Occurrence, Distribution and *Ex Situ* Regeneration of Balsam Apple (*Momordica balsamina* L.) in India

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Momordica balsamina L. has a narrow distribution in India, confined to Rajasthan and Gujarat. *Ex situ* regeneration studies showed that it can be regenerated during October-April in Kerala, simulating the hot days and cool nights that occur in its home range. Even though pollination and seed dispersal by native fauna was observed, it could not naturalize in Western Ghats due to non-adaptability to the high rainfall monsoon period. Few reports of its occurrence and distribution in Kerala are obviously based on misidentification of a herbarium specimen as South India is far beyond its natural range.

Key Words: *Momordica balsamina*, Conservation, Distribution, Ecogeography

Introduction

M. balsamina L. is the type species for the genus *Momordica* L. The generic epithet *Momordica* is derived from the Latin word 'mordeo' meaning 'bitten' (Drury, 1864) for the jagged edges of the seeds (which look like 'bite' marks). Ironically, among the six species occurring in India, *M. balsamina* is unique for its seed shape, which is non-jaggered. World distribution of the taxa is from North, East and South Africa, North and East Australia to West Asia extending to Pakistan and India (Hooker, 1871; Chakravarty, 1982; De Wilde and Duyfjes, 2002). It also occurs in Latin America as an introduced plant.

Known as balsam apple, it is a wild edible vegetable and medicinal plant in Tropical Africa and West Asia (Mishra *et al.*, 1986; Nayar and Singh, 1998; Jeffrey, 2001). Leaves and young fruits are cooked and eaten in Sudan, Senegal, Cameroon and southern Africa. Bright red fruit aril is eaten in Namibia. Ripe fruits are reported to be toxic, especially when consumed in large quantity. An infusion prepared from ripe fruits in olive oil is mentioned in ancient Arabic '*Materia Medica*' for the treatment of cracked heels (Nayar and Singh, 1998). It is used as an anthelminthic, antipyretic, hypoglycemic, abortifacient, aphrodisiac and lactogenic in African ethnomedicine (Watt and Breyer-Brandwijk, 1962; Burkill, 1985; Geidam *et al*., 2007). Utilization is the best method for conservation of biodiversity. Its prospects as a new source of economic products, especially nutraceuticals and therapeutic agents, need to be investigated. Scope for introduction as an ornamental exists by virtue of its elegant foliage and beautiful scarlet red fruits. It is used as camel fodder (Chakravarty, 1982), but there are no reports of its role in ecosystem functions in the desert.

As in the case of other *Momordica* species, there is lot of confusion in India regarding the correct botanical identity of balsam apple. There are several instances of misidentification and few reports of its (unlikely) occurrence in south India and Western Ghats (Subramanian, 1970; Sasidharan, 2004; Nayar *et al*., 2006), far distant from its natural range. Besides, this taxon is poorly represented in the Indian National Genebank of NBPGR, New Delhi (personal communication, Chithra Pandey). Hence, it was considered appropriate to conduct a study on the natural distribution of *M. balsamina* and its field regeneration under *ex situ* conditions prevailing in Western Ghats.

Materials and Methods

Herbarium survey was carried out at CAL (Botanical Survey of India, Calcutta), BSIJO (Botanical Survey of India, Arid Zone Circle, Jodhpur), BSISH (Botanical Survey of India, Eastern Circle, Shillong), MH (Botanical Survey of India, Southern Circle, Coimbatore) and BSI (Botanical Survey of India, Western Circle, Pune) during 2002-2003. Based on the herbarium information, the first author visited Machia Safari Park, Jodhpur (one of the hotspots as per the survey) in October 2003 and could collect one accession (IC467683), besides carrying out *in situ* characterization. A representative seed sample was sent for conservation in the National Genebank of NBPGR (SBJ 03-135, Jodhpur, Kailana Lake Road, 24-9-2003,

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Joseph John K, RHK&NHCP). Seed regeneration was carried out at the Botanical garden of St. Berchmans' college, Changanacherry, Kerala during October 2003 (*Rabi* season) and June 2004 (*Kharif* season). Besides preliminary characterization, observations on interspecific crossability and phenology (flowering, fruiting, pollinators and dispersal agents) under *ex situ* situation were recorded. Soil samples from collection and regeneration sites were analyzed for major physical and chemical characters using standard analytical protocols.

Results and Discussion

Distribution and Occurrence

Natural distribution of *M. balsamina* is restricted to Rajasthan and Gujarat (Fig.1). There are altogether 45 herbarium sheets (eliminating duplicate sheets), 6 from Gujarat and 39 from Rajasthan at CAL (Botanical Survey of India, Calcutta) and BSIJO (Botanical Survey of India, Arid Zone Circle, Jodhpur). Districts of Ajmer, Pali, Ganganagar, Jalore, Bharatpur, Jaipur, Jodhpur and Churu in Rajasthan and Mehsana and Bharuch in Gujarat are the major areas of higher population in the wild. Its distribution in India is in continuation of that in Sindh province of Pakistan.

It is not known from South India or Western Ghats. The lone report of its occurrence in South India (Subramanian, 1970) is based on wrong identification of collection 77286 (Acc. No. 35124 of BSI, Pune), originally identified as *M. balsamina* (on 1-12-1961) and subsequently determined as *M. dioica* Roxb. (on 22-10-1962). Hence, the enumeration of *M. balsamina* in the floristic diversity of Kerala (Sasidharan, 2004; Nayar *et al*., 2006) based on this report does not stand valid.

Vernacular names: Bara-karela (Rajasthan), Karelo-jangro (Sindhi)

Habitat and Ecology: Disturbed habitats in semi-arid and arid tropics, road sides, farm borders and fences on medium heavy soils with slightly acidic pH. *Prosopis cinerarifolia* was the associated vegetation.

Morphology and Taxonomy

M. balsamina is distinguishable from the dioecious taxa by virtue of its monoecious, non-tuberous, annual habit. Unlike the other monoecious taxon (*M. charantia* L.), bracts of the male flowers are at the apex of the peduncle. Flowers are very distinct; the female flower is always smaller and male flower with red nectar guides. Fruits

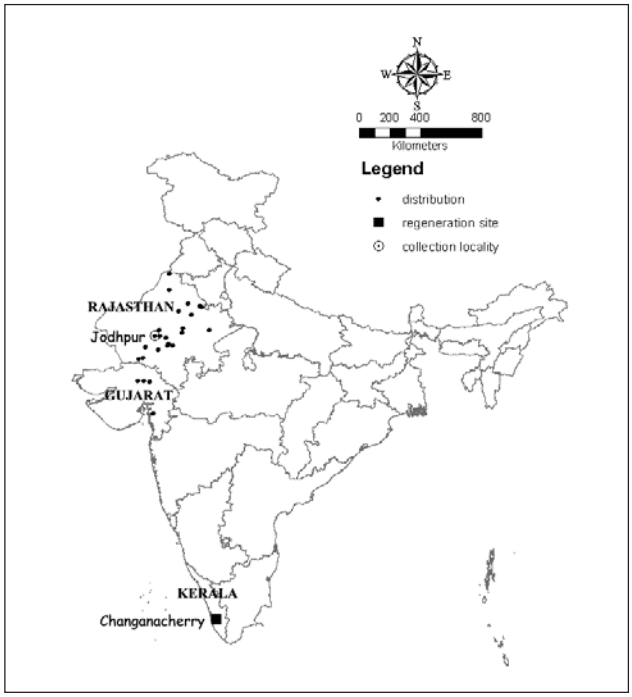

Fig.1: Map showing natural distribution, *in situ* characterization and *ex situ* regeneration sites

are non-pendant, small, bulged, distantly soft tubercled without any bumps or ridges. Seeds are very thin, flat and rugulose on surface, with a thinly grooved margin and finely tuberculate edges.

Herbarium records indicate September to March as fruiting season. Seeds germinate with monsoon showers in July-August (Rajasthan) and attain flowering and fruiting in September. Best time for seed collection is October when peak fruiting was observed in Machia Safari Park, Jodhpur.

Regeneration and Growth under Ex Situ Conditions

As soil and environmental features of native habitat and regeneration sites were different (Table 1), soil amendments by liming and adjusting the growth season to dry winter-summer months helped to get comparable plant growth. Though seeds sown in June germinated fast, they failed to grow beyond 4-leaf stage, due to heavy monsoon showers. October-sown seeds germinated on the fourth day and attained vine length up to 3 m. Germination was epigeal and roots non-tuberous as in the case of *M. charantia*. Plants took 69 days from seed to seed. Days to first male flower was 39 (range 35-42). Fruits took 9 days to attain full size and 22 days to colour

Table 1. Soil and climatic characteristics of natural and regeneration sites

Locality	Latitude	Longitude	Altitude	Soil colour	Soil type	Total N2 (%)	Available P (ppm)	Available K (ppm)	Soil pH	EC (us/cm)	Max. Temp. (°C)	Min. Temp. (°C)	Avg. rainfall (mm)
Jodhpur (*in situ*)	26.2833	73.0333	274	Brown	Calcareous sandy loam	0.063	90.8	257.8	8.5	160.3	41.5	10.0	2 3 . 6
Changanacherry (*ex situ*)	9.750	76.5666	61	Red	Laterite	0.256	17.9	159.4	6.1	120.6	30.8	23.3	2874

breaker stage, 24 days to red stage and finally bursting open on 25th day.

Anthesis was between 4.30-5.00 AM. Small insects such as *Trigona iridipenis* (stingless honeybees), *Solenopsis* sp. (small red ant) and *Nomia* sp. (stingless metallic blue-white striped bees) were the floral visitors observed. As the male flower stalks are very fragile, it is not adapted to pollination by large bodied insects. Nearly 100 % natural fruit set was observed indicating efficiency of pollinators outside the home range of the species. Nectar, mild scent, and yellowish-orange petals with red spots at petal base act as floral rewards and nectar guides. Ripe fruits are orange red in colour and splits open exposing the carmine red seeds (aril) which remain adhered together. The fruit stalk is very short and not pendant unlike in the case of other *Momordica* species and *Pycnotus* sp. (red whiskered bulbul) was found to feed on ripe fruits. After ingestion of seed aril, the seeds are regurgitated effecting dispersal of seeds. Ripe fruits were mildly bitter whereas seed aril was sweet and slimy.

Growth performance of *M. balsamina* outside its home range was comparable to that of native habitat (Table 2). However, a reduction in plant height was observed. On an average, 40 fruits per plant (range 36-52) were obtained under Kerala conditions, which indicates need for raising about 40 plants per accession to get about 6,000 seeds for genebank storage.

As in the case of June-sown seeds, the soil seedbank (from the previous crop) also could not overcome the heavy monsoon climate occurring in the Western Ghats of Kerala. As the seeds do not have dormancy and being non-perennating, it cannot naturalize in the monsoon climate. However, by adjusting the growth season to dry winter-summer months, a simulated growth environment can be created permitting field regeneration. Curators can adapt and improve these methods with an aim to produce maximum seeds. Being an insect pollinated plant, maintenance of isolation distance or selfing is necessary in case of regeneration of more than one accession.

Response to Pests and Diseases and Interspecific Crossability

The plants were free from Ladybird beetle (*Epilacna septima*), red pumpkin beetle (*Aulocophora fevicoli*) and Cucurbit Yellow Mosaic, which are the main pests and diseases of bitter gourd in Kerala (Table 3). However, they were extremely susceptible to fruit fly (*Bactocera cucurbitae*). At its natural habitat also, severe fruit fly damage was observed.

Direct and reciprocal crosses with related taxa (*M. charantia* L., *M. dioica* Roxb., *M. sahyadrica* Joseph and Antony and *M. subangulata* ssp. *renigera* (G. Don) de Wilde) failed to set fruit. Though not coming in the primary genepool of bitter gourd (*M. charantia* L.), it is a potential source of many useful genes conferring resistance to several common pests, which can be

Table 2. Comparative growth performance of IC 467683 at *in situ* and *ex situ* situations

S.No.	Character	*Ex situ* site	*In situ* site
1	Plant height (m)	2.25 (1.5–3.0)	5 (3.0–6.0)
2	Inter node length (cm)	5.5	6
3	Petiole length (cm)	2	2.1
4	Lamina size (cm)	4 x 5	4 x 6
5	Tendril length (cm)	11.5	13.0
6	Male flower peduncle (cm)	0.3	0.4
7	Male flower pedicel (cm)	0.4	0.8
8	Male flower bract size (cm)	0.6 x 0.5	0.6 x 0.6
9	Male flower calyx (cm)	0.7 x 0.3	0.7 x 0.3
10	Male flower petal (cm)	1.3 x 0.9	1.5 x 1.0
11	Male flower diameter (cm)	2.5	2.9–3.0
12	Female flower peduncle (cm)	0.2	0.3
13	Female flower pedicel (cm)	0.4	0.6
14	Female flower bract size (cm)	0.3 x 0.3	0.4 x 04
15	Female flower petal (cm)	0.7 x 0.6	0.8 x 0.8
16	Female flower diameter (cm)	1.5	1.8
17	Ovary length (cm)	0.5	0.7–0.8
18	Fruit weight (g)	6.0	9.3
19	Fruit length (cm)	2.5–3.5	4.0–5.0
20	Fruit diameter (cm)	1.8	2.7
21	Fruit stalk (cm)	0.5	0.8
22	Seeds/fruit	3.0–5.0	4.0–7.0
23	100 seed weight (g)	8.7	9.0
24	Fruit wall thickness (mm)	1.5	1.5
25	Seed length (mm)	9.2	9.2
26	Seed width (mm)	6.5	6.5
27	Seed thickness (mm)	2.4	2.4

Table 3. Observations on tolerance/susceptibility of *M. balsamina* to common pests and diseases in comparison to other species

Biotic agent	*M. balsamina*	*M. charantia* var. *charantia*	*M. charantia* var. *muricata*	*M. dioica*	*M. sahyadrica*	*M. subangulata* ssp. *renigera*
Lady bird beetle (*Epilacna septima*)	1	5	3	5	5	5
Red pumpkin beetle (*Aulocophora fevicoli*)	1	3	3	7	3	3
Fruit fly (*Bactocera cucurbitae*)	9	5	3	3	1	5
Pumpkin caterpillar (*Margaronia indica*)	1	1	1	1	1	3
Gall fly (*Lasioptera falcata*)	1	3	3	1	3	5
Root knot nematode (*Meladogyne incognita*)	1	1	1	1	1	7
Cucurbit Yellow Mosaic	1	3	3	3	3	1
Little leaf disease	1	1	5	5	5	1

Scale: 1-9 (1=no visible sign of susceptibility; 3=low; 5=intermediate; 7=high; 9=highly susceptible)

transferred to the commercial bitter gourd varieties through modern biotechnological tools.

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