

Review Article

Revisiting the Status of Cultivated Plant Species Agrobiodiversity in India: An Overview

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A revisit to the literature on cultivated plant species agrobiodiversity in India revealed that the floristic diversity is represented by 17,926 species of angiosperm, while Indian agriculture cultivates 811 plant species and harbours more than 900 wild relatives of the cultivated plant species distributed over 10 (+ 1) biogeographic regions of the the country, significantly higher than commonly cited in the literature. Further, it revealed the role of Indian communities in domestication to cultivation of around 215 economically important plant species, and adaption of around 600 exotic crop species. Based on new evidence, several species require inclusion and others deletion, and many need further investigations to resolve the issue on country of their origin. Cultivation of crop species in diverse natural and man-made agroecological systems for centuries has generated a huge amount of genetic diversity in a large number of crop species, maintained by the farmers in the form of landraces or farmer's varieties, and conserved as collections/accessions in the national agricultural research system.

Keywords: Agrobiodiversity; Domestication; Cultivation; Genetic Diversity; Wild Relatives of Cultivated Species; Conservation

Introduction

Agrobiodiversity is an evolutionary divergent but highly interrelated component of biodiversity dealing with variation in plants, animals, fish, insects, microbes, avian, etc., used directly or indirectly for food and agriculture. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fiber, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators, etc.) and those in the wider environment that support agroecosystems (agricultural, pastoral, forest and aquatic) and their diversity. It started with planting of economically important plant species together, generally referred to as 'domiculture' (Hynes and Chase, 1982; Singh and Varaprasad, 2008), which on further evolution developed into shifting cultivation and finally to settled agriculture (cultivation). Therefore, cultivated higher plants, referred to as crops, mainly contribute to agrobiodiversity, and are the major component of agroecosystems. Thus, the

diversity of cultivated plant species, and their wild relatives, which can facilitate further genetic expansion of cultivated species through conventional recombinant breeding, introgressing the desirable genes improving genetic potential (genetic resources), are the prime components of plant agrobiodiversity.

The Indian Subcontinent has been recognized as one of the important centers of origin of crop plants. The archaeological evidence and the scientifically authenticated Vedic literature from the northern part (Lallanji and Srivastava, 2008; Fuller, 2006; Murphy and Fuller, 2014), and evidence from south India (Fuller *et al.*, 2004) suggest domestication of a number of crops in the subcontinent. Further, the spread of human settlement to other regions of the subcontinent and trade with other parts of the world led to the introduction of a large number of cultivated plant species into the country. India, being situated at the tri-junction of three realms of global biogeographical zones, namely, Afro-tropical, Indo-Malayan and Paleo-arctic, offered great ecological diversity, starting from

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the temperate high altitude regions of the Himalayas, the Central Peninsular Highlands and Plateaus, the Thar Desert of north-western plains, the tropical rainforest of Western Ghats, and the diverse forest types of Eastern Ghats along the coast. These most diverse ecologies provided conditions for the adaptation of a large number of both indigenous and exotic crop plants bringing a revolution in the growth of agriculture and agrobiodiversity. Crop and economic plant diversity in the Indian gene center has been described in brief (Arora, 1991), and there have been attempts to estimate the crop plant agrobiodiversity from time to time, including both indigenous domesticates (Vavilov 1926, 1935; Zeven and Zhukovsky, 1975; Zeven and De Wet, 1982) and the cultivated species (Pareek *et al.*, 2000; Nayar *et al.*, 2003; Goyal and Arora, 2009; Singh *et al.*, 2013), and their wild relatives (Arora and Nayar, 1984). The present overview is an effort to update the status of cultivated/crop plant species diversity. A survey of literature and records have been conducted to collect information on genetic diversity recorded within a cultivated species, and for its wild relatives (genetic resources). The overview compiles information both on domesticated (brought into cultivation from wild and genetically modified by process of selection and adaptation to suit the human-manipulated environment) and cultivated (regenerated for generations with human intervention, encouraging their reproduction beyond their natural range, with accumulation of genetic change, and increasing the usefulness further) plant species of both major and minor crops, semi-domesticated or wild-foods such as fruits and berries harvested from wild, forage and medicinal and aromatic plants used in local health care, and their wild relatives. Recognizing the vastness of the subject, a detailed discussion on the origin and evolution of each cultivated plant species is beyond the scope of this review. However, an overall picture of genetic diversity generated in major crops due to various selection pressures, natural or man-made-recombination, mutation, and adaptation to diverse agro-ecosystems for centuries is being summarized in tabular form; with number of accessions conserved in the national system to reflect the richness of genetic diversity in each case.

Higher Plant Species Diversity

Based on richness of floristic diversity and species

endemism, India is among the 12 mega-biodiversity centers of the world. It contains 3 of the 34 biodiversity hotspots identified at global level namely, the Himalayas, the Eastern Indo-Myanmar region and the Western Ghats and Sri Lankan region (Conservation International, 2005). The Indian flora represents nearly 12% of the global floral diversity. The floristically rich India has about 148 endemic genera belonging to over 47 families of higher plants (Nayar 1980, 1996). As per the latest estimates of Botanical Survey of India (BSI), India has 47,513 plants species (Singh and Dash, 2014) including species of bacteria. Of these, about 20,141 taxa are of angiosperms with 17,926 species belonging to 2,991 genera and 251 families, representing approximately 7% of the described species in the world (Karthikeyan, 2009). There are about 5,725 species endemic to India, representing 33.5% of the Indian flora (Nayar, 1996), which has increased to 6,000 as per the latest survey (Goyal and Arora, 2009). Of the 5,725 endemic species, 3,471 species are located in Himalayas, followed by 2,051 species confined to peninsular region, and around 239 species to Andaman and Nicobar Islands (Nayar, 1996). However, according to a recent estimation about 4,045 taxa belonging to 975 genera in 155 families are considered as strict endemic to the present Indian political boundaries (Arisdason and Lakshminarasimhan, 2015). Nayar (1996) identified 3 megacenters and 25 microcenters of endemic plants. The three megacenters of endemism in India are the Western and the Eastern Himalayas, the Northeastern Indo-Mayanmar region and the Western Ghats. The Central Himalaya not only includes the fringe endemic species of Eastern and Western Himalayas, but is a crucible of speciation. The moist evergreen forests of the Western Ghats, due to varied topography and microclimatic regimes, have some areas of active speciation. The dominant plant families of the Indian Subcontinent are Poaceae/Gramineae represented by 263 genera and 1,291 species, followed by Orchidaceae (184/1,229), Leguminosae/Fabaceae (173/1,192), Asteraceae/Compositae (167/1,052), Rubiaceae (113/616), Cyperaceae (38/545), Euphorbiaceae (84/528), Acanthaceae (92/510), Rosaceae (40/492) and Lamiaceae/Labiatae (72/454). A total of 42 families have more than 100 species each.

Agricultural Plant Diversity

Agro-Climatic Diversity

Based on phytogeography, climatic and cultural features, the Indian Council of Agricultural Research (ICAR) initially recognized eight agroclimatic regions (Murthy and Pandey, 1978). Planning Commission demarcated 15 agroclimatic zones (Khanna, 1989). National Bureau of Soil Survey and Land Use Planning, based on soil physiography, soil type, bioclimatic and length of cropping season, classified India's land area into 21 agroecological regions (Sehgal *et al.*, 1992). Nayar *et al.* (2009) identified 22 agrobiodiversity hotspots, and Singh (2015) described 21 National Agricultural Biodiversity Heritage Sites based on agricultural history/heritage, richness in cultivated plant species diversity, genetic diversity within crop/cultivated species and innovative agricultural practices developed by local tribes/communities' overtime for sustainability of agriculture and management of natural resources. The hotspots and/or agricultural biodiversity heritage sites have been found closely associated with the agroecological regions with some overlap. Thus, agroecological regions with distinct physiography, soils and bioclimate appear to have been the centers of agricultural biodiversity with crop domestication, cultivation, adaptation and agricultural diversification/development. The ecological diversity of these regions has facilitated diverse and positive harmonious interaction between man, the landscape and the biological diversity, leading to adaptation of diverse crops and within a crop species of diverse genotype(s) with specific traits or gene complexes, reacting and evolving differently. Consequently, generating genetic variability suited to diverse agroclimates and microclimatic conditions created by human intervention (modification) within a specific region. Hence, these agroecological regions appear to be the centers of genetic diversity for desirable traits of crops as per the natural and human selection pressures. For example, cold arid ecoregion should have significant source of variability for cold tolerance, hot arid and semi-arid regions for heat and drought resistance, and the coastal regions for salinity tolerance.

Crop/cultivated Species Diversity

In a geographic region, the cultivated/crop species can be either of primary or secondary origin that is differentiated on the basis of whether the cultivated

species was derived from local or exotic populations of wild progenitors or introduced as cultigens and prepatuated. The former indicates the primary origin and the latter secondary origin.

Indigenous Domesticates: Vavilov (1926) proposed the concept of 'center of origin' for crop plants. The center of origin is a geographical area where a plant species is either domesticated or is considered to have first appeared under cultivation from their wild progenitors developing distinct properties. The Indian subcontinent is recognized as one of the centers of origin/domestication by most evolutionary biologists, starting from Alphonse de Candolle (1883), followed by Vavilov (1926), who initially suggested 5, then 6 and finally 8 centers (1935), which later increased to 11, 12 (Zeven and Zhukovsky, 1975), and 14 in Final Consensus Report: Global Initiative for Security and Sustainable use of Plant Genetic Resources, Oslo Plenary Session 1991, though Harlan (1975) had reduced them to 5. Indian Subcontinent always figured prominently as one of the centers of origin of crop plants with different numbers of cultivated plant species, 117 for India plus 55 for Indo-Malayan center, totalling 172 (Vavilov, 1935); 24 to India plus 73, including Southeast Asia (Harlan, 1975); and 166 (Zeven and De Wet, 1982), out of a total of 2,489 species distributed in 12 regions of global agrobiodiversity.

Based on the presence of wild relatives, their cross-compatibility relationship with cultivated species, intermediate forms, presence of dominant genes, and the extent of varietal diversity listed in literature (De Candolle, 1883; Vavilov, 1926, 1935; Harlan, 1975; Zeven and De Wet, 1982), the status of cultivated plant species of primary Indian origin, requires revision in light of new evidence, with inclusion of several species and deletion of others, while some need further investigation for conclusion. Some representative examples are, *Brachiaria ramosa*, known to have been very widespread in cultivation in the past, though today it is confined to southern (Deccan) India only (Kimata *et al.*, 2000; Fuller *et al.*, 2004; Fuller, 2006, 2011); *Coix lacrymal-jobi* var. *ma-yuen* widely grown as a grain in Assam and northeastern India, with its wild form widespread in India and eastern Asia (Arora, 1977); *Digitaria sanguinalis* cultivated in Kashmir (De Wet, 1995); *Setaria pumila*; syn. *S. glauca*, which was and still

cultivated (Gammie, 1911; Kimata *et al.*, 2000; De Wet, 1995; Fuller, 2011); while *S. verticillata* (famine food), whose cultivated populations were reported from Tamil Nadu (Maheshwari and Singh, 1965), though century ago, it was wild-gathered resource in Maharashtra (Gammie, 1911), and where based on archaeological evidence (Fuller *et al.*, 2004), Fuller (2006) observed that it appeared to have been a crop or companion of *Brachiaria ramosa*; and *Setaria italica* subsp. *viridis*, the spontaneous green foxtail and the closest wild relative of foxtail millet, *S. italica* (Seetharam *et al.*, 2006) found on the northwestern fringes of India in weedy habitats, in cereals; *Vigna umbellata* (rice bean) whose clearly defined wild populations are found in Thailand and Myanmar only, is possibly be of Indo-China domestication, based on cross-compatibility with species found in the southern China (Tomooka *et al.*, 1991; 2003) and India, suggesting possible extension of its domestication; hyacinth bean (*Lablab purpureus*) regarded of Indian origin by Vavilov and African origin by Zeven and Zhukovsky (1975), may be debatable, but the presence of feral/wild population in Southern India (Maass *et al.*, 2005; Fuller and Harvey, 2006) support Vavilov's contention, in pulses; and distribution of wild/feral form of *Momordica dioica* and *M. balsamina* in foothills of Himalayas, central and eastern India through southeast Asia, and their mention in Sanskrit writings (Decker-Walters, 1999) among vegetables. These evidences suggest Indian role in domestication, justifying inclusion of these crops among the crops of Indian origin.

On the other hand, further evidence based on distribution of wild species and presence of most probable ancestral species in the southeast Turkey (Zohary and Hopf, 1988), *Cicer arietinum* (chickpea) is of western Asian origin, though further diversity in colored small grain *Desi* type evolved in India (Weiss and Zohary, 2011); velvet bean (*Mucuna pruriens*), based on widespread distribution, traditional knowledge, multiple Sanskrit names and use, was considered of Indian origin by Eilittä *et al.*, (2002), however, Sorenson and Johannessen (2004) have argued for its American origin with pre-Columbian introduction; similarly in case of amaranths, both grain and vegetable types were considered of Indian origin by Vavilov (1935), whereas Sauer (1967) because of striking concentration and wide distribution of Amaranths species in Americas, concluded American

origin; *Dioscorea alata*, thought to be of Indo-Burma origin (Vavilov, 1935), extending to Malaya, but Harlan (1975) and recent investigations (Lebot *et al.*, 1998; Malapa *et al.*, 2005; Denham, 2011) favors more to have it originated in New Guinea or adjacent parts of Indonesia/Malaysia; both commercial species *Hibiscus cannabinus* (kenaf) and *H. sabdariffa* (roselle) have been found to be of East African origin (Wilson, 1978), despite India having 36 species and old cultivation as fiber crops; and lastly based on naturalization and enormous diversity in tamarind (*Tamarindus indica*), Vavilov (1935) and Harlan (1975) proposed India as one of its center, where from it reached to Persians and Arabs, but it is a native of tropical Africa, where it grows wild as a monotypic indigenous genus (Diallo *et al.*, 2007). These cultivated species justifying dropping from the list of crops of Indian origin.

Further, there are cultivated species, which appears to have independent domestication in India, besides elsewhere, and India is one of the centers of origin. It may be due the presence or extended distribution of wild ancestral species at both the places or trans-introduction of wild species/forms, through natural means. For, example, *Abelmoschus esculentus* (okra) origin is disputed between India (Zeven and Zhukovsky, 1975; Zeven and De Wet, 1982) and Africa (Vavilov, 1935; Joshi *et al.*, 1974), but much evidence suggest India to be one of its centers (Dhankhar *et al.*, 2005); *Anethum graveolens*, a native of the Mediterranean region, grows wild in Europe, Africa and India. European dill (*A. graveolens*) is cultivated in Europe, while the Indian dill (*A. sowa*), is a native of Northern India, bolder than the European, and may be of independent geographic origin; occurrence of wild fenugreek (*Trigonella foenum-graecum*) in Kashmir, Punjab and the upper Gangetic Plain, support Vavilov contention for India to be one of its centers; Hashish (*Cannabis sativa*), a psychoactive drug, whose distribution extend from Eurasia to Western Himalayas and used in medicine and as a narcotic, leading to its genetic diversification and speciation into *C. indica*, with two independent geographic origin (Hillig, 2005); among gourds, Vavilov (1935) designated India to be the center of origin for bottle gourd (*Lagenaria vulgaris*), however, based on indigenous nature of the genus, presence of wild relatives, African origin appeared more probable (Bates *et al.*, 1995).

Nevertheless, evidence has been gathered to suggest that it naturally floated eastwards to India, where its wild forms were domesticated as backyard vegetable, generating further genetic/cultivar diversity. Coconut, *Piper betel*, *Areca catechu*, native to Southeast Asian island countries, might have been brought into cultivation independently in South Asia/India (Table 1) after migration, as is reflected by the cultural and religious association these countries/crops with India.

The subcontinent being the home of one of the oldest civilizations with cultural and trade contacts extending to Near East, central Asia and Southeast Asia, many plant species of these regions might have been brought into cultivation independently, because of their migration or introduction with or without recognition of their economical potential leading to their cultivation. Such speculation was made by Hymowitz (1972) in case of guar or cluster bean, whose domestication he explained through the concept of trans-domestication, according to which *Cyamopsis tetragonoloba* developed from drought tolerant wild species *C. senegalensis*, which was brought to India by Arab traders as fodder between 9th and 13th centuries AD. Such mechanism/speculation can be extended to winged bean (*Psophocarpus tetragonolobus*), which is wild in Africa, with good wild population occurring in humid equatorial conditions in India. Safflower (*Carthamus tinctorius*), though first domesticated and used as textile dye in Near East, was brought by Arabs traders and further domesticated as oilseed in India, generating distinct oilseed Indian population with distinct features making it one of its centers (Knowles and Asheri, 1995); Tosa jute (*Corchorus olitorius*) originated in Africa, migrated to India via Egypt and Syria was brought into cultivation as fiber crop in India based on the Indian experience with *Corchorus capsularis* (Singh, 1995); whereas in case of sorghum (*Sorghum bicolor*), on the basis of diversity observed, the domestication has been visualized outside Africa, most likely in India, and cultivars were reimported to Africa (Haaland, 1996; 1999).

Then there may be debatable cases, needing further investigation, for example among dye yielding plants, henna (*Lawsonia inermis* or *L. alba*) with ancient cultivation in Egypt, but because of its wild occurrence and use in Africa, western and southern Asia, the origin is debated and it might have been

case of independent cultivation in India. Among medicinal aromatic plants, Harlan (1975) associated senna (*Cassia angustifolia*) with Southeast Asia, though it is native of Egypt, Africa. Whereas, noni (*Morinda citrifolia*), commonly believed to be of Southeast Asian origin (Morton, 1992), have been argued for South Asian origin, supporting Vavilov (1935) and others, or a polyphyletic domestication (Singh *et al.*, 2011). Further investigation in debatable or newly suggested center of origin should involve molecular approaches for better phylogenetic resolution and conclusion.

Citrus presents a complex situation with domestication of both basic wild species and those of their hybrid derivatives. *C. aurantifolia* and *C. medica* are of Indian origin and domesticated from wild. Whereas many named species naturally evolved as hybrids, clonally propagated, besides some wild true-breeding species. For this reason, natural lemon, *C. medica*, and *C. limon*, *C. limonia*, *C. jambhiri*, though listed as separate species but latter are post-domestication derivation from early *C. medica*, and may be biosystematically one. *Musa sapientum*, distributed from western Pacific to East India is a hybrid cultivar of *M. balbisiana* x *M. acuminata* (Harlan, 1975), and may also be an example of early introduction and naturalization (secondary origin) or independent cultivation. Further, many native plant species identified with forage, medicinal and ornamental potential were protected/domesticated in nature either under recognized system like Ayurveda in case of medicinal plant or in home-gardens, and harvested for use (Table 1). Presently many are being or brought into commercial cultivation for economic exploitation. Table 1 lists plant species that were most probably domesticated from native wild species, and/or from species either with natural extended distribution or introduction as wild, brought into cultivation in India independently, either for same or different usage (Transdomestication) along with exotic domesticates presumed to be of Indian origin. The families associated with maximum numbers of domesticated species are those having maximum representation in the subcontinent such as Leguminosae with 105 species out of 1,192, Poaceae (89/1,291), Asteraceae (41/1,052), Brassicaceae/Cruciferae (30/267), Solanaceae (28/208), Rosaceae (25/492), Cucurbitaceae (22/99), Arecaceae/Palmae (20/94), Malvaceae (19/93), Apiaceae/Umbelliferae

Table 1: Status of plant species originated/domesticated or first brought into cultivation in India

Species	Common name	Usage ¹	Status on Indian origin; Reference & Remark ²
<i>Abelmoschus moschatus</i>	Musk mallow	M&AP	Indian (Zeven and De Wet, 1982), extends to Indo-Malaya region
<i>Abelmoschus manihot</i> ; <i>A. esculentus</i>	Okra	V	Indian (Zeven and Zhukovsky, 1975; Zeven and De Wet, 1982); African (Vavilov, 1935; Joshi <i>et al.</i> , 1974; Harlan, 1975): One of its center (Dhankhar <i>et al.</i> , 2005)
<i>Abroma augusta</i>	Indian hemp	FI	Indian (Vavilov, 1935)
<i>Acacia arabica</i> or <i>A. nilotica</i>	Gum Arabic/babul	AF	Indian (Vavilov, 1935), multiple uses
<i>Acacia catechu</i>	Catechu/Khair	AF	Indian (Vavilov, 1935), extending from Indo-Malaya region
<i>Aegle marmelos</i>	Bael	FR	Indian (Vavilov, 1935)
<i>Alpinia galanga</i>	Chittarattai	Spi	Indian (Vavilov, 1935)
<i>Amaranthus frumentaceus</i>	Grain amaranth	C	American origin (Sauer, 1967); Indian [De Candolle, 1883; Vavilov, 1935]: <i>Delete</i>
<i>Amaranthus tricolor</i>	Lal sag	V	American origin (Sauer, 1967); Indian (De Candolle, 1883; Vavilov, 1935): <i>Delete</i>
<i>Amomum aromaticum</i>	Bengal cardamom	Spi	Indian (Zeven and De Wet, 1982)
<i>Amorphophallus campanulatus</i>	Jimi-kand	V	Indian (Vavilov, 1935), wild/cultivated
<i>Ampelocissus latifolia</i>	Pureni	FR&M	Indian (ARS/GRIN)
<i>Andrographis echioides</i>	False water willow	M	Indian, native to South India & Sri Lanka (ARS/GRIN)
<i>Andrographis paniculata</i>	Kalmegh	M	Indian, native to India & Sri Lanka (ARS/GRIN)
<i>Anethum sowa</i>	Indian Dill	Spi	Indian (Vavilov, 1935, Zeven and De Wet, 1982): Center for Indian dill
<i>Anogeissus pendula</i>	Anogeissus	AF	Native to India (ARS/GRIN)
<i>Areca catechu</i>	Arecanut	PI	Indian (Vavilov, 1935) & Ceylon: One of its center
<i>Arenga saccharifera</i>	Sugar palm	PI	Indian (Vavilov, 1935), extending to Malaya archipelago
<i>Artocarpus heterophyllus</i>	Jackfruit	FR	Indian (De Candolle, 1883; Harlan, 1975; Zeven and De Wet, 1982)
<i>Artocarpus lakoocha</i>	Monkey jackfruit	FR&M	Native to India, Southeast Asia (Orwa <i>et al.</i> , 2009): <i>Add</i>
<i>Atropa acuminata</i>	Indian Belladonna	M	Indian (Zeven and De Wet, 1982)
<i>Averrhoa carambola</i>	Star fruit	FR	Indian (Vavilov, 1935) Sri Lanka & other islands
<i>Azadirachta indica</i>	Neem	AF	Indian (Orwa <i>et al.</i> , 2009), multiple uses
<i>Bambusa nutans</i>	Bamboo	OT	Indian (Seethalakshmi and Muktesh Kumar, 1998): <i>Add</i>
<i>Bambusa tulda</i>	Bamboo	OT	Indian (Vavilov, 1935; Zeven and De Wet, 1982), wild/cultivated
<i>Barleria cristata</i>	Bluebell	Orn	Native to India & China (ARS/GRIN)
<i>Basella alba</i>	Malabar spinach	V	Indian (Vavilov, 1935)
<i>Bauhinia purpurea</i>	Orchid tree	Orn	Indian (Zeven and De Wet, 1982), a native
<i>Benincasa hispida</i>	Ashgourd	V	Indian [Decker-Walters, 1999], wide distribution, origin uncertain
<i>Berberis aristata</i>	Indian barberry	M	Indian (Wealth of India, 1985), native to Himalayas
<i>Boehmeria glomerulifera</i> ; syn. <i>B. malabarica</i>	Malabar tree nettle	FI & M	Native to Western Ghats & Indo-Malaya (Singh <i>et al.</i> , 2013): One of center
<i>Bombax ceiba</i>	Red cotton tree	Orn	Native to India, China & Indo-Malaya; associated with Hindu epics, Sanskrit name: One of its center
<i>Bombax malabaricum</i>	Cotton fiber	OT	Indian (Vavilov, 1935), wild & cultivated
<i>Borassus flabellifer</i>	Toddy palm	PI	Indian (Vavilov, 1935), wild & cultivated
<i>Brassica juncea</i>	Indian mustard	OI	Indian (Vavilov, 1935; Harlan, 1975)
<i>Brassica nigra</i>	Black mustard	OI	Ethiopia (Hiremath and Murthy, 1988); Indian (Vavilov, 1935): <i>Delete</i>
<i>Brassica rapa</i> var. <i>yellow sarson</i>	Rapeseed	OI	Indian (Vavilov, 1935)

Species	Common name	Usage ¹	Status on Indian origin; Reference & Remark ²
<i>Brachiaria ramosa</i>	Browntop millet	C	Old cultivation in Deccan (Kimata <i>et al.</i> , 2000; Fuller <i>et al.</i> , 2004; Fuller, 2011): <i>Add</i>
<i>Buchanania lanzan</i>	Almondette/ Chironji	FR	Indian (Zeven and De Wet, 1982), native to central India
<i>Bulbophyllum</i> spp.	Orchids	Orn	Indian endemic species (Dressler, 1981): <i>Add</i>
<i>Caesalpinia sappan</i>	Mysore thorn dye	OT	Indian (Vavilov, 1935)
<i>Cajanus cajan</i>	Pigeonpea	GL	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Cajanus scarabaeoides</i>	Peanut grass	FO	Indian (Singh <i>et al.</i> , 2013), wild/cultivated for forage
<i>Canavalia gladiata</i>	Sword bean	V	Indian (Vavilov, 1935; Harlan, 1975), wild/cultivated
<i>Cannabis indica</i>	Marijuana	M	Indian (Vavilov, 1935); <i>C. sativa</i> , Eurasia [Harlan, 1975]: Spread led to independent origin (Hillig, 2005)
<i>Capparis decidua</i>	Ker	FR	Indian (Orwa <i>et al.</i> , 2009), extended to Africa
<i>Carissa carandas</i>	Karonda	FR	Indian (Vavilov, 1935), wild/cultivated
<i>Carthamus tinctorius</i>	Safflower	OI	Near east (Knowles and Asheri, 1995); Indian (Vavilov, 1935): One of its center for oilseed
<i>Cassia auriculata</i>	Tanners' cassia	AF & M	Native to India, Sri Lanka (Joshi, 2000), Ayurveda plant
<i>Cassia fistula</i>	Golden shower	Orn	Native to Indian Subcontinent (Vavilov, 1935)
<i>Cedrela toona</i>	Indian mahogany	AF	Indian (Vavilov, 1935)
<i>Cenchrus biflorus</i>	Indian sandbur	FO	Native of Africa & India (ARS/GRIN): One of center
<i>Cicer arietinum</i>	Chickpea	GL	Turkey (Zohary and Hopf, 1988); Indian (Vavilov, 1935): <i>Delete</i>
<i>Chlorophytum arundinaceum</i>	Safed musli	M	Native to India, Ayurveda medicinal plant
<i>Chlorophytum borivillianum</i>	Safed musli	M	Native to India, Ayurveda medicinal plant
<i>Cinnamomum impressinervium</i>	Tejpat	Spi	Native to India (ARS/GRIN): <i>Add</i>
<i>Cinnamomum tamala</i>	Indian cassia	Spi	Indian (Zeven and De Wet, 1982), native
<i>Cinnamomum verum</i>	Dalchini	Spi	Native to Sri Lanka & Malabar Coast (ARS/GRIN): <i>Add</i>
<i>Cinnamomum zeylanticum</i>	Cinnamon	Spi	Indian (De Candolle, 1883; Zeven and De Wet, 1982)
<i>Citrus aurantifolia</i>	Sour lime	FR	Indian (Vavilov, 1935), wild/cultivated
<i>Citrus medica</i>	Citron	FR	Indian (De Candolle, 1883; Vavilov, 1935), wild/ cultivated
<i>Citrus reticulata</i> x <i>C. sinensis</i>	Temples orange	FR	Accidental hybrid origin, Indian?
<i>Citrus x aurantium</i>	Sour orange	FR	Indian [De Candolle, 1883; Vavilov, 1935), wild/ cultivated
<i>Citrus x limon</i> ; syn. <i>C. limon</i> , <i>C. limonia</i>	Lemon	FR	Indian (Vavilov, 1935), wild/cultivated
<i>Citrus x sinensis</i>	Tight skin sweet orange	FR	Indian (Vavilov, 1935)
<i>Coccinia grandis</i>	Ivy gourd	V	Indian (Zeven and De Wet, 1982): Recent domesticate
<i>Cocos nucifera</i>	Coconut	PI	Indian (Vavilov, 1935): One of its center
<i>Coix lacryma-jobi</i> var. <i>ma-yuen</i>	Jobs tears	C	Indian (Harlan, 1975), wild/cultivated in Northeast India (Arora, 1977): <i>Add</i>
<i>Coleus forskohlii</i> (<i>C. barabatus</i>)	Gandhira	M	Indian (Vavilov, 1935; Valdes <i>et al.</i> , 1987), Ayurveda medicinal plant
<i>Colocasia antiquorum</i> ; syn. <i>C. esculenta</i>	Taro	V	Indian (De Candolle, 1883; Harlan, 1975); One of its center (Vavilov, 1935)
<i>Commiphora wightii</i>	Guggal	M & FO	Native to Middle East & India, Ayurveda & Unani plant
<i>Corchorus capsularis</i>	White jute	FI	Indian (Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982)
<i>Corchorus olitorius</i>	Tussa jute	FI	African origin (Kundu, 1951): Cultivation for fiber in India (Singh, 1995)
<i>Cordia myxa</i>	Cordia	FR	Native to West Asia to India (ARS/GRIN)

Species	Common name	Usage ¹	Status on Indian origin; Reference & Remark ²
<i>Corylus ferox</i>	Himalaya hazelnut	FR	Native to Himalayas & NW China: <i>Add</i>
<i>Corylus jacquemontii</i>	Hazelnut	FR	Native to West Asia to India (ARS/GRIN)
<i>Crossandra infundibuliformis</i>	Crossandra	Orn & M	Native to South India/Sri Lanka (RHS)
<i>Crotalaria burhia</i>	Saniya	FI & M	Indian (Zeven and De Wet, 1982), northwest India
<i>Crotalaria juncea</i>	Sun hemp	FI	Indian (Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982)
<i>Croton tiglium</i>	Croton	M	Indian (Vavilov, 1935)
<i>Cucumis sativus</i>	Cucumber	V	Indian (De Candolle, 1883; Vavilov, 1935; Zeven and De Wet, 1982)
<i>Cullen corylifolium</i>	Babchi	M	South China to India, Ayurveda plant cultivated in India
<i>Curcuma amada</i>	Mango ginger	Spi	Indian (Zeven and De Wet, 1982), native to East India
<i>Curcuma angustifolia</i>	Indian arrowroot	OT	Indian (Zeven and De Wet, 1982)
<i>Curcuma caesia</i>	Black turmeric	M	Indian (Zeven and De Wet, 1982)
<i>Curcuma longa</i>	Turmeric	Spi	Indian (Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982): Extending to Indo-Malaya region
<i>Curcuma mangga</i>	Mango ginger	Spi	Indian (Vavilov, 1935), native to South India to Southeast Asia
<i>Curcuma zedoaria</i>	Zedoary	Spi	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Cyamopsis tetragonoloba</i>	Clusterbean/Guar	GL	Indian (Vavilov, 1935; Harlan, 1975): Transdomestication (Hymowitz, 1972)
<i>Cymbopogon flexuosus</i>	Lemongrass	M & AP	India (Zeven and De Wet, 1982), from East India
<i>Cymbopogon martinii</i>	Palmarosa	M & AP	Indian [Vavilov, 1935; Zeven and De Wet, 1982]
<i>Cymbopogon nardus</i>	Citronella Grass	M & AP	Indian (Vavilov, 1935): Independent domestication
<i>Dalbergia sissoo</i>	Indian rose wood	AF	Native to India (Orwa <i>et al.</i> , 2009)
<i>Datura metel</i>	Datura	M	American (Sorenson and Johannessen, 2004); Indian (Vavilov, 1935): <i>Delete</i>
<i>Dendrocalamus giganteus</i>	Bamboo	OT	Native to Southeast Asia to India (Seethalakshmi and Muktesh Kumar, 1998)
<i>Dendrocalamus hamiltonii</i>	Bamboo	OT	Indian (Zeven and De Wet, 1982)
<i>Dendrocalamus strictus</i>	Dendrocalamus	OT	Indian (Zeven and De Wet, 1982)
<i>Digitaria adscendens</i>	Digitaria	FO	Domesticated in Northeast India for forage: <i>Add</i>
<i>Digitaria compacta</i>	Raishan	C	Native to Indo-China; cultivated in Khasi Hills for glutinous flour: <i>Add</i>
<i>Digitaria cruciata</i> var. <i>esculenta</i>	Khasi's minor millet	C	Indian (Harlan, 1975; Zeven and De Wet, 1982)
<i>Digitaria sanguinalis</i>	Crabgrass	FO/C	Cultivated in Kashmir (De Wet, 1995): <i>Add</i>
<i>Dioscorea alata</i>	Yam		New Guinea [Harlan, 1975; Maass <i>et al.</i> , 2005; Malap <i>et al.</i> , 2005; Denham, 2011]; Indian (Vavilov, 1935): <i>Delete</i>
<i>Dioscorea bulbifera</i>	Potato yam	V	Native to Africa, tropical Asia, Australia (ARS/GRIN)
<i>Dioscorea esculenta</i>	Lesser yam	V	Native to tropical Asia, including India (ARS/GRIN) cultivated in Kerala
<i>Diospyros melanoxylon</i>	Tendu	OT	Native to India & Sri Lanka (ARS/GRIN), bidi making
<i>Dovyalis hebecarpa</i>	Ceylon gooseberry	FR	Indian (Zeven and De Wet, 1982)
<i>Echinochloa frumentacea</i>	Barnyard millet	C	Indian (Seetharam <i>et al.</i> , 2006): <i>Add</i>
<i>Elettaria cardamomum</i>	Cardamom	Spi	Indian (Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982), extending to Indo-Malaya
<i>Eleusine coracana</i>	Finger millet	C	India one of its center (Vavilov, 1935)
<i>Emblica officinalis</i>	Indian gooseberry	FR	Indian (Vavilov, 1935; Zeven and De Wet, 1982) wild/ cultivated
<i>Euryale ferox</i>	Fox nut	FR	Native to temperate Asia [Ayurveda]: Independent cultivation, one of center
<i>Ficus elastica</i>	Rubber	PI	Indian (Vavilov, 1935; Zeven and De Wet, 1982), native to India & Indo-Malay: One of its center
<i>Flacourtia jangomas</i>	Indian plum	FR	Origin India (ARS/GRIN)

Species	Common name	Usage ¹	Status on Indian origin; Reference & Remark ²
<i>Garcinia cambogia</i>	Malabar tamarind	Spi	Native to Western Ghats, India, wild/cultivated
<i>Garcinia indica</i>	Kokum	FR	Indian (Vavilov, 1935)
<i>Girardinia diversifolia</i>	Nilgiri nettle	OT	Indian (Zeven and De Wet, 1982), Himalayan native
<i>Gossypium arboreum</i>	Diploid tree cotton	FI	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Grewia asiatica</i> ; syn. <i>G. subinaequalis</i>	Grewia or phalsa	FR	Indian (Zeven and De Wet, 1982)
<i>Hibiscus cannabinus</i>	Kenaf	FI	East African (Wilson, 1978); Indian (Vavilov, 1935): <i>Delete</i>
<i>Hibiscus sabdariffa</i>	Roselle	FI	East African (Wilson, 1978); Indian (Vavilov, 1935): <i>Delete</i>
<i>Hiptage benghalensis</i>	Hiptage	Orn	Native to India (ARS/GRIN): <i>Add</i>
<i>Hydnocarpus kurzii</i> ; syn. <i>Taraktogenos kurzii</i>	Chaulmoogra (oil)	M & AP	Indian (Zeven and De Wet, 1982)
<i>Indigofera tinctoria</i>	Indigo dye	OT	Indian (De Candolle, 1883; Vavilov, 1935), cultivated from ancient times
<i>Jasminum grandiflorum</i>	Jasmine	Orn	Indian (Zeven and De Wet, 1982)
<i>Jasminum malabaricum</i>	Jasmine	Orn	Native South India & Sri Lanka: <i>Add</i>
<i>Kaempferia galanga</i>	Chandramula	Spi	Indo-Malayan (Vavilov, 1935) extending to India
<i>Kalimeris indica</i>	Indian aster	Orn & M	Native to Asia, including India: One of its center
<i>Lablab purpureus</i> ; syn. <i>Dolichos lablab</i>	Hyacinth bean	GL	Indian (De Candolle, 1883; Vavilov, 1935; Harlan, 1975); African (Zeven and Zhukovsky, 1975): <i>Debated origin</i>
<i>Lactuca indica</i>	Indian lettuce	V	Indian (Vavilov, 1935) protected/harvested from wild
<i>Lagenaria siceraria</i>	Bottle gourd	V	African (Bates <i>et al.</i> , 1995); Indian (Vavilov, 1935): Transmigration & domestication
<i>Lawsonia alba</i>	Henna	M & dye	Cultivation in ancient Egypt and India (Vavilov, 1935), Ayurveda use: One of its center
<i>Limonia acidissima</i>	Wood apple	FR	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Luffa acutangula</i>	Ridge gourd	V	Indian (De Candolle, 1883; Vavilov, 1935; Zeven and De Wet, 1982)
<i>Luffa cylindrica</i>	Sponge gourd	V	India (De Candolle, 1883; Zeven and De Wet, 1982)
<i>Luffa hermaphrodita</i>	Ridge gourd variant	V	Indian (Singh and Bhandari, 1963): <i>Add</i>
<i>Macrotyloma uniflorum</i>	Horse gram	GL	Indian (Vavilov, 1935)
<i>Madhuca indica</i>	Mahua	AF	Indian tropical tree (Zeven and De Wet, 1982)
<i>Magnolia champaca</i>	Champa	Orn & M	Native to Asia, including India (ARS/GRIN), wild/ cultivated
<i>Magnolia gustavii</i>	Magnolia	Orn	Endemic to Northeast India (Nayar, 1996) wild/ cultivated
<i>Mangifera indica</i>	Mango	FR	Indian (De Candolle, 1883; Vavilov, 1935)
<i>Manilkara hexandra</i>	Khirmi,	FR	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Mimusops elengi</i>	Spanish cherry	FR	Indian (Vavilov, 1935), wild/cultivated
<i>Momordica balsamina</i>	Balsam apple	V	Indian (Decker-Walters, 1999) found with Sanskrit name: <i>Add</i>
<i>Momordica charantia</i>	Bitter gourd	V	Indian (Vavilov, 1935)
<i>Momordica dioica</i>	Small bitter gourd	V	Indian (Decker-Walters, 1999), has Sanskrit name: <i>Add</i>
<i>Morinda citrifolia</i>	Noni	OT	Indian (Vavilov, 1935; Zeven and De Wet, 1982; Singh <i>et al.</i> , 2011); Polynesian [(Morton, 1992): <i>Debated</i>
<i>Moringa oleifera</i>	Drumstick	V	Indian (Zeven and De Wet, 1982)
<i>Morus serrata</i>	Himalayan mulberry	OT	Native to Himalaya & South China (ARS/GRIN): One of its center
<i>Mucuna pruriens</i>	Velvet bean	FO	America (Sorenson and Johannessen, 2004); Indian [Zeven and De Wet, 1982; Eilittä <i>et al.</i> , 2002]: Center of diversity: <i>Delete</i>
<i>Murraya exotica</i>	Orange jasmine	Orn	Indian (Vavilov, 1935), native to India & China
<i>Murraya koenigii</i>	Curry leaf	Spi	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Musa sapientum</i>	Banana	FR	East India to Borneo (Harlan, 1975)

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<i>Nardostachys jatamansi</i>	Spikenard	M	Traditional Ayurveda herb, native to Himalaya
<i>Nelumbo nucifera</i>	Indian lotus	Orn	Indian (ARS/GRIN) wild/cultivated
<i>Nerium oleander</i>	Oleander	Orn	Indian (Zeven and De Wet, 1982), native
<i>Ocimum sanctum</i>	Holy basil	M & AP	Native to India, used in Ayurveda for thousands of years
<i>Oldenlandia umbellata</i>	Chay root (dye)	OT	Indian (Vavilov, 1935)
<i>Oryza sativa</i>	Rice	C	Indian (De Candolle, 1883; Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982): One of its center
<i>Panicum sumatrense</i> ; syn. <i>P. miliare</i>	Little millet	C	Indian (Harlan, 1975; Zeven and De Wet, 1982)
<i>Paspalum scrobiculatum</i>	Kodo millet	C	Indian (Vavilov, 1935; Harlan, 1975; Zeven and De Wet, 1982): A case of transdomestication
<i>Phoenix acaulis</i>	Dwarf date palm	Pl	Native to northern India & Myanmar (ARS/GRIN)
<i>Phoenix sylvestris</i>	Date palm	Pl	Indian (Vavilov, 1935)
<i>Picrorhiza kurroa</i>	Indian gentian	M	Native to Himalayas, ancient use in Ayurveda
<i>Pinus roxburghii</i>	Pine timber	Gum/resin	Native to Himalayas (ARS/GRIN), cultivated: <i>Add</i>
<i>Piper betle</i>	Betel leaf	Pl	Indian (Vavilov, 1935); SE Asia (Harlan, 1975): Spread with independent cultivation and use
<i>Piper longum</i>	Long pepper	Spi	Indian (De Candolle, 1883; Vavilov, 1935; Zeven and De Wet, 1982)
<i>Piper nigrum</i>	Black pepper	Spi	Indian (De Candolle, 1883; Vavilov, 1935; Zeven and De Wet, 1982), extending to Indo-Malaya
<i>Plectranthus scutellarioides</i>	Indian coleus	Orn	Native to Asia (India) & Australia (ARS/GRIN)
<i>Pluchea indica</i>	Indian fleabane	V	Indian (Vavilov, 1935), wild/cultivated
<i>Podophyllum hexandrum</i>	Himalayan May apple	Orn & M	Natural to Himalaya (ARS/GRIN), wild/cultivated
<i>Pogostemon heyneanus</i>	Patchouli (flavour)	M & AP	Indian (Vavilov, 1935), native used in perfumery
<i>Polyalthia longifolia</i>	False Ashoka	Orn	Native to India & Sri Lanka (ARS/GRIN): <i>Add</i>
<i>Pongamia pinnata</i> ; syn. <i>Millettia pinnata</i>	Karanj oilseed	Oi & M	Native to Asia, Australia, Pacific (ARS/GRIN), Ayurveda plant & oilseed tree, cultivated in India
<i>Praecitrullus fistulosus</i>	Round gourd	V	Indian (Zeven and De Wet, 1982): Origin Northwest India
<i>Prosopis cineraria</i>	Khejri	AF	Native to West Asia to India (ARS/GRIN), cultivated: One of its center
<i>Psophocarpus tetragonolobus</i>	Winged bean	GL	Indian (Vavilov, 1935; Harlan, 1975): Spread from New Guinea & transdomesticated
<i>Pueraria tuberosa</i>	Indian kudzu	FO & M	Native to India (ARS/GRIN), wild/ cultivated
<i>Putranjiva roxburghii</i>	Indian amulet tree	AF/ M	Tropical Asia/India native (ARS/GRIN), Ayurveda plant
<i>Raphanus caudatus</i>	Oil radish/mungra	V	Indian (Vavilov, 1935), pods used
<i>Rauvolfia serpentina</i>	Serpentina root	M	Indian (Zeven and De Wet, 1982): Ayurveda plant
<i>Rosa indica</i>	Rose	Orn	Domesticated Indian wild species: <i>Add</i>
<i>Rosa odorata</i> var. <i>gigantea</i>	Rose	Orn	Domesticated Northeast Indian wild species: <i>Add</i>
<i>Rubia tinctorum</i>	Madder (dye)	OT	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Rubus albescens</i>	Mysore raspberry	FR	Indian (Zeven and De Wet, 1982), extending to Myanmar
<i>Rubus ellipticus</i>	Yellow Himalayan raspberry	FR	From Himalaya extends to China & India, cultivation
<i>Rumex vesicarius</i>	Khatta palak	V	Indian (Zeven and De Wet, 1982) spread from Southern Europe, West Asia & North Africa: One of its center
<i>Saccharum officinarum</i>	Sugarcane	Sugar	Indian (De Candolle, 1883; Vavilov, 1935; Harlan, 1975) extending to Indo-Malaya

Species	Common name	Usage ¹	Status on Indian origin; Reference & Remark ²
<i>Salvadora oleoides</i>	Pilu	FR/ M	West Asia to India (ARS/GRIN), ancient cultivation cited in Mahabharata: One of its center
<i>Sansevieria zeylanica</i>	Snake plant	Fl/Orn/M	Indian (Vavilov, 1935), Ayurvedic, wild relatives found
<i>Santalum album</i>	Sandalwood	Timber/oil	Indian (Vavilov, 1935), native to semi-arid India
<i>Sapindus mukorossi</i>	N. Indian soapnut	OT	Asia (ARS/GRIN), cultivated in foothills of Himalayas: One of its center
<i>Sapindus trifoliatus</i>	Soapnut detergent	OT	Indian (Zeven and De Wet, 1982), native to South India
<i>Sesamum indicum</i>	Sesame	OI	Indian (Vavilov, 1935); Afro-Indian (Harlan, 1975)
<i>Sesbania aculeata</i>	Dhaincha	AF	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Sesbania cannabina</i>	Prickly sesbania	FO	Indian (Zeven and De Wet, 1982)
<i>Setaria italica</i> subsp. <i>viridis</i>	Green foxtail millet	C	Indian (Fuller, 2006), close to a foxtail variety: <i>Add</i>
<i>Setaria pumila</i> ; syn. <i>S. glauca</i>	Yellow foxtail millet	C	Indian [Gammie, 2011; Kimata <i>et al.</i> , 2000; De Wet, 1995), cultivated since long time: <i>Add</i>
<i>Setaria verticillata</i>	Bristly foxtail millet	C	Indian (Maheshwari and Singh, 1965), cultivated in Tamil Nadu: <i>Add</i>
<i>Shorea assamica</i>	Timber	OT	Native to India with healthy regenerating population
<i>Shorea robusta</i>	Sal timber	OT	Native to India (Orwa <i>et al.</i> , 2009), associated to Hindu traditions
<i>Solanum melongena</i>	Eggplant	V	Indian (De Candolle, 1883; Vavilov, 1935; Zeven and De Wet, 1982): Northeast India domesticate
<i>Strychnos nux-vomica</i>	Nux vomica	M, poison	Indian (Vavilov, 1935; Zeven and De Wet, 1982)
<i>Swertia chirayita</i>	Chiretta	M	Indian (Edwin and Chungath, 1988), Himalayan Ayurveda herb: <i>Add</i>
<i>Syzygium cumini</i>	Jamun/Jawa plum	FR	Indian (Vavilov, 1935) Native to India/Southeast Asia
<i>Syzygium jambos</i>	Rose apple	FR	Indian (De Candolle, 1883; Vavilov, 1935)
<i>Terminalia arjuna</i>	Arjun	M & AP	Indian (Vavilov, 1935) Ayurveda plant
<i>Terminalia bellirica</i>	Bahera	M & AP	Indian (Vavilov, 1935) Ayurveda plant
<i>Terminalia catappa</i>	Indian almond	FR & Orn	Indian (Vavilov, 1935) Ayurveda plant
<i>Terminalia chebula</i>	Harara	M & AP	Indian (Vavilov, 1935) Ayurveda plant
<i>Tinospora cordifolia</i>	Giloe	M	Indian, native, Ayurveda plant: <i>Add</i>
<i>Trachyspermum ammi</i>	Ammi or Ajwain	Spi	Native to Egypt, spread to India: India one of its center
<i>Trichosanthes anguina</i>	Snake gourd	V	Indian (De Candolle, 1883; Vavilov, 1935)
<i>Trichosanthes dioica</i>	Pointed gourd	V	Indian (Vavilov, 1935) : Middle Gangetic Plain domesticate
<i>Trigonella foenum-graecum</i>	Fenugreek	V	India (De Candolle, 1883; Vavilov, 1935) wild type and relatives spread from West Asia to Himalayas: One of its center
<i>Valeriana wallichii</i>	Indian valerian	M & AP	Indian, native to Himalaya, Ayurveda plant
<i>Vetiveria zizanioides</i>	Khas	M & AP	Indian (Zeven and De Wet, 1982)
<i>Vigna aconitifolia</i>	Moth bean	GL	Indian (De Candolle, 1883; Vavilov, 1935; Harlan, 1975), wild & cultivated
<i>Vigna mungo</i>	Black gram	GL	Indian (Harlan, 1975; Zeven and De Wet, 1982)
<i>Vigna radiata</i>	Green gram	GL	Indian (De Candolle, 1883; Vavilov, 1935; Harlan, 1975)
<i>Vigna trilobata</i>	Wild bean	FO	Native to Asia (ARS/GRIN): Sown in India & grazed
<i>Vigna umbellata</i>	Rice bean	GL	Indian [Vavilov, 1935; Harlan, 1975]; possibly Indo-China (Tomooka <i>et al.</i> , 1991; 2003)
<i>Vigna unguiculata</i>	Cowpea	GL	African (Ng, 1995); India [Vavilov, 1935]: <i>Delete</i>
<i>Withania somnifera</i>	Indian ginseng	M	Native to Asia to Africa (ARS/GRIN); wild & cultivated as Ayurveda herb in India
<i>Zingiber officinale</i>	Ginger	Spi	Indian (Zeven and De Wet, 1982) <i>Zingiber</i> word derived from Sanskrit
<i>Zingiber zerumbet</i>	Ginger	Con & M	Originating in India/Malay (Yob <i>et al.</i> , 2011) <i>Zingiber</i> derived from Sanskrit, wild/cultivated: <i>Add</i>
<i>Ziziphus mauritiana</i>	Indian jujube/ber	FR	India (De Candolle, 1883)

1. AF=Agroforestry; C=Cereal; Con=Condiment; Fl=Fiber; FO=Forage; FR=Fruit and nut; GL=Grain Legumes; M=Medicinal; M & AP=Medicinal and Aromatic Plant; OI=Oilseed; Orn=Ornamental; OT=Others; Pl=Plantation; Spi=Spices; V=Vegetable
Add and *delete* reflected for updating/finalization of the list of cultivated species of Indian origin

(18/255), Orchidaceae (16/1229), Rutaceae (15/80), Lamiaceae (15/454), Zingiberaceae (14/178) and Rubiaceae (10/616) (Arisdason and Lakshminarasimhan, 2015; Singh, 2015).

Introduced Exotics: In addition to the indigenously domesticated higher plant species, the agrobiodiversity in the Indian subcontinent was further enriched with the introduction of exotic cultivated plant species domesticated elsewhere, as is reflected by the presence of American cereals such as maize, grain amaranth, vegetables such as pumpkin, etc.; African cereals, such as pearl millet, sorghum, etc. and West Asian legumes, such as chickpea, field pea, grass pea, fanugreek, etc. in the archeological remains (Saraswat, 1992). The introduction of exotic crops got further boost during medieval period, after the discovery of the sea route to India in 1498 by Vasco da Gama's. Portuguese, British, Dutch, French and Spanish intensified the trans-oceanic and maritime trade, bringing more crop species to the Indian shores (16th Century), diversifying and enriching the agricultural crop diversity and gene pools of the subcontinent. Moguls, Spaniards, Portuguese and British introduced a number of cultivated plant species such as apple, pear, apricot, grape, almond, date palm, maize, potato, tomato, beans, onion, garlic, chili, lentil, rubber, pineapple, cashew nut, tobacco, etc.; Arabs brought clove, coriander, cumin, fennel, coffee, cocoa, cinchona, strawberry, blue berry, etc. and the Chinese brought peach, litchi, tea, soybean etc. Recently, a number of fruit species such as Kiwi fruit, Macadamia nut, etc., and ornamental plant species such as Cape jasmine, Gaznia, etc., have been introduced from the New World further enriching agrobiodiversity. Some representative major introduced crops are:

Cereals	Barley, finger millet, maize, oats, pearl millet, sorghum, wheat, and buckwheat, grain amaranth (pseudocereals), etc.
Grain Legumes	Chickpea, field pea, French bean, grass pea, soybean, etc.
Vegetables	Cabbage, carrot, cauliflower, chayote, chilli, cowpea, <i>Cucurbita</i> spp., leafy amaranth, leafy brassica, muskmelon/ <i>Cucumis</i> spp., onion, potato, sweet potato, tomato, etc.

Fruits and Nuts Apple, apricot, cherry, custard apple, grapes, guava, litchi, macadamia nut, papaya, peach, pear, pomegranate, sapota, etc.

Oilseeds Castor, groundnut, niger, rai, rapeseed, safflower, sesame, sunflower, etc.

Fibre crops Cotton, marida hemp, ramie, tossa jute, etc.

Forage/fodder crops Alfalfa, barseem, buffalo grass, Cango grass, clover, Gamba grass, Guniea grass, salt bush, *Setaria* grass, Sudan grass, Tiosinte, etc.

Spices/condiments Aniseed, celery, clove, coriander, cumin, fennel, nutmeg, tamarind, vanilla, etc.

Plantation crops Cashew nut, cocoa, coffee, oil palm, etc.

Medicinal plants *Aloe barbadensis*, anise, *Atropa* spp., *Digitalis* spp. (tilpushpi), *Hyoscyamus* spp., Liquorice, mentha, opium poppy, periwinkle, psyllium or isabgol, rose geranium, senna, *Solanum viarum*, etc.

Ornamental *Antirrhinum*, *Aster*, *Bougainvillea* spp., *Cactus* spp., *Calendula*, *Celosia*, *Chrysanthemum* spp., *Columnnea*, Cyclamen, Dahalia, *Delphinium*, *Dianthus* spp., Freesia, *Gladiolus* spp., *Lilium* spp., ornamental palms, *Tagetes*, *Zinnia*, etc.

Agroforestry *Acacia* spp., *Alstonia venenata*, Australian red cedar, *Delonix regia*, *Eucalyptus* spp., *Populus* spp., etc.

Others Cassava, guayule, hops, jojoba, mulberry, stevia, sugarbeet, tobacco, vilayati babul, etc.

Some of these have acclimatize/naturalized and adapted to diverse ecological conditions offered by

the Indian Subcontinent to such an extent that they appear natural to the land, and have thrown enormous genetic diversity, making India either secondary center of diversity for crops such as maize, finger millet, pearl millet, sorghum, cowpea, cluster bean, sesame, niger, safflower, tomato, muskmelon, pumpkin, chayote/chou-chou, chillies and amaranth, etc.; or regional center of diversity for crops such as barley, grain amaranth, buckwheat, proso millet, foxtail millet, chickpea, bottle gourd, etc.

Additionally, many plants are eaten/grazed by domesticated animals, others have attractive foliage, flowers and canopy of aesthetic value, and many others produce secondary metabolites as part of protective mechanism under stress, which have been found of medicinal significance even for human ailments, and therefore are either protected/domesticated and harvested from natural habitat or marginally cultivated as forage, ornamentals and medicinal and aromatic crop plants. These further enlarged the number of crop groups and cultivated species and thereby the scope of agrobiodiversity used for food and agriculture. A number of them are part of traditional knowledge. There have been attempts to estimate the total number of cultivated plant species in India; National Bureau of Plant Genetic Resources reported 583 in one of its Manuals (Pareek *et al.*, 2000), which were later rationalized to 480 (Nayar *et al.*, 2003), while the fourth country status report submitted to Convention of Biological Diversity (CBD), reported 800 species (Goyal and Arora, 2009). A recent attempt to produce an inventory of cultivated plant species and their wild relative listed 811 cultivated species belonging to 495 genera and 139 families (Singh *et al.*, 2013). The number of cultivated species (both indigenous and exotic) and their wild relatives in the broad groups occurring in India are: cereals (28 cultivated with 70 wild relatives), grain legumes (18, 36), vegetables (105, 168), fruits and nuts (117, 176), oilseeds (19, 13), sugar yielding plants (3, 18), fiber crops (12, 23), forage/fodder (96, 33), spices and condiments (46, 123), plantation crops (20, 21), medicinal and aromatic plants (89, 58), ornamental (182, 90), agro-forestry species (35, 31), and others (41, 14) (Singh *et al.*, 2013).

Genetic Diversity within Cultivated Species

The genetic variation within a population and among

the populations within a species is generally referred to as the genetic diversity. Genetic diversity allows a species to adapt over time and space to diverse, and the changing environment by evolving itself for adaptation suited to prevailing conditions, resistance and tolerance to diseases and climatic stresses, mechanisms such as predator avoidance etc., and in case of cultivated species to diverse man-made cultivation conditions (agro-climate). India has geographical area of about 329 million ha, excluding the marine system. Of the total landmass, the crop land available is estimated to be around 143 million ha. The plant species, both indigenously domesticated and introduced, have interacted with climatic conditions of the 21 broad agro-ecological regions described by Sehgal *et al.* (1992) and within these regions with the microhabitats, developed and used by the traditional farmers to their advantage. These farmers have further worked with these cultivated species for thousands of years through the process of selection, hybridization and adaptation, and thereby evolving and cultivating an enormous range of cultivars. Further, the local communities, based on crops, crop combinations, crop rotation, physical conditions, etc. have evolved around 120 production systems, as estimated by the ICAR. This has resulted in further genetic diversification at genotypic level. The Indian farmers over millennia have generated a large amount of genetic diversity in most cultivated species. Until recent past, i.e., 50 year ago before the green revolution, it was not uncommon to observe significant diversity in the same crop within the same village, or even within the same field, particularly in staple food crops like rice and wheat. For example, in rice (*Oryza sativa* var. *indica*) Dr. Richharia collected 18,541 cultivars (called Raipur collections) from Chhattisgarh region only. Similarly, genetic diversity has expanded in millets, pulses, oilseeds and scores of vegetables and fruits both in tropical and temperate regions of the subcontinent with cultivation/maintenance of hundreds and thousands of landraces/farmer's varieties by the Indian farmers. Table 2 lists the number of distinct indigenous collection/accessions held by the National Genebank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi and the crop-based National Active Germplasm Sites spread across the country in major crops. The possibility of a large number of duplicates in these collections can not be denied, but the numbers do

Table 2: Number of indigenous/total accessions conserved in major crops of various crop groups, reflecting richness of genetic diversity

Crop group/cultivated species	Indigenous collections	Total collections
Cereals		
Rice, <i>Oryza sativa</i>	85793	89258
Wheat, <i>Triticum aestivum</i>	13564	15651
Maize, <i>Zea mays</i>	7418	8188
Kodo millet, <i>Paspalum scrobiculatum</i>	2229	2230
Pearl millet, <i>Pennisetum glaucum</i>	2728	2755
Sorghum, <i>Sorghum bicolor</i>	10927	19402
Grain Legumes		
Pigeonpea, <i>Cajanus cajan</i>	9504	9650
Chickpea, <i>Cicer arietinum</i>	11211	13401
Black gram, <i>Vigna mungo</i>	5820	5820
Green gram, <i>Vigna radiata</i>	3628	3654
Oilseeds		
Indian mustard, <i>Brassica juncea</i>	3677 ²	10660
Groundnut, <i>Arachis hypogaea</i>	7931	11962
Safflower, <i>Carthamus tinctorius</i>	4624	7152
Sugar-yielding Plants		
Sugarcane, <i>Saccharum officinarum</i>	794	1645
Fibre Crops		
White jute, <i>Corchorus capsularis</i>	2507	2663
Sun hemp, <i>Crotalaria juncea</i>	122	122
Asiatic cotton, <i>Gossypium arboreum</i> ; <i>G. herbaceum</i>	1867 + 573 ²	8815
Forage/Fodder crops		
Indian sweet clover, <i>Melilotus indicus</i> (L.) All.	77 ²	77
Prickly sesbania, <i>Sesbania cannabina</i>	622	629
Indian sandbur, <i>Cenchrus biflorus</i> (Vast diversity ⁴)		
Vegetables		
Okra, <i>Abelmoschus esculentus</i>	2454	2691
Eggplant, <i>Solanum melongena</i>	4821	
Tomato, <i>Lycopersicon esculentum</i>	406	1666
Cucurbit vegetables	2650	2709
Leguminous vegetables	12	12
Cole group (<i>Brassica</i> 's)	55	308
Fruits and Nuts		
<i>Citrus</i> spp.	51 ²	
Mango, <i>Mangifera indica</i>	1200	
<i>Musa</i> spp. (field collections)	1407 ²	
<i>Prunus</i> spp. (collections)	260 ²	
<i>Pyrus</i> spp. (collections)	117 ²	

Crop group/cultivated species	Indigenous collections	Total collections
Spices and condiments		
Black pepper, <i>Piper nigrum</i> (9 exotic)	3172 ³	3181
Cardamom, <i>Elettaria cardamomum</i>	618 ³	
Cinnamon, <i>Cinnamomum</i> spp., including <i>Cassia</i>	408 ³	
Cumin, <i>Cuminum cyminum</i> (five institute)	526 ²	
Turmeric, <i>Curcuma longa</i>	1404 ³	
Ginger, <i>Zingiber officinale</i>	668 ³	
Plantation crops		
Tea, <i>Camellia sinensis</i> (TES & UPASI)	2532 + 440 ²	2972
Cocoonut, <i>Cocos nucifera</i> (CPCRI)	150	421
Medicinal and Aromatic Plants¹		
Kalmegh, <i>Andrographis paniculata</i>	94	94
Safed Musli, <i>Chlorophytum borivilianum</i>	34	34
Datura, <i>Datura metel</i>	33	40
Tulsi, <i>Ocimum sanctum</i>	152	152
Sarpagandha, <i>Rauvolfia serpentina</i>	22	22
Giloe, <i>Tinospora cordifolia</i>	4	4
Ashwagandha, <i>Withania somnifera</i>	137	137
Ornamental plants		
Bougainvillea, <i>Bougainvillea</i> spp. (Growing in gardens)	400	
Champa, <i>Magnolia</i> spp.	1	1
Malabar jasmine, <i>Jasminum malabaricum</i>	56	
Kaner, <i>Nerium oleander</i>	Vast diversity ⁴	
Rose, <i>Rosa</i> spp. (11 indigenous spp.; 600 cultivars)	600	
Agro-forestry Species		
Acacia, <i>Acacia catechu</i>	227	227
Babul, <i>Acacia nilotica</i> (immense diversity)	Vast diversity ⁴	
Neem, <i>Azadirachta indica</i> (immense diversity)	Vast diversity ⁴	
Khejri, <i>Prosopis cineraria</i>	48	48
Other crops		
Bamboo, <i>Bambusa</i> spp.	4	4
Indian arrowroot, <i>Curcuma angustifolia</i>	Vast diversity ⁴	
Karanji, <i>Pongamia pinnata</i>	826	826
Henna, <i>Lawsonia inermis</i>	110	110
Jatropha, <i>Jatropha curcas</i>	2053	2053

Source: <http://www.nbpgr.ernet.in:8080/PGRPortal/SimpleSearch.aspx>. 1. 2000 accession of 150 species of medicinal plant collected between 1980-2000; 2. Conserved at respective crop based institute; 3. Prasath *et al.*, (2015): At Indian Institute of Spices Research; 4. Not accounted/conserved *ex situ*

reflect presence of rich and high amount of genetic diversity generated and made available in both indigenous and exotic crops overtime and space, depicting contributions of Indian farmers and farming communities over the centuries.

The evaluation of this genetic diversity collected from different regions of the country invariably shows specific association/evolution of certain gene or gene complexes with agroclimatic conditions or agroclimatic zones that it belongs to. For example, the coastal plains agroclimatic zone is associated with evolution of genetic diversity for tolerance to salinity, submergence, etc. in case of rice and the arid and semi-arid zones are associated with earliness in maturity and tolerance to water stress in case of cereals (millets), legumes and oilseeds.

Wild Relatives of Cultivated Plant Species

Phyto-geographical Diversity

The distribution of wild relatives of crop/cultivated plant species is associated with biogeographical or phytogeographical diversity of the Indian Subcontinent. The Indian Subcontinent is a confluence of at least two biogeographical realms, i.e., Palaearctic and Oriental. The most commonly acknowledged classification of biogeographical zones was proposed by Udvardy (1975) and it recognized 12 biogeographical provinces in India falling in these two realms. An attempt for phytogeographical zonation, based on type of vegetation by Gadgil and Meher Homji (1990), distinguished 16 phytogeographical zones. Roger and Panwar (1988) tried to distinguish biogeographic regions based on faunistic information. However, their classification is also predominantly dependent on plant-community- distribution. Because plant species components provide key even to identify the probable habitat/presence of animals. Their classification included 10 biogeographic zones and 26 biotic provinces. Their maps were further revised by Rodgers *et al.* (2002). Using GIS techniques, they distinguished 10 biogeographical zones and 26 biotic provinces. This classification was done using various factors such as altitude, moisture, topography, rainfall, etc. Considering the natural distribution of the wild species related to crops/cultivated species, the association of these species is predominantly discussed in relation to these commonly agreed 10 biogeographic

zones with further classification of Deccan peninsula into India peninsula and Eastern Ghats, to accommodate the considerable variation in forest and vegetation types as per altitude found in Eastern Ghats (Table 3).

Cultivated Plant Wild Relatives Species Diversity

The centers of origin of crop/cultivated plant species, most frequently are also centers of diversity, particularly for the wild relatives from which the cultivated species were domesticated. Wild related species distribution has also been used as one of the indices to discern the centers of origin of cultivated species. They have offered a rich reservoir of genetic diversity that can be utilized by the breeders in genetic improvement of crop species. In fact, the contribution of wild relatives in genetic improvement of crops has been immense in a large number of crops and needs greater emphasis under the changing global scenario, because of their greater resilience against environmental (climatic) stresses/changes. The wild species related to the cultivated species domesticated in India or the wild relatives of other crop species with extended distribution to India form the peripheral component of agrobiodiversity around the cultivated species gene pool, and it is quite substantial. The first estimate of the wild relatives of crop plants occurring in India was provided by Arora and Nayar (1984) with 334 species, having a break up of 51 in cereals and millets, 31 in grain legumes, 109 in fruits, 54 in vegetables, 12 in oilseeds, 24 in fibers, 27 in spices and condiments and 26 under others. They belonged to 48 families and 116 genera. The India's fourth report submitted to CBD lists 367 wild relatives of crop plants (Goyal and Arora, 2009). The present review, to simplify the estimation, includes the wild progenitors (closest wild relatives, or wild subspecies), some of which may require further research, and does not include taxa related to species known to have been domesticated in Africa or elsewhere, but includes naturalized wild species and distant congeneric wild relatives based on gene pool concept of taxonomic/generic affinity, and cross-compatibility relationship with the cultivated species. It includes wild and weedy species/races of cultivated species that are freely cross-compatible producing nearly fertile hybrids i.e., *primary gene pool*; wild relatives, which are cross-compatible (despite ploidy/genomic differences), but produce hybrids with reduced fertility

Table 3: Representative wild relatives of cultivated species found in different bio-geographic zones of India

Biogeographical Zones ¹	Wild relatives of cultivated species reported ²
Trans-Himalayan zone (Ladakh and Adjacent Areas)	<i>Allium carolinianum</i> , <i>A. chitralicum</i> , <i>A. gilgiticum</i> , <i>A. rubellum</i> , <i>Amaranthus spinosus</i> , <i>Cicer macracanthum</i> , <i>C. microphyllum</i> , <i>Fagopyrum cymosum</i> , <i>Hippophae salicifolia</i> , <i>H. tibetana</i> , <i>Hordeum brevisubulatum</i> ; syn. <i>H. turkestanicum</i> , <i>H. spontaneum</i> , <i>Lactuca dolichophylla</i> , <i>Lepidium latifolium</i> , <i>Populus ciliata</i> , <i>P. gamblei</i> , <i>P. euphratica</i> , <i>P. jacquemontiana</i> var. <i>glauca</i> , <i>P. laurifolia</i> , <i>Salix acmophylla</i> , <i>S. denticulata</i> , <i>S. elegans</i> , <i>S. fragilis</i> , <i>S. sclerophylla</i> , <i>S. wallichiana</i> , <i>Trigonella emodi</i> , and <i>T. podperae</i> (27).
Himalayan zone (Western, North-western & Eastern Himalayas)	<p>Western and Northwestern Himalaya: <i>Abelmoschus manihot</i>, <i>A. moschatus</i>, <i>A. tuberculatus</i>, <i>Aegilops tauschii</i>, <i>Allium altaicum</i>, <i>A. ampeloprasum</i>; syn. <i>A. porrum</i>, <i>A. cernuum</i>, <i>A. chinense</i>, <i>A. fistulosum</i>, <i>A. schoenoprasum</i>, <i>A. senescens</i>, <i>A. stracheyi</i>, <i>A. tuberosum</i>, <i>Avena barbata</i>, <i>A. fatua</i> ssp. <i>fatua</i>, <i>A. sterilis</i> ssp. <i>ludoviciana</i>, <i>Cajanus mollis</i>, <i>C. scarabaeoides</i>, <i>Chenopodium album</i>, <i>C. ambrosioides</i>, <i>C. botrys</i>, <i>C. foliosum</i>, <i>C. giganteum</i>, <i>C. glaucum</i>, <i>C. hybridum</i>, <i>C. murale</i>, <i>Cicer microphyllum</i>, <i>Cucumis hardwickii</i>, <i>Dioscorea hispida</i>, <i>Elymus himalayanus</i>, <i>E. dahuricus</i>, <i>E. dentatus</i>, <i>Fagopyrum acutatum</i>, <i>F. cymosum</i>, <i>F. tartaricum</i> (also cultivated), <i>Hordeum aegiceras</i>, <i>H. brevisubulatum</i>, <i>H. murinum</i> ssp. <i>glaucum</i>, <i>H. spontaneum</i>, <i>Indigofera heterantha</i>, <i>Lactuca serriola</i>, <i>Linum perenne</i>, <i>L. strictum</i>, <i>Luffa graveolens</i>, <i>Malus baccata</i>, <i>M. pumila</i>, <i>Mentha x piperita</i>, <i>M. arvensis</i>, <i>M. spicata</i>, <i>Oryza rufipogon</i>, <i>Prunus jacquemontii</i>, <i>P. jenkinsii</i>, <i>P. tomentosa</i>, <i>Ribes glaciale</i>, <i>Rosa sericea</i>, <i>R. webbiana</i>, <i>Rubus fruticosus</i>, <i>R. hypargyris</i>, <i>R. lanatus</i>, <i>R. moluccanus</i>, <i>R. niveus</i>, <i>R. nutantiflorus</i>, <i>Rumex acetosella</i>, <i>R. patiensia</i>, <i>R. vesicarius</i>, <i>Saccharum filifolium</i>, <i>S. narenga</i>, <i>Salix tetrasperma</i>, <i>Setaria viridis</i>, <i>Solanum incanum</i>, <i>S. xanthocarpum</i>, <i>Taxus wallichiana</i>, <i>Sorbus aucuparia</i>, <i>S. lanata</i>, <i>Trichosanthes himalensis</i>, <i>T. multiloba</i>, <i>T. tricuspidata</i>, <i>Trigonella cachemiriana</i>, <i>T. emodi</i>, <i>T. fimbriata</i>, <i>T. gracilis</i>, <i>T. podperae</i>, <i>Triticum sphaerococcum</i>, <i>Vigna trilobata</i>, <i>V. umbellata</i>, <i>V. vexillata</i> var. <i>vexillata</i>, and <i>Ziziphus oxyphylla</i> (87).</p> <p>Eastern Himalaya: <i>Actinidia strigosa</i>, <i>Albizia kalkora</i>, <i>Allium angulosum</i>, <i>A. wallichii</i>, <i>Amomum aromaticum</i>, <i>A. dealbatum</i>, <i>A. subulatum</i>, <i>Amorphophallus bulbifer</i>, <i>Areca triandra</i>, <i>Artocarpus chaplasha</i>, <i>Avena fatua</i>, <i>Brassica trilocularis</i>, <i>Cajanus elongatus</i>, <i>C. grandiflorus</i>, <i>C. mollis</i>, <i>C. scarabaeoides</i>, <i>C. villosus</i>, <i>Camellia caudata</i>, <i>C. drupifera</i>, <i>C. irrawadiensis</i>, <i>C. kissi</i>, <i>C. sinensis</i>, <i>C. taliensis</i>, <i>Cinnamomum bejolghota</i>; syn. <i>C. obtusifolium</i>, <i>C. caudatum</i>, <i>C. glanduliferum</i>, <i>C. impressinervium</i>, <i>Citrus aurantium</i>, <i>Coffea benghalensis</i>, <i>Cucumis hystrix</i>, <i>Curcuma amada</i>, <i>C. aromatica</i>, <i>C. caesia</i>, <i>C. montana</i>, <i>Digitaria cruciata</i>, <i>Dioscorea deltoidea</i>, <i>D. hamiltonii</i>, <i>D. hispida</i>, <i>D. kamoonsensis</i>, <i>D. lepcharum</i>, <i>D. pentaphylla</i>, <i>D. prazeri</i>, <i>D. wallichii</i>, <i>D. wattii</i>, <i>Duchesnea indica</i>, <i>Eleusine indica</i>, <i>Elymus tangutorum</i>, <i>E. thoroldianus</i>, <i>Eriobotrya dubia</i>, <i>E. hookeriana</i>, <i>E. petiolata</i>, <i>Fragaria vesca</i>, <i>Garcinia hombroniana</i>, <i>G. xanthochymus</i>, <i>Glycine soja</i>, <i>Hordeum agriocrithon</i>, <i>H. spontaneum</i>, <i>Kaempferia sikkimensis</i>, <i>Lactuca cooperi</i>, <i>Lepidium capitatum</i>, <i>Luffa graveolens</i>, <i>Malus baccata</i>, <i>M. sikkimensis</i>, <i>Mangifera khasiana</i>, <i>M. sylvatica</i>, <i>Momordica macrophylla</i>, <i>Musa acuminata</i>, <i>M. balbisiana</i>, <i>M. cheesmani</i>, <i>M. mannii</i>, <i>M. nagensium</i>, <i>M. sikkimensis</i>, <i>M. velutina</i>, <i>Myrica esculenta</i>, <i>Neoluffa sikkimensis</i>, <i>Oryza meyeriana</i>, <i>O. minuta</i>, <i>Phoenix acaulis</i>, <i>P. rupicola</i>, <i>Pimpinella urceolata</i>, <i>Piper betleoides</i>, <i>P. hamiltonii</i>, <i>P. laxivenum</i>, <i>P. mungpooanum</i>, <i>P. ovatistigmum</i>, <i>P. peepuloides</i>, <i>P. sikkimense</i>, <i>P. sonadense</i>, <i>P. tenuirameum</i>, <i>P. wallichii</i>, <i>Prunus arborea</i>, <i>P. bracteopadus</i>, <i>P. jenkinsii</i>, <i>Pyrus pashia</i>, <i>P. serotina</i>, <i>Rhus griffithii</i>, <i>Ribes acuminatum</i>, <i>R. glaciale</i>, <i>Rubus ghankantus</i>, <i>R. hypargyris</i>, <i>R. lineatus</i>, <i>R. moluccanus</i>, <i>R. reticulatus</i>, <i>R. senchalensis</i>, <i>R. sikkimensis</i>, <i>R. wardii</i>, <i>Saccharum filifolium</i>; syn. <i>Erianthus filifolius</i>, <i>S. longisetosum</i>, <i>S. ravennae</i>, <i>S. sikkimense</i>, <i>S. williamsii</i>, <i>Solanum kurzii</i>, <i>S. spirale</i>, <i>Sorbus himalaica</i>, <i>S. microphylla</i>, <i>S. vestita</i>, <i>Trichosanthes cordata</i>, <i>T. tricuspidata</i>, <i>T. wallichiana</i>, <i>Vigna clarkei</i>, <i>Vitis himalayana</i>, <i>V. lanata</i>, <i>V. parviflora</i>, <i>Zingiber capitatum</i>, <i>Z. chrysanthum</i>, <i>Z. clarkei</i>, and <i>Z. zerumbet</i> (129).</p>
Northeast Zone [Brahmaputra Valley (Assam) and northeast Hills]	<i>Alocasia cucullata</i> , <i>A. macrorrhiza</i> , <i>Amomum aromaticum</i> , <i>Amorphophallus bulbifer</i> , <i>Brassica trilocularis</i> ; syn. <i>B. rapa</i> var. <i>trilocularis</i> , <i>Areca triandra</i> , <i>Camellia caudata</i> , <i>C. kissi</i> , <i>Canavalia gladiata</i> , <i>C. virosa</i> , <i>Cinnamomum bejolghota</i> ; syn. <i>C. obtusifolium</i> , <i>C. glanduliferum</i> , <i>C. paniculatum</i> , <i>C. pauciflorum</i> , <i>Citrus assamensis</i> , <i>C. hystrix</i> , <i>C. indica</i> , <i>C. jambhiri</i> , <i>C. latipes</i> , <i>C. medica</i> , <i>Coffea fragrans</i> , <i>C. jenkinsii</i> ; syn. <i>Nostolachma jenkinsii</i> , <i>C. khasiana</i> , <i>Colocasia fallax</i> , <i>C. mannii</i> , <i>Corchorus capsularis</i> (wild form), <i>C. pseudo-olitorius</i> , <i>Cucumis hardwickii</i> , <i>C. hystrix</i> , <i>Curcuma aeruginosa</i> , <i>C. amada</i> , <i>C. aromatica</i> , <i>C. comosa</i> , <i>C. latifolia</i> , <i>C. soloensis</i> , <i>C. sylvatica</i> , <i>Digitaria cruciata</i> , <i>Dioscorea alata</i> , <i>D. decipiens</i> , <i>D. hamiltonii</i> , <i>D. hispida</i> , <i>D. lepcharum</i> , <i>D. pentaphylla</i> , <i>D. prazeri</i> , <i>D. pubera</i> , <i>D. trinervia</i> , <i>D. wattii</i> , <i>Diospyros lotus</i> , <i>Dolichos falcatus</i> , <i>Echinochloa crus-galli</i> , <i>Elaeocarpus floribundus</i> , <i>Eleusine indica</i> , <i>Erianthus ravennae</i> , <i>Fragaria nilgerrensis</i> , <i>Garcinia cowa</i> , <i>G. spicata</i> , <i>G. sopsopia</i> , <i>Gossypium arboreum</i> , <i>Hibiscus furcatus</i> , <i>Indigofera dosua</i> , <i>I. heterantha</i> (Himalyan indigo), <i>Leersia hexendra</i> (Manipur), <i>Luffa aegyptiaca</i> , <i>L. graveolens</i> , <i>Malus baccata</i> , <i>Mangifera khasiana</i> , <i>M. sylvatica</i> , <i>Miscanthus nepalensis</i> , <i>M. nudipes</i> , <i>M. taylorii</i> , <i>M. wardii</i> , <i>Momordica macrophylla</i> , <i>M. subangulata</i> , <i>Mucuna bracteata</i> , <i>Musa</i>

acuminata, *M. assamica*, *M. balbisiana*, *M. cheesmani*, *M. flaviflora*; syn. *M. thomsoni*, *M. itinerans*, *M. mannii*, *M. nagensium*, *M. paradisiaca*, *M. sikkimensis*, *M. superba*; syn. *Ensete superba*, *M. velutina*, *Myrica esculenta*, *Narenga fallax*; syn. *Saccharum longifolium*, *Nicotiana excelsior*, *Oryza granulata*, *O. rufipogon*, *Phoenix acaulis*, *P. dactylifera*, *P. robusta*, *P. rupicola*, *Piper attenuatum*, *P. cornilimbium*, *P. hamiltonii*, *P. khasianum*, *P. makruense*, *P. meeboldii*, *P. oldhamii*, *P. peepuloides*, *P. sylvaticum*, *P. wallichii*, *Prunus arborea*, *P. cornuta*, *P. cerasioides*, *P. jenkinsii*, *P. napanlensis*, *P. undulata*, *P. wallichii*; *Psilanthus bengalensis*; syn. *Coffea bengalensis*, *Pyrus khasiana*, *P. pashia*, *P. pyrifolia*, *Rosa gigantea*, *R. longicuspis*, *Rubus ellipticus*, *R. moluccanus*, *R. paniculatus*, *R. rosifolius*, *Rumex dentatus*, *Saccharum longisetosum*, *S. procerum*, *S. rufipilum*, *S. wardii*, *Sclerostachya fusca*, *Setaria pallide-fusca*, *Solanum khasianum*, *S. kurzii*, *S. nigrum*, *S. spirale*, *S. torvum*, *Sorbus aucuparia*, *S. vestita*, *Syzygium assamicum*, *Trichosanthes bracteata*, *T. cordata*, *T. cucumerina*, *T. himalensis*, *T. khasiana*, *T. tomentosa*, *T. wallichiana*, *Vigna clarkei*, *V. trilobata*, *Zingiber capitatum*, *Z. cassumunar*, *Z. intermedium*, *Z. rubens*, and *Z. spectabile* (150).

Desert zone
(Thar & Kutch)

Acacia nilotica (wild form), *Aegle marmelos* (wild form), *Amaranthus spinosus*, *Citrullus colocynthis*, *Commiphora wightii* (wild form), *C. caudata*, *Crotalaria burhia*, *Cucumis prophetarum*, *Ipomoea cairica* var. *semineglabra*, *Momordica balsamina*, *Moringa concanensis*, *Psoralea corylifolia*, *Saccharum spontaneum*, *Salvadora persica*, *Sorghum bicolor* (weedy forms), *Sorghum halepense*, *Withania coagulans*, and *Ziziphus nummularia* (18).

Semi-Arid zone (Gujarat,
parts of Northwestern
Madhya Pradesh)

Corchorus olitorius, *Grewia bicolor*, *G. flavescens*, *Indigofera coerulea* var. *monosperma*, *I. cordifolia*, *Salvadora oleoides*, *Sesamum alatum*, *Sesbania concolor*, *Solanum nigrum*, *S. purpureolineatum*, *Sorghum halepense*, *Trigonella occulta*, *T. uncata*, *Vinga khandalensis*, *Ziziphus nummularia* (jharber), and *Z. williamsii* (16).

Gangetic Plains (Upper,
middle & Lower Gangetic
Plains)

Abelmoschus cancellatus, *A. manihot*, *A. tuberculatus*, *Allium stracheyi*, *Amaranthus polygamus*, *A. spinosus*, *Amorphophallus bulbifer*, *Asparagus curillus*, *A. sarmentosus*, *Brassica quadrivalvis*, *Cajanus scarabaeoides*, *C. volubilis*; syn. *C. crassa*, *Carissa spinarum*, *Carthamus oxyacantha*, *Carum villosum*, *Chenopodium album*, *C. murale*, *Cichorium intybus*, *Coccinia indica*; syn. *C. grandis*, *Coix agrestis*, *C. aquatica*, *C. lacryma-jobi*, *Corchorus trilocularis*, *C. acutangulus*, *Cucumis setosus*, *Curcuma amada*, *C. ferruginea*, *C. leucorhiza*, *C. rubescens*, *Dioscorea deltoidea*, *D. hamiltonii*, *D. kalkapershadii*, *Echinochloa colonum*, *E. crus-galli*, *Ficus palmata*, *Grewia asiatica* (wild form), *G. optiva*, *Hibiscus surattensis*, *Indigofera caerulea*, *I. gangetica*, *I. thothathri*, *Ipomoea aquatica*, *Lactuca remotiflora*, *Lathyrus aphaca*, *Lepidium draba*, *Luffa echinata* var. *longistylis*, *Malva sylvestris*, *Momordica balsamina*, *M. cochinchinensis*, *M. subangulata* var. *renigera*, *Oryza rufipogon*, *O. sativa* var. *spontanea*; syn. *O. perennis*, *Panicum notatum*, *Paspalum scrobiculatum*, *Pennisetum orientale*, *Phoenix paludosa*, *P. robusta*, *P. sylvestris*, *Piper sylvaticum*, *Polyalthia suberosa*, *Prunus rufa*, *Psilanthus bengalensis*; syn. *Coffea bengalensis*, *Saccharum arundinaceum*; syn. *S. procerum*, *S. bengalense*, *S. longisetosum*, *S. narenga*, *S. ravennae*, *S. spontaneum*, *S. williamsii*, *Sclerophyllum coarctatum*; syn. *Oryza coarctata* (tetraploid), *Sclerostachya fusca*, *Setaria sphacelata*, *Solanum incanum*, *S. indicum*, *S. surattense*, *Syzygium heyneanum*, *Taxus wallichiana* var. *chinensis*, *Trichosanthes bracteata*, *T. cucumerina*, *Trigonella corniculata*, *T. obcordata*, *T. occulta*, *T. polycerata*, *Urena repanda*, *Vigna prainiana*, *V. radiata* var. *sublobata*, *Vitis latifolia*, *Ziziphus oenoplia*, and *Z. oxyphylla* (90).

Indian Peninsula
(Central Highlands: Malwa
Plateau Bundelkhand, Chota
Nagpur and Central and
Deccan Plateau)

Central Highland: *Abelmoschus crinitus*; syn. *A. cancellatus*, *A. ficulneus*, *A. manihot* ssp. *tetraphyllum* var. *megaspermus*, *A. manihot* ssp. *tetraphyllum* var. *pungens*; syn. *Hibiscus pungens*, *A. tuberculatus*, *Acacia donaldii*, *Alocasia macrorrhizos*, *Alysicarpus monilifer*; syn. *Hedysarum moniliferum*, *Amaranthus spinosus*, *A. viridis*, *Cajanus cajanifolius*, *C. scarabaeoides*, *C. sericeus*, *Coccinia indica*; syn. *C. grandis*, *Coix aquatica*, *Colocasia esculenta*, *Corchorus fascicularis*, *C. tridens*, *Cucumis callosus*, *C. hardwickii*, *C. setosus*, *Cucurma longa*; syn. *C. domestica*, *C. angustifolia*, *Dioscorea bulbifera*; syn. *D. sativa*, *D. glabra*, *D. wightii*, *Diospyros chloroxylon*, *D. melanoxylon* (wild form), *D. peregrina*, *D. sylvatica*, *D. tomentosa*, *Echinochloa crus-galli*, *Eleusine indica*, *Grewia damine*, *G. tenax*, *G. villosa*, *Indigofera pulchella*, *I. tinctoria*, *Madhuca indica* (wild form), *Momordica balsamina*, *M. dioica*, *M. subangulata* var. *renigera*, *Mucuna capitata*, *Narenga porphyrocoma*, *Oryza rufipogon*, *Phoenix robusta*, *P. sylvestris*, *Rhynchosia bracteata*, *R. minima*, *R. rufescens*, *Saccharum spontaneum*, *Sesamum laciniatum*, *Solanum torvum*, *Sorghum cernuum* var. *yemense*, *S. controversum*, *S. halepense*; syn. *S. miliaceum*, *S. nitidum*, *Spondias pinnata*, *Syzygium cumini* (wild form), *Trigonella corniculata*, *T. occulta*, *Vigna aconitifolia*, *V. dalzelliana*, *V. hainiana*, *V. mungo* var. *sylvestris*, *V. radiata* var. *setulosa*; syn. *V. sublobata*, *V. trilobata*, *Zingiber capitatum*, *Z. cassumunar*; syn. *Z. purpureum*, *Z. mauritiana*, (wild form), *Z. nummularia*, and *Z. xylopyra* (72).

Central and Deccan Plateau: *Abelmoschus ficulneus*, *A. manihot* ssp. *tetraphyllus* var. *megaspermum*, *Boehmeria platyphylla*, *Canavalia stocksii* (variant of *C. ensiformis*), *Capparis decidua*, *Chionachne koenigii*, *Cichorium intybus*, *Corchorus antichorus*; syn. *C. depressus*, *C. urticaefolius*, *Crotalaria* spp. (27), *Eleusine indica*, *Grewia tenax*, *G. villosa*, *Indigofera deccanensis*, *I. glandulosa* var. *sykesii*, *Linum mysorensense*, *Malva rotundifolia*, *M. subangulata*, *M. sylvestris*, *Momordica cymbalaria*, *Panicum hippothesis* (grains are cooked like rice), *P. psilopodium*, *P. trypheron*, *Phoenix robusta*, *P. sylvestris*, *Sesamum laciniatum*, *Setaria glauca*, *S. pallide-fusca*, *S. pumila*, *Solanum nigrum*, *Sorghum deccanense*, *S. stapfii*, *Vigna hainiana*, *Vigna trilobata*, and *V. trilobata* var. *pusilla* (34 + 26 *Crotalaria*).

Eastern Ghats

(Northeastern Ghats: Koraput, Bastar (Dandakaranya), parts of Andhra Pradesh; South-central Eastern Ghats: parts of Andhra Pradesh and Tamil Nadu)

Abelmoschus angulosus, *A. cancellatus*, *A. crinitus*, *A. ficulneus*, *A. moschatus*, *Allium porrum*, *Amaranthus dubius*, *A. spinosus*, *A. tenuifolius*, *Amorphophallus campanulatus*, *Boehmeria platyphylla*, *Cajanus cajanifolia*, *C. scarabaeoides*, *C. sericeus*, *C. volubilis*, *Canavalia stocksii*; syn. *C. cathartica*, *Carissa inermis*, *Cissus vitiginea*, *Coleus forskohlii*, *Corchorus antichorus*, *Crotalaria perfoliata*, *C. shevaroyensis*, *Cucumis hystrix*, *C. melo* var. *agrestis*, *C. pubescens*, *Cucurma amada*, *C. angustifolia*, *C. pseudomontana*, *C. montana*, *C. zedoaria*, *Cymbopogon flexuosus*, *Dioscorea bulbifera*, *D. hamiltonii*, *D. hispida*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*, *D. puber*, *D. wallichii*, *D. wightii*, *Diospyros melanoxylon*, *D. peregrina*, *D. racemosa*, *D. tomentosa*, *Echinochloa crus-galli*, *Eleusine indica* (wild form), *Grewia abutilifolia*, *G. hirsuta*, *G. tiliaefolia*, *G. tenax*, *G. villosa*, *Indigofera caerulea*, *I. pulchella*, *I. trifoliata*; syn. *I. barberi*, *Jasminum angustifolium*, *J. auriculatum*, *J. scandens*, *Lablab niger* var. *lignosus*, *Luffa graveolens*, *L. umbellata*, *Malva rotundifolia*, *M. sylvestris*, *Mangifera sylvatica*, *Momordica balsamina*, *M. cochinchinensis*, *M. subangulata*, *M. tuberosa*; syn. *M. cymbalaria*, *Musa ornata*, *Oryza coarctata*; syn. *Sclerophyllum coarctatum* (tetraploid), *O. granulata*, *O. jeyporensis*, *O. meyeriana*, *O. nivara* (annual); syn. *O. rufipogon*, *O. officinalis* subsp. *malampuzhaensis*, *O. sativa* var. *plena*, *Panicum hippothesis*, *P. trypheron*, *Phoenix humilis* var. *pedunculata*, *P. loureiroi* var. *pedunculata*; syn. *P. robusta*, *P. pusilla*, *Phyllanthus fischeri*, *P. narayanswami*, *Sesamum alatum*, *S. laciniatum*, *S. prostratum*, *Solanum erianthum*, *S. incanum*, *S. indicum*, *S. nigrum*, *S. surattense*, *S. torvum*, *S. viarum*, *Sorghum miliaceum*; syn. *S. halepense*, *Syzygium alternifolium*, *S. zeylanicum*, *Trichosanthes bracteata*, *T. cucumerina*, *T. cordata*, *T. himalensis*, *T. multiloba*, *T. occulta*, *Vigna pilosa*, *V. umbellata*, *Vitis pallida*; syn. *Cissus adnata*, *V. pedata*; syn. *Cayratia pedata*, *V. repanda*; syn. *Cissus repanda*, *V. setosa*, *V. woodrowii*; syn. *Cissus woodrowii*, *Ziziphus oenoplia*, and *Z. rugosa* (108).

Western Ghats

(Northwestern Ghats: Konkan and Southwestern Ghats: Malabar Coast)

North Western Ghats: *Abelmoschus angulosus*, *A. ficulneus*, *A. manihot*, *Cajanus lineatus*, *C. sericeus*, *Canavalia lineata*, *Cinnamomum goense*, *Coffea wightiana*, *C. crassifolia*, *Cucumis ritchiei*, *C. setosus*, *Curcuma inodora*, *C. pseudomontana*, *C. purpurea*, *C. reclinata*, *Dolichos bracteatus*; syn. *Sphenostylis bracteata*, *Echinochloa colonum*, *Garcinia malabarica*, *G. morella*, *G. talbotii*, *Mangifera sylvatica*, *Momordica tuberosa*; syn. *M. cymbalaria*, *Oryza meyeriana*; syn. *O. indandamanica*, *Panicum hippothesis*, *Pennisetum orientale*, *Piper argyrophyllum*, *P. galeatum*, *P. hookeri*, *P. hymenophyllum*, *P. trichostachyon*, *Vigna dalzelliana*, *V. khandalensis*; syn. *V. grandis*, *Zingiber neesanium*; syn. *Z. macrostachyum*, and *Z. purpureum* (34).

South Western Ghats: *Abelmoschus angulosus*, *A. manihot* ssp. *tetraphyllus*, *Amorphophallus bonoccordensis*, *A. commutatus*, *A. hohenaekeri*, *A. mysorensis*, *A. nicolsianus*, *A. smithsonianus*, *Artocarpus gomezianus* ssp. *zeylanicus*, *A. hirsutus*, *Cajanus candollei*, *C. lineatus*, *Carissa spinarum*; syn. *C. paucinervia*, *Cinnamomum filipedicellatum*, *C. heyneanum*, *C. macrocarpum*, *C. malabatrum*, *C. riparium*, *C. travancoricum*, *C. wightii*, *Colocasia esculenta*, *Corchorus pseudo-olitorius*, *Crotalaria clarkei*, *C. digitata*, *C. grahamiana*, *Curcuma aromatica*, *C. aurantiaca*, *C. caesia*; syn. *C. malabarica*, *C. coriacea*, *C. decipiens*, *C. ecalcarata*, *C. haritha*, *C. karnatakensis*, *C. kudagensis*, *C. nilamburensis*, *C. neilgherrensis*, *C. oligantha*; syn. *C. kannanorensis*, *C. raktakanta*, *C. reclinata*, *C. thalakaveriensis*, *C. vamana*, *Dioscorea hamiltonii*, *D. hispida*; syn. *D. daemona*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*; syn. *D. jacquemontii*, *D. spicata*, *D. tomentosa*, *D. wallichii*, *D. wightii*, *Dolichos uniflorus*, *Ensete superbum*, *Eugenia singampattiana*, *Fragaria nilgerrensis*, *Garcinia morella*, *G. travancorica*, *G. wightii*, *G. xanthochymus*, *Jasminum angustifolium*, *J. flexile*, *J. malabaricum*, *J. mesnyi*, *Linum mysorensense*, *Luffa umbellata*, *Momordica dioica*, *M. sahyadrica*, *Musa superba*, *Myristica dactyloides*, *M. malabarica*, *Olea glandulifera*, *Oryza meyeriana*, *O. officinalis*; syn. *O. officinalis* ssp. *malampuzhaensis*, *Piper argyrophyllum*, *P. barberi*, *P. galeatum*, *P. hapnium*, *P. hookeri*, *P. pykarahense*, *P. schmidtii*, *P. silentvalleyensis*, *P. trichostachyon*, *Pueraria tuberosa*, *Sesamum laciniatum*, *S. malabaricum*, *S. mulayanum*, *S. radiatum*, *Solanum anguivi*; syn. *S. indicum*, *S. erianthum*, *S. incanum*, *S. nigrum*, *S. pubescens*; syn. *S. torvum*, *S. viarum*, *Syzygium arnotianum*, *S. beddomei*, *S. malabaricum*, *Trichosanthes cucumerina*, *T. nervifolia*, *T. tricuspadata*; syn. *T. bracteata*, *T. villosula*, *T. wallichiana*, *Vigna bournaea*, *V. pilosa*, *V. vexillata* var. *wightii*, *Vitis pedata*, *V. repanda*; syn. *Cissus repanda*, *Zingiber cernuum*, *Z. neesanium*; syn. *Z. macrostachyum*, *Z. purpureum*, *Z. roseum*, *Z. wightianum* and *Z. zerumbet* (112).

Coastal Zone

(Sand dunes of West & East Coast)

Caesalpinia pulcherrima, *Canavalia cathartica*, *C. maritima*, *Cassia siamea*, *C. tora*, *Casuarina equisetifolia* (wild forms), *Cissus quadrangularis*, *Citrullus colocynthis*, *Cocos nucifera* (wild forms), *Crotalaria pallida*, *C. retusa*, *C. verrucosa*, *Ipomoea aquatica*, *I. carnea* ssp. *fistulosa*, *I. pes-caprae*, *Ixora arborea*; syn. *I. parviflora*, *Phoenix paludosa*, *Physalis minima*, *Saccharum spontaneum*, *Uniola paniculata*, and *Ziziphus williamsii* (21).

Islands (Andaman & Nicobar and Lakshadweep Islands)

Amorphophallus carnosus, *A. longistylus*, *Bauhinia nicobarica*; syn. *B. stipularis*, *Bombax insigne* var. *andamanica*, *B. insigne* var. *polystemon*, *Canavalia turgid*, *Dioscorea nummularia*, *D. rogersii*, *D. vexans*, *Dipterocarpus andamanicus*, *Ficus andamanica*, *Garcinia andamanica*, *G. cadelliana*, *G. calycina*, *G. kurzii*, *Grewia calophylla*, *Hornstedtia fenzlii*, *Ixora capitulifera*, *I. hymenophylla*, *Jasminum cordifolium*, *J. andamanicum*, *J. multiflorum*, *J. unifoliolatum*, *Mangifera andamanica*, *M. camptosperma*, *Manilkara littoralis*, *Nypa fruticans*, *Oryza indandamanica*, *Phyllanthus andamanicus*, *Piper sarmentosum*, *Polyalthia parkinsonii*, *Pterocarpus dalbergioides*, *Syzygium andamanicum*, *S. kurzii*, *S. manii*, *S. polyanthum*, *S. samarangense*, *Terminalia bialata*, *T. catappa*, *T. manii*, *T. procera*, *Vanilla andamanica*, and *Vigna marina* (44).

1. Modified over Rodgers *et al.*, (2002) as influenced by plant biodiversity, provinces in parenthesis; 2. Source: Singh (2015); Singh *et al.*, (2013)

i.e., *secondary gene pool*; species that are weakly cross-compatible and conventionally do not produce hybrids with cultivated species, i.e., *tertiary gene pool*; and the species that are cross-incompatible with cultivated species and form the peripheral limits of a genera, i.e., *quaternary gene pool*. As cross-compatibility is one main criteria of gene pool concept, it would also include cross-compatible species of other related genera. For example, species of *Aegilops*, *Elymus*, cross-compatible with *Triticum* and *Hordeum* species (Dewey, 1984; Briggs, 1978); *Sclerostachya*, *Miscanthus* and *Narenga* cross-compatible with *Saccharum* (Rao *et al.*, 1979; Parthasarathy and Subba Rao, 1948; Sreenivasan and Amalraj, 2004) and species belonging to genera like, *Rhynchosia*, considered a resource for *Cajanus* (Singh *et al.*, 2006). This helps encompass far greater number of wild relatives of crop species from genetic resources point of view, available for genetic introgression based on available breeding strategies, and thereby part of larger agrobiodiversity. On this basis, and the extended scope of cultivated species to forage, ornamental, agro-forestry and medicinal and aromatic plant crop species, Singh *et al.* (2013) estimated the wild relatives of cultivated plant found in India to be around 902, belonging to 204 genera and 64 families. An attempt has been made to rationalize the estimate with removal of species with unresolved, unaccepted and synonymous botanical name, which has been a major concern in reporting on wild taxa. Table 3 lists the much wild relatives of cultivated plants species distributed in the most commonly accepted 10 + 1 biogeographic zones of India, reflecting the availability of a reservoir of additional alternative genetic

resources, in search of new genes for genetic improvement of crops, to meet the challenges created by climatic change; and food and nutritional requirements of ever-growing human population, and to facilitate conservation.

The present review clearly demonstrates that the maximum number of wild relatives found in India belong to horticultural crops, i.e., fruits and nuts, vegetables, spices, etc. This is obviously because of the fact that Indian Subcontinent offers most diverse ecological conditions, and that most farmers practice the common traditional ways of crop cultivation, the 'home gardens' for subsistence. These factors have provided great opportunities for exploitation of economic plant species from nature, domestication, cultivation; thereby resulting in adoption of a large number of plant species for direct use as food in the form of fruit and nuts, vegetables, medicine, besides the spices and condiments for which the subcontinent is known worldwide. Consequently, horticultural crops are represented by largest number of both cultivated species and their wild relatives, helping India to be the second largest producer of fruits and vegetables in the world, accounting for about 16% of global vegetable production, 10% of world fruit production and 70% of *global spice production*. Besides, maximum number of plant species are being used as condiment (an edible substance) added to food to impart a particular flavor, and for medicinal use following the most ancient healing system, the "Ayurveda" of traditional herbal medicine and natural healing, native to the India. As a result, the present estimate increases the number of families, contributing

to maximum number of domesticated/cultivated plant species with Zingiberaceae related to the spices, and Rosaceae, related to the fruit and nuts.

Conclusions

The above overview of the cultivated plants agrobiodiversity in India updates the information on cultivated plant species and their wild relatives in the India for food and agriculture with increased numbers (around 811 cultivated and 902 wild), reaffirming the leading status of India as one of the megacenters of biodiversity in general and agrobiodiversity in particular. The listing of crop species domesticated from wild and/or brought into cultivation has increased to 215 from 166, reinforcing the status of India as one of the important centers of crop origin/domestication. The fact that being the seat of ancient agriculture and civilizations, agrobiodiversity was further enriched and revolutionized with the introduction of a large number of plant species domesticated elsewhere, both in old and new world, from times immemorial to the extent that many have naturalized to diverse agroclimatic conditions offered by the subcontinent, generating new variability, further revolutionizing the genetic diversity/agrobiodiversity. This scenario demands greater national attention towards the issues related with agrobiodiversity assessment, collection, evaluation and protection, particularly to facilitate effective conservation, using both conventional and biotechnological methods. Hotspot areas, may be priority, to ensure access to (new) genetic resources for sustainable use in the genetic improvement of cultivated species for food and agriculture. This shall facilitate use of genetic resources both at the national and global level, as per the provisions of International Treaty on Plant Genetic Resources for Food and

Agriculture (2001). The attention may initiate with prioritization of the taxa and genera related to major cultivated species in general and food crops in particular, starting with closest wild relatives. It would need both urgent collection for *ex situ* conservation and the management of such taxa under protected areas in partnership among the various national agencies involved in conservation of biodiversity, including rural bodies and farmers (Elangovan and Kiran Babu, 2015), and also with the international agencies aligned to global initiatives for conservation and access to PGR (Khoury *et al.*, 2013). In Indian context, this is very true for wild relatives of crops found in different biogeographic zones that are under greater threat than before, because of the infrastructure development, increasing human population and expanding agriculture even into the remote areas, particularly the forest areas. More than 1,500 species have been identified under threat by BSI and the Ministry of Environment and Forest (Archive, 2001), of which 1,255 have been listed by the International Union on Conservation of Nature in Red List of Threatened Plants in 1997 (Rao *et al.*, 2003). Of these, around 306 fall in the category of wild relatives of crop/cultivated plant species. This scenario, and the fact that very little has been done for collection, protection, and conservation of genetic diversity of wild relatives (within species) to facilitate their direct, and indirect use in genetic improvement of cultivated species, exploiting their potential to full. Despite the fact that they have established credentials in genetic improvement of many field and horticultural crops. They require immediate attention, both from conservation and use perspective, to genetically engineer cultivars meeting the upcoming challenges of overgrowing global population and climatic change.

References

- Archive.is/7ytuq (2001) Studies on Rare and Endangered Species – BSI, India
- Arisdason W and Lakshminarasimhan P (2015) Status of plant diversity in India: An overview p 7, ENVIS Center of Floral Diversity, Hosted by Botanical Survey of India, Kolkata, India
- Arora R K (1977) Job's tears (*Coix lacryma-jobi*) – a minor food and fodder crop of northeastern India *Econ Bot* **31** 358-366

- Arora R K (1991) Plant diversity in the Indian gene center. www.biodiversityinternational.org/fileadmin/biodiversity/.../Web.../ch06.htm
- Arora R K and Nayar E R (1984) Wild relatives of crop plants of India. National Bureau of Plant Genetic Resources (NBPGR), Kapoor Art Press, A 38/3, Mayapuri, New Delhi, India
- ARS/GRIN [Online Database]. Taxonomy for Plants. National Germplasm Resources Laboratory, Beltsville, Maryland: USDA, ARS, National Germplasm Resource Program

- URL: <http://www.ars-grin.gov/4/cgi-bin/npgs/html/taxon.pl>
- Bates D M, Merrick L C and Robinson R W (1995) Minor Cucurbits. In: Evolution of Crop Plants (Eds: Smartt J and Simmonds NW) pp 105-111, 2nd edition, Longman Group UK Ltd.
- Briggs D R (1978) Barley. Chapman and Hall, London
- Conservation International (2005) Biodiversity Hot Spots, 1919 M Street, NW, Suite 600, Washington, DC 20036. (202)912-1000, fax: (202)912-1030 www.conservation.org
- De Candolle A (1883) Origine des plantes cultivées (Ed: Laffitte J) VIII p 379, Paris
- De Wet J M J (1995) Minor cereals. In: Evolution of Crop Plants (Eds: Smartt J and Simmonds NW) pp 202-207, 2nd edition, Longman Group UK Ltd
- Decker-Walters D S (1999) Cucurbits, Sanskrit, and Indo-Aryas. *Econ Bot* **53** 98-112
- Denham T (2011) Early agriculture and plant domestication in New Guinea and Island Southeast Asia. *Curr Anthropol* **52** S379-S395
- Dewey D R (1984) The genomic system of classification as guide to intergeneric hybridization with the perennial Triticeae. In: Gene Manipulation in Plant Improvement (Ed: Gustafson JP) pp 209-279 Plenum Press, New York
- Dhankhar B S, Mishra J P and Bisht I S (2005) Okra. In: Plant Genetic Resources: Horticultural Crops (Eds: Dhillon B S, Tyagi RK, Saxena S and Anshu G J) pp 59-74, Narosa Publishing House, New Delhi
- Diallo B O, Joly H I, McKey D, Hosaert-McKey M and Chevallier M H (2007) Genetic diversity of *Tamarindus indica* populations: Any clues on the origin from its current distribution? *Afr J Biotechnol* **6**
- Dressler Robert L (1981) The Orchids, Natural History and Classification. Harvard University Press, p 352 ISBN 0-674-87526-5
- Edwin R and Chungath J I (1988) Studies in *Swertia chirata* *Indian Drugs* **25** 143-146
- Eilittä M, Bressani R, Carew L B, Carsky R J, Flores M, Gilbert R, Huyck L, St-Laurent L and Szabo N J (2002) *Mucuna* as a food and feed crop: an overview. In: *Mucuna* as a Food and Feed: Current Uses and the Way Forward (Eds: Flores M, Eilittä M, Myhrman R, Carew L and Carsky R) pp 18-46, Workshop held April 26-29 2000 in Tegucigalpa, Honduras. CIDICCO Honduras
- Elangovan M and Kiran Babu P (2015) Crop diversity in Andhra Pradesh and their conservation. In Agri-biodiversity management for sustainable rural development (ED: S. K Suam) National Academy of Agricultural Research management, New India Publishing company, New Delhi. pp 123-137
- Fuller D Q (2006) Agricultural origins and frontiers in South Asia: A working synthesis *J World Prehist* **20** 1-86
- Fuller D Q (2011) Finding plant domestication in the Indian subcontinent. – *Curr Anthropol* **52** S347-S362 doi: 10.1086/658900 [open access]
- Fuller D Q and Harvey E L (2006) The archaeobotany of Indian pulses: identification, processing and evidence for cultivation *Environmental Archaeology* **11** 241-268
- Fuller D Q, Korisetar R, Venkatasubbaiah P C and Jones M K (2004) Early plant domestications in southern India: some preliminary archaeobotanical results *Veg Hist Archaeobot* **13** 115-129
- Gadgil M and Meher-Homji V M (1990) "Ecological diversity" In: Conservation in Developing Countries: Problems and Prospects (Eds: Daniel JC, Serrao JS), Bombay Natural History Society. Oxford University Press, Delhi
- Gammie G A (1911) Millets of the genus *Setaria* in the Bombay Presidency and Sind. Memoirs of the Department of Agriculture in India *Bot Series* **4** 1-8
- Goyal A K and Arora S (2009) Chapter 1. Overview of biodiversity status, trends and threats. In: India's Fourth National Report to the Convention on Biological Diversity pp 15-53, Ministry of Environment and Forest, Government of India, New Delhi
- Haaland R (1996) A Socio-Economic Perspective on the Transition from Gathering to Cultivation and Domestication: a case study of Sorghum in the Middle Nile Region. In: Aspects of African Archeology Association of Prehistory and Related Studies (Eds: Pwiti G, Soper R) pp 391-400, Harare 1996 University of Zimbabwe Publication
- Haaland R (1999) The Puzzle of the Late Emergence of the Domesticated Sorghum in the Nile Valley. In: The rehistory of Food Appetites for Change (Eds: Gosden Ch and Hather H) pp 397-418, London
- Harlan J R (1975) Crops and man. American Society of Agronomy, Madison, Wisconsin, (2nd edition)
- Hillig Karl W (2005) Genetic evidence for speciation in *Cannabis* (Cannabaceae) *Genet Resour Crop Evol* **52** 161-80
- Hiremath S C and Murthy H N (1988) Domestication of Niger (*Guizotia abyssinica*), *Euphytica* **37** 225-228
- Hymowitz T (1972) The trans-domestication concept as applied to guar *Econ Bot* **26** 49-60
- Hynes R A and Chase A K (1982) Plants, sites and domestication: Aboriginal influence upon plant communities in Cape York

- Peninsula *Archaeol Oce* **17** 38-50
- International Treaty on Plant Genetic Resources for Food and Agriculture (2001) Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, Rome, Italy
- Joshi A B, Gadwal V R and Hardas M W (1974) Okra. In: Evolutionary Studies in World Crops. Diversity and change in the Indian Subcontinent (Ed: Hutchinson J B) pp 99-105, Cambridge University Press
- Joshi S G (2000) *Cesalpiniaceae - Cassia auriculata*. Text Book of Medicinal Plants. Oxford and IBH Publishing, New Delhi, pp 119
- Karthikeyan S (2009) Flowering plants of India in 19th and 21st Centuries – A comparison. In: Plant and fungal biodiversity and bioprospecting (Eds: Krishnan S and Bhat D J) pp 19-30, Goa University, Goa
- Khanna S S (1989) The Agro-climatic Approach. In: Survey of Indian Agriculture pp 28-35, *The Hindu*, Madras, India
- Khoury C K, Greane S, Wiersema J, Maxted N, Jarvis A and Struik P C (2013) An inventory of crop wild relatives of the United States *Crop Sci* **53** 1496-1508
- Kimata M, Ashok E G and Seetharam A (2000) Domestication, cultivation and utilization of two small millets, *Brachiaria ramosa* and *Setaria glauca* (Poaceae), in South India *Econ Bot* **54** 217-227
- Knowles P F and Asheri A (1995) Safflower *Carthamus tinctorius* (Compositae) In: Evolution of Crop Plants (Eds: Smartt J and Simmonds N W) pp 47-50, 2nd edition, Longman Group UK Ltd
- Kundu B C (1951) Origin of Jute *Indian J Genet Pl Br* **11** 95-99
- Lallanji G and Srivastava V C (ed.) (2008) History of agriculture in India (up to C.1200 AD) Vol. V. Part I. In: History of Indian Science, Philosophy and Culture in Indian Civilization (Ed: Chattopadhyaya G) p 946 New Delhi, PHISPC (Center of Studies in Civilization)
- Lebot V, Trilles B, Noyer J L and Modesto J (1998) Genetic relationships between *Dioscorea alata* L. cultivars *Genet Resour Crop Evol* **45** 499-509
- Maass B L, Jamnadass R H, Hanson J and Pengelly B C (2005) Diversity in cultivated and wild *Lablab purpureus* related to proven amplified fragment length polymorphism (AFLP) *Genet Resour Crop Evol* **51** 683-96
- Maheshwari P and Singh U (1965) Dictionary of economic plants in India. Indian Council for Agricultural Research, New Delhi, India
- Malapa R, Arnau G, Noyer J L and Lebot V (2005) Genetic diversity of the greater yam (*Dioscorea alata* L.) and relatedness to *D. nummularia* Lam. and *D. transversa* Br. as revealed with AFLP markers *Genet Resour Crop Evol* **52** 919-929
- Morton J F (1992) The ocean-going noni, or Indian mulberry (*Morinda citrifolia*, Rubiaceae) and some of its 'colorful' relatives *Econ Bot* **46** 241-256
- Murphy C and Fuller D Q (2014) Plant domestication in India. In: Encyclopedia of the History of Science, Technology and Medicine in Non-Western Cultures pp 1-8, DOI 10.1007/978-94-007-3934_10005-1 Springer Science+Business Media Dordrecht 2014.
- Murthy R S and Pandey S (1978) Delineation of Agro-Ecological Regions of India. Paper presented in 11th Congress of International Society of Soil Sciences, Enmonton, Canada, pp 19-27
- Nayar E R, Pandey A, Venkateswaran K, Gupta R and Dhillon B S (2003) Crop Plants of India: A check-list of scientific names. National Bureau of Plant Genetic Resources, New Delhi, India
- Nayar M P (1980) Endemism and pattern of distribution of endemic genera (angiosperm) *J Econ Tax Bot* **1** 99-110
- Nayar M P (1996) Hot spots of endemic plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, Kerala, India. 253
- Nayar M P, Singh A K and Nair K N (2009) Agrobiodiversity Hot spots in India: Conservation and benefit sharing Vol I & II p 217 & 307, PPV & FR Authority, NASC Complex, DPS Marg, New Delhi
- Ng N Q (1995) Cowpea *Vigna unguiculata* (Luguminosae-Papilionoideae) In: Evolution of Crop Plants (Eds: Smartt J and Simmonds N W) pp 326-332, 2nd edition, Longman Group UK Ltd
- Orwa C, Mutua A, Kindt R, Jamnadass R and Anthony S (2009) Agroforestry Database: a tree reference and selection guide version 4.0. (<http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp>) World Agroforestry Center, Kenya
- Pareek S K, Bisht I S, Bhatt K C, Kumar A, Koppa M N, Gupta P N, Mittal S K and Singh R (2000) Manual on Exploration and Collection of Plant Genetic Resources and Related Indigenous Knowledge, Agro-biodiversity (PGR)-5, National Bureau of Plant Genetic Resources, New Delhi
- Parthasarathy N and Subba Rao K S (1948) Chromosome numbers of some geographic forms of *Sclerostachya fusca* A. Camus *Indian J Genet Pl Br* **8** 103-104
- Prasath D, Dinesh R, Senthil Kumar C M and Lijo Thomas (Eds) (2015) Annual Report 2014/15, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India, pp 102

- Rao C K, Geetha B L and Geetha Suresh (2003) Red List of Threatened Vascular Plant Species in India. ENVIS, Botanical Survey of India, Ministry of Environment and Forests, New Delhi
- Rao T C R, Bhagyalakshmi K V and Rao J T (1979) Indian Atlas of Sugarcane. Sugarcane Breeding Institute, Coimbatore, India
- R H S (Royal Horticultural Society) <https://www.rhs.org.uk/plants/details?plantid=593>
- Rodgers W A and Panwar H S (1988) Planning a Wildlife Protected Area Network in India. Vol. 1 and 2 A report prepared for the Department of Environment, Forests and Wildlife, Government of India at the Wildlife Institute of India, Dehra Dun, India
- Rodgers W A, Panwar H S and Mathur V B (2002) Executive summary. In: Wildlife Protected Area Network in India: A Review p 44, Wildlife Institute of India, Dehra Dun, India
- Saraswat K S (1992) Archaeobotanical remains in ancient cultural and socioeconomical dynamics of Indian subcontinent *Palaeobotanist* **40** 514-545
- Sauer J D (1967) The grain amaranths and their relatives: a revised taxonomic and geographic survey *Ann Missouri Bot Gard* **54** 103-139
- Seethalakshmi K K and Muktesh Kumar M S (1998) Bamboos of India: A Compendium. BIC, India: KFRI and INBAR
- Seetharam A, Patel D P and Halaswamy B H (2006) Small millets. In: Plant Genetic Resources: Food Grain Crops (Eds: Dhillon B S, Saxena S, Agrawal A and Tyagi R K) pp 204-222, Narosa Publishing House, New Delhi, India
- Sehgal J L, Mandal D K, Mandal C and Vadivelu S (1992) Agro-ecological Regions of India. NBSS & LUP Technical Bulletin No. 24. 2nd Edition. National Bureau of Soil Survey and Land Use Planning, Indian Council of Agricultural Research, Nagpur, Maharashtra, India
- Singh A K, Singh Neeta, Singh S P, Singh N B and J Smartt (2006) Pigeonpea In: Plant Genetic Resources: Food Grain Crops (Eds: Dhillon B S, Saxena S, Agrawal A and Tyagi R K) pp 222-237, Narosa Publishing House, New Delhi, India
- Singh Anurudh K (2015) Agricultural Biodiversity Heritage Sites and Systems in India. Asian Agri-History Foundation, Secunderabad, India
- Singh Anurudh K, Peter P I and Singh K (2011) Revisiting the origin of the domestication of noni (*Morinda citrifolia* L.). *Plant Genet Resour-C* **9** 549-556 DOI: 10.1017/S1479262111000864
- Singh Anurudh K, Rana R S, Mal B, Singh B and Agrawal R C (2013) Cultivated Plants and Their Wild Relatives in India – An Inventory. Protection of Plant Varieties and Farmers' Rights Authority, New Delhi, India
- Singh Anurudh K and Varaprasad K S (2008) Criteria for identification and assessment of agro-biodiversity heritage sites: evolving sustainable agriculture *Curr Sci* **94** 1131-1138
- Singh D and Bhandari M M (1963) The identity of an imperfectly known hermaphrodite *Luffa*, with a note on related species *Baileya* **11** 132-141
- Singh D P (1995) Jute *Corchorus* spp. (Tiliaceae). In: Evolution of Crop Plants (Eds: Smartt J and Simmonds N W) pp 476-477, 2nd edition, Longman Group UK Ltd
- Singh P and Dash S S (2014) Plant Discoveries 2013 – New Genera, Species and New Records. Botanical Survey of India, Kolkata
- Sorenson J L and Johannessen C L (2004) Scientific Evidence for Pre-Columbian Transoceanic Voyages. Sino-Platonic Papers (Ed: Mair Victor H) p 273, Department of East Asian Languages and Civilizations, University of Pennsylvania, Philadelphia, USA
- Sreenivasan T V and Amalraj V A (2004) Sugarcane. In: Plant Genetic Resources: Oilseeds and Cash Crops (Eds: Dhillon B S, Tyagi R K, Saxena S and Agrawal A) pp 200-213, Narosa Publishing House, New Delhi
- The Wealth of India. Publication and Information Directorate CSIR, New Delhi (1985) **2** 116-117
- Tomooka N, Lairungreang C, Nakeeraks P, Egawa Y and Thavarasook C (1991) Mung bean and the genetic resources. TARC, Japan
- Tomooka N, Vaughan D A, Moss H and Maxted N (2003) The Asian *Vigna*: genus *Vigna* subgenus *Ceratotropis* genetic resources. Dordrecht, Netherlands: Springer
- Udvardy M D F (1975) A Classification of the Biogeographical Provinces of the World. ICUN Occasional Paper No. 18, p 49, Morges, Switzerland
- Valdes L J, Mislankars S G and Paul A G (1987) *Coleus barabatus* (Lamiaceae) and the potential new drug forskolin (Colenol) *Econ Bot* **41** 474-483
- Vavilov N I (1926) Centers of origin of cultivated plants. *Tr po Prikl Bot Genet Sel [Bull Appl Bot & Genet Sel]* **16**(2) 139-248 [in Russian]
- Vavilov N I (1935) The Phytogeographical Basis of Plant Breeding. In: Origin and Geography of Cultivated Plants (Ed: Love D) (Transl), Vol 1 pp 330-336, University of Cambridge Press, 1992
- Weiss E and Zohary Daniel (2011) The Neolithic Southwest Asian founder crops: their biology and archaeobotany *Curr Anthropol* **52**(S4) S237-S254

- Wilson F D (1978) Wild kenaf, *Hibiscus cannabinus* L. (Malvaceae) and related species in Kenya and Tanzania *Econ Bot* **32** 199-204
- Yob N, Jofry S M, Affandi M, Teh L, Salleh M and Zakaria Z (2011) *Zingiber zerumbet* (L.) Smith. A review of its ethnomedicinal, chemical, and pharmacological uses. *Evidence-Based Complement Alternate Med*: 2011, Article ID p 12, 543216
- Zeven A C and De Wet J M J (1982) Dictionary of cultivated plants and their regions of diversity. Center for Agricultural Publishing and Documentation. Wageningen
- Zeven A C and Zhukovsky P M (1975) Dictionary of cultivated plants and their centers of diversity. PUDOC, Wageningen
- Zohary D and Hopf M (1988) Domestication of Plants in the Old World. Oxford.