Pulses provide protein of high biological value in vegetarian diets overcoming malnutrition in masses. In rotation with cereal crops, pulses not only serve in nitrogen economy but also enrich soil health as major portion of leaves fall in the field adding organic carbon and most micro-nutrients. Our ancestors had realized the importance of grain legumes and, therefore, these crops became essential component of farming systems in the past.

India is the major pulse producing country in the world with about 33 per cent of the total acreage under pulses and contributing 25 per cent of total world production. Despite contributing around 25 per cent of total world production, India has very low productivity (619 kg ha\(^{-1}\)) as compared to Holland (3286 kg ha\(^{-1}\)), New Zealand (3110 kg ha\(^{-1}\)), Germany (2866 kg ha\(^{-1}\)), Britain (2565 kg ha\(^{-1}\)) and Egypt (2051 kg ha\(^{-1}\)). However, with the adoption of high yielding cultivars of wheat and rice due to rice-wheat cropping system, the area under pulse crops has been continuously decreasing. As a result, per
caput availability of pulses has declined from 69 g day\(^{-1}\) in 1961 to about less than 30 g day\(^{-1}\) in the recent time.

According to FAO and WHO estimates, 1.0 g of protein per caput per day for each kilogram weight are required for proper body growth. Considering average body weight of 60 kg, one would require around 60 g day\(^{-1}\) of protein from different animal and plant sources. Further, presuming that some requirement is met by other food sources, especially vegetables, around 50 g caput\(^{-1}\) day\(^{-1}\) could be considered a reasonable target for proper body growth. To make up this shortfall in supply besides, of course further demand from burgeoning population nearly 12.5 per cent of gross production for seed, feed and wastage (5 per cent for seed, 5 per cent for feed and 2.5 per cent as wastage) at least 30.3 million tonnes of pulses would be required by the end of 2020 AD is more than the double. Mungbean offers a good opportunity to increase its area from 3 million ha to 4 million ha and producing from 400 kg ha\(^{-1}\) to 800 kg ha\(^{-1}\) through development of efficient and stable plant types and production technologies. As there is little scope of area expansion under pulses, its productivity has to be increased through development of high yielding, input responsive and stable cultivars to meet the pulses requirement and reduce import, saving valuable foreign exchange.

Mungbean (\textit{Vigna radiata} L. Wilczek) is an important pulse crop cultivated across the country during \textit{kharif}, \textit{rabi} and \textit{spring/summer}
seasons and is considered to be originated from *Vigna sublobata*. It is also known as green gram-an important short duration grain legume with wide adaptability, low input requirements and the ability to improve the soil fertility by fixing atmospheric nitrogen. Mungbean is well suited to a large number of cropping systems and constitutes an important source of cereal-based diets. Throughout the India the mungbean is used for different purposes. The major portion is utilized in making dal, curries, soup, sweets and snacks. The germinated seeds have high nutritional value compared with asparagus or mushroom. With sprouting, there is an increase in the thiamine, niacine and ascorbic acid concentration.

Mungbean is nutritionally very rich and contains on an average 22.0 per cent protein, 3.3 per cent fat, 5.9 per cent fibre, 51.0 per cent carbohydrate, 4.89 per cent ash, 3.4 per cent minerals and 0.3 per cent vitamins. Variation in protein content is more influenced by the location, climatic conditions, fertilizer level and *rhizobium* inoculation than the genotypes. Mungbean is a rich source of amino acids required for repair of cells and maintenance of body such as cystein (55 mg), isoleucine (264 mg), leucine (484 mg), lysine (43 mg), methionine (75 mg), phenylalanine (378 mg), tryptophan (68 mg), tyrosine (78 mg) and valine (324 mg) per gram of nitrogen. It is fairly good source of thiamine, deficient in tryptophan and sulphur containing amino acids like methionine and cystein but rich in lysine making it an excellent component to cereals. Mungbean is also good source of minerals and
are precursor of vitamin A and vitamin B complex. When seeds of mungbean are allowed to sprout, ascorbic acid (vitamin C) is synthesized.

Iron deficiency continues to be the most prevalent micro-nutrient disorder worldwide. Nearly 3.5 billion people in the developing world are affected. Asia has the highest prevalence of anemia, the serious form of iron deficiency. Women of reproductive age and children are most severely affected. Food based approach to alleviate iron deficiency are long-term oriented. The approaches may include: 1) increasing the production of micro-nutrients rich foods, 2) increasing the intake of micro-nutrients rich food, 3) improving bioavailability of micronutrients and 4) developing cultivars with increased density of micro-nutrients.

Mungbean has about 4-6 mg iron per 100 g, but the presence of phytate and tannin in mungbean reduces its iron bio-availability significantly. AVRDC’s research has shown that the bioavailability of iron from mungbean can be enhanced by sprouting (AVRDC, 1994) or by cooking with vegetables such as tomato and cabbage (AVRDC, 1998). Recipes that can enhance the bioavailability of iron in mungbean (7-11 per cent) have been prepared and are popularized in India (Subramaniam and Yang, 1998; Bains and Ray 2003).

Mungbean grown throughout Asia, Australia and West India alone accounts for 65 per cent of the world acreage and 54 per cent of
the world production. In India, during the period 1971-75 to 1986-90 area increased from 2.11 to 3.13 million ha; production 0.65 to 1.24 million tonnes and productivity from 306 to 397 kg ha\(^{-1}\). Considering the over all period from 1971-75 to 1991-95, area, production and productivity recorded considerable increase. Initially, Andhra Pradesh, Maharashtra and Orissa were the top ranking states in respect of area, whereas during the period 1986-90 the order changed to Orissa, Maharashtra and Andhra Pradesh. Drastic reduction in area under mungbean has been recorded in Orissa whereas considerable increase in area in Rajasthan has been noticed. Presently the top ranking states in area under mungbean are Maharashtra, Rajasthan and Andhra Pradesh.

Biological nitrogen fixation (BNF) is nature’s vital process, in which atmospheric di-nitrogen is reduced to ammonia. Estimates of global nitrogen fixation are in order of 175 million tonnes per year in which legume nitrogen fixation itself accounts for 40 per cent. Values estimated for various legume crops and pasture plants are often impressive. Legumes like soybean, lucerne, clover and lupin fix 234, 205, 175 and 169 kg nitrogen ha\(^{-1}\) year\(^{-1}\), respectively. Hence, BNF represents a major source of nitrogen for plant growth and seed yield in legume crops.

*Rhizobia* are widely distributed in soils of the tropics and have the ability to fix atmospheric nitrogen in symbiotic association. The
amount of nitrogen fixed varies with the strain of *rhizobium*, the plant species and environmental conditions. Beneficial effect of *rhizobium* with pretested efficient strain in different pulses including mungbean has been reported by various workers (Ceylon and Sepetogulu, 1982; Malhotra and Lahri 1970 and Gupta *et al.*, 1988).

The important desirable characters of *rhizobium* are effective nodulation of host-legume, high nitrogenase activity, high competitive ability for nodulation, efficient utilization of photosynthates and tolerance to environmental stresses. It is important to understand the ecology of legume-*Rhizobium* symbiosis and it is not the same as the ecology of *rhizobia* growing as free-living organisms. The legume-*Rhizobium* symbiosis is highly integrated and self-regulatory system. The ultimate amount of symbiotic nitrogen fixation (SNF) in field depends on a complex tripartite interaction of *Rhizobium*-legume host environment. Therefore, the ecology of legume-*Rhizobium* symbiosis should consider the study of 1) *rhizobia* factors, 2) legume factors and 3) environmental features.

In these days of energy crisis, increasing the capacity of biological nitrogen fixation is felt as an additional, if not an alternative to chemical fertilizers. Screening of legume root nodules for nitrogenase, the enzyme which converts nitrogen into ammonia, is commonly done in legume research programmes to identify improved legume plant type and to identify efficient bacterial strain in
agricultural microbiology. Nitrogenase has the capacity to reduce certain other compounds apart from its natural substrate, dinitrogen. Reduction of acetylene by nitrogenase is very well exploited for assaying nitrogenase.

Mungbean is known to fix 50-60 kg nitrogen ha\(^{-1}\) under different agro-climatic conditions. Seed inoculation with *rhizobium* recorded increase in grain yield by 12-16 per cent. Conjunctive use of *rhizobium* with rhizospheric micro-organisms such as phosphate solubilising bacteria (PBS) and plant growth promoting rhizobacteria (PGPR) have been found to reveal synergistic effect on symbiotic parameters and grain yield of mungbean. Efficiency of legume *rhizobium* symbiosis depends primarily on the acceptability of legume host, native rhizobial population, moisture at sowing, cultural practices and mineral N content in the soil. Studies conducted in various agro-climatic conditions with different crop genotypes, tillage operations, use of agro-chemicals like captan / thiram for seed treatment, integrated weed management etc. showed variable results. It, thus, appears that there is a dire need to intensify the research on biological nitrogen fixation (BNF) under different agro-climatic conditions and agronomic manipulations to achieve higher BNF and productivity in mungbean.

Sulphur is one of the important secondary nutrients for plant growth. Sulphur influences plant growth in two ways, firstly by acting as a nutrient, and secondly by improving the soil condition. Sulphur
and its compounds may affect the availability of other nutrients by lowering the soil pH and improving the physical condition of soil. The specific functions of sulphur in plant growth and metabolism are numerous such as it is essential for the synthesis of the sulphur containing amino acids-cystein and methionine, which govern the qualitative and quantitative characters of pulses; it activates certain proteolytic enzymes such as the papainases (papain, bromalin and ficin); it is a constituent of glycosides, co-enzyme-A, glutathione, vitamins-biotin and thiamine, iron, sulphur, protein called ferrodoxin and it increases the oil content of crops such as flax and soybean. Sulphur is also known to promote nodulation in legumes, thereby promoting N-fixation. It also plays a vital role in the chlorophyll formation and influences partioning of photosynthates.

Phosphorus has been referred to as the “master key element” in crop production. Most of the phosphorus present in soil is unavailable to plants, which is made available by action of efficient micro-organisms like bacteria, fungi and even cyanobacteria. These micro-organisms bring about solubilization by the production of organic acid and phosphatase enzyme activity. As regards phosphate, only about 15-20 per cent of the applied phosphorus is utilized by first crop. Hence the current trend throughout the world is to explore the possibility of using alternate nutrient sources for increasing the efficiency of chemical fertilizers.
To overcome the problem of protein energy malnutrition and micro-nutrient deficiencies in children and to meet the minimum requirement of pulses, there has to be an increase of around 0.8 metric tonnes per year in production. This has to come mainly through increase in its productivity and only to a little extent through area expansion. Hence, it is necessary to adopt integrated nutrient management involving use of organic, inorganic fertilizers and bio-fertilizers for achieving the projected production of pulses.

Keeping above facts in view, the present investigation entitled “Studies on relative performance of *rhizobium* strains on mungbean as affected by added doses of sulphur and phosphorus” was carried out with the following objectives:

1. To assess the relative efficacy of different strains of *rhizobium* in relation to nodulation and yield of crop,
2. to study the effect of added doses of sulphur and phosphorus on efficacy of rhizobial nodulation,
3. to study the effect of *rhizobium* strains, sulphur and phosphorus on nitrogenase activity,
4. to work out the interactive effect of sulphur, phosphorus and *rhizobium* strains on crop performance and
5. to study the influence of sulphur and phosphorus on uptake of nutrients.