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REVIEW

SYSTEMATICS, TAXONOMYAND GENETIC RESOURCES OF CUCUMBER FOR SUCCESSFUL UTILIZATION IN BREEDING AND GENETIC IMPROVEMENT

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Abstract: The cucumber (*Cucumis sativus*) is an economically important vegetable crop cultivated and consumed worldwide. Cucumbers originated from India and cultivating from at least 3000 years.It belongs to family Curcurbitaceae, thetwosubfamilies namely Zanonioideae and Cucurbitoideae belongs to Curcurbitaceaewhich also includes 118 genera and 825 species. With eight tribes under the latter subfamily,i.e., Cucurbitoideae, genus *Cucumis* is grouped under tribe Melothrieae. Further, it isdividedinto two groups *Cucumis* (2n=2x= 14 and 24) and *Melo*(2n=2x=24) that contain five cross-sterile species groups. This review has attempted to create a better understanding on cucumber, its origin, distribution, taxonomy, botanical description, floral biology and geneticdiversity.Cucumber is an annual plant; there are three main types/varieties of cucumber slicing, pickling, and seedlesswithin which several cultivars have been created.A cucumber bearsmonoecious, gynoecious type of sex expression and commercially all gynoecious hybrids plants having parthenocarpy trait, which suits for protected cultivation.

Keywords: Cucumber, Genetic resources, Systematics, Taxonomy

INTRODUCTION

The vegetables from Cucurbitaceae family are of great economic importance, Cucumber (*Cucumis sativus* L.) is a member family Cucurbitaceae with chromosome number of 2n = 14. It is grown for edible tender fruits as dessert, pickles and cooked vegetables for its cooling effect. The medicinal benefits of cucumber is extended to people suffering from jaundice and allied liver issues, skin smoothness and brain development is boosted from cucumber seed oil, thus making it useful for Ayurvedic preparation. Globally, cucumber production is approximately 90.60 million tonnes, cultivated over 2.60 million hectares. In India, cucumbers are grown on about 1.03 lakh hectares, yielding around 1.44 million tonnes annually (NHB, 2022).

Cucumber (2n = 2x = 14) is the one of the Asian species and a member of the Cucurbitaceae family. The number of diploid chromosomes in the African group is 24. The cucumber, along with its closest surviving relative, *Cucumishystrix*, has been cultivated for at least 3,000 years and originated in India, where a wide variety of variations have been seen. It was most likely brought to Europe by the Romans or Greeks. Cucumber cultivation was first documented in North America by the middle of the 16th century, followed by France in the 9th century and England in the 14th.

Being an indigenous crop of India, there is a huge diversity and variability exists for many economically important traits and this species and varietal wealth could be exploited for the improvement of commercial important traits like gynoecy, biofortification of nutrients and development of varieties and hybrids resistant to biotic and abiotic stresses. Genetic improvement of any crop needs a proper under understudying of its botany, floral biology, species and varietal variability and their cross compatibility. Hence,in this review article for better understanding cucumber, its origin, distribution, taxonomy, botanical description, floral biology and genetic diversity are briefly discussed.

BOTANY AND FLORAL BIOLOGY

The key characters of the genus are fruit fleshy, many seeded pepo, flowers solitary, flowers lemon–yellow to deep orange, leaves deeply or shallowly lobed not pinnatified, and corolla rotate, deeply 5 parted and small (Fig. 1).

Habitat

Cucumber is anherbaceous vine, which has pubescent stems and unbranched tendrils, thrives in

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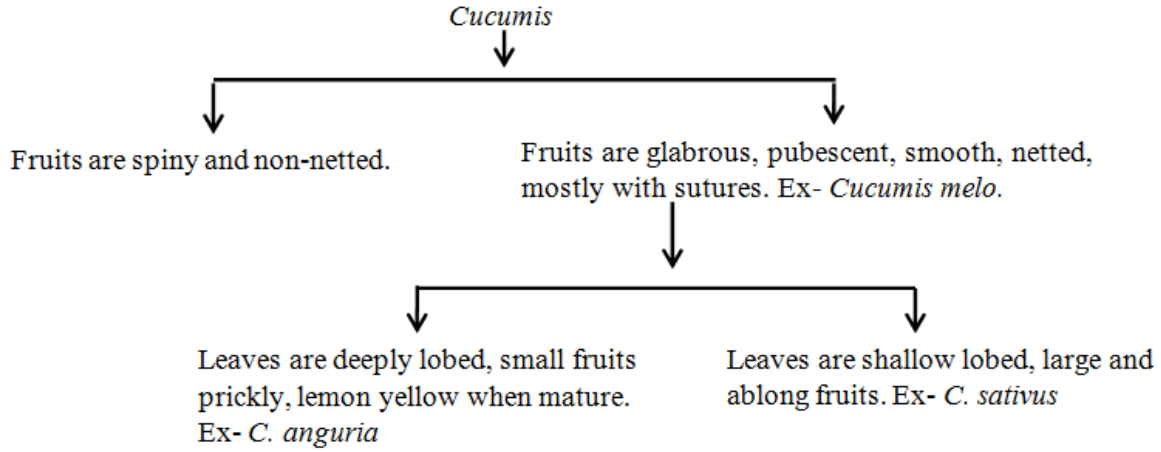
sandy, well-drained soils that are somewhat alkaline and rich in organic matter. It is not frost resistant and prefers full sun exposure in warm, humid areas.

Plant morphology

Cucumbers grow up to 2m to5m long, longleaves up to 30cm, leaves are alternate and simple, with 3-7 palmate lobes and serrated margins yellow 5-merous flowers bearing either female or male organs hairless cylindrical fruits are warty, yellow to green, and up to 50cm long. Diagnostic characters to the genera*Cucumis*ispresented below



Vegetative Plant

*C. sativus*is a morphologically variable annual herbaceous climber. The stems are prostrate, angular, and covered in white pubescence. Stipules are absent, and the plant bears unbranched axillary tendrils up to 30cm long 10-16cm long petioles. The pubescent leaves are alternately arranged on 10-16 cm long petioles, simple, basally cordate, and apically acute with 3-7 palmate lobes. The palmately-veined leaves are nearly orbicular, 7-20cm long and broad.

Flower

The flowers of *C. sativus* are axillary, actinomorphic and infrequently bisexual, while the plant is monoecious (has distinct male and female flowers). The pubescent 5-parted calyx of both staminate and pistillate flowers is made up of white, pubescent sepals that are 0.5–1 cm long. On pistillate flowers, the calyx is joined to the ovary to form a hypanthium, and the sepals are long, narrow, and sharp. About 2 cm long, yellow, campanulate, 5-parted, with oblong to lanceolate lobes, the corolla is fused less than half of its length. Three stamens, two of which have two-celled anthers (0.3–0.4 cm long) and one of which has a single-celled anther, are produced by solitary or three–seven staminate blooms on pubescent pedicels (0.5-2 cm long). Prior to fruit development, pistillate blooms are either single or paired on pedicels that are less than 0.5 cm long than the staminate.Cucumber has the following sex forms namely (i) Gynoecious plants: Only pistillateflowers, (ii) Androecious plants: Only staminate flowers, (iii) Monoecious plants: Staminate and pistillate flowers, (iv) Andromonoecious plants. Staminate and hermaphrodite flowers, and (v) Hermaphrodite plants, only hermaphrodite flowers.

Floral biology

From initial bud stage to the stage when the flower is detached from the pedicel,the entire developmental process can be divided into 8 stages. Opening and closing of the male flowers are mainly influenced by sun rise and sun set, which is by light and time of the day. In cucumber, pollen fertility is up to 14 hours wherein, an thesis occurs around 5.30 – 7.00 hr. dehiscence occurs around 4.30 – 5.00 hr. pollen fertility is up to 14 hrs.

Pollination

Because of stickiness of pollen, wind pollination is unlikely in the crop.Honey bees are more efficient than wild bees at pollinating cucumbers because they collect the nectar that the blooms generate.

Fruit

The fruit is a multi-seeded, cylindrical, indehiscent berry. Cucumbers are glabrous, and can be smooth or warty, yellow or green, ranging from 5-100cm long. They can weigh between 50g and 4kg. Up to 25 fruits can be produced by one plant.

Seed

The white seeds are emarginate, oval, and have pointy ends. They are between 0.5 and 1.8 cm in length. There are 33–40 seeds per gram of seed.

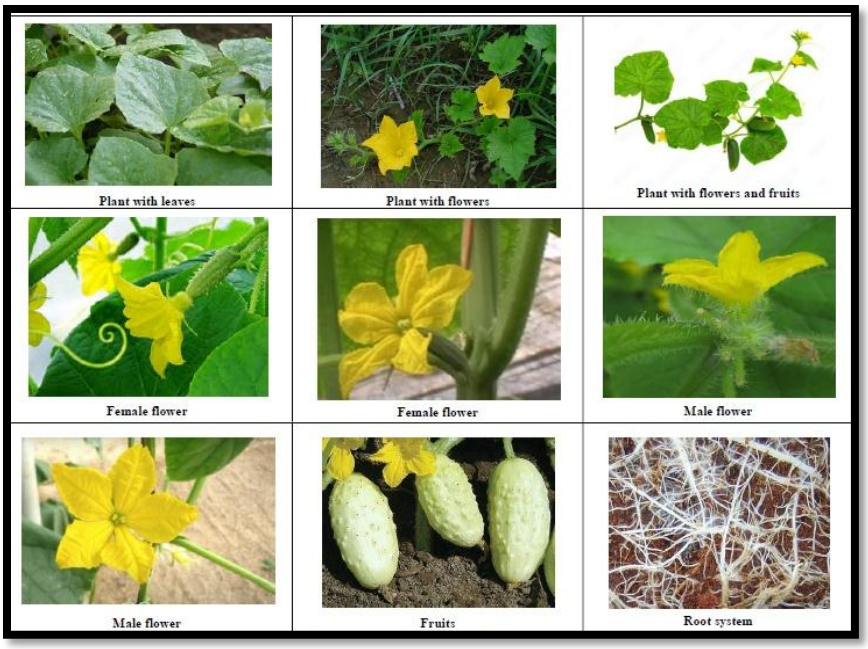


Fig.1. Botanical description of cucumber (Swamy, KRM, 2023)

ORIGIN AND DISTRIBUTION

Cucumber is thought to be one of the oldest vegetables cultivated by man with historical records of 5,000 years ago (Wehner and Guner, 2004). Its diversity occursbetween the Himalayas and Bay of Bengal area. It is originated at foothills of the Himalayan Mountain, where its two botanical varieties were discovered, domesticated cucumber *Cucumis sativus*.var. *sativus*and wildprogenitorofcucumber *Cucumis sativus*var. *hardwickii* (Lv*et al*., 2012). Among all species, *C. sativus*and to a limited extent *C.callosus*(Rottle.) Cogn.are cultivated while *C. hardwickii, C. hystrix, C. prophetarum*L. and*C. setosus*Cogn. arein wild forms. Using DNA sequences from plastid and nuclear markers for about 100 Cucumis accessions from Africa, Australia, and Asia, Sebastian et al. (2010) reported that cucumber is of Asian origin and that its closest relative is Southeast Asian *Cucumishystrix*.

The Romans carried cucumber to Greece and Italy in the second century BC from Mesopotamia. It then made its appearance in France in the ninth century, England in the fourteenth, and North America by the middle of the sixteenth century. The abundance of old names for cucumbers indicates that they spread westward from India. Cucumis is the Latin term from which the English word "cucumber" is derived. Similarly, the German gurke, Greek aggouria, European gherkin, and Bohemian agyrka all have ancient Aryan roots. People of Northern India use *Cucumissativus* var. *hardwickii*, a wild relative of *C. sativus* var. *sativus*, as a laxative. It grows in the foothills of the Himalayan Mountains (Deakin et al., 1971).

EVOLUTION OF CUCUMISSPECIES

Cucumis in Latin means cucumber, the word cucumber was derived from Greek word*kykyon*. The epithet *sativus* is a Latin word, means 'that is sown', referring to the common agricultural use of the species.

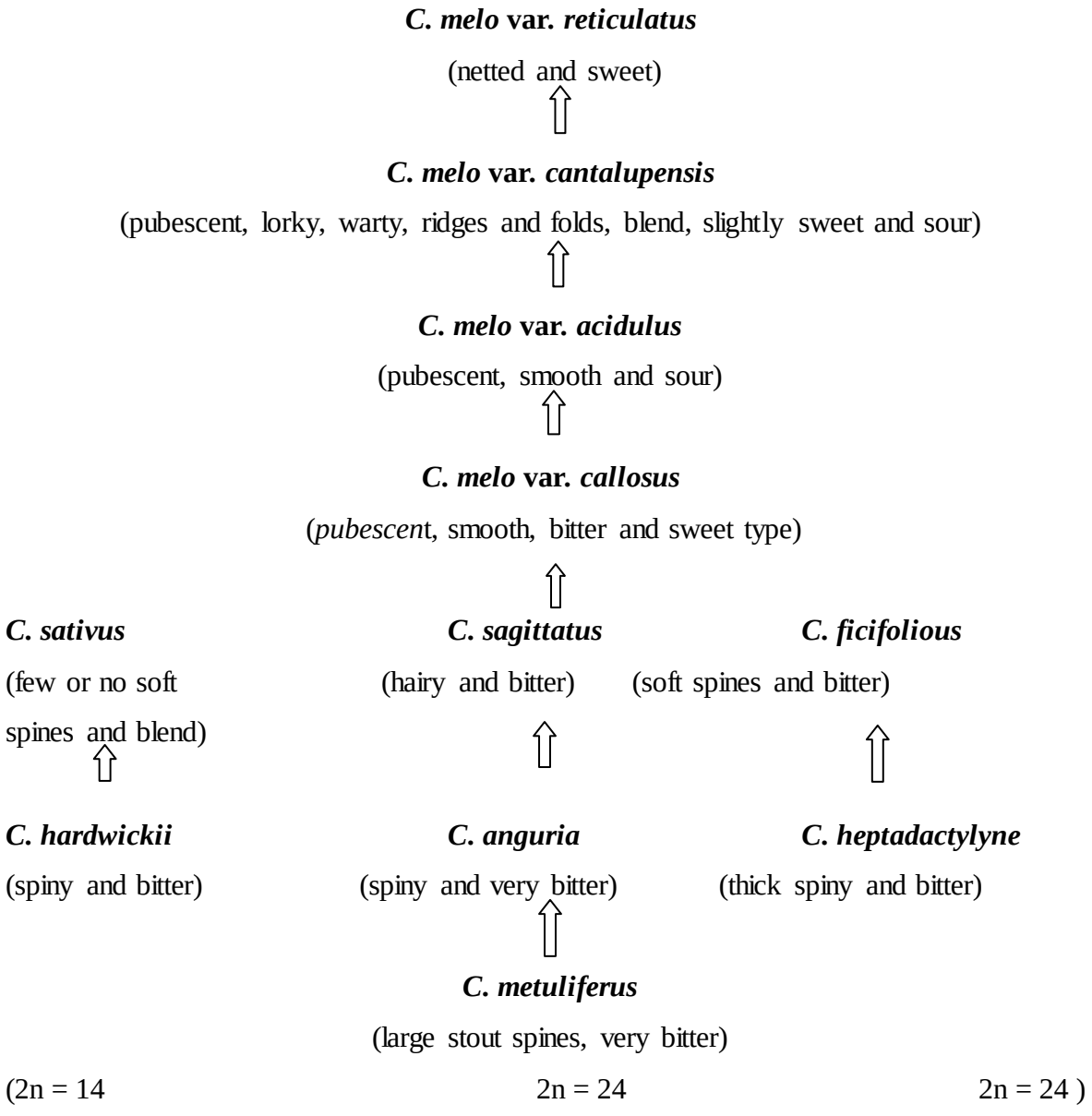
The genus Cucumis is a member of the order Cucurbitales and family Cucurbitaceae. This taxon clearly belongs to the order Passiflorales based on several physical characteristics of its tendrils, pollen grains, and ovules. The family is split into two subfamilies based on the most recent findings in molecular genetics, cytology, cytogenetics, and phytochemistry. There are species in the subfamily Zanonioideae that have little economic significance. The subfamily Cucurbitoideae includes all species of commercial importance (Table 1).

The tribe Melothrieae,which includes the genus Cucumis, is regarded as the most significant member of the Cucurbitaceae suitable for the climatic conditions of Middle Europe. There are 32 species in the genus Cucumis. The species *C. anguria* (West Indian gherkin) and *C. metuliferus* (African horned cucumber) are also commercially investigated in a number of regions in addition to cucumber (Cucumis sativus L.) and melon (*C. melo* L.). Other wild species, such as *C. dipsaceus*, also known as the hedgehog gourd, and *C. myriocarpus*, also known as the gooseberry gourd, are grown as decorative plants and are mostly native to desert and/or semi-arid regions of Africa.

Nuclear DNA study has substantially corroborated the understanding of species connections derived from the biosystematics and phylogeny of Cucumis species based on morphology, crossability, and protein analysis (Deakin et al., 1971; Staub et al.,

1987; 1992). Garcia Mas et al. (2004) most recently used microsatellite markers and ribosomal internal transcribed spacer sequences to identify evolutionary connections among Cucumis species. Their description of a distinct separation between *C. sativus* and the other Cucumis species validated previous investigations, even though their findings did not correlate with any of the previously reported genetic relationships derived using isozyme and restriction fragment markers. Africa is probably where Cucumis species originated in the wild. However, initial sites of domestication for melon and cucumber are probably the Middle East and Southern Asia, respectively, where genes from exotic sources have contributed extensively to plant improvement (Dane *et al.,* 1980).

Protein and DNA marker analyses have been used to evaluate the genetic variation in *C. sativus* var. *sativus* with accessions from China and India, which are the secondary centers of diversity for cucumbers (Staub et al., 1997). Information shows that accessions from various Indian states vary, that Indian and Chinese accessions differ from one another, and that Chinese and Indian accessions are different from other genotypes of *C. sativus* var. *sativus* worldwide. Cultivars developed in the same growing regionsuch as Jiang Su and Anhui in Northern China and Shanghai and the Hunan region in Southern Chinahave different genetic makeups. These findings imply that cultivar variations between Chinese and Indian cultivars may occur within a somewhat small geographic area.Thepossible evolution of cucumis species is presented below



Evolution of synthetic amphidiploid species in Cucumis

For creating a synthetic species in Cucumis via embryo rescue,a sterile F_1 hybrid (2n=19) was produced from a cross between *C. hystrix* (2n=24) and *C. sativus* (2n=14), (Chen et al., 1997b). Following chromosome doublingandfertility selection, the primary amphidiploid (2n=38) produced fertile blooms, fruitset with viable seeds. In fact, backcrossing to *C. sativus* permits the introgression of genes from *C. hystrix* (such as nematode resistance) at quite high ploidy levels (2n=38) since these amphidiploids are cross-compatible with *C. sativus*(Chen et al., 2002). Allotriploid plants (2n=3x=26) were recovered by Chen et al. (2003a) from the cultivation of embryos obtained from a mating between *C. hytivus* and *C. sativus*. These plants shared traits with their *C. hytivus*counterparts.These allotriploid plants can produce unreduced pollen and when used in conjunction with genetic engineering technologies such as alien addition, substitution and translocation lines in repetitive backcrossing strategies can allow for the introgression of foreign genes into commercial cultivars (Barthes and Ricroch, 2001).

Table 1. Diagnostic feature and distribution of wild species of *Cucumis*.

Sl.No.	Species Name and Chr. No	Distribution	Diagnostic features	Fruiting season
1	*Cucumis callosus* 2n =24, Bislumbha	World: S.E. Asia, Africa, Australia. India: Andhra Pradesh, Gujarat, Haryana, Uttar Pradesh, Tamil Nadu, MH, Orissa and WB	Perennial creeping herb with woody rootstock, Fruit is indehiscent, ovate to globose, green with ten yellowish green to white continuous longitudinal stripes, turns yellow and glabrous at maturity, bitter. Seed is ovate to lance-ovate, beaked, funiculus persistent.	Aug-December
2	*Cucumis dispaceus* 2n =24, Hedgehog gourd	West Indies, Africa, North and South America, Saudi Arabia India: Tamil Nadu and Karnataka	Annual climbing herb.Leaves cordate-orbicular.Fruit indehiscent, oblong, green when immature pale yellow at maturity, densely aculeate, bitter. Both ends of seed is acute, ovate to lance-ovate, funiculuscaducous, non-beaked, grey-white.	July-Jan
3	*Cucumis hystrix* 2n = 24, Arphagma (Mizoram)	India: Mizoram	Annual climbing herb.Hairs antrose. Leaves pentangular, middle lobe distinctly elevated andshallow incised at base. Fruit indehiscent, ovate, tapering at both ends, beaked, aculeate; aculiobtuse, green. Seed apex rounded, base acute, ovate to lance-ovate, funiculuscaducous, non-beaked, gery-white.	July-December
4	*Cucumis hystrix var. nov* 2n = 24	China, Myanmar, Thailand India: Arunachal Pradesh, Meghalaya, Mizoram and Nagaland.	Annual climbing herb.Hairs retrose to perpendicular to surface.Leaves pentangular.Fruit indehiscent, ovate, tapering at both ends, beaked, aculeate; aculi acute, green. Seed apex rounded, base acute, ovate to lance-ovate, funiculuscaducous, non-beaked, grey-white.	August to December
5	*Cucumis indicus* Meti, Tausal 2n =20	Endemic to Northern-Western Ghats of India	Annual climber.Leaves angular.Fruit indehiscent, elongated, fusiform, rostrate, pale green with tenlongitudinaldark green stripes, turn pale green to white at maturity, glabrous. Seed apex rounded, base acute, ovate to lance-ovate, funiculuscaducous, non-beaked, grey-white.	August to November
6	*Cucumis javanicus*	-	Annual climber herb.Leaves pentangular.Fruit ellipsoid, pale green, turning dark red at maturity. Seed is elliptic to obovate, apex rounded, beaked, marginated, smooth, grey-white.	August to November
7	*Cucumis leiospermus*	Sri Lanka India: Tamil Nadu, Kerala	Annual climbing herb.Leaves pentangular. Fruit is oval-globose, indehiscent, pale green with ten longitudinaldark green stripes, turning dark red at maturity, 16-17 seeded. Seed is ovate to lance-ovate, funiculuscaducous, apex rounded, short beaked, marginated, smooth, grey-white.	August to December
8	*Cucumis maderaspatanus*	Wide spread.	Annual climbing herb.Leaves pentangular.	August to

	2n = 24 Chirati(Marathi), Mukkapira (Malayalam)	Africa, SW and SE Asia, Australia. India: In all the states	Fruit circular, pale green with 7 -10 dark green longitudinal stripes, turning dark red at maturity, 3-20 seeded. Seed is elliptic to obovate, apex rounded, beaked, marginated, smooth when fresh, scorbiculate when dry, grey-white.	November
9	*Cucumis melo var. agrestis* 2n =24 Kachoori, Tkmak, Shinde (Marathi), Simmatikkai (Tamil)	Worldwide. India: All states	Prostrate annual herb. Leaves shallowly 3-5 lobed. Fruits are indehiscent, ovate – oblong, mottle dark green with tencontinuous longitudinal pale green stripes, turns pale yellow at maturity, mostly bitter, rarely not bitter. Seeds are ovate to lance-ovate, beaked, funiculus persistent, grey-white.	June to December
10	*Cucumis melo* 2n = 24	World wide India: All states	Prostrate annual herb. Leaves shallowly 3-5 lobed. Fruits are indehiscent or dehiscent, oval, globose or elliptic, bicoloured or monocoloured, green, turns yellow or orange at maturity, edible or inedible, bitter or not bitter in taste. Seeds are ovate to lance-ovate, beaked, funiculous persistent, grey-white.	June to February
11	*Cucumis muriculatus*	Burma	Annual climbing hairy herb.Leaves pentangular. Fruits are indehiscent, oblong-round, tapering at both ends, beaked, densely echinate-muriculate, green. Seeds apex rounded, base acute, ovate to lance-ovate, funiculuscaducous, non-beaked, grey-white.	
12	*Cucumis prophetarum* Khat-Kachario (Rajasthan) 2n = 24	Ethiopia, Kenya, Somalia, Egypt, Uganda. Middle East, Pakisthan India: Gujarath, Karnataka, Kerala, Maharashtra, Rajasthan and Tamil Nadu	Perennial creeping herb, with woody root stock. Leaves deeply 3-5 lobed. Fruits are oval to globose, green with ten white continuous longitudinal stripes, green when immature turns yellow at maturity, bitter, aculeate. Seeds both ends acute, ovate to lance-ovate, funiculuscaducous, non-beaked, grey-white.	August to January
13	*Cucumis ritchiei* 2n = 24 Ghugarya (Marathi)	India:Gujarat, Maharashtra, Karnataka. Endemic to Northern-Western Ghats	Annual climbing herb.Leaves pentangular. Fruits are globular, indehiscent, green with ten white longitudinal stripes, turns red or black at maturity, glabrous. Seeds are ovate to rectangular, beaked, base rounded with raised part of margin, turgid, funiculuscaducous, grey-white, margin distinct, three chambered; two lateral chambers empty, middle with cotyledons.	August to November
14	*Cucumis sativus* 2n = 14	World wide India: All states	Annual climbing, herb.Leaves pentangular. Fruits are indehiscent, oblong, rounded or cylindrical, monolocular or bilocular, turns pale yellow, yellow orange or brown at maturity, edible or inedible, bitter or non-bitter in taste. Seeds are ovate to lance-ovate, beaked, funiculus persistent, grey-white.	Throughout the year
15	*Cucumis sativus* forma *hardwickii* JangaliKakadi(Marathi), Wild cucumber (English) 2n = 14	World wide India: All states	Annual climbing, herb.Leaves pentangular. Fruits are indehiscent, oblong to rounded, with ten longitudinal green coloured stripes, rarely white, green when young turns pale yellow to brown at maturity, bitter. Seeds are ovate to lance-ovate, beaked, funiculus persistent, grey-white.	June to December
16	*Cucumis setosus* Meki, Mehaki, Mekunya (Marathi) 2n = 24	Endemic to Northern-Western Ghats. Edible	Annual herb.Leaves pentangular. Fruits are indehiscent, pulp granular, oblong, yellowish green with ten dark green longitudinal stripes, turns pale green to whitish at maturity, setose hairy, Seeds are ovate to lance-ovate, apex rounded, base acute, non-beaked, funiculuscaducous, grey-white.	July to December

17	*Cucumis silentvalleyi* 2n = 24	Kerala and Tamil Nadu. Endemic to Southern-Western Ghats	Annual climber.Leaves angular. Fruits are dehiscent, oblong, fusiform, rostrate, green to pale green in colour with whitish spotted ten longitudinal stripes, turn pale green to white at maturity, retrose hairy, hairs bulbous based. Seeds are ovate to lance-ovate, apex rounded, base acute, non-beaked, funiculuscaducous.	August to November

CLASSIFICATION OF CUCUMBER DIVERSITY

Classification as a sub species: *C. sativus* botanically classified into four sub species *viz*.,

1. *C. sativus ssp. rigidus* – English long fruited of Eastern Asiatic type
2. *C. sativus ssp. agrestis* – Soviet Far East type
3. *C. sativus ssp. gracillis*
4. C. *sativus ssp. sphaerocarpus* (Syn to *C. spaerocarpin*)

Classification as a cultivar'sgroup:Classification of Cucumber based on cultivars groups

1. Field cucumbers, with prominent white or black spines
2. English cucumbers – greenhouse parthenocarpic cucumbers without seeds
3. Sikkim cucumber –Indigenous to India, with reddish brown skinned fruits
4. Orientalcucumber- popular in China and Japan, fruits are long and slender, skin is thin with warts and spines
5. Smooth-skinned Beit Alpha types- most popular in Middle East and north Africa, thin-skinnedfruitswith light-color
6. Lemon cucumber - produces a round, fruit with large five-carpel seed cavity, creamy yellow skin. Its sex expression is andromonoecious
7. Gherkins –fruits very small, immature cucumber fruits used for pickling purpose

CYTOTAXONOMY (CYTOLOGY)

The genus *Cucumis*comprisesabout 30 species distributed over two distinct geographic areas (Jeffrey, 1980; Chen and Adelberg, 2000)

Species forming the Asiatic Group: South–East Himalayais an important origin of the Asiatic group with chromosome ofX =7 (Cucumber belongs).*C. sativus*var.*hardwickii*(2n= 2x = 14) is a progenitor of cultivated cucumber, it's a small bitter cucumber with scattered, short, sharp, stiff and often evanescent spines. It possesses a multiple fruiting and branching habit not present in the cultivated cucumber (Horst and Lower, 1978). It possesses useful characters such as prolific fruit bearing, high number of laterals. Polymorphism level in *C. sativus*var.*hardwickii*is higher than in *C. sativus*var. *sativus*. This species is widely distributed in foothills of northwestern Himalayas (parts of Uttaranchal and Himachal Pradesh) followed by fair distribution in Western Ghats (parts of Maharashtra, Goa, Karnataka, Kerla and Tamil Nadu) and sporadic distribution in Eastern Ghats and parts of Rajasthan (Mt. Abu), at elevations from 800 to 1700 MSL. Its existence in parts of north-eastern region of India is yet to be explored (Bisht*et al*.,2004).

The wild *Cucumis hystrix* is a native of China's Yunnan province. Based on its morphology, it has been categorized as a species in the subgenus Cucumis and mentioned in a number of taxonomic and systematic investigations (Dane, 1991). But until it was recovered in the wild in 1989 and subsequently genetically characterized by Chen et al. (2002), nothing was known about it other than its morphology. With chromosomal number 2n=24, this is the first Asian Cucumis species to be described.This finding challenges the basic chromosome number theory that African *Cucumis*have x=12, and that Asian *Cucumis*have x=7, which has governed the understanding of systematics and phylogenetic in *Cucumis*for decades. Although *C. hystrix*possess the same number of chromosomes as *C. melo*yet its fruit has a typical cucumber taste and flavour. Moreover, *C. hystrix*has been found to be closer to *C. sativus*than to *C. melo*on the basis of isozyme patterns (Chan *et al*., 1995), SSR and RAPD marker analysis (Zhuang*et al*., 2004) and CCSSR marker sequence variation. Besides China, this species is also distributed in India (Assam), Burma and Thailand.

Species forming the African group:Groupconsisting species with basic chromosomeX=12 (Muskmelon).The evolutions of chromosomes in *cucumis*species is not clear. Whitaker(1933) assumed that species with 2n=24chromosomes arisen from species with 2n=14chromosomes by fragmentation but later Trivedi and Roy (1970)reported that by fusion of chromosomes in terminal centromere species with 14 chromosome have arisen from species with 2n=24 chromosomes.Karyologically, the varieties have 2n = 14 chromosomes, and possess three pairs of chromosomes with secondary constrictions besides, other 14 chromosome species C. *Callosus*Rottlesyn*C.Trigonus*Roxb.Cytological investigations have long been recognized to bring about a clear understanding of phylogeny and evolution of crop plants, but such studies have not been rewarding in the genus *Cucumis*due to small size of mitotic chromosomes and their poor stainability. In an intensive cytogenetical attempt with C"banding and pachytene analysis, Ramachandran and Seshadri (1986) compared the genomes of C. *sativus*and C. *melo*(Table 2).The physical mapping of a tandem repeat

sequenceusing the fluorescence in-situ hybridization (FISH) method was similarly impacted by variations in basic karyotype (Hoshi et al. 1999, Koo et al. 2002). Repeats of the ribosomal RNA gene (rDNA) were found in a number of cucumber cultivars. Nevertheless, the rDNA's placements, numbers, and sizes were described without reference to earlier studies. In order to identify the chromosome relationships between the three cultivars of cucumbers from Poland, Japan, and China, DAPI-bands and the locations of the 5S and 45S rDNA sites were examined in this study (Tagashira*et al*, 2006).

Table 2. Karyotypic characters of mitotic chromosomes of *C. sativus*and*C. melo*.

Karyotype characters	***C. sativus***	***C.melo***
Diploid chromosome number (2n)	14	24
Type of chromosomes		
Median	2	8
Sub-median	4	2
Sub-terminal	1	1
Satellite pairs	3	2
Range in chromosome length. *(m)*	1.25-2.72	1. 06-1.88
Average chromosome length *(/lm)*	1.96	1.42
Total chromatin length	27.38	34.04
Total chromatin length	0.60	0.48
Largest/shortest chromosome ratio Category of karyotype of Stebbins (1958)	2.18:1 Lb	1.13:12a

Source: Ramachandran and Seshadri (1986).

Phylogenetic affinities among Cucumisspecies

Phylogenetic relationships among *Cucumis*species have been studied on the basis ofisozyme analysis (Perl-Treves, 1985), plastome DNA restriction analysis, ITS data, Ccssr marker sequence variation and RAPD marker analysis (Jobst, *et al*., 1998). Although the number of groups varied with each study, all of these reports agreed upon two general features of *Cucumis* phylogeny that are also recognized by more classical approaches:

a) The clear separation between C. *sativus*and the rest of the species in the genus

b) The separation of *C. metuliferus, C. melo*and the group of wild African species as three separate entities within the x=12 species.

Garcia Mas *et al*.(2004) have suggested a further division of the group of wild species into two clades first would include *C. sagittatus*(synonymous C. *dinteri)*, with the possible addition of *C. globosus*and C. *humifructus*and second containing the rest of the wild species, would be further sub divided into two sub clades; one including *C. prophetarum, C. ficifolius*and C. *membranifolius*and the other containing the remaining species. Moreover, Chen *et al*.(2005) have proposed the creation of a provisional *Cucumis*species complex to include a subgenus *Cucumis*containing three series;*hystrix, hytivus*and*sativus*but this hypothesis would require rigorous testing and would be the initial step in the precise taxonomic placement of *C. hystrix, C. hytivus and C. satvius.*

The first comprehensive crossability analysis of the genus *Cucumis*waspublishedbyDeakin*et al* (1971), who has divided 16 *Cucumis*species into four cross-sterile groups

Group I: included 9 species viz. *C. anguria, C. anguria*var. *longipes, C. dipsaceus, C. africanus, C. leptodermis, C. myriocarpus, C. prophetarum, C. zeyheri, C. ficifolius*and*C.heptadactylus.*

Group II: included only one species i.e. *C. metuliferus*whichwas not closely related to any other species

Group III: comprised *C. sativus*and*C. hardwickii*

Group IV: consisted of *C. melo, C. humifructus, C. sagittatus*and*C. dinteri.*

Based on pollen tube behavior, *C. africanus*and*C. melo*appear to be the most promising male parents

for crossing with *C. sativus*, but special pollination techniques and advanced embryo culture methods are necessary to overcome interspecific barriers in several crosses (Kho*et al*., 1980). Other more successful interspecific hybridization studies of *C. melo*and*C. sativus*with wild species are presented in Table 3 and 4. However, in practice, most of these results were not repeatable and did not result in fertile hybrids. The sources/donors identified for the improvement of for various traits in cucumber are presented in Table 5.

The cross between *C. sativus*and*C.hystrix*was the first repeatable cross between a cultivated *Cucumis*species and a wild relative (Chen *et al*., 1997b) and represented a breakthrough in interspecific hybridization in *Cucumis*. Firstly, if *C. hystrix*and*C. melo*are cross-compatible and if the F derived from either interspecific hybridization can be made fertile through crossing and/or chromosome doubling, then *C. hystrix*could act as a bridge species between *C. melo*and*C. sativus*. Secondly, the fertile synthetic amphidiploid species *Cucumishytivus*maybe useful as a bridge species for the introgression of desirable genes from *C. hystrix*into*C. Sativus*by either conventional intercrossing or transformation (Chen *et al*., 2003a). Thirdly, if *C. hystrix*and*C. sativus*var. *hardwickii*are cross compatible then opportunities will exist to introgress economically important genes from *C. hystrix*and its derivatives into advanced *C. sativus*var. *hardwickii*derived lines for cucumber improvement (Zhuang*et al*. 2004).

Table 3. Crossing Attempts with *C. sativus*

Cross	Results	References
C. zeyheri ×*C. sativus*	Fruit with unviable seeds	Custers and Den Nijs (1986)
C. sativus ×*C. metuliferus*	Embryos only	Franken *et al*.(1988)
C. sativus ×*C. hystrix*	Sterile plants (2x and 4x)	Chen *et al*.(1997)
C. hystrix ×*C. sativus*	Fertile plants	Chen *et al*.(1998)

Source: (Chen and Adelberg, 2000)

Table 4. Source of resistance to biotic stress, abiotic stress and quality characters

S. No.	Plant introduction	
1	PI 183056	India; large root size
2	PI 183967	India; multiple lateral branching, sequential fruiting, nematode resistance
3	PI 197087	India; downy mildew resistance
4	200815	Myanmar; powdery mildew and gummy stem blight resistance
5	PI 209065	U.S.; high yield
6	PI 212233	Japan; powdery mildew resistance
7	PI 220860	South Korea; gynoecy
8	PIs 418962	China; multiple diseaseresistances
9	EC320556	CMV, scab and powderymildewresistance
10	EC329300	Multiple diseaseresistance, gynoecious line
11	EC388737-39	Gynoeciouslines
12	EC398030	Earlydeterminate type
13	EC398030	Early, cluster bearing, determinate type
14	EC398966-67	Angularleaf spot resistance
15	EC398968-70	Anthracnose resistance
16	EC398971-73	Fruit rot resistance
17	EC398974-90	Downymildewresistance
18	EC398991- 399007	Leaf spot resistance

Table 5. Sources/Donors identified for various traits in Cucumber

Traits	Donors
Extended shelf-life	IC203838,IC203839
Early and determinate	EC398030
Gynoecious line	EC382739
High yield	IC203838, EC237658,VJ/98-176, VJ/98-151
Anthracnose resistance	PI197087, Poinsett
Downy mildew resistance	PI197087
Powdery mildew resistance	Poinsett, Yomaki, PI79376
Cucumber scab resistance	Wisconsin SMR9

Angular leaf spot resistance	Poinsett, MSU9402, PI169400
Bacterial wilt resistance	PI200815, PI200818
Cucumber green mottle mosaic	*Cucumis anguria*, C. *african us*, C. *ficifolius* resistance
Whitefly resistance	*Cucumis asper*, *C. dinteri*, *C. sagittatus*

CONCLUSION

Cucumber is an economically important vegetable grown for edible tender fruits as dessert, pickles and cooked vegetable.It is originated at foothills of the Himalayan Mountain, Its diversity occurs between the Himalayas and Bay of Bengal area. Being an indigenous crop of India, there is a huge diversity and variability exists for many economically important traits. In future, this species and varietal wealth could be exploited to improve commercial important traits like gynoecy, bio fortification of nutrients and development of varieties and hybrids resistant to biotic and abiotic stresses.

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