

L. K. Bharathi  
K. Joseph John

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# Momordica Genus in Asia: An Overview

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 Springer

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ISBN 978-81-322-1031-3      ISBN 978-81-322-1032-0 (eBook)

DOI 10.1007/978-81-322-1032-0

Springer New Delhi Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013930240

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Printed on acid-free paper

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*Dedicated  
to  
the loving memory of  
Late Dr. Shanthi Chandrashekar  
Professor of Genetics,  
Indian Agricultural Research Institute, Pusa, New Delhi-12  
whose understanding, encouragement and professional help  
made this humble endeavour possible.*

AUTHORS

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## Foreword

Asia is home to an extremely rich repository of biodiversity, including many *endemic species* adapted to harsh, fragile and extreme environments and naturally considered to encompass centres of origin for many *domesticated plant species*. This rich agro-ecological diversity in Asia enabled greater species diversity which is manifested in *Momordica* as well, with about ten species in Asia of which seven are in India. Diversification and value addition is one of the major thrust of Indian Horticulture in the twenty-first century and among tropical vegetables, *Momordica* can be a prime candidate for working along these lines.

Presently available books on cucurbits are heavily biased towards more popular gourds like cucumber, melon, pumpkin, squash and watermelon and underutilised cucurbits like *Momordica* do not find a place in major treatments on botany, cultivation and utilisation of cucurbits. From the published literature, it is discernible that the number of researchers working in *Momordica* is rather few and work on crop improvement and management, with the probable exception of bitter gourd, is still in its infancy.

Evidently, a strong need was felt for a comprehensive monograph on Asian *Momordica*, and this book hopefully fills the void. The book covers a whole gamut of aspects like biosystematics, ethno-botany and origin, crop improvement, crop management and utilisation aspects, and will be immensely valuable to researchers, the student community and professional horticulturists alike.

I congratulate the authors, Drs. L. K. Bharathi and K. Joseph John, for bringing out this book collating the present status of Asian *Momordicas* with respect to research and utilisation, hopefully catalysing the efforts on further promotion and utilisation of these versatile crops, undoubtedly the bounties from nature graciously bestowed on us.

New Delhi, November 2012

N. K. Krishnakumar  
Deputy Director General  
(Horticulture)

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## Preface

*Momordica* is a genus of under-utilized and wild-gathered vegetables of importance as food, medicine and ecosystem functions. With the probable exception of bitter gourd, other *Momordica* species are little known outside Asian and African consumers. Rich in minerals and vitamins, bitter gourd (*M. charantia*), teasel gourd (*M. subangulata* subsp., *renigera*) and spine gourds (*M. dioica* and *M. sahyadrica*) are reported nutritionally the best among cucurbits. Sweet gourd (*M. cochinchinensis*) is known as ‘the fruit from heaven’ in South–East Asia, due to its acclaimed properties in enhancing longevity, vigour and vitality. Of course, it is the richest source of  $\beta$ -carotene, the precursor of vitamin A. There is an incredible wealth of traditional knowledge, especially medicinal uses, though not scientifically validated in most cases, among the forest dwelling tribal and native populations. All are extensively used in indigenous systems of medicine including Siddha, Unani, Ayurveda and even Homeopathy.

The biodiversity rich Asia is home to most tropical vegetables and vegetables are the primary source of vitamins and minerals, utilisation of native biodiversity for combating this ‘silent hunger’ afflicting a sizeable population in these countries is still a major challenge for agricultural researchers and administrators alike. Sagacious bio-prospection and judicious utilisation of the natural resources can indeed offer simple and cost-effective solutions to many of our long-standing problems. An exemplary case study is the nutritional supplementation trials in Vietnam by Dr. Voung using the traditionally cultivated gac fruit (*M. cochinchinensis*), which was demonstrated to be an ideal tool for managing chronic cases of vitamin A deficiency in children. This is an example of a highly successful long-term and sustainable strategy by using the indigenously available food resources.

Although bitter gourd is vulnerable to pest problems demanding chemical control and consequent pesticide residues, other *Momordicas* are largely grown in an organic way and hence deserve promotion in the context of the present market demand for green organic foods. Evidently, given the limited information available on their nutritional and nutraceutical value, these crops are not given the due importance they richly deserve. Most of these semi-domesticated crops are endowed with resistance/tolerance to some of the common diseases and pests of

cucurbits. Species like *Momordica balsamina* is least demanding and adapted to suboptimal conditions like dry arid climate and *M. sahyadrica* can be cultivated as a high-value component of cardamom-coffee plantations in the Western Ghats. *M. dioica* and *M. subangulata* subsp. *renigera* are equally prospecting candidates for domestication. At least one of these species can be profitably grown as an ideal homestead vegetable in every home, across extreme environments and diverse ecosystems of the region present interesting opportunities for diversified and nutrition-rich diet.

However, there is a long way to go as most of the species except bitter gourd are in the domestication interphase. Incidentally, Van Rheed's *Hortus Malabaricus*, the first ever printed account of the flora of Malabar or Indian plants for that matter, describe four entities of *Momordica*, which formed the basis for Linnaeus and subsequent botanists to describe the genus and some of the species. However, the irony is that all the four entities (*paval*, *pandipaval*, *erumapaval* and *bempaval*) described and illustrated by him still remain in the wild-undomesticated stage even after 450 years.

Problems like non-availability of adequate high quality planting materials and a comprehensive package of agro-management techniques need greater research attention. If the research gaps are addressed, they can be promoted as major vegetables, thus serving the nutritional and nutraceutical needs of Asian population.

We have endeavoured to give an insight into the present state of knowledge on bitter gourd and other *Momordicas* of South and South-East Asia. Available information on biosystematics, origin and domestication, genetics and crop improvement efforts, ethnobotany and nutritional profile and crop management have been collated thematically under eight chapters. Admittedly, professional and personal experience of the authors spanning over more than a decade forms the bulwark of this book. The authors owe full responsibility for the viewpoints and statements made in the book and in no case the same to be construed as that of the Indian Council of Agricultural Research (ICAR).

We earnestly hope that this will serve as a reference book for all *Momordica* lovers in the world over, especially students in tropical horticulture, crop botany and vegetable breeding. It is our ardent desire that this book will trigger an insatiable quest in the minds of user community to explore deeper into various research gaps in this group of plants.

October 2012

L. K. Bharathi  
K. Joseph John



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## Acknowledgments

We would like to express our appreciation and gratitude to our colleagues and authorities in Indian Institute of Horticultural Research (IIHR) and National Bureau of Plant Genetic Resources (NBPGR). We are indeed indebted to Dr. A. S. Sidhu, Director, IIHR, Bangalore, Dr. K. C. Bansal, Director, NBPGR, New Delhi, and Dr. N. K. Dwivedi, Principal Scientist and Officer in charge, NBPGR Regional Station, Thrissur, for encouraging us in this pursuit. Thanks are also due to Dr. I. S. Bisht, Principal Scientist, NBPGR, New Delhi, and Dr. S. Anbu, Former Dean, Horticultural College and Research Institute, Periyakulam for critically reviewing the concept and offering suggestions thereof. Curators of various herbaria (CAL, BSI, BSISH, MH and CALI) were gracious enough to open their doors and our esteemed friends in BSI, Dr. V. P. Prasad and Dr. Lakshmi Narasimhan, Formerly Liaison officers at KEW, always lend us a helping hand. Sh. P. C. Majhi, Technical Assistant at CHES, Bhubaneswar, helped us in recording some of the field data.

It was Dr. K. C. Velayudhan, Principal Scientist and former colleague at NBPGR who has introduced us to the fascinating world of the wild *Momordica*, for which we are greatly indebted to him. Since then, we were so enamoured of these 'wild beauties' that we chose it as the subject of our doctoral research.

The south Asian species are comparatively better studied, though problems of misidentification, taxonomic confusion and nomenclatural ambiguities are widespread. Whereas the entities exclusive to South-East Asia are poorly collected and inadequately studied and consequently still remains in the realms of botanical interest. It was largely through the efforts of W. J. J. O. de Wilde and B. E. E. Duyfjes, who revised the genus for Malesian region that we know of the species diversity and their distribution in SE Asia.

We salute the memories of several colonial administrators and amateur botanists from Europe like van Rheede, Roxburgh, Hooker, Gamble, and C. B. Clarke to name a few, who painstakingly surveyed the most inhospitable tracts and documented the rich diversity of the Old World tropics and their able successors like Professor H. L. Chakravarty who pioneered botanical research in independent India.

Finally, we owe a great deal of appreciation to our family members for their patient support throughout this period and apologies for compromising attention due to them.

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# Contents

<b>1</b>	<b>Introduction</b> . . . . .	1
	References . . . . .	3
<b>2</b>	<b>Description and Crop Production</b> . . . . .	5
	Description . . . . .	6
	<i>Momordica</i> L. . . . .	6
	Pollen Morphology . . . . .	13
	Crop Production . . . . .	13
	Climatic Requirements . . . . .	13
	Soil Requirements . . . . .	14
	Production Technology . . . . .	14
	Propagation . . . . .	14
	Seed Propagation . . . . .	14
	Vegetative Propagation . . . . .	15
	Plant Establishment and Densities . . . . .	19
	Training . . . . .	20
	Pruning . . . . .	21
	Weed Management . . . . .	22
	Water Management . . . . .	22
	Flowering and Pollination Management . . . . .	22
	Nutrient Management . . . . .	24
	Harvesting . . . . .	24
	Pest and Diseases . . . . .	25
	Seed Production . . . . .	30
	Hybrid Seed Production . . . . .	31
	References . . . . .	32
<b>3</b>	<b>Origin, Domestication and Distribution</b> . . . . .	37
	Origin . . . . .	38
	Distribution . . . . .	39
	Herbarium Representation . . . . .	40
	Species Distribution, Hotspots and Ecological Amplitude . . . . .	40
	References . . . . .	43
<b>4</b>	<b>Taxonomy and Biosystematics</b> . . . . .	45
	Taxonomy . . . . .	46
	History . . . . .	46

Delimitation of the Taxon . . . . .	47
Diagnostic Characters . . . . .	47
Current Taxonomic Status . . . . .	47
Taxonomic Key. . . . .	49
Biosystematics . . . . .	50
Morphology . . . . .	50
Deoxyribonucleic Acid. . . . .	54
Cytology . . . . .	55
Crossability . . . . .	56
Cucurbitacins/Seed Fat. . . . .	57
References . . . . .	57
<b>5 Ethnobotany and Nutritive Value . . . . .</b>	<b>61</b>
Ethnobotany . . . . .	62
Folk Taxonomy. . . . .	65
Nutritive Value . . . . .	65
Other Phytochemicals . . . . .	72
References . . . . .	72
<b>6 Cytogenetics and Genetics . . . . .</b>	<b>77</b>
Cytogenetics . . . . .	78
The Tools. . . . .	78
The <i>Momordica</i> Genome . . . . .	78
Karyotype. . . . .	81
Interspecific Hybridisation . . . . .	82
Genetics . . . . .	83
References . . . . .	85
<b>7 Genetic Resources, Germplasm Characterisation/Evaluation and Maintenance . . . . .</b>	<b>89</b>
Genetic Resources . . . . .	90
Gene Pool Classification . . . . .	90
Genetic Erosion and Threat Status. . . . .	90
Present Status of Germplasm Holdings. . . . .	91
Plant Descriptors . . . . .	91
Habit . . . . .	91
Seedlings . . . . .	91
Roots . . . . .	91
Sexual Reproductive System. . . . .	93
Tendrils . . . . .	93
Leaves . . . . .	93
Inflorescences/Flowers . . . . .	95
Fruits . . . . .	95
Seeds . . . . .	96
Descriptors and Descriptor States . . . . .	97
Collection, Regeneration and Maintenance . . . . .	97
Characterisation and Evaluation . . . . .	111
Conservation Strategies . . . . .	117
References . . . . .	119

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<b>8 Crop Improvement</b> . . . . .	123
Floral Biology. . . . .	124
Sex Form . . . . .	124
Alteration of Sex Expression . . . . .	126
Sex Modification. . . . .	126
Parthenocarpy . . . . .	127
Current Goals of Breeding . . . . .	127
Breeding Methods and Techniques . . . . .	128
Varieties. . . . .	137
India . . . . .	137
China. . . . .	140
Australia . . . . .	140
Philippines . . . . .	141
Japan . . . . .	141
Taiwan. . . . .	141
Thailand. . . . .	141
Sri Lanka . . . . .	141
Pakistan . . . . .	141
Bangladesh. . . . .	141
USA . . . . .	141
References . . . . .	143

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## About the Authors

**Dr. L. K. Bharathi** was born on 20/03/1974 and is presently working as a Scientist at Central Horticultural Experiment Station a regional research station of Indian Institute of Horticultural Research, Bengaluru. He did his B.Sc. and M.Sc. Degrees from Tamil Nadu Agricultural University, Coimbatore and Ph.D. from Indian Agricultural Research Institute, New Delhi. He joined in Agricultural Research Service as a Scientist at Central Agricultural Research Institute, Port Blair, in 1999 and has more than 13 years of experience in vegetable crop improvement especially in *Momordica* species. He has published more than 20 Research Papers in Indian and International Journals of Repute. Presently, he is engaged in the improvement of *Momordica* species through interspecific hybridization.

**Dr. K. Joseph John** was born on 20/03/1960 and is presently working as a Senior Scientist at the Thrissur Regional Station of the National Bureau of Plant Genetic Resources (NBPGR) New Delhi, the nodal agency for PGR management in India. He did his B.Sc. and M.Sc. degrees from the University of Kerala and Ph.D. from Mahatma Gandhi University, Kottayam. He joined ICAR service as ARS Scientist at VPKAS, Almora in 1986 and has over 26 years of experience in plant genetic resources management of tropical vegetables and tree fruits. He did his Ph.D. on “Ecogeography and Genetic Diversity of the Genus *Momordica* L in India”. Under this work, the genus *Momordica* was revised for India; a new species endemic to the Western Ghats was described and validly published; status of Assam kakrol was elucidated and ethnobotany of the genus in Western Ghats was documented, besides devising of descriptors and taxonomic key for dioecious and monoecious taxa and preparing ecogeographic conspectus for *Momordica*. He has carried out over 25 plant exploration and collection missions in Western Ghats, Andaman and Nicobar Islands, Lakshadweep and in the north-eastern states of India for cucurbits and other vegetables. He has published over 30 research papers in National/International Journals. Presently, he is engaged in the Biosystematics of Indian entities of *Cucumis* and *Abelmoschus*.

**Abstract**

The genus *Momordica*, native to the paleotropics, comprises about 59 species, of which 10 occur in Asia and 7 in India. Bitter gourd is cultivated extensively in the warmer regions of the world, while teasel gourd is cultivated to a small extent in Bangladesh and eastern and north eastern parts of India. The Asiatic *Momordica* are unique in the sense that most of them are edible with multiple medicinal properties as expounded by the rich ethno botanical literature, though not validated through clinical trials in most cases. Taxonomy and identification of Asiatic *Momordica* are often confusing and the problem is compounded by the prevalence of identical vernacular names and wrong or interchangeable usage of common names for these entities. All available information are reviewed, collated and synthesised in this book, which hopefully give an overall picture of the current understanding on the taxonomic status, distribution, genetics, cytology, reproductive biology, crossability relationships, genetic resources, crop improvement, husbandry and ethnobotany of this important group of under-utilised vegetables.

**Keywords**

*Momordica* · Bitter gourd · Teasel gourd · Sweet gourd · Spine gourd · Under-utilised vegetables

The genus *Momordica* (Cucurbitaceae) is a native of the Paleotropics (Robinson and Decker-Walters 1997) and the name *Momordica* derives from the Latin word ‘mordeo’ (means to bite) probably in allusion either to the bitten appearance of the grooved margins of the seeds (Durry 1864) or for the biting taste of the ripe fruits of *M. balsamina*, the type species (Genaust 1996).

The genus *Momordica* comprises 59 species (Schaefer and Renner 2010) distributed in the warm tropics, chiefly in Africa and with about 10 species in Southeast Asia (de Wilde and Duyfjes 2002). In the flora of Tropical Africa, 14 species viz. *M. cardiospermoides* Klotzsch, *M. cissoides* Benth. (syn. *M. guttata*, *M. maculata*), *M. pterocarpa* A. Rich, *M. angiosantha* Hook. f.,

*M. trifoliata* L., *M. balsamina* L., *M. charantia* L., *M. welwitschii* Hook. f., *M. cucullata* Hook. f., *M. morkorra* A. Rich., *M. mannii* Hook. f., *M. corymbifera* Hook. f., *M. multiflora* Hook. f. and *M. cymbalaria* Fenzl ex Naud (syn. *Luffa cymbalaria*) are described (Oliver 1979). Of these, only *M. charantia*, *M. balsamina* and *M. cymbalaria* occur in Asia. Including a newly described entity, presently 12 species of *Momordica* occur in Asia out of which nine are dioecious and 3 are monoecious. The dioecious taxa are *M. dioica* Roxb., *M. sahyadrica* Joseph and Antony, *M. cochinchinensis* (Lour.) Spreng. and *M. subangulata* Blume (subsp. *subangulata* (G. Don) W. J. de Wilde, subsp. *renigera* (G. Don) W. J. de Wilde), *M. rumphii* W. J. de Wilde, *M. clarkeana* King, *M. denticulata* Miq. and *M. denudata* (Thwaites) C. B. Clarke. The monoecious taxa are *M. charantia* L. (var. *muricata* (Willd.) Chakrav. and var. *charantia* L.), *M. cymbalaria* Fenzl ex Naud and *M. balsamina* L. Among these species, six each occur in Malaysia (de Wilde and Duyfjes 2002) and India, where *M. charantia*, *M. subangulata* Blume and *M. cochinchinensis* (Lour.) Spreng. are common; Sri Lanka has three species, of which *M. charantia* and *M. dioica* Roxb. are also represented in India.

The genus includes a major commercial vegetable crop bitter melon/bitter gourd/balsam pear (*Momordica charantia* L.) which is grown in India, Sri Lanka, Philippines, Thailand, Malaysia, China, Japan, Australia, tropical Africa, South America and the Caribbean, a semi domesticated vegetable crop teasel gourd [*Momordica subangulata* Blume subsp. *renigera* (G. Don) de Wilde] which is grown commercially in India (West Bengal, Odisha, Assam, Tripura, Mizoram, Andaman and Nicobar islands) and neighbouring Bangladesh. Bitter gourd is consumed regularly as part of several Asian cuisines and has been used for centuries in ancient traditional Indian, Chinese and African pharmacopoeia. It is a common cucurbit in the wild flora of Africa, occurring almost throughout tropical Africa and occasionally collected from the wild as a vegetable or medicinal plant.

Apart from bitter gourd and teasel gourd the genus *Momordica* comprises a number of small and often poorly known species that bear edible fruits esteemed for their medicinal, nutritional properties and taste. Local people in India are reported to gather and consume teasel gourd, sweet gourd, spine gourd, mountain spine gourd (*M. sahyadrica*) and balsam apple. Their cultivation is restricted to specialised geographical pockets in different agro-geographical regions, mainly by tribal and poor farming communities (Behera et al. 2011). *Momordica* species are also common elements in home gardens (Joseph 2005) of India. Wild food plants can make the diet more balanced and hence can play an important role in combating the silent hunger (deficiency of vitamins and minerals in the diet). These *Momordica* species could also help in poverty alleviation by providing income generating opportunities to tribals/farmers by linking the development of these crops to market opportunities. Although these species, like other minor plant species, do not contribute much as basic foods, yet they do contribute significantly to diversify the human diet. They provide important chemical compounds for the nutraceutical industry and most importantly have the potential to act as sources of additional income for farmers. While all are nutritious fruit vegetables, they are still wild gathered or underutilised except bitter gourd, though teasel gourd (*M. subangulata* subsp. *renigera*) is cultivated to a limited extent in east and northeast India and Andaman Islands. SE Asian *Momordica* are in general highly adapted to high rainfall, humid tropics with low sunshine hours. Similarly, African taxa are better adapted to arid-dry climate. In the event of unforeseen climatic extremes, these species will offer scope for utilisation as direct crops for domestication or as genetic resources for trait incorporation.

Dioecious species of *Momordica* L. are noteworthy for the diverse vernacular names ascribed to it in various Indian languages and dialects. However, more interesting is the ambiguity in taxonomic identity, i.e. the same species being identified under different botanical



names and different species known by the same scientific name. *Bhat karela* of Assam or ‘teasel gourd’ is known as *Momordica dioica* Roxb. in the botanical parlance (Mishra and Sahu 1983; Ali et al. 1991; Jeffrey 2001; Roy et al. 1966; Sen and Dutta 1975; Hossain et al. 1996) whereas in most of agricultural literature, it is referred to as *Momordica cochinchinensis* Spreng. (Shadeque and Baruah 1984; Handique 1988; Vijay and Jallikop 1980; Mohanty et al. 1994; Ram et al. 2002; Rasul et al. 2004; Sanwal et al. 2011). But in reality it is none of these two but *M. subangulata* subsp. *renigera*. It was even described as a new taxonomic entity, *M. hybrida* (Mondal et al. 2006). Common names such as ‘sweet gourd’ and ‘spine gourd’ are used interchangeably as also the vernacular names *kaksa* and *kakrol*. Between *M. charantia* and *M. balsamina* also there is ambiguity in taxonomical identity. The wild bitter gourd (*M. charantia* var. *muricata*) is often misidentified and reported as *M. balsamina* (Maurya et al. 2007).

This publication sets out to provide an insight into current taxonomic delineation facilitating correct botanical identification, reliable distribution data for further enhancing the germplasm collections, to unravel the species relationships enabling the breeders in introgression of genes from wild to cultivated plants, along with an overview of current status and prospects for further exploitation of these underutilised species. In furtherance of these objectives, the relevant information on taxonomy, morphology, cytology, crossability, reproductive biology, diversity, distribution, genetic resources and breeding is reviewed, distilled and synthesised in the overall thematic framework. Of course, the personal experience of the authors, spanning over two decades of working in this genus, forms the bulwark. Admittedly, this publication is skewed in favour of Indian species which is holding >50 % of the Asian *Momordica* species diversity, as information on entities exclusive to Southeast Asia, being rather truly wild, are rather limited and is one step in the long process leading to total understanding of the genus *Momordica* for its exploitation for human health and well-being.

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### Abstract

Twelve species of *Momordica* have been botanically described from Asia. All the species grow well in hot, humid areas and seems to be almost day-neutral and like most cucurbits prefer a well-drained soil with a pH of 6.0–6.5. In annual species, direct seeding is the usual production practices while all the dioecious taxa exhibit varying degrees of gradual release of seed dormancy. Low temperature and hard-seededness are reported to be the main reason for slow and poor germination in *M. dioica* and saponins are reported to inhibit seed germination in *M. cochinchinensis*. Tuber pieces are commercially used as planting material in teasel gourd while in sweet gourd, a better and reliable method is to use rooted vine cuttings/wedge grafting. Though many workers proposed rooted vine cuttings as an alternative propagation tool for *M. dioica*, there are no reports on ratooning behaviour of such propagules. Tissue culture propagation would be of immense importance for production of *M. dioica* and *M. sahyadrica* where propagation through stem cuttings, root tubers and seeds are difficult. Protocols have been established for direct shoot regeneration from nodal segments, cotyledons and plantlet regeneration from the cell suspension cultures. In monoecious species, male and female flowers are borne separately on the same plant while for dioecious species, provision of 10 % male plant in the field is considered imperative for good fruit set. In case of teasel gourd, artificial pollination gave 95–100 % fruit setting, but natural pollination contributed only about 25–50 % fruit set. Experimental data on nutrient management of *Momordica* species are not very extensive. However, generous amounts of organic matter in the soil, from animal source are beneficial for the growth. Harvesting starts about 50–60 days after sowing and is done twice or thrice a week and fruit responds quickly to the presence of ethylene and should be isolated from fruits that produce large amounts of ethylene to prevent post-harvest ripening. Fruit borer, fruit fly, powdery mildew, downy mildew are the major pests of *Momordica* species.

### Keywords

Seed germination • Breaking dormancy • Tissue culture • Pollination management • Insect pests

## Description

### *Momordica* L.

Climbers, annual or perennial; glabrous or pubescent. Leaves simple, entire or lobed or (sub) pedately 3–5 (12–15 in African) foliate. Tendrils simple, unbranched. Flowers medium to large, monoecious or dioecious, sometimes ± zygomorphic, petals imbricate off white, cream or yellow. Inflorescence of male flowers solitary or in short loose pseudo-racemes, each flower stalk with a persistent hooded bract; female flowers solitary, in axils, also with a conspicuous or rudimentary bract. Male flower pedicels minute or long, receptacle tube short, cupular or saucer shaped, calyx lobes entire or scarious, adnate at base. Petals 5, free, entire, 1–3 with an incurved scale inside at the base-receptacle juncture. Stamens 3, anthers 1-one thecous, 2-two thecous, filaments very short, free, inserted at the mouth of the receptacle tube; thecae usually coherent, connective sometimes swollen, pistillode absent. Female flowers calyx as in the male or distinct, petals as in the male; ovary oblong-fusiform, ribbed, warty or soft papillose, ovules mostly many, horizontal; stigma 3-lobed; staminode absent. Fruit ovoid ellipsoid to fusiform, fleshy, ornamented with soft spines, warts or tubercles and ridges, irregularly or regularly 3 valved, dehiscent, rarely indehiscent. Seeds many, enclosed in orange-red sarcotesta (aril). Small or large, flattened or turgid on faces, smooth or sculptured, margins often undulate and dentate.

#### 1. *M. charantia* L. (Source Joseph 2005)

Annual, slender climber, 2–4 m high, scarcely to densely pubescent (tender parts wooly), monoecious. Leaves: blade usually deeply palmately 5–9 lobed, reniform to orbicular or sub orbicular in outline, 2.5–8 × 4–10 cm, cordate

at base, acute or acuminate at apex, lobes ovate or obovate, narrowed at base, margins sinuate to undulate, mucronate, petioles 1.5–5 cm long. Flowers solitary, pubescent, petals yellow. Male flowers: stalks slender with bract mid way or towards base; peduncle 2–5 cm long; bract reniform, 5–11 mm diameter, green, mucronate at apex, margins entire; pedicel 2–6 cm long; receptacle tube cup shaped, 2–4 mm long and 2–3 mm wide; sepals ovate-elliptic, 4–6 × 2–3 mm, pale green touching each other and protecting the corolla tube; petals obovate, 10–20 × 7–15 mm, mucronate at apex, scales 2; filaments 1.5–2 mm long, inserted in the throat of the receptacle tube; anthers coherent; disc shortly cup shaped, c. 1.5 mm diameter. Female flowers: peduncle 1–6 cm long; bract 1–9 mm diameter; pedicel 1–8 cm long; sepals narrow, oblong lanceolate, 2–5 mm long; petals smaller than or equal to that in male, 7–10 mm long; ovary fusiform, narrowly rostrate, 5–11 × 2–3 mm, muricate, tuberculate or longitudinally ridged: style c. 2 mm long; nectary 3 at stylar base. Fruit pendulous, stalk 2–15 cm long; discoid, ovoid, ellipsoid to oblong or blocky, often narrowed at ends, sometimes finely rostrate, 3–8 × 2–5 cm, white or green turning orange on maturity, soft tuberculate with 8–10 broken or continuous ridges, splitting from base into 3 valves exposing the arillate seeds; seeds 5–15, squarish rectangular, ends subtridentate, faces compressed, sculptured, 5–9 × 3–6 mm, margins grooved, testa brown or black.

#### 2. *M. balsamina* L. (Source Joseph 2005)

Slender trailing herb, 1.5–3 m high, annual, sub glabrous, monoecious; stems round, internodes 5.5–6 cm; tendrils delicate, 11–13 cm long, basal 1–1.5 cm uncoiled. Leaves 3–5(–7) lobed to c. halfway or more, sub circular in outline, 4–6 cm diameter, base cordate with a cuneate petiole-blade juncture, mucronate at