1. INTRODUCTION

The term '**biosystematics**', first proposed by Camp and Gilly, (1943), is an experimental approach at population level to delimit the natural biotic units considered that morphology, cytogenetics and ecology (Clausen, *et al.,* 1945, 1967). During the last three decades biosystematics has attained vast dimensions and good number of publications have appeared (Stebbins, 1950; Radford, *et al.,* 1974; Simpson, 1977; Stace 1980). This trend has been rapidly changed in the experimental analysis of cytogenetics, breeding, anatomy, palynology, chemotaxonomy and ecological aspects, to develop a natural biological system of classification. But this area of research is expensive, lengthy and laborious process while recently many molecular biological techniques were emerged, in addition to understand what is a true biological species. Quite apart from the current debate over species concept and utility of using the species is an "**evolutionary significant unit**" (Moritz, 1994; Dimmick, *et al.,* 1999). Further, such studies have often the best measure of existing diversity, but as a way of assessing priorities across a complex and continuous system, while missing of many rare species especially when those rare taxa are restricted to species-poor habitats. As a precisely geo-referenced collection increases, the fine knowledge on distribution of taxa in space becomes very greater.

1.1. General introduction

Amaranths are hardy, fast growing pseudocereals that have promising potential as nutritious subsidiary food crops. It might be supposed that a world shortage of food would be searching the new products in all available food crops. But there is no world food production saturation because of population rate is greater than the rate of production. Since prehistoric times mankind has used about 3000 plant species and gradually the tendency has been to concentrate on fewer and fewer species and most of

the worlds present food comes from a mere 20 or so species (Vietmeyer, 1986). A remarkable collection of poor peoples' crops are forgotten is to be found in the high land of South America. The Indians there are among the poorest people in the Western hemisphere and, except for the potato, their crops remain outside the main stream of agronomic science (Vietmeyer, 1986).

We need a revitalized worldwide investigation on potential food crops, such an effort would expand our agricultural resource base and ease our dangerous dependence on relative handful crops. It would build a more stable food supply for drought-stricken Africa and other parts of the third world. A notable poor persons' crop, *Amaranthus* group yielding the fresh broad leaves and young stems commonly used for the kitchen. This utilizing property have always been popular among the tribal and rural communities and poor families in India. For the central and south Americans, Amaranth was an important food since 500 years ago. Such dual-purpose staple food of Aztecs, Incas and other Indian people of ancient Mexico, and they remain as neglected crop of the present generation. Both Aztecs and Incas revered the crop, when heated, the tiny seeds burst and take on a flavor reminiscent of popcorn. But, because Aztecs created idols out of popped Amaranth and ate them in Payan ceremonies involving human sacrifice, the conquering spaniards banned Amaranths cultivation and forced the crop into obscurity. Then this political act helped to bring down the Aztec religion and culture. Some farmers in the isolated mountain regions of Mexico and South America have been practiced the ancient tradition of growing Amaranths.

The Amaranth seed possess good amounts of starch, which can match the highly priced starch of waxy maize in quality. A blend of Amaranth flour and wheat flour reached the perfect score of 100 in meeting the theoretically balanced essential amino acids scale set by the nutritionists who measure the protein quality. The grains are popped and they taste like crunchy, nutty-flavored popcorn. The light and crisp popped seeds are delicious as a snack or cold breakfast cereal with milk and honey, as a breading, on chicken or held together with a dash of honey in sweets. The grains are used in making confection with honey or syrup after popping the grains.

Pounded grains can be used in the preparation of invigorating drinks. Parched and milled grains are used to make grainy, light coloured flour suitable for pancakes, biscuits, breads, cakes and other baked foods. Amaranth flour without any gluten content need to be necessarily mixed with wheat flour to make the baked products rise. *Amaranthus hypochondriacus* is cultivated for grain and the seed used as food in a variety of ways (Pal and Khoshoo, 1974). In places where it is grown for local consumption and forms the staple diet of the people (the Sutlej Valley and higher elevations in Kumaon and Gharwal), the seeds are used in a similar way to wheat being first ground in to flour then made into a dough with water. From the dough thin cakes or 'chapatis' are prepared by patting between the palms, and baking over a fire. In Nepal (Singh, 1961) the parched seeds are ground to flour and eaten as gruel ('satto') with milk or water. The popped grains are put in milk and the porridge thus made is taken in most parts of India on fast days, as the cereals are not allowed. The popped grains are mixed with jaggery and made into balls or cakes as sold in Lucknow (U.P.) markets.

In 1975 an Australian researcher, Downton reported a few seeds yielding high levels of both total protein and of the nutritionally essential amino acids i.e., lysine, which is usually deficient in plant protein, including the protein in all common varieties of major cereal crops. The lysine is very important basic amino acid (including arginine) for the formation of nucleosomes. In 1991 Prakash and Pal worked on the nutritive values of grain Amaranths and the composition of fat, proteins, carbohydrates, minerals, etc were estimated. The protein quality is better as much as it is richer in certain essential amino acids including lysine and methionine, and the protein efficiency is comparable to casein (Subramanian and Srinivasan, 1951). Thus Amaranth seeds have potentialities as a subsidiary food and may play an important role in feeding the hungry world. Amaranths is an ancient crop, which has received increased attention from researchers in recent years, (now grown on over 200,000 acres per year in China) since 1996, Harold Corke *et al.*, worked on the quality of starch in grain amaranths' starch quality. Amaranthus starch has special characteristics i.e., low gelatinization temperature, low peak viscosity, with promising applications in the food industry. Recent work has focussed on production of high yielding, high-quality food grade pigments, similar to red beet pigment, from

Amaranths. Amaranth oil is a high-quality vegetable oil, and also an excellent potential of squalene. Genetic resources for oil composition are being characterized.

The group consists of quick growing plants and high yielding of leaf and grains, there are four popular New World species of grain amaranths like *Amaranthus caudatus, A. edulis, A. hypochondriacus* and *A. cruentus*. The *Amaranthus edulis* is classified as a race of the species native to Peru and other Andean countries. These species produce large seed heads loaded with white or pink coloured nutritious seeds. *Amaranthus* leaves are the rich source of proteins, vitamins and minerals, the tender leaves and stems are cooked and eaten as greens. A quick growing healthy Amaranth stand crop can yield nearly to 1 tonne of grains per hectare. The pale seeded varieties endowed with good appearance, excellent flavour and popping qualities, the dark seeded ones generally used as greens and for ornamental purposes. Interestingly crop reaches maturity with in three months, the seed heads has to be harvested before seed fall off, because when they are ripe, seed shedding is a major problem. The harvested heads are then threshed and winnowed to get clean, shiny seeds.

A quick growing Amaranths are well acclimatized to any new environment and grow vigorously even in unfavorable conditions and without any apply of fertilizers. They are blessed with an efficient type of photosynthesis, the C-4 carbon fixation pathway etc. The Amaranths perform well in high temperatures and it is easy to cultivate even in hot and dry regions of the world. The Amaranths have wide variety of wild relatives in the world. The occurrence, distribution and taxonomy of these taxa are yet to be explored in majority portion of the country. Further, the diversity existing among the wild *Amaranthus spp.*, is complex which requires systematic treatment to provide clear taxonomic circumscription among them. The present study was taken up to establish the clear boundaries for each taxon in the group and provide detailed description along with key for easy identification.

About the family

Amaranthaceae, one of the core families of Centrospermae and its reference to the order has always been beyond the dispute. It is well known tropical family represented with about 3 tribes, 65 genera and over 1000 species including many cosmopolitan weeds (Townsend, 1980). Amaranthaceae family is characteristically lacking central crystalloid in p-type sieve element plastids (Behnke, 1976). The most interesting and specific feature of the family is the restricted radiation into the forest ecosystem in this family. The family is known for anomalous secondary growth (Wilson, 1924; Joshi 1931a,b; Belfaur 1965; Timonin, 1987a.b), occurrence of betalains (Harborne, 1984) and presence of unique protein deposition in the sieve element plastids (Behnke, 1976; Mabry, 1977) and the possession of kranz anatomy (Treguna and Downton, 1967, Das and Santakumari, 1977, Rajendrudu, *et al.,* 1986), etc.

About the tribe

The tribe *Amarantheae* represented by 15 genera and more than 45 species among which 13 genera and 44 species (including varieties) have been reported from Southern peninsular India. The type genus *Amaranthus* (meaning "not withering" Brenan, 1961) comprises largest number of species represented in India (Sen and Singhal, 1985). Many of its species are popularly known as grain amaranths and identified as having potential economic value as an alternative to present day grain crops. Analysis and nutrition experiments show that the grain is comparable to the cereals as carbohydrate food and superior in protein and fat content (Sauer, 1967; Lexander, *et al.,* 1970). Food and Agricultural Organization (FAO) has recognized these crops as highly valuable in Africa, Latin America and Asia. Due to their high economic and nutritional value *Amaranthus caudatus* and *A. hypochondriacus* held the attention of scientists at NBRI, Lucknow and investigations have been pursued in that direction.

Due to its highly evolved characters and varied complexity in the members of the tribe *Amarantheae* the critical systematic analysis is carried out to understand the molecular basis for the existing taxonomic diversity in the group with special reference to *Amaranthus* complex in south India (Fig.1). The application of Biosystematics in taxonomic analysis of this group was mainly concerned with the complex and indistinct variations existing among them. Numerical taxonomy, the powerful technique is applied to evaluate the affinity or similarity between taxonomic units and the ordering of these units into taxa on the basis of their affinities (Table-11, 18).

The maximum number of characters was used for taxonomic assessment and classification as proposed by Adanson (1763). The present investigation is an attempt to find the interrelationship existing among the taxa under the tribe *Amarantheae* of Amaranthaceae with the help of following aspects

1. External Morphology
2. Leaf architecture
3. Epidermal studies
   a) Trichome complex
   b) Stomatal complex
4. Palynology
5. Karyology and Nuclear DNA analysis
6. Seed morphology
7. Phytochemistry
8. Ecological studies
9. Numerical analysis/Taximetrics

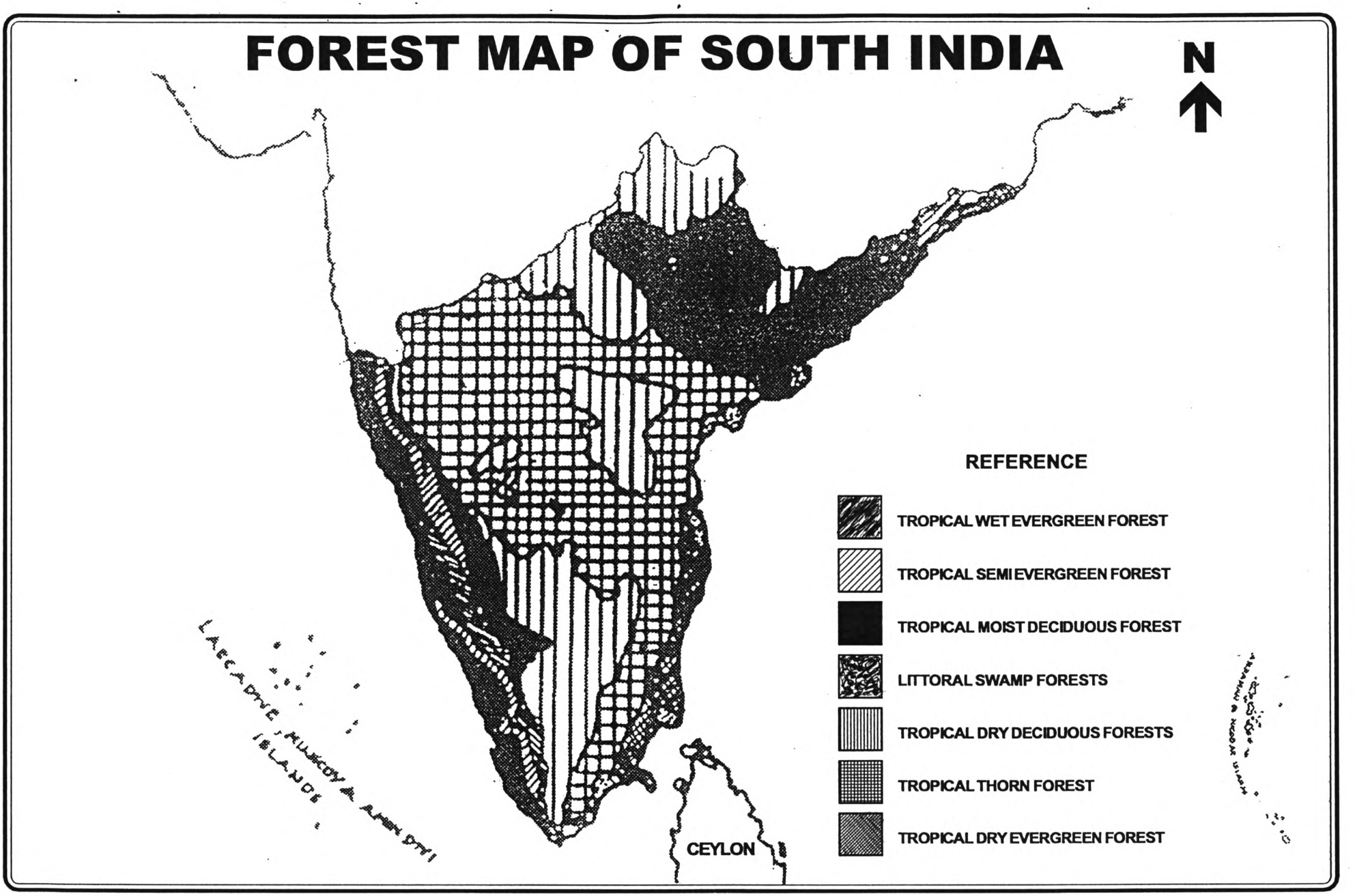
FOREST MAP OF SOUTH INDIA
N
REFERENCE
TROPICAL WET EVERGREEN FOREST
TROPICAL SEMI EVERGREEN FOREST
TROPICAL MOIST DECIDUOUS FOREST
LITTORAL SWAMP FORESTS
TROPICAL DRY DECIDUOUS FORESTS
TROPICAL THORN FOREST
TROPICAL DRY EVERGREEN FOREST
CEYLON

Fig: 1

1. 2. Objectives of the present investigation

- **Exploration and systematic enumeration of amaranth diversity in south India**
- **Systematic evaluation and preservation of taxa from different Phytogeographical regions to understand the role of ecoclimatic factors on Phenetic diversity**
- **Delimitation and Establishment of taxonomic boundaries to the taxa in the light of biosystematic studies**
- **To assess the extent of diversity in genome size both at intra-specific and inter-specific level**
- **Cladistic analysis to understand taxonomic kinship among the taxa and Construction of cladogram**
- **Construction of taxonomic keys for the taxa to enable easy identification.**