1. INTRODUCTION

Phosphorus (P) is one of the major essential macronutrients for biological growth and development. Phosphorus is second only to nitrogen (N), but the least available mineral nutrient required by plants which is bound to many soil constituents. The sources of phosphorus occur in two forms, viz., organic and inorganic forms which are important to plants. The inorganic forms of phosphorus mostly occur in association with iron, aluminium oxides, all silicates and calcium carbonates. However, a large portion of soluble inorganic phosphate applied as chemical fertilizer to soil is unavailable to plants due to rapid immobilization (Dey, 1988).

Organic matter constitutes a second major component of soil phosphorus of about 30-50% of total soil phosphorus. The biggest reserve of phosphorus is rock phosphate which is the basic raw material for phosphatic fertilizer production. Almost 40 million tons of phosphatic rock deposits are available in India (Roy Choudhury and Kaushik, 1989). Microorganisms play a central role in soil nutrient cycling and in plant nutrition. Under appropriate conditions, microorganisms can solubilize the insoluble forms of phosphorus making available for plant nutrition and for themselves. Microbially-mediated aspects increase plant-available phosphorus levels.

A large number of heterotrophic and autotrophic soil microorganisms including cyanobacteria are known to solubilize inorganic phosphates (Roy Choudhury and Kaushik, 1989). The phosphate solubilizers belong to a diversified group that includes Pseudomonas species such as, Pseudomonas putida (Viveganandan and Jauhri, 2000; Kumar and Singh, 2001; Manna et al., 2001; Villegas and Fortin, 2002), Pseudomonas aeruginosa (Musarrat et al., 2000),
*Pseudomonas corrugata* (Pandey and Palni, 1998), *Pseudomonas stutzeri* (Vazquez et al., 2000), and *Pseudomonas fluorescens* (Di Simine et al., 1998; Deubel et al., 2000). Species of *Bacillus, Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Micrococcus, Aerobacter, Flavobacterium* and *Erwenia*, and fungi like *Penicillium* and *Aspergillus* have also been demonstrated. Phosphate solubilizers of different groups are found abundantly in rhizosphere soils rather than non-rhizosphere soils. The microflora of rhizosphere include bacteria, fungi, actinomycetes, algae, protozoa, small animals, etc. Mostly, plant growth-promoting rhizobacteria (PGPR) and yield-increasing bacteria (YIB) are restricted to the rhizosphere. The phosphate solubilizers and diazotrophic organisms which influence the availability of mineral nutrients to plants come under beneficial non-infective microorganisms. Considerable populations of phosphate solubilizers in soils and rhizosphere soils have been reported by Sperberg (1958), Katzenelson *et al.* (1962), Raghu and Mac Rae (1966), Stevenson (1986). *Rhizobium, Bradyrhizobium, Azorhizobium, Frankia* and mycorhizae are considered to be symbiotic partners with roots.

The use of P solubilizers as inoculants has been found to increase growth, yield and phosphorus uptake by many crop plants. Mineral phosphate solubilization by P solubilizers in turn help in increasing the yield (Bhagyaraj *et al.*, 2000). The effect of two phosphate solubilizers, *viz.*, *Bacillus circulans* and *Cladosporium herbarum*, and the VAM fungus *Glomus* sp. on wheat was found to be higher in grain and straw yield (Singh and Kapoor, 1999). *Azatobacter* and *Phosphobactrin* inoculation on potato (*Solanum tuberosum*) resulted in increased yield (Kamla Singh, 2000). Straw yield significantly increased with an increased application level of phosphorus on rice...
field (Mulugetaseyoum and Heluf Gebrekidan, 2005). In black gram, phosphate-
solubilizing bacteria increased the seed yield (Reddy and Swamy, 2000). Yield
increase in pea by 48% and P uptake by 39% by *Penicillium bilaji* inoculation were
reported in greenhouse experiments (Gleddie, 1993). *Aspergillus* sp. and *A. awamori*
have been found to be very beneficial in soybean and gram crops (Baskar *et al.*, 2000;

Several enzymes are involved in decomposition of organic phosphorus
compounds (Jennings, 1995). Hoffmann (1968) initially suggested three types of
phosphatases, acid, neutral and alkaline, based on the pH optima. Acid phosphatases
(E.C.3.1.3.2) occur ubiquitously among plants and animals (Hollander, 1971; Panara
*et al.*, 1990). Acid phosphatases are maximally active in the acidic pH range, catalyse
the hydrolysis of a variety of phosphate esters which are widely distributed in nature
(Hollander, 1971). Park and Van Etten (1986) reported that studying acid phosphatase
is difficult due to their multiform occurrence in organisms, relative specificity, small
quantity and their instability in solution. The activity of acid and alkaline phosphatases
are correlated with organic matter and total phosphorus content as reported by Nahas
*et al.* (1994). The application of municipal waste compost stimulated the phosphatase
producing microorganism (Perucci and Guisquiani, 1990). Satchell and Martin (1984),
Weiss and Trespendorfer (1993) reported that phosphatase activity can be effected by
earth worms and other soil animals. According to Greaves and Wembly (1965) up to
90% of the microflora in the rhizosphere are capable of producing phosphatases.

Foxtail millet (*Setaria italica* (L.) Beauv.) is an important minor millet grown
extensively in areas of low rainfall. In India, it is mainly grown in Madhya Pradesh,
Andhra Pradesh, Tamil Nadu, Karnataka, Orissa, Gujarat, Maharashtra and Uttar Pradesh. Anantapur district of Andhra Pradesh receives a poor annual rainfall of 154 mm and temperature of 31 ± 9°C resulting in frequent droughts. Under these conditions foxtail millet, being one of the short duration crops (75-90 days), is cultivated as a minor millet mixed crop. Furthermore, foxtail millet is grown as one of the staple food crops of Anantapur district since it not only resists drought conditions but also withstands delayed monsoon, and is suitable for both black and red soils. To control major insect pest and to get higher crop yield, neem oil and neem cake are generally used as both insecticides and soil amendments during cultivation of foxtail millet. Neem oil (azadirachtin) acts principally as a repellent of common insect pest and used to control whiteflies, aphids, thrips, caterpillars, beetles, mealybugs, gypsy moths and others on food and greenhouse crops (Thomson, 1992).

Groundnut (Arachis hypogaea L.) is one of the principal cash crops grown in dryland of India (Dharne et al., 2001). In Andhra Pradesh it covers a major area of 7.5 million hectares with a production of 6.4 million tons in kharif season (Bera et al., 2002; Sawashe et al., 2003). Within the state, Anantapur district, a semiarid region, occupies a predominant place in groundnut cultivation (Anonymous, 2003). Thus, the present-day agriculture involves abundant cultivation of this crop because of its vital role in edible oil seed production (Kori et al., 2002). Consequently, this condition led to inherit risk of yield loss due to drought, diseases and pests (Kairon, 2001; Galgunde and Kurundkar, 2002). More than 120 species of insect pest are reported to attack groundnut crop at various stages of growth, impending potential crisis for peanut growers (Verma et al., 2002; Weeks and Wells, 2003).
The progressive increase of pest problem and the demand for agricultural food production necessitated the application of agrochemicals that ensure high quality and crop yield (Graebing et al., 2002). Among the fungicides, Mancozeb 75 WP (Dithane M-75) is generally recommended for foliar application on groundnut crop (Lal and Pandey, 1982). Dithane M-45 at 1.5 kg/ha controlled both tikka and rust diseases simultaneously and recorded significantly higher yields of groundnut pods (Ponniah et al., 1982). The chlorinated organic pesticides are one of the major groups of chemicals responsible for environmental contamination. They have been used both extensively and intensively inspite of their high persistence in soil environment. The cyclodiene insecticide, for instance, endosulfan has been used indiscriminately throughout the world as a broad-spectrum insecticide to control major insect pests (Dhaliwal and Arora, 1998). As such, it is one of the commonly used insecticides used in groundnut cultivation (Recommendations by A.P. Agricultural University published in A.P. State Agricultural Officers Association Diary, 2004).

The universal application of pesticides to agricultural crops often exposes the environment to pollution hazards. Large quantities of pesticides reach the soil either by direct application or as runoff from treated crop fields (Goring, 1972). The persistence coupled with toxicity of these pesticides may pose a serious threat to non-target organisms including soil microbes and their biochemical processes in the soil ecosystem. Pesticides with the exception of fumigants and some broad-spectrum fungicides have little deleterious influence on soil processes when applied at field rates (Wainwright, 1978).
The present study, concerning the phosphate-solubilizing microflora in soils, was undertaken with the following objectives.

- To isolate phosphate-solubilizing microorganisms from rhizosphere and non-rhizosphere soils of foxtail millet and groundnut.
- To identify the efficient strains of soil isolates in phosphate solubilization.
- To select a suitable medium for phosphate solubilization.
- To isolate acid phosphatase from the efficient strains of *Aspergillus* sp. isolated from rhizosphere soils.
- To assess the impact of pesticides that are generally applied in cultivation of foxtail millet and groundnut on phosphate solubilization by *Aspergillus* spp.