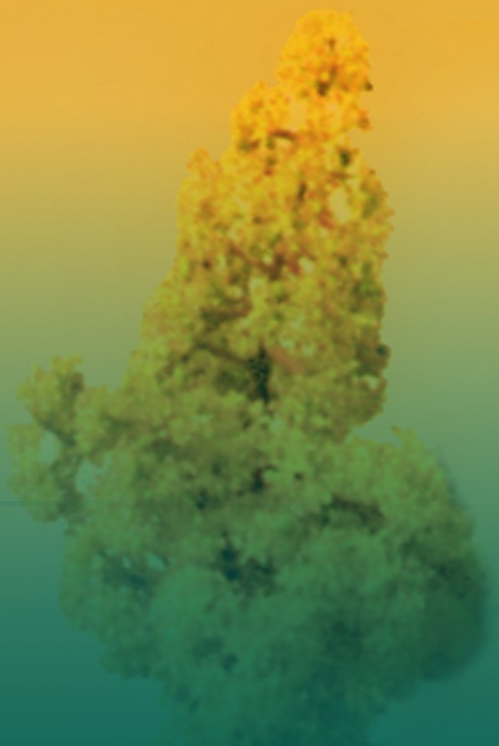
D. K. Chakrabarti



Mango Malformation

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Dedicated to my beloved parents Late Snehamoyee and Prasanta Kumar Chakrabarti

Preface

The economic impact of malformation disease of mango, one of the most important among fruit crops in the Indian sub-continent, is so serious that it fascinated the scientists of at least four different disciplines viz. plant physiology, horticulture, entomology and plant pathology (mycology and virology). But instead of combined multidisciplinary efforts to sort out the problem, the scientists in the Indian sub-continent and Egypt made piece meal approach, remained confined to the fragmented knowledge of their respective disciplines, refused to appreciate the merits of research in other disciplines and thus created confusion about the nature of the cause of the disease and failed to suggest field effective control measures. The scientific arguments were degraded into personal bickering to the extent that others who did not belong to any of the camps preferred to play safe and referred the disease as a "malady of unknown origin". Later the scientists of Israel, South Africa, USA, Mexico, Central America, Cuba, and Australia have participated in the research of mango malformation after appearance of this disease in their respective countries. The scientists of these countries are unequivocal about the nature of the causal organism. In India also the scenario has seen a gradual shift during the last twenty years. A consensus is being built up accepting *Fusarium moniliforme* var. *subglutinans* as the inducer of the malady. A single step control measure has been replaced by an integrated management strategy. However, the confusion that prevailed over several decades has not been totally resolved in the mind of some academics. The present monograph aims to address them with critical appraisal of the current status of the researches on this disease of international importance.

Faizabad, India D. K. Chakrabarti

Acknowledgement

In early seventies when I was a post-graduate student fortuitously came across for the first time a malformed plant in Varanasi, India, I was instantly attracted by its unusual appearance. Fortunately, my research supervisor Dr. S. Ghosal , Professor, Banaras Hindu University, indulged me to take it up as my Ph.D. research problem. My co-supervisor, Dr. C. Sen, Professor, B. C. Agriculture University, who had already been shot into fame for his research on mango black tip disease, prepared a strategy for me to deal with such a complex as well as socially sensitive plant disease. Time can not erode his interest in mango malformation and affection for me. Professor Sen inspite of his inclined health has painstakingly gone through the manuscript and corrected it with the same spirit as he used to in my college days. He has also kindly written the Epilogue of the monograph. Later after leaving the college, when I was struggling hard to make my passion of research on the malformation a profession, Dr. B. P. Singh, Deputy Director, National Botanical Research Institute, Lucknow provided me the much needed succor. A number of colleagues from different disciplines of plant sciences and students afterwards joined me, may be primarily due to affection for me or for obtaining their master degree. But soon they themselves like me became passionately involved with the problem. Without their unstinted help, many aspects of the disease could not be unveiled. To name a few are Dr. Kanika Biswas, Professor Banaras Hindu University, Dr. Vinod Singh, Principal Scientist, Centre of Sub-tropical Horticultural Research and Dr. Rajesh Kumar, Plant Protection Officer (U.P. Govt.).The research contributions of my other associates have been mentioned in the text.

I shall never forget the farmers at Rudauli-Sohawal mango belt of Uttar Pradesh who reposed unflinching faith on our research and allowed us to conduct experiments in their orchards, their only asset and extended ungrudging cooperation all through. Their plight due to this destructive disease and expectation for remedy from us, were the driving force for my team.

I thank the almighty as he has blessed me with a supporting family. No words can acknowledge the indebtedness to my sister, Dr. Rina Chakrabarti, Professor, Delhi University, my son engineer Pinaki Chakraborty, Computer Scientist, Jawaharlal University and my wife Rekha . But they vehemently opposed to spell out my emotion for them. So I acknowledge their contribution without speaking anything.

I am highly thankful to Zuzana Bernhart, the Senior Publishing Editor, Springer and her assistant Elisabete Machado. When at one time I got nervous wondering if the readers would accept the monograph, Zuzana's encouraging letters worked a magic on me.

Different professional societies like Indian National Science Academy, Indian Science Congress Association, Kothari Scientific Research, Uttar Pradesh Council of Agricultural Research, Indian Society of Mycological and Plant Pathology etc. encouraged me and my students by bestowing various prestigious awards. We are grateful to them.

I also acknowledge with gratitude the generous financial assistance in form of research projects from various agencies viz. Uttar Pradesh Council of Agricultural Research, World Bank, Indian National Science Academy, and Indian Council of Agricultural Research.

I am aware that we have 'miles to go' to completely unwind the mystery of malformation and find out easy and a single stroke solution. In view of the current enthusiasm among the new generation scientists and their improved techniques, I am hopeful that it is not far away when the stride to tame the devastating malady will trump the success of century old efforts.

Contents

Introduction

Mango is one of the world's most important fruit crops. Mango was originated in the Indo-Burma region from where it travelled to different parts of the world since the sixteenth century. Mainly the Muslim missionaries, the Spanish voyagers and the Portuguese introduced the mango from India to different countries (Fig. 1). Thus, besides India, mango is now being cultivated in about 85 countries. Important countries growing mangoes are China in far east, Philippines, Indonesia, Thailand, Burma, Malaysia and Sri Lanka in south-east Asia, Egypt, south-east Africa, South Africa, Israel, tropical Australia, the USA (Hawaii and Florida), Mexico, Brazil, Cuba and the islands of the West Indies. In 2004, world mango production was 26.5 million metric tons and total area under mango production was 3.69 million ha (www.natx.com). Top mango growing countries of the world and production scenario in 2007 are listed in the Table 1.

Almost each part of mango plant is used for different purposes. While wood is used as a timber, leaves and dried twigs are used for various religious purposes and the fruit is consumed raw or ripe. Raw fruits are used for making flour and drinks. Ripe fruits besides being consumed as dessert, are processed into jam, squash, slices, pulp, juice, nectar and mango leather. The kernel contains 8–10% fat which is used in soap industry. Its starch can be used in confectionary industry.

In India there are more than a thousand varieties of the mango which belong to one species, *Mangifera indica* L. The important commercial varieties are maintained in cultivation through vegetative propagation by grafting. They differ from one another mainly in fruit characters and a few other minor features like colouration of emerging leaves, colouration and pubescence over the panicle branches etc. In India, only three species of *Mangifera* have been reported which are (1) *M. indica* L., (2) *M. khasiana* Pierre and (3) *M. sylvatica* Roxb. In Malaysia, there occur 41 species of the genus *Mangifera* (Mukherjee 1950).

The genus *Mangifera* L. belongs to the family Anacardiaceae. The chromosome number of *M. indica* is 2n = 40 and n = 20 (Mukherjee 1950). On the basis of morphology, the chromosomes have been distinguished into 11 types, of which eight are distinct and three are intergrading (differences between the compliments are inconspicuous). The varieties of mangoes and allied species differ from one another mainly in assortments of these chromosome types. The primitive type(s) gave rise

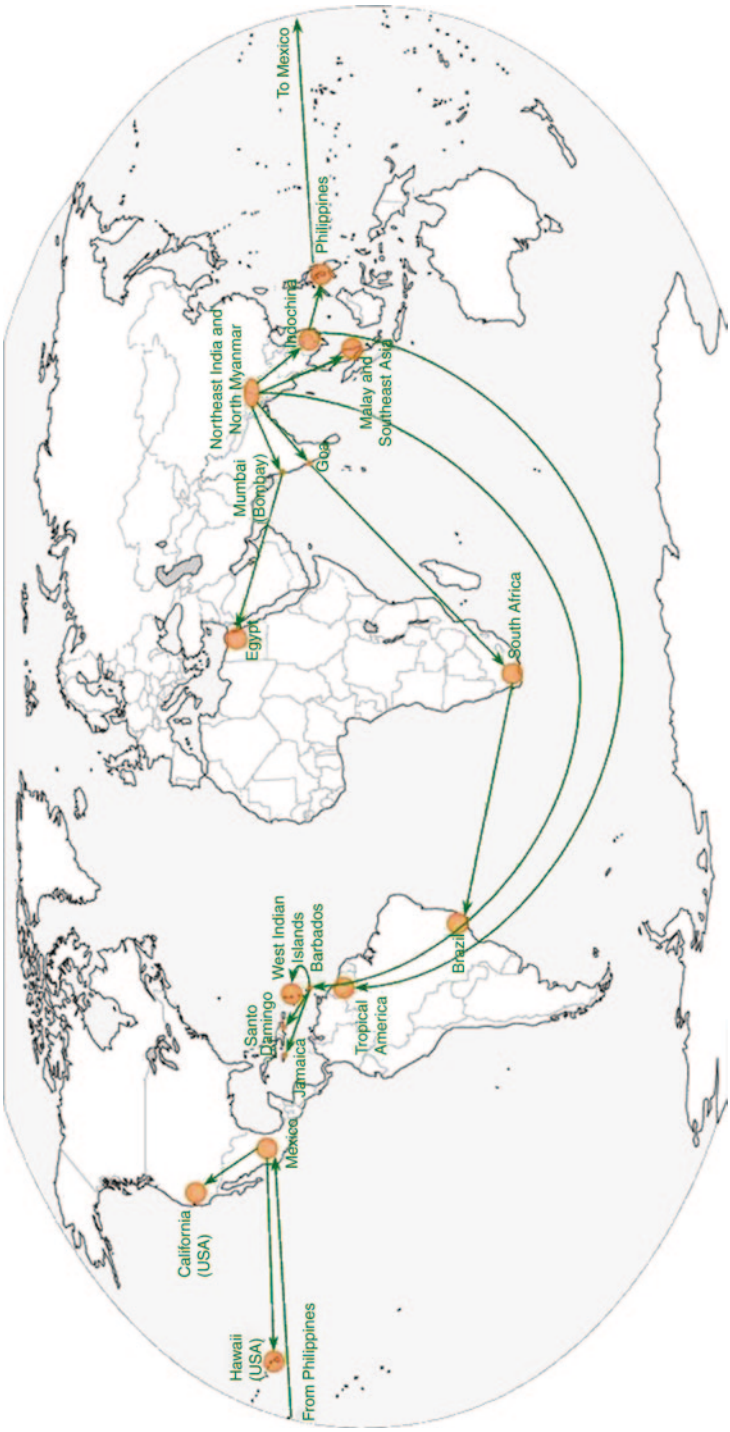

Fig. 1 The pathway of movement of mango cultivars from its place of origin to different countries

Table 1 Top mango growing countries in the world and production scenario in 2007. (Source: FAO, United Nation, Economics and Social Department. The Statistical Division)

Country	Production (million MT)
India	13.50
China	3.75
Pakistan	2.25
Mexico	2.05
Thailand	1.80
Indonesia	1.62
Philippines	0.98
Nigeria	0.93
Vietnam	0.37
World	33.40

to the mango varieties originated through alloplopolyploidy, most probably through amphidiploidy. The difference between numerous varieties took place primarily through gene mutations, the selected types being preserved under cultivation by grafting. The area of the maximum range of diversity is possibly the centre of origin of the species (Mukherjee 1950).

There are hundreds of varieties in mango, out of which only some are of commercial importance. The commercial varieties of mango, although having a wide range of adaptability, are specific to different sets of climatic factors. Thus, in India different regions have their own commercial varieties (Table 2).

Performance of the north Indian varieties undergoes marked change when grown under south Indian conditions and vice versa. For instance, if Langra and Dashehari of the north Indian varieties are grown under south Indian conditions the trees flower and fruit sparsely. Similarly, Neelum, a south Indian variety, tend to be sufficiently dwarf under north Indian conditions accompanied by reduction of fruit size and delayed ripening.

In India almost all the commercial cultivars are monoembryonic. A few that are polyembryonic (having more than one embryo in seed) are comparatively of little economic value and confined to the west coast of India. The seedlings arising from polyembryonic seeds are highly uniform and can be used as such for vegetative multiplication.

The present commercial varieties of mango in India by and large are alternate bearers. Neelum and Bangalora although are regular bearers but inferior in fruit quality. Therefore, for producing a regular-bearing variety with fruit quality acceptable to consumers researches were initiated at Indian Agricultural Research

Table 2 Commercially grown mango cultivars in different agro-climatic zones in India

Different regions in India	Varieties grown
Northern part	Bombay green (early), Langra, Dashehari and Chausa
Eastern part	Fazli, Kishenbhog, Himsagar, Langra, Gulabkhas and Zardalu
Western part	Alphanso, Pairi, Malkurad (Goa), Kesar, Rajapuri and Jamadar (Gujarat)
Southern part	Beneshan (Banganpalli), Neelum, Bangalora Rumani, Suvarnarekha, Mulgoa, Raspuri and Badami

Table 3 Important commercial mango varieties of different countries

Country	Varieties
India	Alphanso, Benishan, Kesar, Dashehari, Himsagar
China	Zipdieya, Mabrouka, Al-Fons, Kent, Kiet, Tommy Atkins
Pakistan	Sindhri, Anwar Rataul, Fajri, S.S.-1, Dashehari
Thailand	Brahman, Okrong
Indonesia	Golek
Mexico	Manila, Ataulfo, Haden, champagne, Kent, Kiet, Tommy Atkins
Sri Lanka	Ruby
Israel	Maya, Sheky
Australia	Kensington Pride, R2E2
South Africa	Heidi, Haden, Kent
Venezuela	Super Haden
Brazil	Extrema
Egypt	Hindi Besennara, Ewais, Genovea, Timour, Zebda
Vitenam	Xoai Tuong, Keow Savoey, Falam, Nam Klangwan
Florida	Haden, Kent, Kiet, Tommy Atkins
Philippines	Carabe
Kenya	Boribo, Apple, Ngowe

Institute, New Delhi (IARI). Among the hybrids developed at IARI, Mallika and Amrapali (a cross between Neelum and Dashehari) have already been very popular. Apart from above, in recent years many more hybrids have been released which are dwarf, regular bearers with attractive skin colour. However, international trade of mangoes is dominated by varieties like Keitt, Tommy Atkins, Alphanso etc. The important commercial mango varieties in different countries are listed in the Table 3.

Mango is very well adapted to tropical and subtropical climates. It thrives even at an altitude of 1,500 m. However, it cannot be grown commercially in areas above 600 m. It cannot stand severe frost, especially when the trees are young. Dry weather before flowering is conducive to profuse flowering. Rains during flowering is detrimental to the crop. Strong winds and cyclones during fruiting seasons can play havoc as they cause excessive fruit drop. Mango starts flowering early in eastern States of India viz. West Bengal, Bihar and eastern Uttar Pradesh due to onset of high temperature early in the season. In the south under moderate temperature conditions even during winter the flowering may start in September–November. In some coastal areas (e.g. in Kanyakumari in India) there are varieties that flower and fruit twice a year (off-season bearing). The off season bearing is conditioned by the differences in night and day temperatures and humidity.

The mango is a deep-rooted tree and requires soil profile of at least 2 m depth. It grows well on wide variety of soil except extremely sandy, rocky, waterlogged, heavy textured and alkaline and calcareous soil.

Although a number of propagation techniques have been suggested, inarching although cumbersome and time consuming, is the only technique in vogue. Veneer grafting has started gaining grounds in recent years for mass scale commercial propagation.

A large number of insect pests and diseases attack mango crop, causing damage to all parts of the plants. More than 492 species of insects, 17 species of mites and 26 species of nematodes are known to infest mango trees, about 45% of these have been reported from India. Almost a dozen of them have been found damaging the crop to a considerable extent causing severe losses, and therefore, may be termed as major pests of mango. These are hoppers, mealy bugs, inflorescence midge, fruit fly, scale insects, shoot borer, leaf webber and stone weevil. The insects other than these are less injurious to mango crop and are placed in the category of minor pests.

Mango suffers from several diseases at all stages of its life. All the parts of the plant, viz. trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. They cause rot, die-back, anthracnose, scab, necrosis, blotch, spots, mildew etc. Some of these diseases like powdery mildew are of great economic importance as they cause heavy losses in mango production.

In addition to diseases and insect pests, mango crop also suffers from many physiological disorders. Of which black tip of fruits, fruit drop, clustering in mango fruits and biennial bearing are very serious particularly in northern States of India.

The pests and diseases of mangoes have been generally well investigated and largely managed; suitable pesticides have been developed for all major biotic pest problems. Besides, all the pests and diseases may not be found in every mango growing countries and many are localized in a particular region with sporadic appearance in some years.

At present malformation has emerged as a serious threat to the mango industry the world over and has been designated as a plant disease of international importance. The disease has drawn wide attention from different quarters for the following reasons: (1) the disease infects the inflorescence converting them into malformed and unproductive bunches; thus, causing direct loss in yield and that too every year; (2) affects the growth and vigour of plants; (3) in nursery it produces bunchy top on seedlings and kills the root stocks; (4) due to the prevalence of the disease, there is a restriction on export of mango saplings from India; (5) the disease is wide spread, prevalent in all the mango growing countries in the world; (6) once the plants are infected, they remain diseased throughout i.e. the disease is endemic; (7) etiology and epidemiology are poorly understood; (8) all the commercial varieties and newly developed hybrids are apparently susceptible and (9) failure to find out satisfactory control measures. This uniqueness has proved to be an enigma, and has drawn the attention of scientists all over the world for decades. This monograph is a humble effort to present a critical appraisal of existing information on various aspects of mango malformation.