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DISTRIBUTION, DOMESTICATION AND DIVERSITY OF *CUCUMIS* SPECIES COMPLEX IN INDIAN SUB-CONTINENT

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*The sub-continent of India is considered to be the place of origin for cucumber (*Cucumis sativus *L) and a centre of diversity for melon (*C. melo *L). Centres of origin and diversity have long been regarded as valuable sources of both biotic and abiotic plant stresses. A large number of variants are cultivated traditionally in different parts of India, which may have evolved through natural and human selection aided by repeated introgression from wild forms. An account of distribution, of* Cucumis *species complex including wild relatives and their domestication and diversity mainly in Indian sub-continent has been reviewed. Crop variability, genetic erosion status and priorities for* Cucumis *species collection in India and elsewhere are also discussed.*

Indian sub-continent is considered to be the centre of origin for cucumber (*Cucumis sativus* L) and a centre of diversity for melon (*C. melo* L) (Zeven and de Wet, 1982). Diversity is reported to occur in several *Cucumis* species viz., *C. hardwickii* Royle, *C. hystrix* Chakra., *C. setosus* Cogn., *C. trigonus* Roxb. (syn. *C. callosus* Rottl. Cogn.) and *C. prophetarum* L including cultivated cucumber and melon in this region (Arora and Nayar, 1984). The use of wild and cultivated cucurbits in India dates back to pre-historic times. Melon seeds were prominent among the stored materials excavated from the archaeological sites at Harappa and other locations (2000-1700 BC). A strikingly large number of variants evolved gradually through introgression and selection from wild forms, many of which are still cultivated in different parts of India. These landraces contain valuable genes for adaptability to diverse agro-ecological zones, resistance to diseases and pests as well as stress

environments including drought on one side and govern other desirable traits like flavour, taste and flesh characteristics on the other. This paper reviews distribution of cultivated *Cucumis* species (*Cucumis sativus* L and *C. melo* L) and their wild relatives, their domestication and diversity mainly in the Indian sub-continent. Based on distribution of genetic variability, existing collections and genetic erosion status, the priorities for *Cucumis* species collection in India and elsewhere are also discussed.

DISTRIBUTION AND DOMESTICATION

The genus *Cucumis* comprises about 30 different species which are distributed over two geographically distinct areas (Esquinas-Alcazar and Gulick, 1983). South-east of Himalaya is an important region for Asiatic group, of which cucumber (*Cucumis sativus*) is a member. The African group is spread over large parts of Africa and the Middle East to central Asia extending to Pakistan and southern Arabia. Most species with basic number X=12 are found in this region with a few tetraploids and hexaploids. Host-parasite and phytogeographic studies led Leppik (1966) to propose North-east Africa, Arabia and the eastern Mediterranean areas as the primary gene centre and south Africa as secondary gene centre of the genus *Cucumis*. The cultivated species include *C. sativus* L. *C. melo* L and *C. anguria* L. Among the wild species, 17 have been identified from southern Africa (Meeuse, 1962) and 13 from tropical eastern Africa (Jeffrey, 1967). Of these, *C. prophetarum* migrated to India, whereas *C. hardwickii* Royle is indigenous to India. For *C. melo*, India, Turkey and Afghanistan have been recorded as secondary gene centres (Whitakar and Bemis, 1976). Cucumber (*Cucumis sativus*) apparently was domesticated in India (de Candolle, 1886). It shares the chromosome number of 2n=14 with *C. hardwickii*, found wild in the foothills of Himalayas. The free hybridisation with cultivated *sativus*, with no reduction of fertility in F_2 generation suggested that *C. hardwickii* is likely progenitor of cultivated cucumber. However, the absence of semi-wild or wild forms of cucumber unlike other species, like *C. melo* (Seshadri, 1986) does not provide an evidencing support to the hypothesis which has extensive distribution in Africa. At one point X=7 was considered primitive in *Cucumis* and was thought to have given rise to X=12 through fragmentation of chromosomes (Whitakar, 1933; Ayyangar, 1967 and Bhaduri and Bose, 1947). However, this hypothesis could not be confirmed cytologically and X=12 is now regarded as primitive (Yadava *et al.*, 1944). The base number X=7 probably evolved from X=12 (Singh and Roy, 1974). *Cucumis* taxa with X=12 have greater phenotypic variability and

geographic distribution, and despite the higher chromosome number, they have almost the same half chiasma per chromosome value as taxa with X=7 (Yadava *et al.*, 1984). These factors suggest that both group of species have a common chromosome complement. The evolution of species with X=7 may have been favoured to restrict recombinations by reducing the chromosome number but retaining the same chiasma frequency. This could be a factor contributing to their comparatively restricted phenotypic variability and distribution.

The species of African group of *Cucumis* are mostly diploid with basic chromosome number X=12. The Asiatic group is also diploid, but with a chromosome number of X=7. The fragmentation theory of Bhaduri and Bose (1947) suggests that *C. melo* with chromosome number 24 was derived from *C. sativus* or a closely related species. Trivedi and Roy (1970) proposed another hypothesis of fusion or translocation of the chromosomes for the origin of *C. sativus* from *C. melo*. Ramachandran and Seshadri (1986) are of the view that the fragmentation theory and their own hypothesis of reduction by haploidy and fragmentation are hardly tenable for establishing a relationship between cucumber and muskmelon.

Interspecific hybridisation provided useful information on species relationships. Deakin *et al.* (1971) presented the first comprehensive data on cross-compatibility relationships of *Cucumis* species and on the pollen fertility of F_1 hybrids. As a result, *Cucumis* species was placed into four groups : (1) the Anguria group includes all the spiny fruited interfertile annual, perennial, and advanced polyploid species; (2) the Melo group, comprising the wild, non-spiny species and the cultivated *C. melo*; (3) Metuliferus group, represented by *C. metuliferus*, having distinct morphology and being cross-incompatible with other *Cucumis* species; and (4) Sativus group, containing the cultivated *C. sativus* and the wild *C. hardwickii* with 2n=14. Jeffrey (1980) classified the entire genus *Cucumis* into two subgenera :

(i) Sub-genus *Cucumis* (X=7), there are 3-4 Chinese-Himalayan species including *C. sativus, C. callosus, C. hystrix* Chakra. and *C. bisexualis.*

(ii) Sub-genus *Melo* (X=12), 30 species mostly tropical and south African

  (a) *anguria* group-dioecious, monoecious or andromonoecious; perennials with yellowish-brown striped fruits, closely related and partially fertile inter-specific

hybrids; *C. anguria, C. dispacus, C. prophetarum, C. myriocarpus* and *C. aculeatus.*

(b) *melo* group — monoecious, andromonoecious; perennials or annuals with smooth fruits; *C. melo* L, *C. sagittatus* Peyr., *C. dinteri* and *C. humifructus* Stent.

(c) *metuliferus* group — monoecious annuals with red spiny fruits; *C. metuliferus* Naud.

(d) *hirsutus* group — dioecious, perennials with smooth orange fruits, *C. hirsutus* Sond.

In India, according to Chakravarty (1982), only 6 species occur. Some are cultivated. Five wild species of *Cucumis* included *C. agrestis C. hystrix, C. setosus, C. prophetarum* and *C. hardwickii. C. callosus* occurs mainly in Punjab, Himachal Pradesh, Rajasthan, Uttar Pradesh, Bihar, Orissa, Tamil Nadu and Karnataka. Wild related species of *C. sativus* are *C. hardwickii* and *C. trigonus. C. hardwickii* – a small fruited bitter cucumber with sparse and stiff spines has been found wild in the foothills of north-west Himalayas and southern hills; *C. setosus* is endemic to Maharashtra state; *C. prophetarum* to Sirohi (Abu) of Rajasthan, Gujarat, Maharashtra, Tamil Nadu and Karnataka and *C. hystrix* to Meghalaya, Assam and Mizoram. *C. sativus* L. is the only cultivated species indigenous to India.

DIVERSITY OF CULTIVATED SPECIES AND THEIR WILD RELATIVES

(a) Cucumber (*Cucumis sativus* L)

Cucumber is one of the oldest cultivated vegetable crops. It has been known in history for over 5000 years and is considered to be native to India. It originated in India in the north-western foothills along Nepal Himalayas. Later, it was introduced into Europe, Near East, China and elsewhere, being the secondary gene centre (Zeven and de Wet, 1982). The Near Eastern centre is known for xerophytic types. It carries sources of resistance to powdery mildew, *Sphaerotheca fuligenea* from China and Japan. Cucumber is the only cultivated species in the genus with chromosome number 2n=14, while other species have 2n=24 and are mostly African. Cucumber has two forms – creeping one, cultivated in the fields during hot season while climbing forms cultivated during rainy season. Morphologically they differ in fruit size.

Genetic variation present in the cultivated varieties of *C. sativus* does not seem to be sufficient to solve the specific problems connected with the improvement of this plant species. For the increase of genetic variability concerning quantitative inherited characters, and especially as sources of resistance, collection of material from natural habitats of *C. sativus* is essential. *C. sativus* var. *hardwickii* which crosses readily with cucumber since it lacks character for fruit inhibition (Horst and Lower, 1978).

Cucumber is grown throughout India, but maximum genetic diversity occurs in north India with respect to bearing habit, maturity, yield, shape, size, skin colour, skin ornamentation, spines and vine habit etc. Cultivars differ in adaptability/suitability to different seasonal/climatic conditions viz., (a) hot weather type, creeping small fruits, dark-green/sometimes rusty-brown, ovoid with thin and smooth rind, called *Gherkins* grown at the beginning of the spring season under irrigation, less popular but generally preferred for pickling; (b) rainy season crop, early cluster small fruits with scattered black spines, medium green fruits with black spines, long fruits with spines, netted types with cracking skin on ripening. Large fruits with thick rind, suited to wide variety of soils in hills or plains, more popular, used for salads or for cooking in curries, are also available. In north-eastern and western Himalayas, long fruited genotypes occur. Folk selection pressure has resulted in the development of (i) very long fruited types particularly in western India including foothills of Himalayas and (ii) medium and small fruited types in gangetic plains.

In cucumber, two varieties are reported. *C. sativus* var. sativus has 3-5 lobed leaves, ovary usually 3-placentiferous with fruits oblong, obscurely trigonus or cylindric. This variety is cultivated all over India and in all tropical and sub-tropical regions. Another variety, *C. sativus* var. sikkimensis Hook. f. has 7-9 leaves, ovary often 5-placentiferous, fruits ovoid-oblong, adapted both to temperate and humid climates. *C. hardwickii* is a wild type related to *C. sativus*, adaptable to cold climate and confined to western Himalayas. It has 5-angular ovate leaves, glabrous/tuberculate fruits much smaller than cucumber. The fruits have sparse and stiff spines.

In India, immature and mature fruits are eaten raw as slicing cucumber in salad. It is rarely used as vegetable. Strikingly large number of variants are still cultivated traditionally in different parts of India and these have evolved gradually through and human selection aided by repeated introgressions from wild forms. It is estimated that about 95-100 distinct landraces are available in different agro-ecological/eco-geographical zones of India. Locally

adapted landraces included **Sawanariya** (from Sikar, Laxmangarh Shekhawati areas and Chomun in Jaipur); **Balamkakdi** (from Tonk, Kir-ka-kheda, Pindwara and Abu Road); **Balamkhira** (from Nalchha in Dhar district, Malwa region, Madhya Pradesh) and **Bhus** (from Bhikangaon/Pati areas in west Nimar region, M.P.) (Fig 1) and many others. The landrace variability in Rajasthan is atuned to dry conditions and adapted under ago- ecological niches with acute water stresses. Amazing diversity in fruits has been sampled. Germplasm collections varied in plant habit (bushy to prostrate), in sex type (monoecious generally to gynomonoecious/ andromonoecious), fruit shape (elliptical, elongated, oblong, globular, stem-end tapered., blossom-end tapered), fruit skin colour (yellowish-white, light-green, medium-green, dark-green, yellow, with uneven colour to dark-green colour at stem-end portion and light-green with whitish splashes on other parts of the fruit), fruit skin mottling, colour of stripes (absent, white, green and yellow), in fruit skin glossiness (dull, glossy), fruit length (15-46.2 cm), fruit width (7.2-30 cm), fruit weight (110-4900g), in stem-end/ blossom-end fruit shape (depressed, flattened, rounded and pointed), flesh texture (smooth, grainy, soft), flesh colour (white, greenish white, green) and in seed coat colour (white, tan, yellow) (Umesh Chandra and Koppar, 1992).

In Madhya Pradesh, variability occurred in cucumber distinctly in two types. One type with fruit length 30-36 cm with diameter of 7-15 cm. The fruits on maturity had smooth, greenish skin with mostly both end of the fruit equally broad. In other type, the fruit length varied from 15-36 cm with range of diameter 15-22 cm, skin was rough with rusty brown colour. Uttar Pradesh collections varied in fruit shape, fruit ribs (generally absent to occasionally superficial), fruit skin colour and flesh texture (Fig 2).

Some of the newly bred cucumber cultivars included Japanese Long Green, Poinsette, Solan Green, Kalianpur Green, Straight Eight, Poona Kheera, Kheera Prome, Sheetal, Balamkhira and F_1 hybrid Pusa Sanyog (CSC, 1985).

(b) Melons (*Cucumis melo* complex)

India is considered as one of the regions of diversity for melon (*C. melo* L) which is not to be confused with watermelon (*Citrullus lanatus*). *C. melo* (muskmelon) is originated in Africa. The primary centre of diversity in melon is south-west and central Asia, mainly Turkey, Syria, Iran, Afghanista, north and central India, and Transcaucasia, Turkmenistan, Tadijkistan and Uzbekistan. Secondary centre of diversity are China, Korea, Portugal and Spain (Esquinas – Alcazar and Gulick, 1983). Chinese and Japanese melons have small fruits and an unpleasant strong taste.

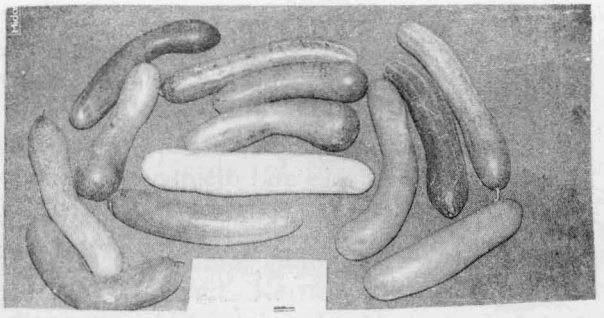

Fig. 1. : 'Balam Kakdi' landrace from Abu Road, Rajasthan

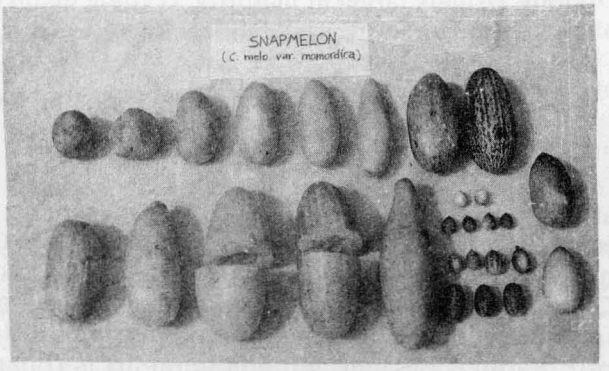

Fig. 2: Snapmelon — variability in shape and size of fruits

Munger and Robinson (1991) suggested 7 horticulturally important melon groups :

1. *C. melo agrestis* (**Kachri**) : Wild types with slender vines and small, inedible fruits. Probably synonym of *C. melo callosus* (*C. callosus*) and *C. melo trigonus* (*C. trigonus*).
2. *C. melo cantalupensis* Naud. (muskmelon or cantaloupe) : Medium sized fruits with netted, warty, or scaly surface, flesh usually orange but sometimes green, aromatic or musky flavour. Fruits dehiscent at maturity. Usually andromonoecious.
3. *C. melo flexuosus* Naud. (*C. melo* var. utilissimus in Indian literature) : snakemelon, snake cucumber, **Tar-Kakri**; fruit

long and slender, used when immature as an alternative to cucumber, monoecious.

4. *C. melo momordica (C. melo* var. momordica); **phut** or snapmelon, grown in India and other Asian countries and distinct from any other group. Flesh is white or pale orange, low in sugar and mealy. The smooth surface of the fruit cracks as maturity approaches and disintegrates; monoecious.
5. *C. melo conomon* Mak. (pickling melon or sweet melon): small fruits with smooth skin, white flesh and early maturity, andromonoecious.
6. *C. melo inodorus* Naud. (winter melon): smooth or wrinkled surface with flesh usually white or green and lacking musky odour. Usually larger at maturity, keeping quality longer than muskmelon, and in dehiscent at maturity. Mostly andromonoecious.
7. *C. melo dudaim* Naud. (mango melon, pomegranate melon) : Fruits small globular, smooth, mottled but not netted, flesh with acid flavour. pickling type.

Out of 7 popular melons, *C. melo agrestis* (syn. *C. melo callosus* or *C. callosus*), *C. melo cantalupensis* (muskmelon); *C. melo* var. utilissimus (*C. melo flexuosus*), snakemelon, snake cucumber, **Tar Kakri**; *C. melo* var. momordica (**phut** or snapmelon); are available in Indian sub-continent. Snapmelon florishes well in local regions of Jodhpur, Barmer, Bikaner and adjoining areas (Bhandari, 1967). It is an important cucurbit and is used especially by poor communities in famine. Monoecious types are common in snapmelon. This area, the 'Goldmines' of snapmelon has tremendous diversity in this crop. The germplasm varied in fruit shape, fruit ribs (generally absent but occasionally superficial to deep ridging), fruit skin colour, texture (smooth, grainy, with spines, with stripe, streaked), blossom scar (generally obscure but occasionally conspicuous), fruit length, (2.5-34.0 cm), fruit width (2.5-13.0 cm), fruit weight, (6.8- 149.2g) and flesh colour. **Kachri** melons (*C. melo agrestis*) have more or less uniform diversity in Rajasthan, Madhya Pradesh, Uttar Pradesh and southern states. **Tar Kakri** or snake cucumber (*C. melo* var. utilissimus) is grown throughout India and shows a wide variation. Muskmelon occurs more in *tarai* region and western Uttar Pradesh, Chhotanagpur area, West Bengal, Assam, Karnataka and coastal Andhra Pradesh, and possesses interesting variation. In **Kachri**, several fruits of large size are observed in Madhya Pradesh which may be due to introgression of semi-wild *C. melo agrestis* with cultivated melons.

Further studies are needed to establish such facts (Umesh Chandra and Koppar, 1992).

Some of the newly bred varieties included in muskmelon — 'Arka Jeet', an improved variety from local 'Bati' of Lucknow, 'Arka Rajhans' — from Karnataka, Sel. 445 from Rajasthan, 'Allahabad Khajira', 'Lucknow Safeda' from U.P., 'Durgapura Madhu' from Rajasthan, 'Kutana' and 'Punjab Sunheri' from Punjab, 'Bathese' from Andhra Pradesh, 'Sarda' of M.P., 'Gujarat Muskmelon I', 'Gujarat Muskmelon 2', 'Hara Madhu', 'Pusa Madhuras', 'Sharbat-e-Anar'; 'Hingan', 'Jalbudata', are other promising varieties. 'Pusa Sharbati' and 'Punjab Hybrid' are crossbred varieties. 'Arka Sheetal' and 'Karnal selection' are snakemelon varieties. (Thomas *et al.*, 1983).

(c) Other Cucumis species

In *Cucumis*, for *C. hardwickii* and *C. trigonus*, much variability occurs in the Himalaya., While *C. setosus* is restricted to eastern plains, *C. hystrix* extends its range from eastern plains to north eastern hills in Assam, Tura range in Meghalaya and Mishmi hills. Localized variability at species level occurs in western ghats for *C. hystrix* and *C. setosus* in comparison to drier northern plains, where only *C. prophetarum* occurs (Arora and Nayar, 1984; Table 1). Apart from these, *C. aculealus* Cogn. (Ethiopia), *C. anguria* (Ethiopia and S. Africa), *C. dispacus* Spach. (an ornamental from Africa), *C. ficifolius* A. Rich. (Ethiopia), *C. frageri* Naud. (wild in Nigeria), *C. metuliferus* Naud. cultivated as ornamental and as fruit in Africa and *C. zeyheri* Sond, (from S. Africa), are species of African region. Recently four new species from Somalia viz., *C. jefferyanus, C. pubituberculatus C. baladensis* and *C. hastatus* have been added to the genus (Thulin, 1991).

CUCUMIS SPECIES AND DISEASE RESISTANCE

In cucumber, there is lack of resistance to some important pathogens and insects/pests such as cucumber green mottle virus, nematodes etc. *C. hardwickii* possesses resistance to green mottle virus, downy and powdery mildews. *C. hystrix* Chakra. carries resistance to rootknot nematode, powdery mildews and tolerance to green mottle mosaic virus. High level resistance to rootknot nematode occurs in *C. metuliferus*. *C. sativus* var. sativus landraces collected from Rajasthan possess resistance to powdery mildews (*Sphaerotheca fulgenea*) and tolerance to green mottle mosaic virus (Table 1).

Table 1 : **Indian *Cucumis* species, their distribution and useful characteristics**

Crops species	Distribution	Useful characteristics
Cucumis sativus var. sativus	Gujarat, Rajasthan, Uttar Pradesh, Cachar (Assam) and Khasi Hills (Meghalaya)	Resistance to powdery mildew *(Sphaerotheca fulgenea)*, tolerance to green mottle mosaic virus
C. sativus var. hardwickii	Foothills of Himalayas, DehraDun and Mussoorie (UP), Himachal Pradesh, Jammu & Kashmir	Resistance to cucumber green mottle mosaic virus, downy *(Pseudoperonospora cubensis)* and powdery mildews
C. sativus var. sikkimensis	Arunachal Pradesh, Sikkim, Nagaland and Manipur	Adaptable to cold climates; resistance to Anthracnose *(Colletotrichum orbiculare)*
C. hystrix Chakra.	Plains of eastern India, north-eastern hills and Assam valley western ghats, eastern India Upper gangetic plains, West Bengal and peninsular region	Resistance to root-knot nematode, powdery mildews and tolerance to green mottle mosaic virus
C. setosus Cogn.	Eastern India, upper gangetic plains, West Bengal	Resistance to anthracnose, adapted to high rainfall areas
C. profetarum	Largely distributed in the dry north-western plains, Rajasthan (Sirohi district) and adjoining belt	Resistance to root-knot nematode, drought resistance
C. callosus (syn. *C. trigonus*)	Widely distributed in eastern and western ghats north-eastern region, extending to Himalayas	Drought resistance
C. melo var. momordica	Rajasthan, Uttar Pradesh, Madhya Pradesh, Khasi Hills (Meghalaya), West Bengal	Drought resistance; resistance to downy mildew.
C. melo var. agrestis (Kachri)	Rajasthan, Madhya Pradesh, Uttar Pradesh and Southern India	Drought resistance

PRIORITIES FOR GERMPLASM COLLECTION

Based on distribution of genetic variability, existing collections and genetic erosion status (Table 2), first priorities included southwestern Asia, from Turkey to Afghanistan *(C. melo)*; India, sub-Himalayan tract to north-eastern hills, western ghats, eastern peninsular tract and Indo-gangetic plains (*Cucumis* species wild and cultivated); and Myanmar and southern China (*C. melo*). Second priorities included India, South-east Asia, Southern China (*C. melo* and wild *C. sativus*), tropical Africa, especially Sudan (*C. melo*), tropical and southern Africa (*C. anguria*)) and Iberian peninsula (*C. melo*).

Table 2 : **Crop variability and genetic erosion status in Indian region**

Crop	Cultivated/ wild	General variability status	Genetic erosion status
Cucumis sativus (Cucumber)	Cultivated	Very high	High
C. setosus	Wild	Low	High
C. profetarum	Wild	Low	High
C. hardwickii	Wild	High	High
C. melo	Cultivated	Very high	Medium
C. melo var. momordica (Snapmelon, **phut**)	Semi-wild/ cultivated	Very high	Low
C. melo var. utilissimus (Snakemelon, **Tar-kakri**)	Cultivated	Medium	Medium
C. melo var. agrestis **(Kachri)**	Semi-wild	High	Low

Melons are insect – pollinated; much genetic diversity may, therefore, exist within a population. This diversity may not be obvious in small population; plant collectors should, therefore, sample enough within population diversity by collecting seeds from larger plant populations in the field.

REFERENCES

Arora, R.K. and E.R. Nayar, 1984. Wild relatives of crop plants in India. *NBPGR Sci. Monogr.* 7:90p

Ayyangar, K. Rangaswami, 1967. *Bull. Nat. Inst. Sci. India* **34**: 380-96

Bhaduri, P.N. and P.C. Bose, 1947. Cytological investigations in some common Cucurbits with special reference to fragmentation of chromosomes as physical basis of speciation. *J. Genet.* **48**: 237-56

Chakravarty, H.L ., 1982. Fascicles of Flora of India- II Cucurbitaceae. Botanical Survey of India, 136p

CSC. 1985. Handbook on Cultivars, Central Seed Committee, Dept. of Agri. & Cooperation, Govt. of India, New Delhi, p 394-408

Deakin, J.R., G.W. Bohn and T.W. Whitaker, 1971. Inter-specific hybridization in *Cucumis*. *Econ. Bot.* **25**: 195

de Candolle, A. 1882. Origin of Cultivated Plants, New York

Esquinas-Alcazar, J.T. and P.J. Gullick, 1983. Genetic resources of Cucurbitaceae — A Global Report. International Board for Plant Genetic Resources, Rome, 101p

Horst, E.K. and L.R. Lower, 1978. *Cucumis hardwickii*, a source of germplasm for the cucumber breeding. *Cucurbit Genet. Coop. Rep.* 1: 5

Jeffrey, C. 1967. Cucurbitaceae. *In*: Flora of Tropical India, E. Milne-Redlead and R.M. Polhill (Eds). Crown Agents, London

Jeffrey, C. 1980. A review of Cucurbitaceae. *J. Linn. Soc. Bot* 81: 233-47

Leppik, E.E. 1966, Searching gene centers of the genus *Cucumis* through Host-parasite relationship. *Euphytica* 15: 323-328

Meeuse, A.D, J, 1962. The Cucurbitaceae of Southern Africa. *Bothalia* 8: 1-111

Munger, H.M. and R.W. Robinson, 1991. Nomenclature of *Cucumis melo* L. *Cucurbit Genet. Coop. Rep.* 14: 43

Ramachandran, C. md. V.S. Seshadri, 1986, Cytological analysis of the genome of Cucumber (*Cucumis sativas* L) and muskmdon (*Cucumis melo* L). *Z Pflanzenzucht* 96: 25

Seshadri, V.S. 1986. Cucurbits. *In* : Vegetable crops of India, T.K. Bose and M.G. Som (Eds.), Naya Prokash, Calcutta. p. 91-164

Singh, A.K. and R.P. Roy. 1974. Karyological studies in *Cucumis* L. *Caryologia* 27: 153-60

Thomas, T.A., Ranbir Singh and R. Prasad. 1983. Genetic resources for improvement of vegetable crops. *South Indian Hort. (30th Commemoration issue)*: 53-73

Thulin, M. 1991. New species of *Cucumis* (Cucurbitaceae) from north-east tropical Africa. *Nordic J. Bot.* 11 (5): 535-42

Trivedi, R.N. and R.P. Roy, 1970. Cytological studies in *Cucumis* and *Citrullus*. *Cytologia* 35: 561

Umesh Chandra and M.N. Koppar. 1992. Joint exploration and germplasm collection of cucumber and melons in India. National Bureau of Plant Genetic Resources, New Delhi, 83p

Whitakar, T.W., 1933. *Bot. Gaz* 94: 780- 90

Whitakar, T.W., and W.P. Bemis. 1976. Cucurbits. *In*: Evolution of crop plants, N.W. Simmonds (Ed.), Longman, London. p 64

Yadav, K.S., A.K. Singh and H.C. Arya. 1984. Cytogenetic investigation in *Cucumis* L.I. Meitic analysis in twenty four *Cucumis* species. *Cytologia* 49: 1-9

Zeven. A.C. and J.M.J. de Wet. 1982. Dictionary of cultivated plants and regions of diversity. Wageningen. 259p