



Origin and Biological Diversity of Horticultural Crops

The Editor

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Origin and Biological Diversity of Horticultural Crops

— Editor —

Prof. K V Peter



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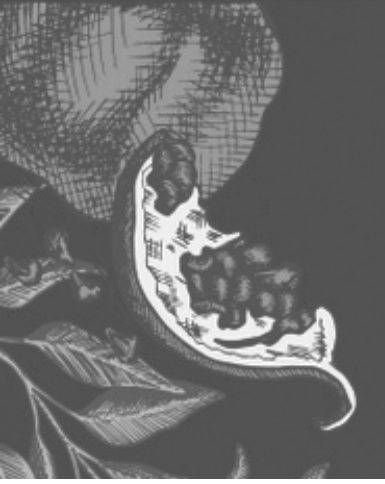
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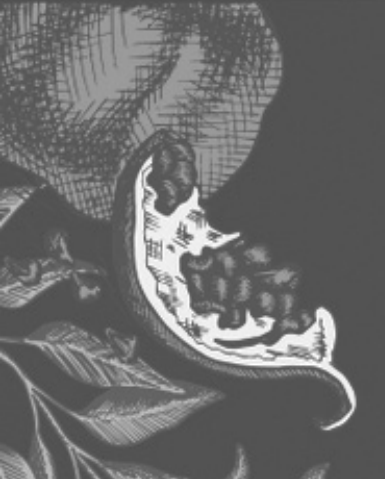
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Dedication

"Public Policy, Science and Technology, Progressive Farmers and a Vibrant Public Distribution System are the four pillars of the much lauded *Green Revolution*. Prof. M.S. Swaminathan, as an Institution provided the vital input of Science and Technology".

The book is dedicated to him on his 94th birthday.

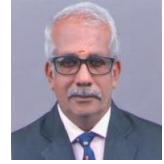


Acknowledgement

The book *Origin and Biological Diversity of Horticultural Crops* is the compiled contributions of 47 eminent scientists from 22 Research Institutes/Universities. I express gratitude to all of them. Prof. N. Kumar Hon. Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore wrote the Foreword to the book. Dr. B.N.S. Murthy, Horticultural Commissioner, Ministry of Agriculture and Farmers Welfare GOI, wrote the Preface. I am grateful to both of them. The publisher Mr. Vardhan Gupta, Brillion Publishing, New Delhi deserves appreciation for error free printing and publication well in time.



TAMIL NADU AGRICULTURAL UNIVERSITY



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Foreword

"If I were to look over the whole world to find out the country most richly endowed with all the wealth; power and beauty that nature can bestow-in some parts a paradise on earth-I should point to India – *F. Max Muller.*

Charles Darwin authored the classical book "*On the origin of Species by Means of Natural Selection*" published on 24th November 1859. The book introduced the scientific theory that populations evolve over the course of generations through a process of natural selection. There are about 320 thousand species of plants. Green plants provide a substantial proportion of the world's molecular oxygen and are the basis of most of Earth's ecosystems, especially on land. Plants that produce grain, fruits, vegetables, tubers, spices and condiments, medicinal and aromatic bio-products, plantation crops, ornamentals, mushrooms, bamboos and edible aquatic products are basics to human sustenance, health and wellness. Overexploitation of economic crops for high value products without regeneration and conservation is leading to extinction of plants. Natural calamities like floods and hurricanes, earth quakes resulting flow of lava, cloud bursts, forest fire, illegal entry into forests and plundering economic plant parts and extinction of pollinators like bees and birds are causing irreversible loss to biological diversity. Realizing the national importance of biological diversity, Indian Parliament enacted The Indian Forest Act-1927, The Agricultural Produce (Grading and Marketing) Act-1937, The Indian Coffee Act-1942, Import and Export (Control) Act 1947, The Rubber (Production and Marketing) Act-1947, The Tea Act-1953, The Spices Board Act-1986, The Seed Act-1966, The Protection of Plant Varieties and Farmers Rights (PPVFR) Act, 2001, The Biological Diversity Act (BDA), 2002, Plant Quarantine (Regulation of Import into India) order 2003, The Biological Diversity Rules (BDR), 2004, The Food Safety and Standards Act 2006 and The National Green Tribunal Act 2010. Authorities and Boards were established to enforce and implement the Acts legislated. The National Biodiversity Authority (NBA) Chennai is responsible to

implement the BDA, 2002 and BDR 2004. The Protection of Plant Varieties and Farmers Right Authority, New Delhi implements the PPVFR Act 2001. Research Institutes exclusively for survey, collection, conservation, description, cataloguing-conventional and molecular -were established under ICAR & CSIR, Botanical Survey of India and State Councils for Science and Technology and Parks-State, National and Private-ICAR-NBPGR with its regional stations at Akola, Bhowali, Cuttack, Rajendra Nagar, Hyderabad, Jodhpur, Hatia, Ranchi, Shillong, Shimla, Srinagar and Vellanikkara conduct survey, collection, maintenance and conservation of plant genetic resources. The present edited book ***Origin and Biological Diversity of Horticultural Crops*** carries information on the threats and prospects of biodiversity, biodiversity of selected fruits, vegetables, ornamentals and bamboo. Forty seven working scientists from 22 Research Institutes who contributed the 20 chapters need mention for their resolve to transfer knowledge and information. I appreciate Prof. K.V. Peter, Former Vice-Chancellor, Kerala Agricultural University, Thrissur for conceptualizing the book and editing the manuscript. The publisher Brillion Publishing, New Delhi has done a commendable job.



(N. Kumar)

Place : Coimbatore

Date : 02.05.2019



Dr. B.N. Srinivasa Murthy
Horticulture Commissioner



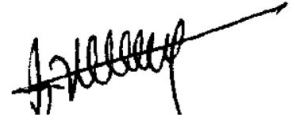
Government of India
Ministry of Agriculture and Farmers Welfare
Krishi Bhawan, New Delhi-110001

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Preface

The very existence and survival of human being is unambiguously linked to biodiversity. In this direction, reviews on Centre of Origin of Plants and Biological Diversity of Crops have always attracted the attention of evolutionary biologists, plant geneticists and all stake holders in food, nutrition, environment and energy security (FNEE). With drastic change in climate, life styles, food and nutrition needs, urbanization and migration within and outside, there are visible impacts on evolutionary biology of plants. Impact of limiting inputs like space, water, energy and nutrients is telling adversely on the biological diversity. Deforestation and human intrusion into protected hot spots of biodiversity are accelerating extinction of plant species. Biodiversity is the wealth of any nation. India legislated the Biological Diversity Act-2002 and Protection of Plant Varieties and Farmers Rights (PPVFR) Act-2001 and established The National Biodiversity Authority, Chennai and Protection of Plant Varieties and Farmers Right Authority, New Delhi to implement the above acts respectively. The ICAR-NBPGR, New Delhi is vested with survey, collection, maintenance, characterization and conservation of crops germplasm. All the Crop based Institutes like ICAR-IISR, Calicut, ICAR-NRC Banana and ICAR-NRC Grapes, Pune, ICAR-NRC Pomegranate, Sholapur etc are mandated with collection and conservation of germplasm in assigned crops. The Council for Scientific and Industrial Research (CSIR) has established many Research Institutes to undertake research on bio-prospecting and products development from plants. CSIR-Central Drug Research Institute Lucknow (CDRI), CSIR-Central Food Technological Research Institute, Mysore (CFTRI), CSIR-Central Medicinal Aromatic Plants Research Institute, Lucknow (CIMAP), CSIR-National Botanical Research Institute, Lucknow (NBRI) and CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram (NIIST) are a few Research Institutes working on biological diversity and products development. The Botanical Survey of India, Kolkata (BSI) under Ministry of Environment, Forest and Climate Change conducts intensive recording on flora-coastal, aquatic, terrestrial, mountainous-and advises government on flora introduced and getting extinct. The Indian Council of Forestry Research and Education, Dehradun (ICFRE) organizes and supports research projects on conservation of forest flora.

It has established 9 Regional Research Institutes and 5 centers spread all over the country. The present book Origin and Biological Diversity of Horticultural Crops carries 20 chapters on fruits, vegetables, ornamentals, bamboo etc authored by 47 well known scientists from 17 Research Institutes/Universities. I compliment Prof. K.V. Peter Former Vice-Chancellor, Kerala Agricultural University for compiling and editing the book. Brillion Publishing, New Delhi is to be praised for publication of the book.

A handwritten signature in black ink, appearing to read 'B.N.S. Murthy', written in a cursive style with a long horizontal stroke extending to the right.

(Dr. B.N.S. Murthy)

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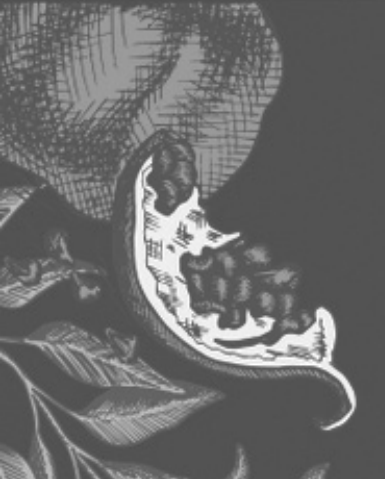
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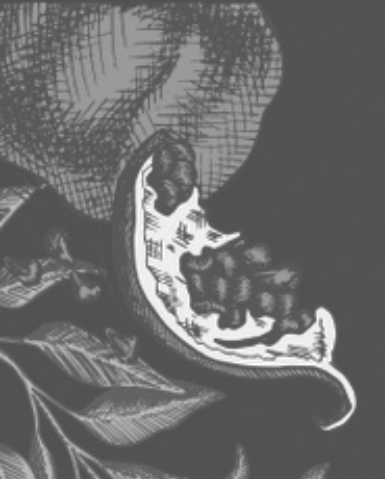


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Introduction

“Coming age is the age of knowledge. However rich, poor or powerful, if they want to move ahead, only knowledge can lead them to that path”-**Narendra Modi**

To many people 'biodiversity' is almost synonymous with the word 'nature' and, 'nature' brings to mind steamy forests and the big creatures that dwell there. But biodiversity is much more than that, for it encompasses not only the diversity of species, but also the diversity within species,"-Cary Fower.

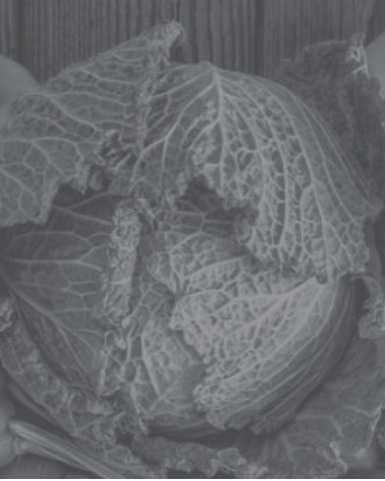
Charles Darwin on 24 November 1859 published the historical and much read and studied work of scientific literature "On the origin of species by Means of Natural Selection or the Preservation of Favoured Races in the struggle for Life". Natural selection resulting from biotic and abiotic stresses, calamities and war fares led to emergence of biotypes, races and varieties resulting to diversity for survival. Biological diversity is the wealth of any nation and conservation is a pre-requisite for existance and welfare of living organisms including man. Nikolai Vavilov in 1924 proposed centres of origin of plants initially 8 in number expanded to 12 (Chinese, Indian, Indo-Malayan, Central Asiatic, Persian, Mediterranean, Abyssinian, South American, Central American, Chilean, Brazilian-Paraguayan and North American). The Indian Centre of agrobiodiversity has 22 hotspots (Cold Desert, Western Himalayan, Eastern Himalayan, Brahmaputra Valley, Khasia-Jaintia-Garo Hills, North Eastern Hills, Arid Western, Malwa Plateau and Central Highlands, Kathiawar, Bundelkhand, Upper Gangetic Plains, Lower Gangetic Plains, Gangetic Delta, Chotanagpur, Bastar, Koraput, Southern Eastern Ghats, Kaveri, Deccan, Konkan, Malabar and Islands). At the

Global level (United Nations) a Convention on Biological Diversity was envisaged with a Conference of Parties. India's National Report to the convention on Biological Diversity is much read and discussed. Indian Parliament enacted several legislations with the purpose of ownership, registration and use of biological resources and The Biological Diversity Act-2002, the Biological Diversity Rules 2003 and The National Green Tribunal Act 2010 were legislated, A National Biodiversity Authority (NBA) at National level, State Biodiversity Boards (29 states) and Biodiversity Management Committees totaling 139831, except in Haryana and Jammu and Kashmir were formed and are in working mode as per statutes, regulations and powers delegated. Horticultural crops-Fruits, Vegetables, Herbs and Spices, Medicinal and Aromatic Plants, Plantation Crops, Tubers, Bamboo and Mushrooms-have received special attention in the working of Biodiversity Management Committee. Climate resilient horticultural crops, future horticultural crops considering shrinking space to grow, depleting water resources-surface and underground-, increasing pollution and pollutants, new life styles, migration to urban areas and to better pastures within and outside the country are causing extinction of established crops and emergence of new crops associated with new pests and diseases and biotic and abiotic stresses. Species of plants and animals which are on the verge of extinction in the states of Bihar, Goa, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Mizoram, Odisha, Punjab, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand and West Bengal are listed in the documents published by the State Biodiversity Boards and are emphasized for conservation and maintenance. Availability of biological diversity in horticultural crops has been made use of by breeders to increase production and productivity as seen from crop performance in 1999, 2017 and envisaged in 2023. India's position in Potato was third next to China and Russian Fed in 1999, fourth in 2000, third in 2001, 2002, 2003 and second in 2014 and the expected share in production by 2023 is 18.8% of world production a quantum jump due to use of potato genetic resources at ICAR-Central Potato Research Institute, Shimla and its regional stations. India ranks second to China in total production of Vegetables and melons and fruits in 2014. Area, production and productivity of horticultural crops have reached 25.9 million ha, 314.7 million tons and 12 tons/ha in 2018-19. Data on various horticultural crops are available in www.indiaagristat.com.

The present edited book *ORIGIN AND BIOLOGICAL DIVERSITY OF HORTICULTURAL CROPS* carries 20 chapters authored by the authorities in the subject. Chapter I authored by Hanchinal (2019) deals with the threats and prospects of biodiversity conservation and management in India. The Protection of Plant Variety and Farmers Right Authority has identified 22 agro-biodiversity hotspots across the country. India with 17% of the world's population, only 2.4% of the world's land area and with 4.00% of the water bodies is considered as one of the 17 mega-biodiversity countries housed in 12 mega diversity centres of the world, accounting for 7-8% of recorded species of the world and is a major centre of domestication of crop plants. Centre of origin, taxonomy and biodiversity of fruits-Annonaceous fruits, ber, carambola, chironji, guava, litchi, pomegranate, minor fruits, fruits in Satpura hills and sapindaceous fruits are dealt in detail by Sakthivel and Sampath Kumar, Trina Adhikary and Saipal Singh, Mahantesh Kamatyanatti *et al*, Mishra *et al*, Evening Stone Marboh *et al*, Sarvamangala *et al*, Maheswar *et al*, Radheshyam Sharma *et al* and Narayan Lal. Centre of origin and biodiversity of vegetables-cabbages,

cucurbits, oriental pickling melon, ridge gourd- and ornamentals-celosia, chrysanthemum, lilies and underutilized ornamentals-are authored by Hament Thakur, Choudhary and Dhurendra Singh, Shruti *et al*, Meenakshi Sood, Mangaiyarkarasi and Aruna, Bhargava *et al*, Chandrashekar *et al* and Safeena *et al*. Salil Tiwari (2019) overviewed biodiversity and distribution of bamboos in India.

Each chapter narrates origin, distribution, biodiversity, taxonomy and systematics and uses both household and industrial.



CHAPTER

13



Cucurbits

B.R. Choudhary and Dharendra Singh

“The more colorful the food, the better. I try to add color to my diet, which means vegetables and fruits.”

-Misty May-Treanor

The crops belonging to family Cucurbitaceae are generally known as ‘Cucurbits’. It consists of a wide range of vegetables either used for salad (cucumber) or for cooking (all gourds) or as dessert fruit (muskmelon, watermelon) or candied or preserved (ash gourd). Majority of cucurbits are characterized by presence of bitter principle *i.e.* cucurbitacin at some portions of plant and at some stages of development. Cucurbitacins are tetracyclic tryterpins having extensive oxidation levels. Fruit is essentially an inferior berry and is called as ‘pepo’ due to hard rind when mature.

The family Cucurbitaceae includes about 118 genera and 825 species, many of which are economically important crops, notably those of the genera *Cucumis*, *Cucurbita*, *Citrullus*, *Momordica*, *Lagenaria*, *Luffa*, *etc.* Among cucurbits,

watermelon, muskmelon, roundmelon, bottle gourd, ridge gourd, *kachri*, longmelon, snapmelon, *etc.* are mainly grown in arid regions of India.

S. No.	Common name	Botanical name	Chromosome number (2n)
1	Bitter apple	<i>Citrullus colocynthis</i>	22
2	Bottle gourd	<i>Lagenaria siceraria</i>	22
3	Kachri	<i>Cucumis callosus</i>	24
4	Longmelon	<i>Cucumis melo</i> var. <i>utilissimus</i>	24
5	Muskmelon	<i>Cucumis melo</i> L.	24
6	Ridge gourd	<i>Luffa acutangula</i>	26
7	Roundmelon	<i>Pracitrullus fistulosus</i>	24
8	Snapmelon	<i>Cucumis melo</i> var. <i>momordica</i>	24
9	Watermelon	<i>Citrullus lanatus</i>	22

Bitter apple

Bitter apple (*Citrullus colocynthis*) is a perennial cucurbit and known as *Indrayan* in Hindi. It is native of arid regions and occupies the vast area extending from the west coast of northern Africa (Senegambia, Morocco and the Cape Verde Islands), eastward the Sahara, Egypt, Arabia, Persia and Baluchistan and throughout India. At the Red Sea, near Kossier, it occurs in immense quantity. In India, it is found most abundantly in north-western plains, especially in Barmer, Bikaner, Jaisalmer and Jodhpur districts of Rajasthan and Gujarat in wild form.

Bitter apple is considered a very close relative to watermelon. It is perennial with prostrate or climbing angular stems and bifid tendrils; leaves ovate or triangular, deeply 3-lobed; flowers monoecious, yellow, solitary, axillary; fruit pepo, 4-10 cm in diameter, smooth, globose, green mottled with yellow blotches, pulp bitter, spongy; seeds numerous, white or light brown. The roots are large, fleshy leading to a high survival rate due to the long tap root. It possesses extreme abiotic resistant attributes which may be exploited in improvement programme of watermelon.

Fruit contains 15% pulp, 62% seed and 23% rind. The mesocarp contains glucose (1.3% on flesh basis). The processed mesocarp may be good sources of pectin. The juice of the fruit contains citrullin, citrullene and citrullinic acid. The fruits of bitter apple also contain cucurbitacin B and its glycoside, cucurbitacin I. The peel free flesh of ripe fruits contains yellow bitter oil. The seeds are used for edible purposes as well as to extract oil. Seeds contain 16.7% yellow coloured semi-dry oil rich in linoleic acid.

The bitter taste and the powerful medicinal properties of the pulp are due to the presence of amorphous glucoside colocynthin. An ether soluble crystalline and tasteless substance insoluble in water is present in *colocynth*, which is called colocynthin. *Colocynth* possesses several medicinal properties and is used in treating bilious derangements of chronic constipation and dropsy, fevers and cases requiring purgatives. The pulp is also used for varicose veins and for piles. It is diuretic, expectorant, and is also used in remedies against cancer and wounds.

Bottle gourd

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] synonymously called white flowered gourd or calabash gourd is a member of Cucurbitaceae family. It is commonly grown in India, Ethiopia, Africa, Central America and other warmer regions of the world. The fruits are consumed as vegetable or for making sweets (*halwa, kheer, petha* and *burfi*) and pickles. *Kofta* is one of the most popular preparations of tender fruits of bottle gourd. The fruits have cardiatic and diuretic properties and have cooling effect. It is good for patients suffering from biliousness and indigestion. The dry hard sell of fruits is used for making a wide range of articles like bowls, bottles, ladles, containers and musical instruments. It was named as bottle perhaps the shape of its fruits resemble bottle. In addition, the seeds and seed oil are also edible. The fruits contain 0.2% protein, 2.9% carbohydrate, 0.5% fat and 11 mg vitamin C per 100 g fresh weight.

Bottle gourd has been found in wild form in South Africa and India. However, it is probably indigenous to tropical Africa on the basis of variability in seeds and fruits. In India, some wild forms are also found in coastal areas of Malabar (North Kerala) and humid forests of Dehradun (North India).

Lagenaria siceraria (Mol.) Standl. belongs to family Cucurbitaceae with chromosome number $2n=22$. It is annual climber having tendrils on leaf axils. Monoecious in sex form and highly cross pollinated. Flowers are solitary, appear on leaf axils and white in colour. Sepals 5 united at the base to form a tube and the calyx lobes alternating with corolla tubes. Petals are 5 in number, united and white in colour. Stamens are 3 attached to the calyx tube. Ovary is inferior, three carpellary but one or three celled with three parietal placentas. Anthesis takes place between 5.00-7.00 pm except when the temperature is low. The fruit formation could be recognized only after 24 hours of pollination. Fruit is essentially a berry and called a pepo because of its hard and tough rind at maturity. The tender fruits are light green in colour with white coloured flesh. Fruits have different shapes like pyriform, round, long slender with or without neck. Seeds are many, flat and light yellow in colour on maturity and attached to fruit in parietal placentation.

Varieties

Pusa Summer Prolific Long: Fruits are 40-50 cm long and 20-25 cm in girth. It is suitable for growing during summer as well as rainy season.

Pusa Summer Prolific Round: It has vigorous growth, round fruits of 15-18 cm girth. It is prolific bearer and heavy yielder.

Pusa Santushti: Fruits attractive green, smooth, pear shaped, fruit length 18.50 cm, fruit diameter 12.40 cm, sets fruit under low temperature (10-12°C) as well as high temperature (35-40°C), fruit weight 0.8-1.0 kg. Maturity in 55-60 days. Yields 280-290 q/ ha during *kharif* and 260 q/ ha during summer.

Pusa Sandesh: Fruits attractive green, round, deep oblate, medium sized, weighing 600 g; first picking in 55-60 days in *kharif* and 60-65 days in summer. Yield potential is 320 q/ ha.

Pusa Meghdoot: F_1 hybrid between Pusa Summer Prolific Long x Sel.-2. Fruits are long, light green and attractive. It is early, high yielding and suitable for cultivation in spring-summer season.

Pusa Manjari: F_1 hybrid between Pusa Summer Prolific Round x Sel.-11. Fruits are round and high yielding.

Pusa Hybrid-3: Fruits green, slightly club shaped without neck; suitable for easy packing and long distance transportation; first picking in 50-55 days. Gives an average yield of 420 q/ ha (summer) and 470 q/ ha (*kharif*).

Pusa Naveen: Fruits round, 15-18 cm in girth, green; prolific bearer; suitable for both summer and *kharif* seasons; first picking in 60-65 days and produce 320 q/ ha yield.

Arka Bahar: This is an early variety. Fruits are light green, length 30 cm, diameter 7 cm, fruit weight 800-900 g and yield 480-550 q/ ha. It is tolerant to anthracnose and suitable for rainy and summer season cultivation.

Kashi Bahar: This is a long fruited hybrid with green vine and vigorous growth, fruit straight, light green, length 30-32 cm, fruit weight 780-850 g and yield 500-550 q/ ha. It is suitable for rainy and summer season cultivation. It is tolerant to anthracnose, downy mildew and *Cercospora* leaf spot under field conditions.

Thar Samridhi: Fruits are round weighing 450-700 g and ready for first harvesting at 50-55 days after sowing. Fruit yield is 240-300 q/ ha. It is suitable for hot arid conditions.

Punjab Komal: The fruits are light green, tender with pubescence, medium long and borne on 4-5th node onwards. Produce 10-12 fruits per vine. It is tolerant to cucumber mosaic virus. The yield potential is 400 q/ ha.

Punjab Round: Fruits are round-flat, tender and shining. Average yield is 375 q/ ha.

Kachri

Kachri (*Cucumis callosus*) is a very drought hardy cucurbitaceous vegetable, found growing in the arid region during rainy season. The mature fruits are usually cooked with various vegetable preparations, *chutney*, pickles and are also used for garnishing the vegetables or as salad. *Kachri* is one of the components of the delicious vegetable popularly known as *Panchkuta* in the desert districts of north-western India. It is annual plant and monoecious in sex form. Anthesis occurs at 5-9 am. Unripe fruits are bitter in taste but at ripening they become edible.

Nutritive value (per 100g of fresh edible fruit)

Moisture	88.2%	Fibre	1.21%	Copper	0.0046mg
Carbohydrate	7.45%	Calcium	0.09mg	Zinc	0.052mg
Protein	0.28%	Phosphorus	0.0029mg	Manganese	0.058mg
Fat	1.28%	Iron	0.182mg	Vitamin C	29.81mg

Varieties

AHK-119: Fruits are small, egg shaped weighing 50-60 g. Harvesting begins 68-70 days after sowing and continues upto 110-120 days and produce 95-100 q/ ha. It is suitable for dehydration.

AHK-200: Fruits are 100-120 g in weight. Harvesting starts 65-76 days after sowing and continues upto 90-100 days. It produces 115-120 q/ ha. Fruits are suitable for garnishing the vegetables and salad.

Longmelon

Longmelon (*Cucumis melo* var. *utilissimus*) is a warm season crop and mainly grown in tropical, subtropical and milder zones of India. It is also the best adapted for river bed cultivation, a kind of vegetable forcing being used in different parts of India where the crop is grown in the river beds during winter season to get early produce. Longmelon is popularly known as *Kakri* or *Tar Kakri* which is valued for tender fruits eaten raw along with salt and pepper. If it is taken without salt, it is not easily digested. Similarly, drinking of water immediately after eating fruits causes indigestion. Due to its cooling effect, it is very popular during summer months in most parts of the country.

The centre of origin for *Cucumis* species is likely Africa for the wild species. However, the initial site of domestication for the melons is probably the Middle East Asia from there the genes have contributed extensively to plant improvement. India also possesses considerable variability in melons and therefore, considered as the secondary centre of origin of melons. Longmelon is cultivated throughout India, Pakistan (Punjab and Sind) and prefers to grow in sandy soil and hot, dry weather. It is very popular particularly in Rajasthan, Punjab and Uttar Pradesh. River beds of Yamuna, Ganga and Narmada in the North and Kaveri, Krishna and Godavari in the South India are the major growing centres of longmelon. Presently, it is being cultivated throughout the world under tropical and subtropical climatic conditions.

The immature fruits of longmelon contain about 90% water, and are not particularly high in nutrients, but its flavour and texture have made it popular for use as a fresh addition to salads, as well as pickled and prepared in relishes. It possesses both curative as well as nutritive value.

Longmelon is mainly warm season crop and successfully grown in tropical and subtropical regions. It flourishes well under warm climate and cannot tolerate frost and strong winds. Freezing kills the plants and cool weather below 16°C slows or stops the growth. The optimum temperature for germination of seed is 25-30°C and grows well at day temperature between 25 and 35°C. Growth virtually stops at temperature below 10°C and temperature above 40°C has adverse effect on flowering and fruiting. It tolerates cool climate better than muskmelon. Low temperature, high relative humidity and short day length stimulate the development of female flowers. It may show slight photoreaction to short days for flowering. High humidity increases the incidence of diseases, particularly those affecting foliage.

Varieties

Arka Sheetal: This variety is developed by ICAR-IIHR, Bengaluru through pure line selection from a local collection (IIHR 3-1-1-1-5-1) collected from Lucknow. Fruits are medium sized, light green and high yielding (350 q/ ha). Fruits are free from bitter principle. It is tolerant to high temperature.

Punjab Longmelon-1: Developed at PAU, Ludhiana. Its vines are long, stem pubescent, angled and light green. It is an early maturing variety with long, thin and light green fruits.

Thar Sheetal: Early in harvesting and took 45-50 days in first harvesting from sowing. The fruit length, number of marketable fruits per plant and marketable fruit yield varied from 25-30 cm, 18-22 and 132-142 q/ ha, respectively. Bear light green coloured and tender fruits at edible stage which are free from bitterness.

Muskmelon

Muskmelon (*Cucumis melo* L.; $2n=2x=24$) is commonly known as cantaloupe, melon, muskmelon, casaba or winter melon. It is native of tropical Africa more specifically in the eastern region, south of Sahara Desert. India, Persia, China and Southern Russia are considered secondary centres of diversity of muskmelon. The fruits are used as dessert which contains 0.6% protein, 0.2% fat, 3.5% carbohydrates, 32 mg calcium, 14 mg phosphorus, 1.4 mg iron, 16 mg carotene and 26 mg vitamin C per 100 g fresh weight of fruit. Seed kernels are also edible, tasty and nutritious, since they are rich in oils and energy. Great morphological variation exists in fruit characteristics such as size, shape, colour and texture, taste and composition, and *C. melo* is therefore considered the most diverse species of the genus *Cucumis*. It is dicotyledonous, annual, climbing, or trailing herb. Monoecious and andromonoecious are the most common sex forms however, andromonoecious form is predominant.

Varieties

Pusa Madhuras: It has been developed at ICAR-IARI, New Delhi. Fruits are round, salmon flesh, juicy and sweet (12-14% TSS). It is moderately resistant to *Fusarium* wilt.

Pusa Rasraj: A monoecious line M_3 developed at ICAR-IARI, New Delhi and crossed with Durgapura Madhu gave rise to the F_1 hybrid, Pusa Rasraj. Fruits are oblong with 11-12% TSS.

Arka Rajhans: It is a selection from local collection (IIHR-107) of Rajasthan at ICAR-IIHR, Bengaluru. Fruits are round-slightly oval, medium large with white and firm flesh having 11-14% TSS. Average fruit weight is 1.25-2 kg. It is moderately resistant to powdery mildew.

Arka Jeet: It is a selection from 'Bati' strain of Lucknow (UP) which has been developed at ICAR-IIHR, Bengaluru. Fruits are small, flat-round, with attractive orange rind, weighing 300-500g. Flesh is white and sweet with medium soft texture.

Kashi Madhu: It has been developed at ICAR-IIVR, Varanasi. Fruits are round, with open prominent green sutures, weight 650-725 g, half slip in nature, thin rind, smooth

and pale yellow at maturity, flesh salmon orange (mango colour), thick, very juicy, total soluble solids (TSS) 13-14% and seeds are loosely packed in the seed cavity. It is tolerant to powdery and downy mildew, medium maturity and yields 200-270 q/ ha.

Hara Madhu: This variety has been developed at PAU, Ludhiana from the local material of Kutana type (a local collection of UP). Vines are 3-4 m long and vigorous. Fruits are large, round, slightly tapering towards the stalk end. There are 10 prominent green sutures, average fruit weight is 1 kg. Flesh is green with small seed cavity and 12-15% TSS. The yield potential is 12 t/ ha.

Punjab Sunehri: It is a selection from the cross between Hara Madhu and Edisto developed at PAU, Ludhiana. Fruits are round to elliptical, devoid of sutures, netted and thick skinned. Flesh is salmon-orange, thick and sweet (11% TSS). Shelf-life and transport quality is excellent. Average yield is 16 t/ ha. It is moderately resistant to *Fusarium* wilt.

Punjab Hybrid: This is an F_1 hybrid developed at PAU, Ludhiana having the parentage as male sterile line (*ms-1*) x Hara Madhu. It has 2-2.5 m long vines, vigorous luxuriant growth, globular fruits with distinct sutures, weighing about 800 g. Flesh is creamy yellow. Rind is netted, TSS is about 12%, it is early in maturity, has good post harvest life and transportability. It is moderately resistant to powdery mildew.

Durgapura Madhu: Very early cultivar with pale green rind, oblong in shape, light green flesh with dry texture developed at ARS, Durgapura (Rajasthan). Fruits are very sweet (13-14% TSS). Resistant to *Fusarium* wilt.

RM-43: Developed at ARS, Durgapura (Rajasthan). Fruits are oblong, small seed cavity, TSS 12-14%. Good keeping quality and transportability. Field resistant to powdery mildew and root rot.

RM-50: Developed through hybridization (Durgapura Madhu x Sel-1) followed by pedigree selection at ARS, Durgapura (Rajasthan). Fruits ovate, pale green rind having ten green sutures. Flesh green with 14-16% TSS. Average fruit weight is 500 g. Yield potential is 17-20 t/ ha.

MHY-3: It is a selection from cross between Durgapura Madhu and Pusa Madhuras made at ARS, Durgapura (Rajasthan). Fruits are flatten-round with light green flesh and 13-15% TSS. It is resistant to moderately resistant against powdery mildew, downy mildew, root rot and virus under field conditions.

MHY-5: Developed through hybridization (Durgapura Madhu x Hara Madhu) followed by pedigree selection at ARS, Durgapura (Rajasthan). Fruits with smooth rind and medium seed cavity, roundish flat and tapering at end. Rind is green yellow in colour. The flesh is light green, texture soft and TSS 13-16%. Average fruit weight is 700-800 g. Yield potential is 18-20 t/ ha.

Ridge gourd

Ridge gourd [*Luffa acutangula* (Roxb.) L.] is an important warm season vegetable crop belonging to the family cucurbitaceae widely cultivated in tropical and sub-tropical parts of the world. The immature tender green fruits are cooked as vegetable which have

good nutritive value and high yield potential. It is good source of carbohydrates, vitamin C and minerals.

Genus name was derived from the product '*Loofah*' used as bathing sponges, scrubber pads, doormats, pillows, mattresses, cleaning utensils, *etc.* this species contain a gelatinous compound called *luffein*. It is cultivated for its immature fruits which are cooked as vegetable. Fibre of mature dry fruit is used as a bath sponge.

Ridge gourd is an annual climber. Leaves are simple smooth, five lobed. Tendrils are present on leaf axils. The flowers are solitary pale yellow to yellow in colour. It is monoecious in sex expression with very high male to female sex ratio. Staminate flowers are borne in racemes. Anthesis starts in the evening by 5.00 p.m. and continues upto 8.00 p.m. Anthers dehiscence is seen immediately after anthesis. Fruit has 10 longitudinal ridges and angled. Seeds are black in colour and pitted.

It is a creeper and has a climbing or trailing habit. There is a wide variation in shape and length of fruits. Warm and humid climate is favourable for its growth and development. The optimum temperature requirement is 25-30°C.

Varieties

Pusa Nasdar: Early, fruits club shaped and light green in colour.

Pusa Nutan: Pusa Nutan has long (25-30 cm), straight, attractive green fruits with ten longitudinal angular ridges and a tapered neck, tender flesh, having an average fruit weight of 105 g, and it is suitable for spring-summer and kharif season. The variety is ready for first harvesting in kharif in 45-50 days and in 55-60 days in spring-summer. It is field-tolerant to luffa yellow mosaic virus.

Arka Sujath: An advanced pedigree selection of the cross IIHR-54 x IIHR-18. Fruits lush green and tender, medium long (35-45 cm) fruits with prominent ridges and delicate aroma. Good transport and cooking qualities. Crop duration is 100 days and yields 53 tones/ha.

Arka Sumeet: An advanced pedigree selection of the cross IIHR-54 x IIHR 18. Fruits lush green and tender long fruits (50-65 cm) with prominent ridges and delicate aroma. Good transport and cooking qualities. Crop duration is 110 days and yields 50 t/ ha.

Arka Prasan: Produces green, long, tender fruits. Excellent cooking quality, nutritionally rich in antioxidant activity and minerals like phosphorus, calcium and zinc.

Arka Vikram: An F₁ hybrid which produces green, long, tender fruits. Excellent in cooking quality, nutritionally rich in antioxidant activity and minerals like potassium, calcium, iron, zinc and manganese.

Thar Karni: Fruits 20-25 cm long weighing 90-110 g and cylindrical with 10 longitudinal shallow ridges. Tolerant to high temperature. Tolerant to mosaic disease under filed conditions.

Roundmelon

Roundmelon (*Praecitrullus fistulosus* pang. Syn. *Citrullus vulgaris* var. *fistulosus*) is also known as round gourd, Indian squash, squash melon and *Tinda*. It is an important summer vegetable crop in North India, especially in Punjab, Uttar Pradesh and Rajasthan. It is grown for small, tender fruits that are roughly spherical and about 5-8 cm in diameter. The fruits at cooking stage contain 1.4% protein, 1.4% fat, 3.4% carbohydrates 1% fibre, 0.5% Minerals, 13 mg carotene and 18 mg vitamin C/ 100 g of fresh weight. Fruit has a cooling effect to the body. Fruits are also useful for dry cough and for improving blood circulation in the body. It is believed to have originated in India. Roundmelon is extensively cultivated in North India. It is also cultivated in other South Asian countries like Pakistan, Sri Lanka and Bangladesh.

This was earlier considered as a subspecies of watermelon and was *Citrullus vulgaris* var. *fistulosus*. In cytological studies, chromosome number is found as $2n=24$ which is different from that of watermelon ($2n=22$). Russian taxonomist Pangalo (1930) raised it to status of a separate species and renamed it as *Praecitrullus fistulosus*.

It is an annual creeping herb having green or light green hairy leaves. Anthesis takes place from 6.00 am to 8.30 am. The dehiscence starts one hour before anthesis and continues up to 7.30 am. At high temperature, stigmatic fluid starts drying and stigma becomes non-receptive by 2.00 pm. Maximum fruit set is recorded during first four hour after anthesis. The fruits are round having hairs or sometimes smooth with blackish seeds. Fruits are dark green in early stage and turns to lighter green when they reach optimal stage for cooking.

Varieties

Arka Tinda: An advance pedigree selection of cross between local selection T-3 (from Rajasthan) x T-8 (from Punjab) in 1970 by SVRC. It is early maturing variety of summer season, tolerant to fruit fly. Fruits are large, tender and light green in colour. Average fruit weight is 60 g and yield is 100 q in 8-10 pickings.

S-48: Plants are vigorous (75-100 cm). It bears 8-10 fruits per vine that are medium in size (50 g), flat round, pubescent, light green in colour with white, less seedy and tender flesh. It matures in about 60 days and yields about 65 q/ ha.

Snampmelon

Snampmelon (*Cucumis melo* var. *momordica*) is commonly grown as inter crop in maize. Its immature fruits are used as salad, vegetables and other culinary preparations. Fruits at ripening stage develop suture. Its fruits are generally less sweet as compared to muskmelon; hence it is much liked by the people who are suffering sugar related disorders. Snampmelon pulp is suitable for preparation of jam by adding equal quantity of sugar to pulp. Good quality wine with excellent aroma and taste can be prepared with its pulp.

Nutritive value (per 100 g of edible part)

Moisture	Carbohydrate	Protein	Fat	Vitamin A	Minerals
95.7%	3.0%	0.3%	0.1%	265IU	0.4%

Snapmelon is probably originated in the tropical regions of Africa and Asia. It is a very popular vegetable of arid region. It is commonly grown as a rainfed crop in Rajasthan and Gujarat. A great extent of genetic variability exists in snapmelon in India with respect to vegetative growth, quality attributes and resistance to biotic and abiotic stresses.

It belongs to the genus *Cucumis* and species *melo* and has been placed under the botanical variety *momordica*. It is an annual, vines 5-6 m long, leaf petiolate, 3-4 lobed, surface rough; flower yellow in colour, monoecious, staminate flowers appear first latter on pistillate flowers; anthesis begins from 5.0 to 8.30 am and also during evening, stigma remains receptive 36 h before to 48 h after anthesis; fruit size varies, unripe fruits taste bitter.

Snapmelon prefers warm and humid climate. For the germination of seed temperature between 30-35°C is required whereas temperature range of 32-37°C proves conducive for fruit growth and development. It is mainly grown as intercrop in maize and cotton when plants get enough humidity for growth. Snapmelon can be grown in different kind of soils, however, humus rich with ample provision of drainage is considered ideal. The optimum pH of soil is 7°C for its cultivation.

Varieties

AHS-10: It is an early high yielding selection from the local land race. The fruits are oblong and medium in size, 850-950 g in weight, 17-20 cm in length and 9.7 to 10.5 cm in diameter having 4.5-5% TSS. Edible flesh thickness is 2.1-2.6 cm, the fruit cavity 5.5-6.1 cm wide. Its average yield is 225-230 q/ ha.

AHS-82: This is selection from the local genetic material collected. Plants are vigorous with average vine length of 2.25 m. Each vine bears 4.5-5.0 fruit giving yield of 245-250 q/ ha. The flesh is sweet (4.3-4.9% TSS), tasty and pink in colour.

Watermelon

Watermelon [*Citrullus lanatus* (Thunb.) Mansf.] is the most cultivated cucurbitaceous vegetable crop in the world. It is popularly known as *Tarbuji*, *Kalinda* and *Mateera* in India. Watermelon is indigenous to Tropical Africa chiefly the Kalahari Desert where wild forms are still found. *C. colocynthis* (L.) Schard is the probable ancestor of watermelon which is bitter in taste and known as *Tumba* or 'bitter apple'. Watermelon act as a coolant, thirst-quencher, detoxifier, diuretic, febrifuge, and, according to some natural healers, an aphrodisiac. The fruits of watermelon are fleshy, juicy and sweet. Mostly eaten fresh, provide a delicious and refreshing dessert in hot weather. The major nutritional components of the fruit are carbohydrates (6.4 g/ 100g), vitamin A (590 IU) and lycopene (4100 µg/ 100g), an anti-carcinogenic compound found in red flesh of watermelon which is beneficial in prevention of heart attacks and certain types of cancer. Pink-fleshed watermelon contains significantly higher quantity of beta-carotene than yellow-flesh varieties. It is a rich in iron content among all members of cucurbitaceous crops. The rind is rich in citrulline, an amino acid that contributes to the removal of ammonia from the body and wound healing. Watermelon seeds are rich in fat (about 45% edible oil) and protein (30-40%). The seeds are powdered and baked like bread in India. The seed kernels are also used in various sweets and

other delicacies. The unripe fruits are also cooked as a vegetable in some parts of India. The juice is an alternative drink to drinking water in desert areas.

Watermelon is native to Tropical Africa chiefly the Kalahari Desert (the current nations of Namibia and Botswana) where wild forms are still found.

Varieties

Arka Aiswarya: It is F_1 hybrid having crop duration of 95-100 days. Fruits are oval, green with light green broken stripes, red flesh, crispy, delicious, juicy and 13-14% TSS weighing 7.5 kg. Good in keeping and transport qualities.

Arka Akash: High yielding F_1 hybrid. Fruits are oblong, red fleshed, juicy weighing 6.5 kg with TSS of 12-13% and very good in taste. Yields 65-70 t/ ha in crop duration of 90-95 days.

Arka Jyoti: A mid-season F_1 hybrid developed by crossing IIHR-20 x Crimson Sweet. It produces round fruits weighing 6-8 kg with light green rind and dark green stripes. Flesh colour is crimson having excellent texture, excellent flavour and sweet (11-13% TSS). Yields 50-60 t/ ha.

Arka Madhura: It is triploid and seedless variety. Suitable for year round production under protected conditions. Fruits are sweet (13-14% TSS) and juicy. Gives 50-60 t/ ha fruit yield. Shelf life is long and good transport quality.

Arka Manik: Developed by crossing IIHR-21 x Crimson Sweet followed by modified backcross method. Fruits are round to oval weighing 6 kg with light green rind and dark green stripes. Flesh is deep crimson with granular texture, pleasant aroma and very sweet (12-15% TSS). Seeds are small with dark brown specks on the testa. It stands well in transport and storage. It possesses triple resistance against powdery mildew, downy mildew and anthracnose. It produces 60 t/ ha in crop duration of 100-115 days.

Arka Muthu: High yielding variety with unique character of dwarf vine (1.2 m), shorter internodal length and early maturing type (75-80 days). It has round to oval fruits with dark green stripes and deep red flesh. Average fruit weight is 2.5-3 kg with 12-14% TSS. Fruit yield is 55-60 t/ ha.

Asahi Yamato: It is a mid-season Japanese introduction. Fruits are medium sized weighing 6-8 kg with rind light green, deep pink and crisp flesh having 11-13% TSS. Seeds are small and brown in colour. Fruits ripen in about 90-95 days after sowing.

Durgapura Kesar: It is a late variety. Fruits are slightly ovicular shaped with light green rind. Flesh colour is saffron, juicy, moderate in sweetness (10-11% TSS) and seeds large. Average fruit weight is 4-5 kg and average fruit yield is 35 t/ ha.

Durgapura Lal: Leaves are non-lobed which help to distinguish the variety easily (marker gene). Fruits are round, dark green with dark lining, thin and hard rind weighing 4-5 kg. Flesh is crisp, dark red with 10-11% TSS. First picking starts at 105-110 days after sowing and produce 35-45 t/ ha fruit yield. It is moderately resistant to blight, powdery mildew and bud necrosis under field conditions.

Durgapura Meetha: It is a late maturing variety (125 days). Fruits are round with light green thick rind, red fleshed with 10-11% TSS. First picking starts in 110-120 days after sowing. Average fruit weight is 6-8 kg with yield potential of 40-50 t/ ha. It possess good keeping and transport quality.

Pusa Bedana: It is a seedless triploid variety developed by crossing Tetra-2 (Tetraploid) x Pusa Rasal (Diploid). Fruits are dark green weighing 5-6 kg, somewhat triangular in shape with tough rind, red fleshed, seedless with 12-13% TSS. It takes 115-120 days for first fruit harvest.

Sugar Baby: It is introduced from the USA. Fruits are slightly small in size weighing 3-5 kg, round having bluish-black rind and deep pink flesh with 11-13% TSS and small brown seed. Fruits ready for harvesting in 85-90 days after sowing.

Thar Manak: It is developed through selection from the local land races found in arid region. It is drought hardy and suitable for cultivation in arid regions during rainy season. Early and first fruit harvesting can be done in 75-80 days after sowing.



Diversity in muskmelon



Diversity in watermelon

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