CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Fresh tropical fruits are still winning ground on world markets. Production has risen by 4% annually since 1997 (Anonymous, 2001), and exporters of diverse fruit have grown by more than 10% annually. The bulk of these fruit (98%) are grown in developing countries and the biggest importers are the European Union (41%) and North America (33%). Nonetheless, the traded amount is only a fraction of the total production since less than 10% of the total fresh fruits produced are shipped abroad. More than 40% of fresh fruit exporters originate from Latin America and the Caribbean. Africa, in particular Cote D'Ivoire, Cameroon, Ghana, Kenya and South Africa, account for 14% of the world trade. Among the tropical fruit, pineapple accounts for 44% of the total traded volume, followed by mangoes (27%), avocados (12%) and papayas (7%). The main reason for increase in demand of tropical fruit is the growing familiarity of consumers with tropical fruit; their taste and nutritional values.

Mangoes (*Mangifera indica*) are produced in more than 100 countries through both the tropics and the subtropics, from 36^{o} northern latitude in Spain, to 33 ^{o} southern latitude in South Africa (Galan-Sauco, 1993, 1996). The mango is the third most cultivated tropical fruit in the world and the most important producers in the world

are India (1,963,000 ha. in 1993), Thailand (235,666 ha. in 1995), Mexico (152,103 ha. in 1997) and Brazil (53, 107 ha. in 1997) (Sao Jose & Reboucas, 2000).

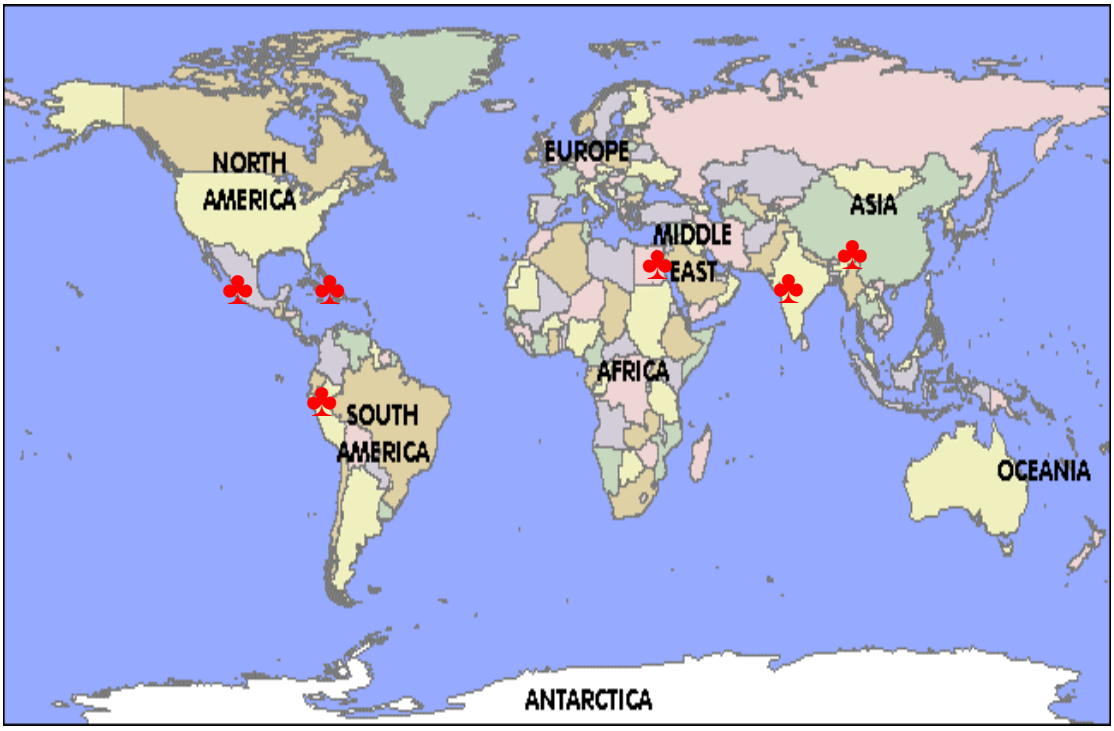

Figure 1.1 World main mango producing areas.

(Source: http://www.fao.org/inpho/compend/img/ch20/inpho@fao.org).

According to Fig. 1.1, the major mango producing areas of the world can be grouped in to six regions: A) Florida (USA), Mexico, Central America B) West Indies (Caribbean Islands) C) South America D) Africa/Arabian Peninsula E) Indian Subcontinent F) Indochina (China)/ Indonesia/ Pacific.

The total world production in 2002 was 25,754,509 metric tons (FAOSTAT, 2003). Poor orchard yield is partly due to wide tree spacing, conventional orchards having tree spacing ranging from 10-12m (Oosthuyse, 1993a; b; c). High density planting, increased tree complexity, post-harvest pruning combined with sound irrigation and

nutrient management are currently raising sustainable yields up to the 20-30 t ha^{-1} range in the hot tropics (Wolstenholme & Whiley, 1995). Looking at the trend of world export of fresh mangoes (Anonymous, 2001), the average for 1994-97 was 371,000 tons, 469,000 tons in 1998, 498,000 tons in 1999 and 510,000 t. in 2000. The world total import was 672,204 MT in 2002 where the largest importer was USA (263,354 MT) and the next was Netherlands (71,479 MT) (FAOSTAT, 2003).

The mango is a member of the family Anacardiaceae in the genus *Mangifera*. Cytological studies indicate an allopolyploid origin for mango with a haploid number n = 20 and a diploid number 2n = 40 (Mukherjee, 1950). There are 41 *Mangifera* species distributed from India and Sri Lanka in the west to Papua New Guinea and the Philippines in the east (Mukherjee, 1953). Although at least 13 species have edible fruit, *Mangifera indica L*. is the only species widely planted and produced on a large commercial scale (Schaffer *et al.,* 1994). Well-known close relatives of mango are cashew nut *(Anacardium occidentale L.)* and pistachio nut *(Pistacia vera L.),* which also belong to the Anacardiaceae family. The primary evolutionary center of mango is reputed to be the subtropical, north-eastern Indo-Burmese region, where it is found growing in the forests (Sukonthasing *et al.,* 1991).

The mango is a medium to large (9-31 m) evergreen tree, with an open or dense symmetrical canopy (Sukonthasing *et al.,* 1991), long tap-root, and dense mass of fibrous surface roots (Purseglove, 1968). Leaves are simple, 15-40 cm long, 2-10 cm wide, lanceolate, hypostomatal, leathery in texture (Chacko, 1986; Schaffer *et al.,* 1994) and may be retained on the tree for 4-5 years if not damaged by diseases or insects (Scholefield *et al.,* 1986). The inflorescence is many branched, terminal

panicle, 10-60 cm in length bearing 300 to more than 4000 polygamous (male and hermaphrodite) flowers (Chadha & Pal, 1986). Sen (1962); Chadha & Pal (1986), on the other hand, stated that the average number of flowers per inflorescence is between 200-3000, depending on the cultivar, tree vigour, cultural practices and weather conditions. These figures were confirmed by Scholefield & Oag (1984). Both male and hermaphrodite flowers are greenish-yellow, 5-8 mm in diameter, with four or more staminodes and usually one fertile stamen. Each male flower has one abortive pistil, while each female flower has a monocarpel ovary with a lateral style and a simple stigma (Singh, 1960) containing only one pachychalazal ovule (Robbertse *et al*., 1986).

The fruit is a fleshy one-seeded drupe, variable in shape (nearly round, oval, or ovoid-oblong), from 2.5-30 cm in length, weighing 60 g to more than 2.3 kg and greenish, greenish-yellow, yellow, red, orange, or purple in colour (Sukonthasing *et al.*, 1991). The seed may be either mono-embryonic (one zygotic embryo) grouped under Indian types or poly-embryonic (2-12 nucellar embryos, one may be zygotic), enclosed in a hard endocarp, which is grouped under Indo-Chinese types (Crane & Campbell 1991; Schaffer *et al.*, 1994). A broad generalization is that cultivars of the Indian type often have highly coloured skin while those of the Indo-Chinese type are predominantly green-yellow when ripe (Schaffer *et al.*, 1994). Hybridization occurs freely between cultivars of each group (Whiley *et al.*, 1993) resulting in cultivars with wide ranging genotypic and environmental responses (Singh, 1987).

Mango trees may live for hundreds of years and some trees planted during the 16th century in India have survived to the early 20th century (Mukherjee, 1953). The tree

conforms to Scarrone's architectural model, in which tree growth and form is determined by an orthotropic, periodically active, terminal meristem which produces an indeterminate trunk bearing tiers of branches (Halle *et al.,* 1978). Schaffer *et al.* (1994) also explained that each branch-complex is orthotropic and sympodially branched as a result of terminal flowering. Tree growth is episodic and there is a temporal separation between reproductive and vegetative stages of growth (Cull, 1987).

Each period of vegetative growth, called a "flush", terminates when all new leaves (10-12 per flush) are fully expanded (Whiley *et al.,* 1989). A period of dormancy usually follows each flush (Scholefield *et al.,* 1986). The number and frequency of flushes and the amount of growth expressed as increase in shoot and leaf dry matter produced per year, depends upon cultivar, climatic conditions, tree maturity, current fruit load, and previous cropping history (Issarakraisila *et al.,* 1991).

The period between floral initiation and anthesis can be as little as four weeks under tropical conditions (Scholefield *et al.,* 1986). This rapid organogenesis demonstrates the capacity of the tree to take advantage of favourable environmental conditions. Initial fruit set in mangos can be heavy with many fruitlets developing on each panicle. However, fruit drop, particularly during the first four weeks after set, is severe with more than 80% of the initial fruit shed before maturity (Singh *et al*., 1965). Many cultivars, e.g., Kensington (syn. ‘Kensington Pride’), Tommy Atkins, and Haden usually bear one fruit per panicle through to maturity, while others like Sensation, Irwin, Lippens, and Nam Dok Mai often retain two or more fruit per panicle to maturity (Scholefield *et al.,* 1986). Mango fruit growth follows a simple

sigmoidal curve (Ram *et al.,* 1983) with fruit maturing 3-4 months after set (Sukonthasing *et al.,* 1991).

Flowering and fruit set are the most critical of all events occurring after establishment of a tree crop. Given favourable growth conditions, the timing and intensity of flowering greatly determines when and how much fruit are produced during a given season (Davenport & Nunez-Elisea, 1990). A fundamental understanding of mango flowering in the tropics and subtropics is, therefore, essential to efficiently utilize cropping management systems which comprise both the flowering and crop production seasons (Davenport & Nunez-Elisea, 1997). Several new approaches to the study of mango flowering have been made (Chacko, 1991; Davenport, 1993).

1.2 Problem statement

Mango is the most important fruit produced in most parts of eastern and southwestern Ethiopia, both in area coverage and quantities produced. There are also ample garden mango trees in different parts of the country at farmer's holdings. The livelihood of most of these farmers is highly supplemented by the selling of mango fruit. In the eastern parts of the country, where mangoes are produced, the area covered with mango reaches about 35% of the total acreage allotted for fruit production (Alemaya University staff survey, 1996). More area coverage is expected in the south western and rift valley regions of the country due to more conducive climatic and edaphic factors. Some amongst many reasons that are suggested for the low yield of mangoes in those areas include, high and bimodal production of flowers and fruit in one year and low in the other (Alemaya University staff survey, 1997). Ethiopia being situated

very close to the equator is characterized by two erratic and unreliable flowering periods due to bimodal rainy periods and low temperature (main raining season is June-August and the short one is on February-March). This situation exhausts the tree's carbohydrate reserve and usually the yield obtained is below expected, compared to the mango growing areas in the world. Subsequently, the trees usually experience an alternate bearing rhythm. Besides, excessive vegetative growth is a common characteristic of most mango cultivars resulting in unmanageable and large trees, with low fruit retention capacity. Some of the unsolved problems mentioned above, like alternate bearing and poor fruit retention are not confined to Ethiopia, and need to be addressed, particularly to the benefit of South African mango growers.

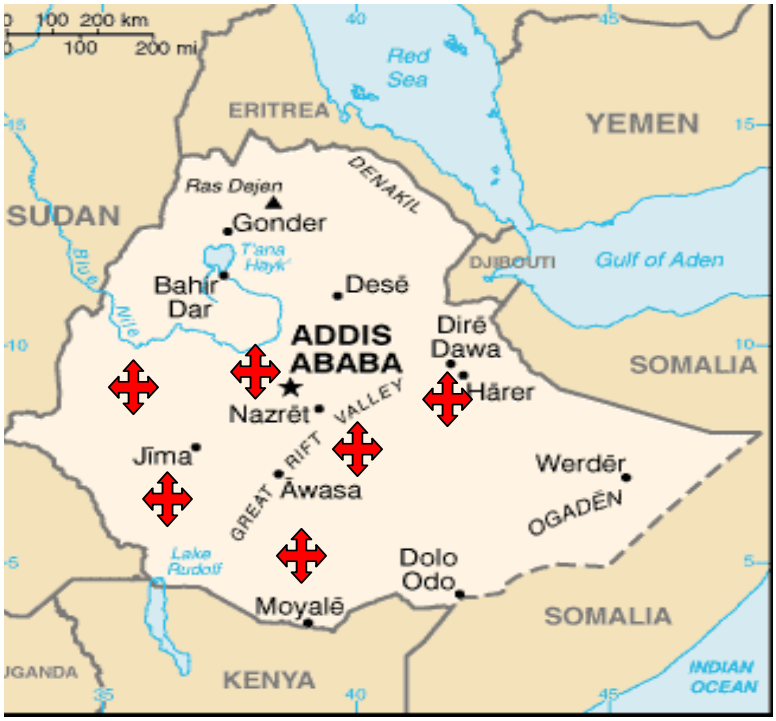

Figure 1.2 Major mango producing areas of Ethiopia (red crosses). (Original map source: http://www.1uptravel.com/worldmaps/ethiopia.html)

1.3 Main objectives of the project and hypotheses tested

In general, the yield obtained from mango trees in Ethiopia is low and irregular. The fruit quality also needs improvement. South African mango producers also encountered similar problems and the following objectives were identified for this thesis:

1) To investigate the effects of some cultural practices like specific fruit thinning mechanisms and various tree-pruning techniques. The results will show whether these practices have a beneficial effect on yield and quality components as well as starch reserve of the trees.

2) To assess the effects of potassium nitrate and paclobutrazol on various aspects of vegetative growth, flowering and fruit related developments of mango in Ethiopia. This has not been investigated previously.

3) To investigate whether the partial flower induction by suitable cold temperature can be substituted, complemented or intensified by application of some growth regulators.

The Hypotheses tested in the study were:

1. In areas like Ethiopia, where poor floral induction prevails, applications of paclobutrazol (alternative growth retardants with low toxicity and limited persistence in fruits are available) or potassium nitrate may complement the

floral induction process or increase intensity of flowering and ultimately fruiting.

2. Panicle and bud pruning treatments will activate dormant axillary buds. The activated axillary buds may have a better chance of flowering and fruit setting than apical buds. Applications of renewal and post harvest pruning will also have various beneficial effects on the trees with respect to better vegetative growth that can mature early and bear the coming season's crop.
3. Paclobutrazol reduces tree vigour (excess vegetative growth) that may in turn strengthen reproductive growth of the trees. Trees that are unproductive due to excess vegetative growth and crowding of branches could be improved with application of paclobutrazol.
4. Mango trees normally produce excess fruit beyond the tree's capacity of which most of them ultimately drop. Hence, fruit thinning before the occurrence of excess fruit drop is crucial. Fruit thinning, however, should be quantified to obtain sustainable production and quality.

The specific objectives and research methodologies for the experiments is presented in detail under each chapter. The chapters are arranged in the order of their priority being prepared to be submitted for publication. Chapter 3 is accepted for publication in Experimental Agriculture, Chapter 4 is accepted in New Zealand Journal of Crop and Horticultural Science, Chapter 5 has been revised and sent back for publication in Australian Journal of Experimental Agriculture, Chapter 6 is accepted in New Zealand Journal of Crop and Horticultural Science and Chapter six is submitted to Journal of Recent Research Updates in Horticulture (Research Syndicate).