by the formation of branching filaments (Lechevalier and Lechevalier, 1981; Lechevalier, 1989). Though actinomycetes were known to early microbiologists, they were overlooked because of their slow growth on agar plates and lack of knowledge regarding their activity; it was presumed that these microorganisms were of little importance in soil transformations. Only in recent times, this group of microorganisms came to close scrutiny with the interest in the chemotherapeutic use of antibiotics produced by them. In soil, actinomycetes are second only to bacteria in number (Alexander, 1978). Their main ecological role is in the decomposition of organic matter and this was most vividly elucidated by Waksman (1959) and others (Lacey, 1973; Goodfellow and Williams, 1983). The most important genus of the group is considered to be *Streptomyces*, as they are abundantly distributed in soil and are the source of most of the antibiotics in current use (Starr *et al.*, 1981).

Although actinomycetes occur in the rhizosphere, there is little evidence of what roles they play, apart from their possible influence on root pathogens (Goodfellow and Williams, 1983). Most of the interests have centered on the possibility that streptomycetes may protect roots by inhibiting the development of potential fungal pathogens (Goodfellow and Simpson, 1987). Many of the earlier studies on biocontrol of microorganisms have been made through the management of resident antagonists in non-treated field soil. The mechanism of suppression of pathogens in such soils involve several factors. In order to understand the actual mechanisms, a thorough understanding of the quantity, quality and ecology of various microorganisms is necessary. Among these microorganisms, actinomycetes play a very important role in the suppression of pathogens in the rhizosphere soil (Thirumalachar, 1968; Goodfellow and Williams, 1983; Goodfellow and Simpson, 1987; Weller, 1988). This prompted to undertake the present study and an attempt has been made through this work to elucidate the nature and properties of rhizosphere actinomycetes of two vegetable crops and one oil yielding crop viz., *Abelmoschus esculentus* L. (Moench.), *Momordica charantia* L. and *Helianthus annuus* L. and also those of the actinomycetes isolated from the non-rhizosphere soil.

1.7 OBJECTIVES OF THE PRESENT STUDY

i. To understand the quantitative nature of the bacterial, actinomycete and fungal populations of the rhizosphere and control soil.

ii. To study the qualitative nature of actinomycetes from the rhizosphere and control soil.

iii. To determine the qualitative and quantitative differences between the rhizosphere actinomycetes from the three crops and control soil.

iv. To identify the actinomycetes from the rhizosphere and control soil.

v. To determine the metabolic activity of the actinomycetes from the rhizosphere and control soil.

vi. To study the antagonistic activity of the rhizosphere and control soil actinomycetes.

vii. To determine the sugar and amino acid constitution of exudates from the seedling roots of the three crop plants.

viii. To find out the relationship, if any exists, between the carbohydrates present in root exudates and their utilization by the rhizosphere actinomycetes.

ix. To determine the antagonistic potential of rhizosphere and soil actinomycetes against root pathogens in agar culture and in soil culture conditions.

The results of the investigation, it is hoped, would help in understanding the microbiological activity of actinomycetes in the rhizosphere. Probably such a knowledge may contribute towards success in manipulation of rhizosphere actinomycetes for the biological control of plant diseases.