INTRODUCTION

The soil surrounding the roots of plants is an energy rich hot spot for microbial activity. In this dynamic region interactions between the plant and microbes are always going on. Root exudates, rich in include amino acids, organic acids, carbohydrates, sugars, vitamins, mucilage and proteins, act as messengers that stimulate biological and physical interactions between roots and soil organisms. The microorganisms present around the root may exert beneficial, neutral or detrimental effect on the growth and productivity of the plants. The beneficial bacteria which live at the vicinity of the host root either promotes plant growth through direct action or via biological control of plant diseases and are defined as plant growth promoting rhizobacteria (PGPR) (Kloepper and Schroth, 1978). The PGPR can remain either inside the host tissue as symbionts or may remain outside the host as free living, thus may be divided into two groups according to their niche: iPGPR, which establish symbiotic association with the host, thus produce nodule and remain localized inside the structure; and ePGPR, which live freely in the rhizosphere, do not produce nodules, but still promote plant growth (Gray and Smith, 2005). Presently several genera are designated as PGPR and are known to be associated with several crop plants, viz. *Azotobacter, Azospirillum, Azoarcus, Bacillus, Burkholderia, Enterobacter, Erwinia, Klebsiella, Pseudomonas, Serratia, Pantoea, Acinetobacter, Rhizobium* etc. The mechanism of plant growth promotion by PGPR has not been completely elucidated, but there are several mechanisms by which different PGPRs have been reported to facilitate the growth of host plant directly and/or indirectly by inhibiting the growth of pathogens (Glick, 1995). The mechanisms by which PGPR can promote the plant growth may include phosphate solubilization (Nautiyal, 1997), phytohormones like Indole-3 acetic acid (IAA), cytokinin, gibberellins production, breakdown of plant induced ethylene by production of 1-aminocyclopropane-1-carboxylate (ACC) deaminase, which can cleave ACC, and increase mineral and N-availability in the soil (Kloepper, 1992; Glick, 1995), siderophore production (Joshi et al. 2008), hydrolytic enzymes (Zhang and Yuen, 2000) and biocontrol activities against deleterious plant pathogens (Antoun et al. 1978), secondary metabolites such as volatile compound HCN (Defago and Haas, 1990). The use of PGPR also showed enhancement of growth of plants when applied *in vivo*.

Nithya et al. (2013) studied the potentiality of nine *Bacillus* and *Pseudomonas* strains to induce systemic resistance in two sorghum cultivars against extremely pathogenic grain mould pathogens-*Curvularia lunata* and *Fusarium proliferatum*. They screened nine bacterial strains (*Bacillus pumilus* SB 21, *Bacillus megaterium* HiB 9, *Bacillus subtilis* BCB 19, *Pseudomonas plecoglossicida* SRI 156, *Brevibacterium antiquum* SRI 158, *B. pumilus* INR 7, *P. fluorescens* UOM SAR 80, *P. fluorescens* UOM SAR 14 and *B. pumilus* SE 34) were screened to induce systemic resistance in sorghum cultivars 296B and Bulk Y against *C. lunata* and *F. proliferatum*, respectively. Among the strains tested, SRI 158 was found highly effective in reducing grain mould severity in both the genotypes.

Dubey et al. (2014) isolated two promising isolates *Bacillus* sp. BSK5 and *Bacillus subtilis* BSK17 from the rhizosphere of chickpea. These two strains solubilised inorganic phosphate, produced IAA, siderophore, Hydrocyanic acid and secreted extracellular chitinase and β-1, 3-glucanase which antagonised and caused mycelial deformities in two phytopathogens- *Macrophomina phaseolina* and *Fusarium oxysporum* in dual culture and by culture filtrate.

A study was conducted by Bakhshandeh et al. (2014) to evaluate the phosphate solubilization activity of bacteria isolated from the rhizosphere of rice paddy soil in northern Iran. The effect of temperature, NaCl and pH on the growth of these isolates was studied by modelling. Three of the most effective strains from a total of 300 isolates were identified and a phylogenetic analysis was carried out by 16S rDNA sequencing. The isolates were identified as *Pantoea ananatis* (M36), *Rahnella aquatilis* (M100) and *Enterobacter* sp. (M183). These isolates showed multiple plant growth-promoting attributes such as phosphate solubilization activity and indole-3-acetic acid (IAA) production. The M36, M100 and M183 isolates were able to solubilize 172, 263 and 254 µg /ml of $Ca_3(PO_4)_2$ after 5 days of growth at 28 °C and pH 7.5, and to produce 8.0, 2.0 and 3.0 µg/ml of IAA when supplemented with L-tryptophan (1 mg/ml) for 72 h, at 28 °C and pH 7.0, respectively. The solubilization of insoluble phosphate was associated with a drop in the pH of the culture medium and there was an inverse relationship between pH and solubilized P. There were no significant differences among isolates in terms of acidity tolerance based on their confidence limits as assessed by segmented model analysis and all isolates were able to grow at pH 4.3-11 (with optimum at 7.0-7.5). Based on a sigmoidal trend of a

three-parameter logistic model, the salt concentration required for 50% inhibition was 8.15, 6.30 and 8.23% NaCl for M36, M100 and M183 isolates, respectively. Moreover, the minimum and maximum growth temperatures estimated by the segmented model were 5.0 and 42.75 °C for M36, 12.76 and 40.32 °C for M100, and 10.63 and 43.66 °C for M183.

Asari et al. (2016) have reported the colonization of *Arabidopsis* roots with *Bacillus amyloliquefaciens* UCMB5113 caused change in root structure and promoted growth. They showed that the rhizobacterium *Bacillus amyloliquefaciens* subsp. *plantarum* UCMB5113 stimulated the growth of *Arabidopsis thaliana* Col-0 by increased lateral root outgrowth and elongation and root-hair formation, although primary root elongation was inhibited. In addition, the growth of the above ground tissues was stimulated by UCMB5113. Specific hormone reporter gene lines were tested which suggested a role for at least auxin and cytokinin signalling during rhizobacterial modulation of Arabidopsis root architecture. UCMB5113 produced cytokinins and indole-3-acetic acid. The production of IAA was stimulated by root exudates and tryptophan. The plant growth promotion effect by UCMB5113 did not appear to depend on jasmonic acid in contrast to the disease suppression effect in plants. The exudates from the isolate inhibited primary root growth, while a semi-purified lipopeptide fraction did not and resulted in the overall growth promotion indicating interplay of many different bacterial compounds that affect the root growth of the host plant. In another study of Asari et al. (2016) reported the beneficial role of *Bacillus* VOC for the improvement of growth and pathogen control. They have screened four strains of *Bacillus amyloliquefaciens* subsp. *plantarum* strains were screened for VOC effects on *Arabidopsis thaliana* Col-0 seedlings and *Brassica* fungal phytopathogens. VOC from all four *Bacillus* strains could promote growth of *Arabidopsis* plants resulting in increased shoot biomass but the effects were dependent on the growth medium. Dose response studies with UCMB5113 on MS agar exhibited significant plant growth at low levels of bacteria in presence of root exudates. However, senescence signs were observed for plants exposed to 15 times higher levels of UCMB5113 on MSA after longer exposure while the plant growth promotion remained at similar magnitude in all cases. Interestingly, the higher bacterial density on MSA supplemented with root exudates did not result in chlorosis while the growth-promoting effect was even

stronger. VOC antagonized growth of several fungal pathogens *in vitro*. However, the plant growth promotion efficacy and fungal inhibition potency varied among the *Bacillus* strains. VOC inhibition of several phytopathogens indicated efficient microbial antagonism supporting high rhizosphere competence of the *Bacillus* strains. GC-MS analysis showed a high production of diacetyl (2, 3- butanedione) and acetoin (3-hydroxy-2-butanone) by UCMB5113 on M9 medium.

Jute is a natural long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus*, family Malvaceae. Jute is one of the cheapest natural fibres and is second only to cotton in amount produced and variety of uses. The suitable climate for growing jute (warm and wet climate) is offered by the monsoon climate during the monsoon season. Temperatures ranging 20˚C to 40˚C and relative humidity of 70%–80% are favourable for successful cultivation. Jute requires 5–8 cm of rainfall weekly with extra needed during the sowing period. Due to its good spinable characteristics, it is a good textile fibre. It is well known as golden fibre. At present jute and jute goods are suffering many problems both in home and abroad. International market of jute and jute goods is now suffering from decreasing fund of price for not only the synthetic fibre come in competition but also the inferior quality. Cultivation of jute also suffers from attacks by various pathogens during different stages of growth, the most important being *Macrophomina phaseolina* causing stem rot (Ashraf and Javaid, 2007). Very little work has been done on microbial population of jute rhizosphere. Akhter and Mandal (1996) studied the bacterial population in the Rhizosphere of Jute and allied fibrous plants. Saha et al. (2000) investigated the changes in soil properties and crop productivity as affected by long-term fertilization for 25 years in the New Gangetic alluvial soil with jute-rice-wheat cropping sequence.

So it can be concluded that, in spite of being an important crop of large area of India and Bangladesh the rhizosphere of jute has not yet been studied well. Non judicial uses of chemical fertilizer and fungicide cause soil contamination, fungicide resistance and harmful effects to non-target organisms. In order to adopt eco-friendly and inexpensive alternate disease management strategies, increasing use of plant growth promoting microbes as biofertilizers and biocontrol agents provide alternatives to the use of chemicals for disease control.

The present study has been undertaken with the following objectives:

Objectives

1. Isolation, biochemical characterization and identification of bacteria from the rhizosphere of jute.
2. Determination of ability of isolated bacterial strains to promote growth *in vitro*.
3. *In vitro* screening of PGPR strains for evaluation of antagonistic activity against some common pathogens.
4. *In vivo* testing of PGPR for evaluation of growth promotion and disease suppression.
5. Determination of biochemical changes related to growth promotion.
6. Analysis of defence related responses induced by PGPR.