I. INTRODUCTION

Rice is the essential and very important food source among cereals for a rapidly growing population. It sustains more than half of the world’s population as being their staple diet and constitutes 20 percent of the total food energy intake of the world’s population. In Asia, more than 2 billion persons derive between 60 and 70 percent of their daily dietary energy from rice and its by-products (FAO, 2006). But, the production of rice is restricted by a world-wide shortage of cultivation space. Hence, in future, more rice has to be produced from less land that too in a sustainable way. High yielding varieties (HYV) and hybrids have been introduced to meet this challenge, but these HYVs and hybrids demand very high additional nutritional input, especially nitrogen. Thus, global agriculture now relies heavily on N fertilizers derived at the expense of petroleum that is vulnerable to political and economic fluctuations (Shenoy et al., 2001).

Low input efficiency of N fertilizers, decline in crop yield under continuous cropping, nitrogen losses due to leaching and de-nitrification, nitrate pollution, acidification of soils and emission of green house gases such as ammonia and nitrous oxide, are some economic and environmental factors that need to be considered while using chemical nitrogen fertilizers (Shreshta and Ladha, 1996). Apart from this, run-
down of N supply capacity of agricultural soils, lack of purchase power of poor farmers, gap between the researchers and farmers in N management of crops and soils for increasing production efficiency, have made the researchers to think about exploiting alternative or supplementary nitrogen sources to encourage sustainable agriculture. In this context, Biological Nitrogen Fixation (BNF) assumes importance in the lowland soils that provide 86% of the world’s rice.

Among the conventional BNF systems of rice, the free living/associative diazotrophs have low to moderate potential to supply N to rice because, N\(_2\) fixed outside the plant is subjected to losses. Green manure crops like *Azolla* and *Sesbania* have high N supply potential to support higher grain yield of rice, but farmers are reluctant to use them as there is no economic advantage over chemical N fertilizer (Ladha *et al.*, 1993). If a BNF system could be assembled in the rice plant itself, then N supply potential could be enhanced as fixed N would be available directly to the plant with little or no loss. This would also ease the economic burden of the farmers.

It has been a long standing goal, in the field of biological nitrogen fixation to extend the nitrogen fixing symbiosis to presently non-nodulating cereal plants, such as rice. Celebrated legume-rhizobium symbiosis for atmospheric di-nitrogen fixation has induced rice biologists to target for such a symbiotic system in rice too. A number of researchers have described the induction of ‘nodule like structures’ on the roots of
cereals, primarily by the use of plant growth regulators, such as 2,4-D, NAA, IAA, or by either cell wall degrading enzymes in the presence or absence of rhizobia.

The nodule like structures induced on roots of non-legumes are referred as ‘Paranodules’, just to indicate their distinction from the legume system, as they are deliberately induced (Tchan and Kennedy, 1989). These can be induced by several methods, viz., treatment with auxins, such as 2,4-D, NAA, IAA; by treating the roots with hydrolytic enzymes or by inoculation of roots with genetically engineered strains of rhizobia, etc. (Kennedy and Tchan, 1992). The paranodules thus induced, have many implications in cereals, most important being providing a niche to symbiotic nitrogen fixing microbes and hence, non-legumes can also derive benefits of biological nitrogen fixation like legumes.

There are several reports on nitrogen fixing microbes like Rhizobia, Azorhizobia and Azospirillum colonizing these paranodules and fixing di-nitrogen inside the paranodules (Chen et al., 1993; Christainsen-Weniger, 1996). In fact, it was found that these paranodules are more efficient in nitrogen fixation compared to the legume nodules (Kennedy and Tchan, 1992). Also, there seems to be preferential colonization of the paranodules when different strains of diazotrophs were used for inoculation (Gurudatta, 1999).
Paranodulation response in rice was found to exhibit high degree of genetic variation, behaving as a heritable trait (Kalagudi and Shenoy, 1998), indicating good potential for selection of genotypes with higher frequency of paranodule induction, from the populations screened. Since, the phenotyping for the paranodulation response is tedious and time consuming, there is a need for developing molecular (preferably DNA) marker/s that co-segregate tightly with paranodulation trait. Such molecular tag/s would be very useful not only in selection of donors for the trait from the germplasm collection, but also in unambiguous recovery of the desired segregants in combination breeding programmes aimed at combining higher paranodulation trait with better agronomic performance, i.e., in Marker Aided Selection (MAS) for better paranodulation response.

Keeping these in mind the present investigation was undertaken with the following objectives -

1. To map the QTL responsible for paranodulation trait;
2. To identify the markers which are flanking the paranodulation response QTL; and
3. Validation of the identified markers on genotypes already characterized for paranodulation induction response, but not included in the mapping study.