CHAPTER - 1

INTRODUCTION
India is basically an agricultural country and about 75% of the total population are residing in the rural areas depending mainly on agriculture. Paddy is one of the major cereal crops for Indians covering approximately 40 million hectares area. On a global scale, it covers more than 150 million hectares with an average production of 3.5 tonnes per hectare. India is the largest rice growing country of the world producing 84.7 million tonnes of rice grain. The average production in India is about 1.9 tonnes per hectare and in Asia 90% of the total rice is grown and consumed. Nearly 2.86 billion people in Asia derive 45% - 60% of their calorie from rice. The population in India is steadily growing posing a serious threat to the national food security. In order to feed the growing millions, attention must be focussed on improving the productivity and stability of rice production on an ecologically sustainable basis (Swaminathan 1991).

Nitrogen is the key element for realizing the potential yield from modern high yielding rice varieties. It is well established that 19 – 21 kg N is removed from soil to produce 1 tonne of brown rice (Murayama 1979). The total nitrogen requirement for a potential yield of 15 tonnes per hectare is estimated as 300kg per hectare (Setter et al. 1994). Considering that soil supplies about 50 – 80 kg nitrogen per hectare and the efficiency of fertilizer nitrogen is about 50%, 440 – 500 kg fertilizer nitrogen per hectare will be required in order to achieve this goal. So chemical nitrogen fertilizer application is still an indispensable component of modern agricultural practices. But in order to promote sustainable rice production, there should be good management of
practices so that the cost of production as well as environmental degradation should be kept in mind without lowering the production. In the vast areas of the developing world, the fertilizers are not adequately available at affordable cost, and moreover it disturbs the equilibrium of agro-ecosystem and causes environmental degradation. The continuous and exclusive use of the chemical fertilizers not only endangers the soil health by reducing the population and activity of beneficial soil microorganisms, but also leads to pollution of both the atmosphere, surface water and ground water. This calls for a new judicious crop-feeding strategy of utilizing organic manures, and biofertilizers along with the appropriate doses of chemical fertilizers, which is called the integrated plant nutrient management (Peoples and Crasswell, 1992; Hamdi, 1995; Roger 1995).

The production of organic manure does not keep pace with the increasing demand of the crop production. Therefore various types of living organisms are cultured in the laboratory as well as in the field for practical application in crop production as biofertilizers.

Manufacture of chemical fertilizers containing nitrogen is a high energy budgeted process that is based on the non-renewable resource of fossil fuels. One unit of nitrogen requires two units of fuel. (The energy requirement of 1 Kg fertilizer is 80 MJ or 11.2 KWH for nitrogen, 12 MJ or 1.1 KWH for phosphorus and 8 MJ or 1 KWH for potassium). As long as energy costs were low, nitrogen was cheap. The energy crisis in early 1970’s changed this situation and as a result increased attention has been given to the development of methods of increasing the efficiency of nitrogen fertilizers as well as biological nitrogen fixation. The nitrogen fixing mechanism
which is happening in nature and industry is essentially similar in biological systems but without requiring industrial energy. The essential feature is the crucial role of the enzyme nitrogenase and certain trace metals as well as requirement of solar-powered ATP molecules supplied indigenously. Nitrogenase activity of the nitrogen fixing organisms, particularly free-living ones, largely depends on the concentration of combined nitrogen in the medium either due to the fixation of molecular nitrogen or due to addition of chemical nitrogen. In case of symbiosis, however, regulation of nitrogen fixation in response to combined nitrogen is mediated by the host rather than by the symbiont. Besides, the nitrogen fixation may be either by free-living or symbiotic organisms.

The soil needs adequate quantity of organic matter to maintain its physical, chemical and biological properties. Despite special efforts for increasing supplies of organic manures, their supply is still scarce and even becoming more costly. The practice of green-manuring where feasible is the principal supplementary means of adding organic matter to the soil. This includes selection of a fast growing nitrogen fixing crop and incorporation of the biomass into the soil so as to be decomposed equally rapidly in order to make the nutrients including nitrogen and other elements in available form. In this context Azolla-Anabaena symbiotic system has been regarded as a very promising component in rice cultivation. The Azolla, the popular water fern fixes atmospheric nitrogen with the help of algal symbiont, Anabaena Azollae present in its specialized leaf cavities. All the six species of Azolla are widely distributed under the diverse agro-ecological conditions (Lumpkin and Plucknett 1982, Nierzwicki Bauer 1990, Watanabe and Kushari 1992, Singh and Singh 1997).
There are many reports from many countries regarding beneficial effect of *Azolla* application on growth and yield of rice. Now the ability of *Azolla* has been explored in many directions besides its high nitrogen fixing capacity. It has been found to be useful as a suppressor of weeds, ammonia volatilization, water evaporation and scavenger of potassium and phosphorus. The plant is a palatable food for pigs, ducks and fishes. It is a promising candidate for improving the water quality of polluted water. But there are some problems too that limit its wide utilization in rice cultivation. Primarily the survival of *Azolla* inoculum beyond the temperature range of 14°C to 35°C and under intense solar insolation during summer poses a great problem for rapid vegetative multiplication. Moreover, heavy infestation of pests during wet seasons and requirement of large quantity of nutrient, particularly phosphorus are of serious concern for the management of *Azolla* multiplication technology.

Despite the traditional use of this plant as biofertilizer in China and Vietnam for over a century, it has been extended only in certain areas of Philippines, Thailand, Indonesia and India where ecological amplitude of essential requirements fairly exists or has been manipulated. In India technology for large-scale production and use of *Azolla* in rice farming has been developed (Singh 1989; Kannaiyan 1994; Kushari 1987). Sporadic attempts have been made in certain areas in extending *Azolla* in farmers' field based on the development of appropriate technology but have met with little success. Recently National Cooperative Development Corporation, Govt. of India is trying to extend the *Azolla* Biofertilizer Technology through Cooperative Societies (Kushari and Kushari, 2000).
The primary need for large scale application of Azolla in farmers' field is to produce bulk quantity of inoculum at a low cost in a simple way. The production site of Azolla inoculum should be near the rice-field and these sites should contain high concentration of nutrients most likely to suit the rapid vegetative growth of Azolla. Hence suitable sites for inoculum production that do not impinge on the productivity of agricultural lands are stagnant water bodies like ponds and ditches as well as slow-flowing water bodies that receive good quantity of nutrients through runoff. Here again the production of vegetative inoculum suffers from certain limitations. It is very difficult to transport over a long distance and is easily decomposable. Moreover it can not tolerate extreme cold or extreme heat. So the alternative way of vegetative inoculum production is to produce bulk quantity of spores of desirable species.

Sporocarp technology helps in the maintenance of Azolla germplasm particularly under unfavourable conditions. Sporocarp can resist adverse conditions and remain viable for longer periods because of the sporangial covering around them. Their storage, transportation and distribution are easier and economical. But the use of sporocarps has also certain limitations. All the species do not produce sporocarps round the year. The most serious limitation of sporocarp technology is that the spores take about 25 – 30 days to develop mature plant. So in order to remove this bottleneck and to develop the appropriate sporocarp technology; detailed investigations are needed on the ecological factors influencing profuse sporulation of the desirable Azolla species as well as rapid growth of the sporelings (plantlets) so that sporocarp technology can be used directly in the field or as a means of producing vegetative inoculum depending on the various factors involved in agricultural practices.

Based on the above problems of sporocarp technology, the objective of this work was aimed at two directions:

1) Study of sporulation capacity of six species of Azolla at different seasons of the year in order to identify the species with better sporulation capacity.

2) Study of germination and viability of spore of most potential species. Evaluation of the growth of sporelings in different seasons of the year. Manipulation of the growth rate of slow growing sporelings by Phytonol, IBA, GA3 and NAA in relation to important environmental factors.