CHAPTER - 1

INTRODUCTION

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Green plants have sustained human life through ages. The early man was furtunate to live in aubndance of nature surrounding him. But gradually with the passage of time, man felt the scarcity of nature and today he could not get his requirements due to limitation of resources. This led him to exercise his intelligence in directing nature's evolution for more production and for finding out more and more plants for food and other requirements. Hence several areas of plant science have been exploited not merely for an enquiry but for crop improvement to cope with the growing demand. Cytogenetics is one of such areas of plant science which has been utilised in the field of agriculture in bringing about several plant species under cultivation, in producing large number of high yielding varieties of crops & in evolving several new plant species carrying valuable characters.

There are various plant species which have long association with human civilization and it is believed that the centres of origin of these species are the seats of ancient civilization. Among the various species rice, wheat and maize are believed to be very old ones and their centres of origin have been the seats of three most ancient civilizations. Similarly grain amaranths are believed to be another group of ancient food crops which have long association with human race. There is evidence that some amaranths originated even before man took to organised agriculture and were around the camps and fishing villages of prehistoric people who conveniently used them for food as and when required (Sauer, 1967).

Amaranthus Linn. is the fifth largest genus in the family Amaranthaceae which includes about fifty species in the world flora and is represented in India by twenty species (Santapau and Henry, 1973). It is the most important genus in the family. Most of the species are found under cultivation and few species like A. spinosus L. and A. viridis L. are grown on waysides and waste places as weeds. However, all the members of the genus are annual herbaceous plants. Although most of the species are grown as pot herbs and are widely used as vegetable greens, there are some species which are exclusively grown for the grain. Some of them, for their brilliant attractive colours, are also used as ornamentals but all these species are commonly referred under two names as vegetable amaranths and grainamaranths.

The genus Amaranthus L. has a history of thousands of years of cultivation as vegetable and grain producing plants. Archeological digs in the Tehuacan Valley of Mexico have found cultivation of amaranths during 6700 to 5000 B.C.. Basing on eco-geographical, morphological, ethnobotanical and physiological studies, Sauer (1950, 1967) also reported that cultivation of grain amaranths began with the dawn of American-Indian Agrilcutre (4800 B.C.). Since then it had been an important crop in Mexico, Central and South America. This suggestes that it is one of the oldest food crops in the new World. The grain amaranths as a domesticated crop reached it's peak during the reign of the Aztec empire. This, along with maize were the chief food crops before the introduction of cereals such as wheat and rice from the old world. But after the fall of Aztec empire, the cultivation of grain amaranths diclined to small pockets scattered throughout central and south America. The long association of amaranths with human civilization is probably due to the ability of these plants to adapt readily to new environment created by man. Since they can grow in open sun and disturbed habitat with minimum crop management, they became an easy crop for early people to cultivate and domesticate. Hence distinct vegetable and grain species were gradually developed.

The main areas of cultivation of grain amaranths are now in Asia,mostly in Nepal and Northern India. Many investigators (De Candolle, 1886; Vavilov, 1950) believe that grain amaranths have been cultivated in Southern Asia from time immemorial , Indo-Burma region being considered to be the centre of their origin. On the other hand, vegetable species, though found throughout the tropics and sub-tropics with some in temperate zones, are mostly confined to tropical Asia and Africa, which probably represent the centres of their origin (De Candolle, 1886). In fact , there is a wide spread cultiviation of vegetable species in all over India though the grain species are cultivated in northern India, mostly in Punjab plains, Utter Pradesh, Madhya Pradesh, Plains of Gujrat and Maharashtra and some in the tribal belts of Bihar and Orissa.

Most of the species are cultivated for green vegetables like that of spinach and other crops used as cooked green. They are considered one of the best tropical greens. They have high nutritive value containing 1-6% protein, requisite vitamns and high minerals (Elias, 1977). The tender leaves and stems of most of the Amaranthus species are edible and are used regularly in the diet of several communities of the world. Their popularity is based on their good yield, mild flavour, high nutritive value, easy source of vitamns to the poor, source of vitamin A to the pre-school children and ability to grow in hot climate. On the other hand, although the species of grain amaranths comparatively less in number, are important like any other food crop. It is the third group of food grain and is referred to as pseudo-cereals. It's yield is 8-12 q/ha under intensive cultivation. The grain has high nutritive value containing 12-15 % protein with high fat, minerals and lysine level. Amino acid content of the grain is in optimum balance as required in the human diet. The lysine content is essentially high in comparison to that found in common grains. Besides this, the members of the genus have C_4 pathway with high photosyntehtic efficiency. It is one of the few dicotyledons which has the potentiality to become a grain crop. It is used in the areas of south America, Africa and Asia and supplied substantial portion of protein, minerals and vitamns in the diet. Thus this may be developed as a food source for low income people of the third world countries as well as alternative crop in the developed countries.

Inspite of so much importance, the genus has been neglected during crop improvement programme in the past. However, in recent years it has again attracted the attention of scientists all over the world due to it's attractiveness as a crop, varying climatic adaptability, rich germ plasm resource with genetic variability, high protein qualilty, good grain yield, wide spread use as green vegetables and finally it's movement around the world during 16th and 17th centuries (Feine et al., 1979).

Taxonomy of the genus has been difficult. Taxonomic problems are mainly due to variation in pigmentation and their segregation within the population and the plasticity in growth under different day lengths and other environmental variations (Sauer, 1967). Inspite of these difficulties, taxonomic revisions have been carried out time to time by many taxonomists. Baker (1949) gave a detailed taxonomic treatment of the family Amaranthaceae. Various workers like Walton (1968), Townsend (1974) have also attempted to make taxonomic revision of the family. Extensive taxonomic revision, specially in dioecious Amaranthus, has been carried out by Sauer (1955) basing on species identification through constant characters particularly shapes and proportions of pistillate flower parts. However, taxonomically the genus Amaranthus L. has been devided into two more or less equal sections (Aellen, 1961), section Amaranthus Sauer (Amaranthotypus Dumort) and section Blitopsis Dumort (Thellung, 1914). The section Amaranthus includes grain types, dry amaranths, domesticated ornamentals, most of the vegetable types and some common weeds. This includes A.caudatus L.,A.hypochondriacus L., A.edulis Speg. and A.cruentus L.. These species are charaterised by a compound terminal inflorescence that is indeterminate in all species except A. edulis Speg.. Flowers are usually pentamerous with a dehiscent utricle that is circumscissle. The grain amaranths are further distinguished by relatively short and weak bracts, pale seed and high yield.

The section Blitopsis comprises number of species including A.tricolor L.,A.blitum L., A.spinosus L.etc. These species are charcterised by axillary determinate flowers and if there is any terminal inflorescnece, it is very short . Flowers are usually bi or trimerous with an irregular dehiscent utricle. The basic floral structure in both the sections is a dichasial cyme commonly called as glomerule. An initial staminate flower is followed by an indefinite number of pistillate flowers. The glomerules are on a leafless axis and form a complex panicle. Prior to stamen exertion, the pistils in the glomerule are receptive to pollen.

Genetic variability of Amaranthus L. exceeds most of the commercial crops. It exhibits varying phenotypes and is adapted to various climatic conditions . Leaf size varies greatly between and within the species. Simiarly plant colour varies from green to magenta with multitude of intermediates and combinations. The characteristics of varying phenotypes have been the major factors in making the genus cosmopolitan.

Realising it's importance, it was proposed to undertake the cytogenetic studies in this genus involving the cytology, inter-specific hybridization, induced polyploidy, mutation and tissue culture. Cytology, at times, has been helpful to solve the taxonomic problems. But the basic information about the chromosomal make up is essential for taking up any genetic experiment for the improvement of the crop. Cytology of some members of Amaranthus has been worked out earlier but the information are contradictory and inadequate. Keeping these in view, cytological analysis of large number of species, their biotypes and varieties was undertaken during the present study to add cytological data for the revision of the genus which has not been done yet.

At the same time genetic improvement of the crop has not been promising. That is probably due to the fact that most of the species are monoecious and cause a problem in breeding. Although half of the species have been suspected to have evolved through hybridization (Grant, 1959a), still interspecific hybridization has been a failure in combining members of the section Amaranthus with those of the section Blitopsis. Some of the naturally occurring interspecific hybrids are sterile. However interspecific hybridization in nature has been emphasized by various workers as one of the sources of species evolution within the genus. Therefore interspecific hybridization was undertaken during the present study to make genome analysis and to evolve synthetic vegetable types.

Induction of polyploidy has been a fruitful line of investigation in a number of crop plants. Induced tetraploidy has often been exploited in plants to increase the total biomass besides the other characters. Encouraging results have been obtained in lettuce, spinach, ryegrass, red clover, alfaalfa etc. (Mehta and Swaminathan, 1957; Zeven, 1980). Furthermore, the autotetraploids have usually shown increased levels of proteins, alkaloids and vitamns (Darlington, 1942). However, there are no substantial works of autotetraploidy in the genus Amaranthus L., though a few attempts have been made in past. Realising this, autotetraploidy was induced in three grain species of the genus during the present work. At the same time, chromosomal analysis of an existing induced autotetraploid of one vegetable amaranth was carried out in detail to analyse the multivalent segregation in relatiion to the increased pollen and seed fertility.

Mutation is another important line of genetic investigation in crop plants specially in cereals. However, very little attempt has been made to induce mutation in the genus Amaranthus L. for genetic improvement. Since there is greater homogeneity in chromosome numbers and chromosome morphology, gene mutation is considered to be one of the major factors causing variation and possibly responsible for the polymorphism within species. Keeping this in view, induction of mutation through physical and chemical mutagens was attempted in some species in order to study the various responses of this group of plants to the mutagenic agents and their relative mutability.

Tissue culture method has opened up completely a new line of investigation in biological science. Promising results have been obtained within a limited period in a large number of plant species. Since in vitro methods are simple and efficient in multiplication and help in maintaining the heterozygousity and overcome the sexual sterility or imcompatibility problem, it helps in the production of sufficient number of plants of unique genotype for evaluation and further development of the strain.

This method has useful application in breeding and basic research studies. Therefore, during the present study, a preliminary attempt was made to initiate callus formation from different explants of some members of Amaranthus L. and to study the regenerating capacity of the calli. Attempt was also made to isolate and culture the protoplasts so that the technique could be used for interspecific hybridization through parasexual method, as attempt for sexual breeding has not met with success.