Chapter 1

INTRODUCTION
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*Mangifera indica* L. (mango), the national fruit of India, is the most popular fruit of the country due to its luscious taste and flavour. Mango is a fruit tree of tropics, which attain a height of ca. 10-20 m with large canopy. It grows well on laterite or alluvial soil having pH of 5.5 to 7.5 and a rainfall of 75-200 mm round the year.

1.1 Taxonomic position of mango

The genus *Mangifera* is one of the 73 genera (ca. 850 spp.) belonging to the family Anacardiaceae in the order Sapindales. There are 41 species of *Mangifera* including the wild ones, a good account of which is given in a treatise by Kostermans and Bompard (1993). However, almost all the cultivated mangoes bearing edible, delicious and flavoured fruits, originated in Indian subcontinent belong to a single species *Mangifera indica* (Singh, 1960; Majumdar and Sharma, 1990). Within *M. indica* there are 2 distinct types that can be distinguished on the basis of their mode of reproduction and their respective centers of diversity (i) monoembryonic - a subtropical group including all the edible and commercial varieties (Indian type) and (ii) polyembryonic - a tropical group including the cultivars, which have inferior quality of fruit (Southeast Asian type) (Mathews and Litz, 1992).

1.2 Major areas of distribution

The mango is now cultivated throughout the tropics and in many subtropical regions. The mango cultivation originated in India and according to DeCandolle (1884) its cultivation appeared to have begun at least 4000 years ago. The mango has natural distribution throughout Southeast Asia. Polyembryonic cultivars predominate in Southeast Asia, Central America, Haiti, Hawaii, U.S.A, Australia and South Africa. Monoembryonic cultivars occur in South America, Africa and Florida (Mathews and Litz, 1992). Mango is cultivated throughout India, Mexico, Bangladesh, China, Thailand, Brazil, Philippines and Indonesia. In Africa, mango is produced in Egypt, Madagascar, Nigeria, Sudan, Tanzania and Zaire.
In India, monoembryonic varieties chiefly dominate, but few polyembryonic cultivars occur along the west coast of India, which have been introduced from Southeast Asia by the Portuguese. However, some mango varieties change their monoembryonic status under the influence of agro-climates. Mango variety Mulgoba which is monoembryonic in India becomes polyembryonic in Florida, U.S.A (Singh, 1968).

1.3 Nutritional and commercial value

Mango fruits have a high nutritional value. It contains amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins and vitamins. Its fruits are initially acidic, astringent and rich in ascorbic acid (vitamin C). When ripe, they contain ample amount of vitamin C and are rich in provitamins A, B₁ and B₂. Fruit acidity is primarily due to presence of malic acid, while sucrose is the principal sugar of ripe mango.

Mango fruits have great economical and commercial importance. Fruits are put to multifarious use right from young to mature and ripe stages. The unripe fruits used as pickle, while ripened ones utilized in preparation of jam, jellies, juices, squash, various confectionary items, flavouring ice-creams, shakes, etc. Dried unripened fruits are utilized for the preparation of 'amchur'. All such items have great demand for home consumption and provide a platform of a large mango industry. The tree bark provides tannins used for tanning leather, while the stone of fruits yields starch. Wood of tree provides timber of cheap quality chiefly used for inferior quality of furniture, doors, windows, berths, etc.

1.4 World production and place of India

The mango ranks 5th in total fruit production after banana, citrus, grape and apple. The world production of mango is 25,646,000 MT (FAO, 2002). India occupies first place in mango production and produces about 11,500,000 MT of fruits, which is about 50% of total world production.

In the world scenario, during 2001, mango production was maximum in Asia, i.e., ca.19,824,000 MT followed by North America where it was 2,365,00 MT. In Africa it was approximately 2,290,000 MT, while in South America it was 1,134,000 MT. However, in Europe, Spain is the only country that has commercial
production of mangoes. Mexico is the second largest mango producing country and is the leader in export of fresh mangoes.

In the past two decades, mangoes have become important in international trade and high quality fresh fruits are utilized in expanding markets in North America, Japan and Europe (Galan, 1993); and of late, also in Middle East. Although more than 500 cultivars of mango exist, only few are important in international trade, primarily being the Florida cultivars, namely, Haden, Irwin, Keitt, Tommy Atkins, Palmer and Vandyke. Of lesser importance are Alphonso (India and Pakistan), Kensington Pride (Australia), Manila (Mexico and Philippines) and Pairie (India and Pakistan).

Despite huge orchard area and long history of cultivation, the quality of fruits of existing mango varieties of India lack in certain attributes, which accounts for its meagre share, i.e., hardly 0.025% in international trade. India exports besides Alphonso another 3 varieties namely, Mulgoa, Inam Pasand and Banganapally (Anonymous, 2005).

1.5 Important edible and rootstock varieties

The commercially important edible varieties of mango in India are Alphonso, Dashehari, Langra, Chausa, Safeda, Fajri and Bombay Green and to a lesser extent Himsagar, Mallika, Pairie, Suvarnarekha, Fernandin, Mulgoa, Inam Pasand, Bangapally, Amrapali and Neelum.

The important rootstock varieties include Totapari Red Small, Romani, Goa, Muvandan, Chandrakaran, Ambalavi, Olour, Kurukkan, Vellaikolamban, Bappakai, etc.

1.6 Conventional methods of propagation, their drawbacks and importance of rootstocks

Since mango is a highly heterozygous woody perennial and has a long juvenile period (6-8 years approx.), alternate bearing, large number of staminate flowers, high frequency of premature flower and fruit drop and inefficiency of fruit set and its breeding is impractical (Majumdar and Sharma, 1990; Mathews and Litz, 1992). It is conventionally multiplied through different vegetative propagation methods such as grafting, inarching, budding, etc., are being employed to multiply
its planting material. All these methods are time consuming and labour intensive (Ram, 1997).

Because of heterozygous nature of mango, seeds from a single tree give rise to seedlings of enormous variations. It has to be, therefore, multiplied by means other than seeds even in case of rootstocks, because the rootstock plays a significant role regarding the performance of grafted scion, for its different traits as fruit size, shape, colour, etc., disease resistance and physiogonomy (Prakash and Raoof, 1994; Hartmann et al., 1997). That is why, in practice, although all the edible varieties of mango are propagated by grafting, enough variation exists in the fruits of a particular variety. Therefore, for maintaining perfect traits of specific mango varieties, not only careful selection of clonal scions is required, but also the judicious selection of rootstocks. Sustained maintenance of uniform quality of particular varieties is also imperative for export of mango and its products. High density orchards of mango with dwarf trees are considered ideal for increased fruit production. Therefore, production of uniform and desirable rootstocks is necessary. The good quality rootstock will ward off several of the soil-borne diseases of mango caused by fungi and nematodes (Lim and Khoo, 1985; Prakash and Raoof, 1989; Powers and McSorely, 1994; Ploetz and Prakash, 1997).

1.7 In vitro nucellar embryogenesis, its importance for clonal propagation applicable to mango

In vitro nucellar embryogenesis is an efficient tool for clonal micropropagation. It involves in vitro formation of embryos from nucellar tissue cultured on nutrient media supplemented with growth hormones. The embryoids develop from single cells and pass through globular, heart-shaped, torpedo-shaped and cotyledonary embryo stages to give rise to complete plantlets. However, all these stages are not so distinct in case of zygotic embryogenesis. In vitro nucellar embryogenesis has a unique feature in producing not only true-to-mother type plants, but also disease free, including virus-free plants. It has several advantages over other micropropagation techniques for plant regeneration. The advantage includes the efficiency of the process as it has a high multiplication rate. Unlimited number of embryos can be produced from a single explant, formation of plantlets
in fewer steps, and genetic uniformity of the plantlets (Vasil and Vasil, 1986; Thorpe, 1988; Merkle, 1995). *In vitro* nucellar embryogenesis has been extensively employed in fruit trees, considering horticultural applications in clonal propagation, freeing plants from diseases as well (Wann, 1988). Major work on nucellar embryogenesis has been done in *Citrus*. The technique has been employed in both monoembryonic as well in polyembryonic trees like *Vitis vinifera, Malus domesticum, Ribes rubrum, Eugenia malaccensis, Myricaria cauliflora, Musa* spp. etc. In mango, nucellar polyembryony has been expected to be of great practical value for its conventional methods of propagation are highly inadequate (Litz, 1997). In mango, the performance of scion is affected by the quality of rootstock. The problem can be alleviated if genetically uniform rootstocks could be made available to suit different agro-climates and also compatible scion variety. This will help in raising uniform orchards of trees of desired height and crown, while also containing the variation indirectly promoted with the use of variable rootstocks. But so far, only few promising results have been obtained in India and abroad, as the induction of predictable nucellar embryogenesis and convertibility of nucellar embryos and *ex vitro* survival of the plants are yet to be achieved.

### 1.8 Scope of biotechnological research--*in vitro* approaches for improvement of quality plant production

The application of biotechnology precisely for obtaining sufficient quantity of healthy and clonal propagules of commercially important scion and rootstocks, for which successful nucellar polyembryony leading to micrografting, holds the key of success to boost mango production. Utilization of nucellar embryogenesis in mango rootstock varieties, where it is easily available as also in case of edible varieties, which though monoembryonic, it has been induced through *in vitro* culture of nucellus, has been recommended on this score. The nucellar embryogenesis, which has been successfully utilized for producing true-to-mother type plants in many fruit plants, in mango it has been intractable despite the spectacular success in producing nucellar embryos even in monoembryonic varieties.
Different aspects of biotechnological applications in mango are covered in some exhaustive reviews, viz., Litz et al., 1993,’95; Litz and Lavi, 1997; Litz and Jaiswal, 1991; Singh et al., 2004.

1.9 Objectives of the investigation

While reviewing the literature it is seen that despite extensive work done, success has not yet been achieved in the *in vitro* multiplication of mango. Hence the present study has been undertaken with the following objectives:

i. To develop nutrient formulations for induction and augmentation of nucellar embryogenesis in rootstock and scion varieties of *Mangifera indica* L.

ii. To effect nucellar embryo proliferation, their synchronized development, maturation, germination and conversion into plantlets and effect clonal multiplication.

iii. Histological studies related to nucellar embryogenesis.

iv. To understand the chemical basis of growth regulation to some extent.