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Review Article

Ancient Alien Crop Introductions Integral to Indian Agriculture: An Overview

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India is one of the major centers of agricultural plant biodiversity. Many of the crop plants were domesticated and a far greater number were introduced and absorbed into the country from different parts of the world since ancient times. The archaeobotanical remains and sculptural depictions and their reference in ancient literature (Sanskrit) present unambiguous evidence for introduction of 65 crop species before the 8th century. These species include crops from Americas, Africa, Near East, Central Asia, China, and Southeast Asia. The ancient introduction/occurrence of these species in India is speculated because of geological and geographical fragmentation of continental landmass followed by drift, natural or man-made transoceanic migration/movements and trade and cultural exchange. The evidence generated clears the wrong perceptions about the time of introduction of many crops such as maize, sunflower, cashew nut and others.

Keywords: Ancient Crop Introductions; India; Archeological; Archaeobotanical; Sanskrit

Introduction

India is one of the mega agrobiodiversity countries of the world. Many plant species have been domesticated here (Vavilov, 1935; Harlan, 1975; Zeven and de Wet, 1982; Singh, 2017). The agrobiodiversity of the indigenously domesticated higher plant species was further enriched with introduction of exotic crops since ancient times, as reflected by the presence of American cereals and pseudo-cereals such as maize and amaranths, African cereals such as pear millet and sorghum, West Asian legumes such as field pea, grass pea and chickpea, and Chinese proso millet and buckwheat in the archeological remains and/or in ancient Indian agriculture writings. Most of these crops have acclimatized and adapted to diverse ecological conditions offered by the Indian Subcontinent to such an extent that many appear natural to the land, and have thrown enormous genetic diversity, making India either a secondary center of diversity for crops such as pearl millet, sorghum, maize, amaranths, cowpea, niger, safflower, muskmelon, pumpkin, chilies and others or regional center of diversity for crops such as barley, grain amaranth, buckwheat, proso millet, foxtail millet, chickpea, bottle gourd and others.

The hypotheses about ancient introductions are based more on presumptions of evolutionary biologists and researchers rather than on hard data belonging to evolution of agriculture, societies, economics, and trade. Systematic and scientific investigations in world crops such as rice, wheat, maize and others have revealed that much information in this regard can be deduced from archaeobotanical, archeological and literary records (Smartt and Simmonds, 1995). Regarding Indian Subcontinent, there have been scattered attempts in this direction, limiting the scope to certain regions (Kajale, 1991; Fuller, 2000; Blench, 2003; Sorenson and Johannessen, 2004; Fuller, 2011), crops (Kulshrestha, 1985) or crop groups (Singh, 2016). There is no comprehensive review. The present article is an attempt for a comprehensive documentation of ancient alien crop introductions, based on evidence from archaeobotanical and archeological (architectural) remains, and their reference in ancient

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oriental literature, particularly Sanskrit writings published before the medieval period/8th century AD.

Indices Used to Identify Ancient Introductions

The hard data from the following sources have been used to draw inferences regarding introductions of crop species during ancient times.

- Archeological remains: Sculptural and graphic depiction of plants or a plant part in architectural monuments, such as caves, temples, etc. dated to ancient times
- Archaeobotanical remains: The remains of plant material obtained from various archeological excavation sites with carbon dating for ancient period
- Literary: Reference of plant species in writings/ literature of oriental language, particularly the Sanskrit, the *Vedic* literature with vernacular name
- Ancient dating: Based on the above evidence, listing of only those plants falling into the period before medieval period, i.e., 8th century

Archeological remains are the strongest fool-proof evidence for availability/cultivation of an exotic crop plant in ancient times, particularly from Neolithic-Chalcolithic period in Harappa, Gangetic Plains, and other parts of India including South India. They prove beyond doubt the presence/cultivation, thereby ancient introduction of crops, resolving the controversies regarding crops such as maize, sunflower, cashew nut, tamarind, and others.

However, in following the above criteria, the difficulties listed below are likely to be encountered.

- Limited archeological evidence in crops propagated vegetatively (leafy vegetables, root and tuber crops)
- Lack of knowledge of oriental languages, such as Sanskrit, Prakrits, Pali, Dravidian, etc.
- Difficulties in identification and verification of Latin synonyms of plant species
- Poor documentation/inadequate information regarding minor crops of marginal significance, such as vegetables, forage and ornamental, because of limited appreciation in their country of origin
- Difficulties in distinguishing the ancient introductions from those from medieval period because of lack of indigenous information and pro-west attitude of historians

In crops of African origin, access to the Indian Subcontinent, both through land and sea-route, is possible. It is difficult to distinguish between the two routes and in some crops, it might have occurred through both. Phylogenetic studies including use of molecular markers may be needed to decide on the nearest dates and relationships with existing genetic diversity.

Linguistic data have hardly been used; however, in the present article reference to Sanskrit writings and Sanskrit names and their resemblance with the names in their country of origin have also been considered, particularly in case of American and African crops. In this regard, Indian inventory *Bhava Prakash Nighantu* (Indian Materia Medica) with commentary in Hindi by Bhava Mishra [(ca. 1600 AD), 1995] has been relied upon.

Possible Reason for Common Occurrence and/ or Introduction to Such Distances

The common intercontinental occurrence of crop species in ancient times in India and distant continents such as the Americas can be visualized based on geological/geographical events, and both physical and biological forces. For example, occurrence of crop species in Americas and India can be explained as a consequence of distribution of these species during bi-hemispheric continental time on either side of the oceans, which got fragmented and separated into present continental landmasses due to continental drift; or the natural transoceanic intercontinental seed-migration by action of ocean waves as few seeds are equipped for floating long distances and survive; or by wind flow as some others are very light to be carried long distances; or early human migration facilitated by transoceanic voyages in both directions across major oceans carrying plant material. These are to be inferred based on circumstantial evidences and by systematic investigation.

Regions such as Africa, Mediterranean, Central Asia and China are connected with Indian Subcontinent by extended contiguous landmass. In such a situation, it is possible that human movements for settlement in greener pastures, cultural exchange, trade and/or invasion facilitated introduction of exotics, including the plant material. For example, introductions from Africa could have followed one of the following three routes: 1. From African main land to North Africa, Egypt to the Near East to Iran to Northwestern India. 2. The Sabaean Lane, along the Red Sea or along the southern edge of the Arabian Peninsula and then travel, either via coasting or crossing the sea. 3. Open sea movement between East Africa and western coast of India. Archaeobotanical remains, historical records of ancient Egypt and common cultivation of a crop species between Africa, Egypt, and India are the evidences to support the possible introduction following first route. Obviously, absence of a crop in Egypt and presence in Africa and India is sufficient reason to believe that it was transported via either of the above other two routes.

China, India, Central Asia and the Far East were culturally and commercially connected with each other during ancient times by the Silk Route/Road. A network of trade routes, connecting the East and the West, predominantly China and India to the Mediterranean Sea during various periods of time, both via Himalayan passes and coasting across the Arabian sea, and Indian and Pacific oceans existed in the past. These contacts, besides cultural exchange (spread of Buddhism), also led to exchange of plant material.

The present knowledge about the development of maritime technology does not allow us to visualize when it became possible to cross the open oceans. However, there is evidence for trade between Aksumite kingdoms, China, and India (Munro-Hay, 1996). Blench (1996) describes ethnographic and textual evidence for Austronesian incursions on the East African coast.

Lastly, intellectual advancement of Indian societies, the inheritors of ancient civilizations, and support from royals/rulers for innovations, starting from Indus Valley to Gangetic Plains, might have led to independent exploitation/domestication or diversification of certain economic plant species that came to Indian borders with extended distribution. This probably happened in case of *Fagopyrum tataricum, Malilotus indicus* and *Trigonella foenum-graecum*. This also includes the possibility of trans-domestication of certain sister crop species, as proposed by Hymowitz (1972) for domestication of cluster bean (*Cyamopsis tetragonoloba*) in India. As per his hypothesis, drought tolerant sister wild species *C. senegalensis*, brought by Arab traders as fodder between 9th and 13th centuries AD, was domesticated/evolved into cluster bean.

Probable Ancient Crop Introductions

***Abelmoschus esculentus* (L.) Moench, Okra**

The genus *Abelmoschus* is of Asiatic origin, however, the exact ancestral home of the cultivated *A. esculentus* is disputed between Africa (Vavilov, 1935; Joshi *et al*., 1974), and India (Zeven and Zhukovsky, 1975; Zeven and de Wet, 1982). Much evidence suggests India to be one of its centers (Dhankhar *et al*., 2005). The existence of Sanskrit names, *Tindisha* and *Gandhamula*,supports its ancient cultivation, either because of early introduction from Africa through a sea route (because of its absence in the intermediate land route via Egypt) or independent domestication.

***Alliums -Allium cepa* L., Onion**

The Central Asiatic region is considered primary center of origin of onion whereas the near east Asiatic and Mediterranean regions are the secondary centers. The earliest records of onion cultivation come from Egypt. In India, its reference is found in 6th century BC writings *Bhava Prakash Nighantu* [Bhava Mishra (ca.1600 AD), 1995] with Sanskrit names, *Palāṇḍuḥ* and *Sukanda*. Archaeobotanical remains of *A. cepa* have been recorded in Middle Gangetic Plains-Waina, Ballia and Raja-Nala-Ka-Tila in Uttar Pradesh (UP) (Saraswat, 2005). It is an indispensable flavoring agent in Indian cuisine, cooked as vegetable, eaten raw, and used as herbal medicine.

***Allium sativum* L., Garlic**

Garlic is also of Central Asian origin. The trade relationship between Mesopotamia, Egypt, and India during Mohenjo-Daro period, about 3000 BC, led to its introduction into India. Later, the bulbs as seed were brought and grown. The Arabian traders and the Greeks (Alexander the 300 BC), 'Yavans', brought

garlic's use in cooking as a condiment and into *Ayurveda* system of medicine. Its Sanskrit names, *Mahaaushadha, Lashunaha, Granjanaha, Aristaha, Mahakandaha* and *Rasonakaha,* were first published in Amarsingh's '*Amar Kosh'* brought out in 600 AD at the time of king Vikramaditya (Amarsimha, 2001). Three cloves of *A. sativum* were found carbonized at Harappa site Balu in Haryana (Saraswat and Pokharia, 2002).

Amaranths - Amaranthus caudatus L., Grain Amaranth

Native to Andean region around the Andes Mountains in South America. Amaranths have a common occurrence in India. It has Sanskrit name *Rajagiri* (Chopra *et al.*, 1956; Torkelson, 1999), and has also been found in archaeological remains dated to before 800 BC (Saraswat *et al*., 1994; Saraswat, 2004b). Its food uses in India are like that of Central America. The other ancient introductions of amaranths are:

Amaranthus hypochondriacus L.; syn. A. leucocarpus

A native of the northern Mexican highlands, introduced into India three millennia BP, as is indicated by its traditional use and local names in Nepal - *marcha* in northwest, *nana* in central, *pilim* among Sherpa of central Nepal, and *latav* in Katmandu. It is widely cultivated as food crop in the Himalayan region. *Amaranthus spinosus* L., the spiked amaranth, a native of Americas, is widely distributed as weed throughout south India and beyond. It appeared to have been transported accidentally along with seeds of other crops. Its Sanskrit names are *Tanduliya*, meaning 'a field weed' (Chopra *et al*., 1956; Torkelson, 1999), and *Kataib* and *Chaulai* (Pullaiah, 2002). Another species, *A. cruentus*, appears to be a later introduction.

Anacardium occidentale L., Cashew nut

A native of Brazil or Venezuela, cashew nut is generally believed to have been introduced into India in the 16th century AD (1560) by the Portuguese (Sauer, 1993). However, depiction of complete plant with flowers and fruits at the Jambukeshvara temple in Tiruchirapalli, Tamil Nadu, built 2500 years back (Gupta, 1996), and sculptural depiction of cashew nut fruit at the Bharhut Stupa, dated ca. 200 BC, suggest its ancient cultivation (Cunningham, 1879). It has Sanskrit names *Beejara Sula* or *Bijara Sala* (Balfour Edward, 1871-1873), *Shoephahara* (Nadkarni, 1914) and *Kajutaka* (Pullaiah, 2002). South India is the major producer of cashew nut in India.

Ananas comosus (L.) Merr., Pineapple

A native of Brazil, pineapple was introduced into India, probably by the 5th century AD via Middle East. A sculpture depicting its fruit has been found on the *vanamala* of Vishnu in his *Varaha avatara* in the Udayagiri cave temples in Madhya Pradesh (MP), dated ca. 5th century AD (Gupta, 1996). This could not have been possible without locals and artisans being familiar with the plant and its fruit. The other place with such depiction is at Moti-Shah Ka-Tuk, Shatrunjaya Hill complex, Palitana in Gujarat, believed to be more than 1000-year old. Its Sanskrit names are *Anamnasam* and *Bahunetraphalam* (Pullaiah, 2002). Fruit is used medicinally too.

Annonas - Annona cherimolia Mill., Large Annona, Custard Apple

Native of the highlands of Colombia, Ecuador and Peru, custard apple is also found in Mesoamerica. The tree was reportedly introduced into India in 1820 (Balfour Edward, 1871-1873). However, the fruit of *A. cherimolia* is shown held by a sculpted goddess figure on a wall of a Hoysala Dynasty temple in Karnataka, dated to 13th century (Johannessen and Wang, 1998). This suggests its much early introduction to reach this status of cultural, social, and religious recognition.

Annona reticulata L., Bullock's Heart, Custard Apple

A native of tropical America, custard apple is naturalized in India to an extent that some authors considered it a native. It has Sanskrit names *Rama Sita* (Balfour Edward, 1871-1873), *Luvunee* (Watson, 1868), *Ramphala* (Chopra *et al.*, 1956; Torkelson, 1999), *Ramphal* (Pullaiah, 2002) and *Krishnabeejam*.

Annona squamosa L., Sugar Apple

The main cultivated fruit species with comparatively loose carpel fruit, also a native of tropical America. Sugar apple grows wild in MP, and is naturalized and

thriving in Karnataka, Maharashtra, and southern India. It is mentioned in writings dated beginning of the present era and Ramayana, ca. 2000-1000 BC up to AD 200. Its Sanskrit names are *Shubhâ* and *Suda* (Nadkarni, 1914), *Gandagatra* and *Sitaphala* (Chopra *et al*., 1956), *Sitaphalam* (Torkelson, 1999) and *Sitaphalam, Gandhagathra* and *Shubha* (Pullaiah, 2002). Association of these species names with Lord Rama and his wife Sita, suggests that they probably used these fruits during their exile (Bhishagratna, 1907). Sculptured fruits have been described resembling to these species by Cunningham (1879) from Bhárhut Stupa, 200 BC, whereas Watt (1889) reported sugar apple fruit from Ajanta caves, and Gupta (1996) found it in the hands of various deities from temples situated in different parts of the country. Fruit pieces and seeds of these two species have been found at Sanghol in Punjab and at Raja-Nal-Ka-Tila and Tokwa in UP, dated to about 1700/ 1600 BC to 200 BC (Saraswat *et al.*, 2008). These evidences confirm their ancient cultivation, contradicting De Candolle's (1882) suggestion for their introduction by the Portuguese in the 16th century.

Canavalia ensiformis (L.) DC., Sword bean (Jack bean)

Based on archaeological evidences (Mexico 3000 BC), sword bean appears to be of Mexican/Central American origin. However, it is found wild in the eastern part of India from the Himalayas to Sri Lanka and Thailand, and is cultivated. It has a Sanskrit name *Shimbí* (Watt, 1889). Sorenson and Johannessen (2004) reported existence of *Canavalia* seeds in an archaeological site in India dated to 1600 BC, and visualized that the voyagers who carried the *Phaseolus lunatus*, lima bean, from Peru to India, also carried *C. ensiformis* (or *C. obtusifolia*). Therefore, both new world and old word origin, and/ or its early introduction are possible, needing further investigation. Both, green pods and beans are eaten.

Capsicum annuum L., Chili Pepper

A native of South America,chili pepper is now cultivated throughout India. It is generally believed to have been introduced into India by the Portuguese in 16th century AD. However, Chilies have been grown and used in India much earlier, as chilies are mentioned in *Siva* and *Vamana Puranas*, dated ca. 6th-8th century AD. In *Siva Purana*, it is mentioned as an ingredient of a remedy for consumption (pulmonary tuberculosis). In Sanskrit, it has been referred to as *Marichiphalam* (Nadkarni, 1914), *Katuvira* and *Marichi-phalam* (Torkelson, 1999) and *Katuirah* and *Rakta maricha* (Pullaiah, 2002). Archeologically, its plant has been graphically depicted at Jambukeshvara Shiva temple at Tiruchirappalli in Tamil Nadu, with developmental stages of fruits, besides fully developed leaves, flowers, and fruits (Gupta, 1996).

Carthamus tinctorius L., Safflower

Genus *Carthamus* is distributed from Spain and North Africa across the Middle East to North India. Most evidence suggests origin of *C. tinctorius* in an area bound by the eastern Mediterranean and Persian Gulf (Knowles, 1969). Based on variability and ancient culture, Vavilov (1935) proposed India as one of its centers of origin. However, it appears that from the Middle East, where it was used for coloring textiles, the safflower was introduced into India probably by the Arab traders and trans-domesticated into an oilseed crop. It is one of the oldest crops brought into cultivation for seed oil in India. Ancient *Sanskrit* scriptures described it as *Kusumbha*. Its flowers have been used in preparation of *Ayurveda* medicines. Achenes of safflower have been found in archeological remains at sites such as Imlidih-Khurd in UP and Middle Gangetic Plains (Saraswat *et al.*, 1994; Saraswat, 2005), while grains have been discovered at Savalda (ca. 2300-2000 BC) in western Maharashtra, confirming its ancient cultivation.

Cicer arietinum L., Chickpea (Bengal gram)

It is a pulse crop, first grown in Turkey about 7000 BC, and was subsequently introduced into India as early as 2000 BC (Vishnu-Mittre, 1974). Ramanujam (1976) reported the presence of chickpea (radiocarbon dated at 5450 BC) and provided evidence of its cultivation in the Mediterranean basin during 3000-4000 BC. In ancient Sanskrit writings, it has been referred to as *Chanaka*. Chickpea grains have been found at Savalda in Maharashtra (ca. 2300-2000 BC), at Imlidih-Khurd in UP, at Balu, Kunal in Haryana and Middle Gangetic Plains (Saraswat *et al*., 1994; Saraswat and Pokharia, 2002, 2003; Saraswat, 2005), confirming its early introduction and cultivation.

***Citrullus lanatus* (Thunb.) Matsum. & Nakai, Watermelon**

It is a native of southern Africa. Archaeologically, colocynth seeds have been dated to about 5800 BP and those of watermelon at about 4000 BP (Zohary and Hopf, 2000) in Nile Valley. By 4th-7th century AD, it reached India with naturalization of both wild *C. colocynthis* and *C. lanatus*, in the western plains of the subcontinent, making it a secondary center of genetic diversity. Sushruta mentions it in his *Sushruta Samhita* (6th century BC) for cultivation along the banks of the Indus River. He called this fruit as "Kalinga". In Sanskrit writings, it has been referred to as *Tarambuja. Krishnabija, Latapanasa, Madhuraphala* and *Alpapramanaka*.Seeds of watermelon have been found in the archaeological remains at Imlidih-Khurd in UP, at Balu in Haryana and Middle Gangetic Plains (Saraswat *et al*., 1994; Saraswat and Pokharia, 2002; Saraswat, 2005), confirming its ancient cultivation.

***Corchorus olitorius* L., Tosa jute**

The larger genetic diversity within the species points to Africa as the primary center of its origin, with India or Indo-Myanmar region being the secondary center of diversity, where it has been cultivated for centuries. From Africa, *C. olitorius* spread to India via Egypt and Syria in ancient times (Kundu, 1951). Discovery of jute textile (not *Tosa* jute) at Harappa (Wright *et al*., 2012) suggests use of jute in textile production in the subcontinent during the peak of urbanization in the Indus Valley. However, whether Indians had knowledge of *Tosa* jute needs investigation. The first recorded history of the use of jute as a textile fiber was in the 1500s in India. In Sanskrit, it has been referred to by names such as *Patta, Kakka Tapattraka, rAjazana,* and others in *Bhava Prakash Nighantu*.

***Cucumis melo* L., Muskmelon**

Musk melon is a native of Africa with populations extending to south-western Asia. Its initial domestication took place in Africa followed by dispersal and subsequent differentiation into cultivars in the Near East and Asia including India or with independent domestication. Indian Subcontinent is the original home of local variants and the common groups, probably resulted from re-domestication of feral forms in early times (Bates and Robinson, 1990). In Sanskrit, it has been referred to as *Kalinga*, *Kharvuja* and *Madhuphala*. The seeds of muskmelon have been found in archaeological remains at Imlidih-Khurd in UP, at Balu, Kunal in Haryana and Middle Gangetic Plains (Saraswat *et al.*, 1994; Saraswat and Pokharia, 2002, 2003; Saraswat, 2005), confirming its ancient cultivation.

Cucurbitas–*Cucurbita ficifolia* Bouche, Malabar Gourd

Cucurbita species are native to Central America, and are generally believed to have been introduced into India including Malabar gourd by the Portuguese in the 16th century (Merrick, 1995). But its further differentiation and extension of distribution to Khasi Hills (Arora and Singh, 1973), Tibet and Himalayas would have required a longer period than a few centuries, much before the advent of Portuguese in India (Sorenson and Johannessen, 2004). Therefore, probably it got introduced several millennia ago. It is cultivated in Malabar, therefore got English vernacular name Malabar Gourd, and in the agricultural valleys of Tibet. In Sanskrit, it is called *Kamāndalu* and *Kimhada*. However, archaeological evidence is lacking to support its ancient cultivation/introduction.

***Cucurbita maxima* Duch., Squash (Winter squash)**

It is native to the Americas, with earliest remains found in Peru, 2000 BP, where it was present at least 4,000 year back. Levey (1966) lists *C. maxima* (also *C. pepo*) from Al-Kindi treatises (9th century AD), presuming both were under cultivation at that time, and are referred in a medieval medical text from India. It is cultivated with large variation in fruit size, going up to 8 feet in circumference. It has Sanskrit names, *Punyalatha*, and *Dadhiphala* (Nadkarni, 1914) and *Pitakusmandah* (Pullaiah, 2002), to support its ancient presence. *Cucurbita moschata* Duchesne, winter or banana squash, is another native of Central Americas with earliest remains found in Peru (4000 BP), Southern Mexico (5000 BP), Northern Mexico (3000 BP) and Southwest United States (1000 BP). Circumstantial evidence for its historical connections with India and similarity of vernacular names, *Kumhra* and *Kumra* with those of Mayan, *Kum, Kuum* (Roys, 1931) support its ancient cultivation in India.

***Cucurbita pepo* L., Pumpkin**

Pumpkin is a native of southern part of North America. But it is widely cultivated all over India as a backyard garden crop. It is mentioned in the *Atharvaveda* dating before 800 BC; in the Buddhist *Jatakas* and Hindu texts as early as the 4th century AD: and as an ingredient of *Ayurveda* medicine in an Indian text of the 9th century and in medieval text (Levey, 1966). It has Sanskrit names, *Kurkaru* and *Kushmanda* (Chopra *et al*., 1956; Torkelson, 1999).

***Eleusine coracana* (L.) Gaertn., Finger millet (Ragi)**

The center of domestication of finger millet is controversial. Based on the varietal diversity, Vavilov (1935) suggested India to be one of its homelands. Whereas, Porteres (1951) and Harlan and Stemler (1976), based on occurrence of its probable ancestor, the wild tetraploid *Elusine africana*, which crosses freely with cultivated finger millet; nomenclature and language suggested African origin. Record of carbonized seeds of cultivated finger millet associated with Iron Age in Zimbabwe (Inyanga) corroborate it (Summers, 1958). Nevertheless, discovery of grains at Harappa, Malhar in UP and Middle Gangetic Plains (Saraswat *et al*., 1994; Herman 1997; Saraswat, 2005) and of a true caryopsis at Hallur in Karnataka (1000 BC) (Fuller, 2003) confirms its ancient cultivation in India (may be one of its centers). Probably, it travelled to India at the same time as sorghum and pearl millet did.

Buckwheats - *Fagopyrum esculentum* Moench, Buckwheat

It is a native of southwestern China, as is reflected by the presence of the wild ancestors *Fagopyrum esculentum* ssp. *ancestrale* and *F. homotropicum* that are interfertile with *F. esculentum*, and distribution of the wild forms in Yunnan province of China. The oldest known remains in China dates to ca. 2600 BCE. It is believed to be cultivated in India at the same time, where it reached through extended natural distribution, though there is no supportive evidence for this belief. An analysis of RAPD variation suggested two diffusion routes - one extending from northern China to Korea-Japan and the other extending southwards to Himalayan region (Sharma and Jana, 2002). It neither has Sanskrit name nor is found in archaeological records. The other species:

***Fagopyrum tataricum* (L.) Gaertn.**

Tartary buckwheat, is a native of the Himalayan region with distribution of its ancestral species *F. tataricum* ssp. *potanini* extending from Tibet to western Himalayas of India. The Chinese accessions show greater genetic similarity with this wild ancestral species supporting its origin from Yunnan in China. The accessions of the northwestern Himalaya stand distinct with narrow genetic diversity, indicating either introduction from China or independent geographic domestication in Indian Himalayan region (Sharma and Jana, 2002), which may be one of its centers.

***Gossypium barbadense* L., Tetraploid cotton**

A native of South America, tetraploid cotton was introduced into India via Polynesia (Pacific). Because it has Sanskrit name *Maghani* (Chopra *et al*., 1956; Torkelson, 1999), it might have reached India before 1000 AD, and came into cultivation.

***Guizotia abyssinica* (L.f.) Cass., Niger**

Niger originated in the Ethiopian highlands as an oilseed crop. It is believed to have been brought to India by the Ethiopian immigrants, probably in the 3rd millennium BC along with crops such as finger millet (Dogget, 1987) and its wild relatives. In ancient Sanskrit writing, it has been referred to as *Rama Tilah*. There are no archaeological finds of niger in India.

***Helianthus annuus* L., Sunflower**

A native of Central and South Americas, sunflower is cultivated all over India from very early times as an ornamental and probably also as an oilseed crop. It is mentioned in the Charaka's *Charaka Sahmita* dated no later than the 4th century AD (Aiyer and Narayan, 1956). Its Sanskrit names are *Suriya-mukhi* (Nadkarni, 1914; Chopra *et al.*, 1956; Torkelson, 1999) and *Adityabhakta* and *Suryamukhi* (Pullaiah, 2002). Graphic depiction of sunflower is found in Rani Gumpha cave, Udaigiri in Orissa dated to the 2nd century BC (Gupta, 1996). Johannessen and Wang (1998) recorded carvings of sunflower from the same temples of Hoysala Empire in Karnataka, as those of maize cob, confirming its early cultivation.

***Hibiscus cannabinus* L., Kenaf or Deccan hemp**

Kenaf is believed to have originated in ancient Africa (Western Sudan), occurring as early as 4000 BC (Kobayashi, 1991). It spread to India at an early period via Persia, as Kenaf is a Persian word. It naturalized to south Asia, so much so that several workers have considered it native. Nevertheless, further domestication and cultivation led to development of cultivar diversity in south Asia (Busson, 1965). It has been referred in *Sanskrit* literature of ancient India of 7th century with name, *bAlamUlikA*.

***Hordeum vulgare* L., Barley**

Barley was one of the first grains domesticated in Fertile Crescent (Crescent shape moist region consisting of Western Asia, the Nile Valley and delta). The distribution of wild barley (*Hordeum vulgare* ssp. *spontaneum*) ranges from North Africa and Crete in the west to Tibet in the east. It was introduced to North India in ancient times and was probably the principal food grain in early days. Later, with wheat it diffused to South India. Barley is mentioned in early Sanskrit records with names such as *Yava*, *Sithashuka*, *Atiyava* and *Akshata*. Being an ancient crop, grains of barley have been found at several archaeological sites, particularly in Gangetic plains, such as Imlidih-Khurd in UP, Balu, Kunal in Haryana, Middle Gangetic Plains (Saraswat *et al.*, 1994; Saraswat and Pokharia, 2002, 2003; Saraswat, 2005), confirming its ancient cultivation.

***Hordeum vulgare* Lvar. Nudum Hook.f., Hulless barley**

Hulless or "naked" 6-row barley is a form of domesticated barley with an easy-to-remove hull. Naked barley is mentioned in '*Vedas'* with Sanskrit name '*Yav*'. It is used in religious ceremonies. Archaeobotanical remains of naked barley were found preserved at Neolithic culture at Mehrgarh (Period I: 4-7th Millenium) (Rao, 2008) and at *Chamar Culture* or *Ravidas Culture* in Jammu region. Its seeds have been found at Harappa site, Balu, Kunal in Haryana (Saraswat and Pokharia, 2002; 2003).

***Ipomoea batatas* (L.) Lam., Sweet potato**

This native of South America is cultivated all over India as poor-man's food. Sweet potato was mentioned in the Hindu record known as *Silappadikaram* with Sanskrit names "*Valli"* (Aiyer and Narayan, 1956), and *Pindalah* and *Raktaluh* (Pullaiah, 2002), which are similar to the names used in northwestern South America. This confirms its introduction in the early AD centuries via Polynesia.

***Lagenaria siceraria* (Molina) Standl., Bottle gourd**

Bottle gourd is one of the oldest cultivated plants, which originated from wild population in southern Africa, and might have been carried from there to Asia by oceanic drift during summer monsoon or with human migration. Genetic research on archeological samples published by the National Academy of Sciences, December 2005 suggested that it may have been domesticated earlier than food crops and livestock. Based on the analysis of archeological samples, researchers indicate two unrelated domestications: one 8-9,000 years ago in Asia and the other 4,000 years ago in Egypt. Old Indian scripts and the fossil records indicate its culture even before 2000 BC. It is cultivated all over India as backyard garden crop from early times. In Sanskrit, it is referred to as *Alābu* (Nadkarni, 1914) and *Kutukumbi* (Pullaiah, 2002) confirming its ancient cultivation. Fruit used as vegetable and for medicinal properties, and the shell for making musical instruments and water holding pots.

***Lathyrus sativus* L., Grass pea (Khesari)**

Presumed to have originated in Southwest and Central Asia (Smartt, 1990) or the Balkan Peninsula in the early Neolithic period. Grass pea may have been the first crop domesticated in Europe around 6000 BCE. It is an economically important crop in India, grown for dual purpose. Split seeds are used as '*dal*' for human consumption and its vines as fodder for livestock. In Sanskrit literature, it has been referred to as *Thriputa, Kalaaya, Khandikaa, Lanka, Sandika* and *Dirghamoola* in *Bhava Prakash Nighantu*. Seeds of *L. sativus* have been found in archaeological remains at Malhar in UP, Balu, Kunal in Haryana, and Middle Gangetic Plains (Saraswat *et al*., 1994; Saraswat and Pokharia, 2002, 2003; Saraswat 2004a, 2005) reflecting its ancient cultivation.

***Lawsonia inermis* L., Hena**

Hena is native to northern Africa and western and

southern Asia. In ancient Egypt, around 6,000 years ago, it was used as a cosmetic hair dye. Henuttamehu's (17th Dynasty, 1574 BCE) hair had been dyed in bright red at the sides, probably with henna. Whether it was brought into use at the same time or before or later in India is not known, but the use of *Mehndi* and turmeric has been described in *Vedas*. The existence and use of Henna for the last 5,000 years can also be found in the books of Charaka and Sushruta and other texts, and in the paintings and sculptures. In Sanskrit, it has been referred to as *Mendika*, *Ragangi* and *Raktgarbha*. It is being used as skin and hair dye in India since long time as is evidenced from the paintings of famous Ajanta-Ellora caves.

***Lense culinaris* Medik., Lentil**

Lentil originated in the Fertile Crescent and then spread to the Indo-Gangetic Plain. De Candolle (1882) suggested its arrival with Sanskrit speaking people, the Aryans, based on non-tenable theory of Indo-Aryan migration. In Sanskrit, it is referred to as *Masura*, *Renuka*, *Mangalya*, etc. in *Bhava Prakash Nighantu*. Seeds of lentil have been found in archaeological remains at Malhar in UP, Balu, Kunal in Haryana, Middle Gangetic Plains (Saraswat *et al*., 1994; Saraswat and Pokharia, 2002, 2003; Saraswat, 2004a, 2005) confirming its ancient introduction and cultivation.

***Linum usitatissimum* L., Flax or Linseed**

Wild flax grows from Northern Africa to India, though it was first domesticated in the Fertile Crescent region. The earliest evidence of wild flax use as a textile comes from Republic of Georgia, where spun, dyed, and knotted wild flax fibers were found in Dzudzuana cave, dated 30,000 years ago in Upper Paleolithic period. In India, there is evidence for its cultivation 5,000 years ago (3000 BCE). It has several Sanskrit names such as *Uma*, *Kshuma*, *Atasi*, *Neel Pushpin*, and *Picchla* [Bhava Mishra (ca.1600 AD), 1995]. Archaeobotanical remains of flax or linseed seed have been found at Harappa and elsewhere in North India (Saraswat *et al*., 1994; Kajale, 1996; Saraswat and Pokharia, 2003; Saraswat, 2005; Pokharia *et al*., 2009).

***Melilotus indicus* (L.) All., Sweet clover**

Sweet clover is naturally distributed over Macaronesia, northern Africa, Europe, and temperate and tropical Asia, including India. Therefore, it may either be a case of early introduction or independent domestication, as indicated by archaeobotanical remains discovered at Kunal in Haryana, Malhar in UP (Saraswat and Pokharia, 2003; Saraswat, 2004a).

***Medicago sativa* L., Lucerne, Alfa-alfa or Rijka**

Originated in South-central Asia, Lucerne is commonly believed to be introduced into India in 1900. However, De Candolle (1882) considered Ladakh as one of the centers of its origin. Archaeobotanical discovery of seeds at Kunal in Haryana (Saraswat and Pokharia, 2003) confirms its ancient cultivation/introduction in the country.

***Morus alba* L., White mulberry**

White mulberry is native to northern China, Japan, and India. However, some believe it extended from Northwestern India into Asia Minor and Persia. This tree is cultivated in all the provinces of China for 4,000 years for rearing of silk-worms and making silk fabric. It was introduced into India from China during the ancient times, and is now grown widely in the subcontinent. The ancient treatise, *Arthashastra* (7th century BC and 2nd century BC) mentions Assam's growing silk trade. Bush cultivation of white mulberry in Bengal for feeding silk-worms is well known. In Sanskrit, it is called *Tula* (Chopra *et al*., 1956). Indian variant, *Morus indica* native of southern India, is also cultivated. *Ayurveda* practitioners have used mulberry for health benefits.

***Mucuna pruriens* (L.) DC.,Velvet bean**

Although a native of the Americas, velvet bean was present in Polynesia and the Malay region in prehistoric times (Cook, 1901). Others believe it occurs commonly throughout the tropical regions of the Americas, Africa, and India. In India, it is mentioned in texts dated before the rise of Buddha. Its Sanskrit names are, *Atmaguptä* and *Kapikachchhu* (Nadkarni, 1914; Torkelson, 1999) and *Atmagupta* and *Vanari* (Pullaiah, 2002). It is used as cover, forage, and vegetable crop. Its seeds are described as a strong aphrodisiac and roots, a tonic in *Ayurveda*.

***Nicotiana tabacum* L., Tobacco**

A native of the Americas, as per *Materia Medica*, tobacco is an agricultural crop introduced into India in 1605 AD. Others believe that it began in the New World and was carried to India after its introduction into Europe (Ashraf, 1985). However, the use of the water-cooled smoking device, '*Hooka*', is shown in pre-Columbian art of India, along with references to tobacco in traditional medical practices. Its Sanskrit name is *Tamakhu* (Chopra *et al.*,1956; Torkelson, 1999). Archaeologically, a temple in Himachal Pradesh dated to 1422–1424 AD depicts the use of the *Hooka*. Photographic documentation of this depiction is also available from other temples (Archaeological Survey of India).

***Pachyrhizus erosus* (L.) Urb., Yam bean**

A native to the Americas, yam bean was introduced into India at least before 1000 AD and probably much earlier. In Sanskrit, it is called *Sankhálu* (Watt, 1889). It is cultivated throughout India for its large edible root, but does not occur in wild corroborating its early introduction.

***Panicum miliaceum* L., Proso millet**

Both, the wild ancestor and the location of domestication of proso millet, are unknown. It first appeared independently as a crop in Transcaucasia and China about 7,000 years ago. It is an early introduction into India, and is extensively cultivated in the country. In Sanskrit, it is called, *Cheenaka*, *Kakakangu* and *Kangu* [Bhava Mishra (ca.1600 AD), 1995], and *aNu*. Crop remains of *Panicum miliaceum* have been found at Raja-Nala-Ka-Tila in UP (Saraswat, 2005).

***Paspalum scrobiculatum* var. *polystachyum* (R. Br.) Stapf; syn. *P. scrobiculatum* L., Kodo millet**

It originated in tropical Africa and probably travelled to Indian Subcontinent (Porteres, 1976) across the Indian Ocean may be by natural process like wind. It was domesticated in India 3,000 years ago and is still being domesticated in Deccan Plateau, where it has become a major food crop. Spikelet specimen found at archaeological site Malhar in UP has been linked to this species (Saraswat, 2004a).

***Pennisetum glaucum* (L.) R. Br., Pearl millet**

Based on the presence of wild relatives, southern edge of Sahara has been considered area of domestication of pearl millet. It was introduced into India very early, probably by sea-route, as it is not found in Nile Valley and Near East for possibility of a land transfer. In Sanskrit, it is called, *ikSupattra*, *vATa*. Well-founded archeological remains of pearl millet (1000-2200 BC) have been obtained from several sites in Harapan culture, Gangetic Plains, and Deccan Peninsula, such as Rangpur in Gujarat, Narhan in UP and Hallur in Karnataka (Saraswat *et al*., 1994; Herman, 1997; Fuller, 2003). This suggests its first introduction to North India, followed by its spread to other parts, reaching South India by 1500 BC as revealed by archaeological remains at Hallur, district Haveri in Karnataka.

***Phaseolus lunatus* L., Lima bean (Lobiya)**

A native to Central America and the Andes from Peru to Argentina in South America. Large lima bean was first domesticated in the Andean highlands and the small lima bean probably arose in the Pacific coastal foothills of Mexico. Cultivated throughout India, *Phaseolus vulgaris, P. lunatus* and the phasey bean have been recorded by Vishnu-Mittre *et al*. (1986) from deposits of Malwa and Jorwe cultures (1600-1000 BC) at Diamabad, district Ahmednagar, Maharashtra. American bean is also encountered from proto-historic sites in peninsular India (Pokharia and Saraswat, 1999). However, no Sanskrit names are associated with it.

***Phaseolus vulgaris* L., French or Kidney bean (Rajma)**

Phaseolus vulgaris has American origin. In India, it is cultivated all over, but not known in wild (Chopra *et al.*, 1956). Archaeologically, and based on Sanskrit name *Simbi*, it was present in the southwest Asia and India all the way back to Sumerian times. Archaeological remains were found from pre-Prabhas and Prabhas cultures at Prabhas Patan in Gujarat dating 1800 BC to 600 AD; from post-Harappa, Chalcolithic site Inamgaon (about 1600 BC); from Diamabad in Maharashtra (Vishnu-Mittre *et al.*, 1986); and from Neolithic site Tekkalkota (C14 1620±108 BC) in Karnataka (Sorenson and Johannessen, 2004).

***Phoenix dactylifera* L., [*P. sylvestris* (L.) Roxb., Indian, Date palm]**

Exact place of origin of date palm is unknown. It

probably originated around Iraq and has been cultivated since ancient times (4000 BCE) in Mesopotamia to Egypt. It is naturalized and widely cultivated in India along with local species *Phoenix sylvestris* from ancient time. It has several Sanskrit names [Bhava Mishra (ca.1600 AD), 1995] (Table 1). Earliest archeological evidence (7000-5500 BC) of date cultivation in India is from Mehrgarh in Baluchistan, a Neolithic civilization site. Evidence of its cultivation is found in the Indus Valley, including the Harappa period 2600 to 1900 BC. Stone remains of date have been found from Rohira in Punjab, and Balu in Haryana (Saraswat and Pokharia, 2002).

***Cherries – Physalis lanceifolia* Nees and *P. peruviana* L.,Winter cherry or Ground cherry**

Ground or winter cherry has tropical American origin. Both species are grown in Indian gardens where it is called *Ras bhari*, though reference to species specificity is confusing. They were introduced around 1,000 to 2,000 years ago. The historical records show their presence in ancient India, where they were referred to as *Rajaputrika* and *Lakshmipriya* in Sanskrit (Chopra *et al.*, 1956; Torkelson, 1999). Presence of *P. peruviana* in eastern Polynesia suggests the possible role of natural transoceanic forces for their spread to India.

***Peas - Pisum arvense* L.; syn. *P. sativum* subsp. *Arvense* (L.) Asch., Field pea**

Native to the Mediterranean region and North Africa, field pea is widely grown for forage. It was domesticated around 7,000 years ago, as indicated by the seeds found in archaeological sites in Turkey. In Sanskrit, it is referred to as *Sitla*, and by a few more names in *Bhava Prakash Nighantu* (Table 1). The seeds of field pea have been found at Harappa and at several Neolithic sites in Gangetic Plains (Saraswat, 1992, 2005; Saraswat and Pokharia, 2002; 2003). Two broken-pieces of seeds morphologically comparable to *P. arvense* have been recorded from Neolithic site, Tokwa in UP (Pokharia, 2008), reconfirming its ancient presence.

***Pisum sativum* L., Pea**

The wild pea is restricted to the Mediterranean basin and the Near East, and was probably domesticated there. The earliest archaeological finds of pea date from the late Neolithic era of current Greece, Syria, Turkey, and Jordan. In the second half of the 2nd millennium BC, it appeared in the Gangetic basin and southern India (Zohary and Hopf, 2000). In Sanskrit, it has been referred to as *Renuka, Satila, Triputa, Ananu* and *Hrenu*. Archaeological remains have been found in Harappa, North West India dating back to 2250-1750 BC, and Gangetic Plains (Saraswat *et al*., 1994) with record of cultivation during the 1st millennium BC. With its natural distribution extending to northwestern India, Pakistan and adjacent areas of former USSR and Afghanistan, some believed its origin in this region, and then spread to Europe (Kay, 1979; Makasheva, 1983).

***Portulaca oleracea* L., Purslane**

Portulaca is found throughout warmer parts of the world, predominantly in the Americas and has been used as vegetable from time immemorial. It is native of North America. In India, it grows all over and called *Sanhti*, *Punarva* or *Kulfa*. In Sanskrit, it is referred to as *Lonika, Mansala* and *Ghotika* (Chopra *et al.*, 1956, 1958; Torkelson, 1999; Pullaiah, 2002). Being a leafy vegetable, its archaeobotanical remains are not expected. It is eaten as spinach and in curries.

***Psidium guajava* L., Guava**

Guava is a native of tropical America. The site of Caral in the Supe Valley of Peru yielded remains of guava, dated between 2627 and 2020 Cal BC. It is naturalized and cultivated all over India, and has several Sanskrit names such as *Pérālā* (Nadkarni, 1914), *Mansala*, *Amruta-phalam* and *Perukah* (Chopra *et al.*, 1956, 1958; Pullaiah, 2002). It finds mention in *Charaka Samhita*, indicating that it was introduced not later than the 4th century or considerably earlier, negating the common belief for its introduction by the Portuguese in 17th Century.

***Ricinus communis* L., Castor**

Domesticated in West-Central Africa, castor spread to Egypt (4000 BC) and then reached India (2000 BC). In Sanskrit, it is referred to as *Eranda, Gandharva hasta* and by few more names in *Bhava Prakash Nighantu*. The earliest archaeobotanical record of castor in India was found at the late Harappa site, Hulas (Saraswat, 1993) dated between 1800-1300 BC. Since then, it has been recorded both in

Table 1: Summary of evidences from archeological remains, literature and Sanskrit names on ancient crop introductions into India

Species name(s)	Archeological remains	Literary/Sanskrit	Center of origin	Introduction/cultivation time
Abelmoschus esculentus, Okra		*Tindisha*, *Gandhamula*	Africa/South, SE Asia	Early introduction/one of center
Allium cepa, Onion	Seeds	*Durgandha*, *Palānduh*, *Sukanda*, etc.	Central Asia	800-1600 BC
Allium sativum, Garlic	3 cloves	*Aristaha*, *Lashunaha*, *Granjanaha*, etc.	Central Asia	2500 BC; during Harappa period
Amaranthus caudatus, Amaranth	Grains	*Rajagiri*	Andean region	Before AD 1000
Amaranthus hypochondriacus			N. Mexican Highland	3 or more millennia BP
Amaranthus spinosus, Amaranth		*Tanduliya*, *Chaulai*, etc.	Americas	Two millennia ago
Anacardium occidentale, Cashew nut	Sculptured fruit	*Beejara Sula*, *Kajutaka*, etc.	Brazil or Venezuela	Before 2nd century BC
Ananas comosus, Pineapple	Sculptured fruit	*Anamnasam*, *Bahunetraphalam*	Brazil, Central America	5th century AD
Annona cherimolia, Large Annona	Sculptured fruit		Colombia, Ecuador, Peru	Before 13th century AD
Annona reticulata, Bullock's heart/Custard apple	Sculptured fruit: Fruit pieces & seeds remains	*Rama Sita*, *Ramphal*, *Luvunee*, etc.	Tropical America	By 2nd century BC
Annona squamosa, Sugar apple	Sculptured fruit: Fruit pieces & seeds remains	*Sitaphalam*, *Gund-gatra*, *Suda*, etc.	Tropical Americas	Mid of 3rd millennium BC
Canavalia ensiformis, Sword bean	Seeds	*Shimbí*	Mexico/ Central America	Before 1600 BC
Capsicum annuum, Chili	Sculptured plant	*Katuvira*, *Marichi-Phalam*	Tropical America	7th century
Carthamus tinctorius, Safflower	Achene & grains	*Kusumbha*	Eastern Mediterranean and Persian Gulf	Chalcolithic period (1300-600 BC) from middle east
Cicer arietinum, Chickpea	Seeds	*Chanaka*	Southeast Turkey	2000 BC
Citrullus lanatus, Water melon	Seeds	*Kalinga*, *Tarambuja*, etc.	Africa (Nile Valley)	Egypt, India one of its center
Corchorus olitorius, Tossa jute	Seeds (*C. capsularis* ?)	*Nadeek*, *Nadishak*, *Tapattraka*, etc.	Eastern Africa	Ancient times
Cucumis melo, Muskmelon	Seeds	*Dashangula*,*Kalinga*, *Madhuphala*, etc.	Africa	Very early introduction or extended distribution of wild type
Cucurbita ficifolia, Malabar gourd		*KamaGalu*, *Kimhada*, etc.	Central America	Several millennia ago
Cucurbita maxima, C. *moschata*, Winter squash		*Dadhiphala*, *Punya-latha*, etc.	Central America	Two millennia ago
Cucurbita pepo, Pumpkin		*Kurkaru*, *Kushmanda*, etc.	Central America	Before 4th century
Elusine coracana, Ragi or finger millet	Seeds & Caryopsis		African	Early Iron phase (2150-800 BC) or 3000 BC
Fagopyrum esculentum, Buckwheat			Southwestern China, Yunnan	500-1000 BC

Fagopyrum tataricum, Tartary Buckwheat			Southwestern China/ India	Early introduction /one of its center
Gossypium barbadense, 4 x Cotton		*Maghani*	South America	Much before AD 1000
Guizotia abyssinica, Niger		*Rama tilah*	Ethiopia, Africa	3rd millennium BC (Dogget 1987)
Helianthus annuus, Sunflower	Sculptured flowers	*Adityabhakta*, *Suryamukhi*, etc.	Americas	Beginning of present era/ before AD 400
Hibiscus cannabinus, Kenaf		*bAlamUlikA*	West Africa (West Sudan)	Early Pre-Columbian
Hordeum vulgare, Hulled barley	Seeds	*Akshata*, *Atiyava*, *Yava*, *Sithashuka*,	Southern fertile crescent	3000-2850 BC, before *Vedic* period
Hordeum vulgare var. *nudum*, Naked-barley	Seeds	*Yav*	Fertile crescent	2600-2500 BC
Ipomoea batatas, Sweet potato		*Valli*, *Pindalah*, *Raktaluh*	South America	Early AD centuries
Lagenaria siceraria, Bottle gourd	Fossil	*AlÃ¢bu*, *Kutukumbi*	Africa	Earlier than 10,000 BP
Lathyrus sativus, Grass pea	Seeds	*Kalaaya*, *Khandika*, *Lanka*, etc.	Near East/ Mediterranean	2500 BC
Lawsonia inermis, Hena	Cave depiction	*Mendika*, *Ragangi*, *Raktgarbha*, etc.	Egypt, fertile crescent	*Vedic* period
Lense culnaris, Lentil	Seeds	*Masura*, *Renuka*, *Mangalya*, etc.	Fertile crescent (Near East/ Mediterranean)	2500 BC
Linum usitatissimum, Linseed	Seeds	*Atasi*, *Kshuma*, *Neel pushpin*, etc.	Fertile crescent (Georgia)	3,000 BCE (600-1300 BC)
Malilotus indicus, Sweet-clover	Seeds		North Africa, Eurasia, tropical Asia, India	Neolithic-Chalcolithic (1950-1300 BC)
Medicago sativa, Alfa-alfa	Seeds		South-central Asia	2500 BC
Morus alba, Mulberry		*Tula*	China	Cultigens 3rd millennium BC
Mucuna pruriens, Cowhag		*Atmagupta*, etc.	Americas	Earlyfirst centuries AD
Nicotiana tabacum, Tobacco	Sculptured *Hooka*	*Tamakhu*	Americas	By AD 1000
Pachyrhizus erosus, Yam bean		*Sankhálu*	Americas	Before AD 1000
Panicum miliaceum, Panic millet	Crop remains	*Cheenaka*, *Kakakangu*, *Kangu*, etc.	Transcaucasia and China	700-1600 BC
Paspalum scrobiculatum, Kodo millet	Spikelet		Tropical Africa	Domesticated in India 3000 years ago
Pennisetum glaucum, Pearl millet	Seeds	*ikSupattra*, *vATa*, etc.	Sahel, Africa	About 3000 BC
Phaseolus lunatus, Lima bean	Seeds		Americas	Before 1600 BC
Phaseolus vulgaris, Kidney bean	Seeds	*Simbi*	Americas	Before 1600 BC
Phoenix dactylifera, Date Palm	Stones	*Bhumikharjurika*, *Duraroha*, etc.		2500 BC; Harappa
Physalis lanceifolia and *P. peruviana*, Ground cherry and Husk tomato		*Rajaputrika*, *Lakshmipriya*, etc.	Tropical America	Pre-Columbian 1-2000 year ago
Pisum arvense, Field pea	Seeds	*Sitla*,*Kalaya*, *Vartul*, Sateen, etc.	Mediterranean/ North Africa	Neolithic period (2200-1950 BC)
Pisum sativum, Pea	Seeds	*Ananu*, Renuka, *Satila*, etc.	Mediterranean/ Near East	2000 BCE or before

Portulaca oleracea, Purslane		*Lonika, Mansala, Ghotika,* etc.	North America	During Pinyin in Rome
Psidium guajava, Guava		*Amruta-phalam, Mansala*, etc.	Tropical South America	2000 years ago
Ricinus communis; Castor bean	Wood	*Eranda, Gandharva hasta*, etc.	West-Central Africa	2000 BCE; Chalcolithic time (1300-600 BC)
Setaria italica; Foxtail millet	Caryopsis	*Rajika, BhAvajJA, PriyaGgukA*, etc.	Near East (China)	800-1600 BC
Sorghum bicolor; Sorghum	Seeds	*Yavanal, Zikharib, YavanAla*, etc.	Northeastern quadrant of Africa/Ethiopia	Over 3000 years ago
Tagetes erecta; *T. patula*; Normal and dwarf marigold		*Ganduga, Sthulapushpa*, etc.	South-central Mexico	While Sanskrit was an active language
Tamarindus indica; Tamarind	Charcoal remains	*Amlika,Tintrini, Yamadutika*, etc.	Tropical Africa	At an early date (*Vedic* period)
Trifolium alexandrium; Barseem	Seeds	*Tripatra*	Egypt	2500 BC; Harappa excavation
Trigonella foenum-graecum; Fenugreek	Seeds	*Chandrika, Maithika*, etc.	Mediterranean	Ancient introduction with medicinal use
Triticum aestivum ssp *aestivum*; Bread wheat (6x)	Seeds	*Godhuma, Sumana, Kanika*, etc.	Fertile Crescent	6500 BCE; Neolithic/ Chalcolithic period
Triticum durum; Durum wheat (4x)	Seeds	*Godhuma, Samita* etc.	Mediterranean/ southwest Asia	6500-3000 BCE
Vigna unguiculata; Cowpea	Seeds	*Harimanth, Mahamasha*, etc.	West-Central Africa	2000 BP
Vitis vinifera; Grapes	Seeds	*Draksha, Madhurasa* etc.	Eurasia, Central Asia for hybridization	2000 BC
Zea mays; Maize	Sculptured cob	*Sasyam, Stamba-kari*, etc.	Mesoamerica (Mexico)	1st century BC

Data synthesis on archaeobotanical records has been presented by Vishnu-Mittre (1974), Kajale (1991) and Saraswat (1992), including most crops

Indus valley and Gangetic Plains (Saraswat 1992, 2004b, 2005). The use of castor oil in India for lighting lamps and in local medicine as a laxative, purgative, and cathartic has been documented since 2000 BC.

Setaria italic (L.) P. Beauv., Foxtail millet

Foxtail millet is a native of China with history of cultivation dating back to the Neolithic Era over 4,000 year ago (Baltensperger, 1996). It moved from China to south and westward to reach India. In South India, it is a staple diet for the people from the *Sangam* period. In Sanskrit, it has been referred to as *BhAvajJA, PriyaGgukA, Rajika*, etc. confirming its ancient cultivation. It occurred in Harappa levels (2500-2200 BC) at Shikarpur (Kutch). Also, it was recovered from the earliest strata of Rojdi, placed within 400 years of the oldest find of domestication. Three carbonized seeds were reported from *Jorwe* culture levels and Daimabad in Mahararashtra (Vishnu Mittre *et al*., 1986). Archaeobotanical remains have also been found from upper and middle Gangetic Plains (Saraswat, 2004a; 2005). It was also grown at Manjhi (Saran, Bihar) during the red ware levels (250 BC-250 AD).

Sorghum bicolor (L.) Moench., Sorghum

Most studies concur with African origin of sorghum with domestication stretching from Southwest Ethiopia to Lake Chad. It reached India in prehistorical time (Burkill, 1937) as early as 4000 BP. It is widely grown in India. In Sanskrit writings, it is called *Yavanal* [Bhava Mishra (ca.1600 AD), 1995]. The web-dictionary lists *VRttataNDula*, *Zikharib*, *YavanAla* and *ViravRkSa* too as its other names. Harlan and Stemler (1976) argued for sea transport introduction of guinea sorghum, as there are no residual landraces in the intervening territories. Haaland (1996; 1999) argued that wild sorghum might have been cultivated

in Ethiopia, but domestication took place outside Africa, most likely in India. There have been suggestions for reimport of cultivars developed in India. Archeological remains found at Tuljapur Garhi in Osmanabad, Maharashtra (Kajale, 1988; Saraswat, 1993) (2200-900 BC), and at Hulas in Gangetic Plains (Saraswat *et al*., 1994; Saraswat and Pokharia, 2003; Saraswat, 2004ab; 2005) corroborate these facts.

***Tagetes erecta* L., *T. patula* L. (dwarf), Marigold**

A native of South-central Mexico, some believe marigold originated in Africa (Pandey, 2000). It arrived in India while Sanskrit was the active language, and is referred to as *Zanduga* (Chopra *et al*., 1956; Torkelson, 1999) and *Sandu*, *Sthulapushpa* and *Ganduga* (Pullaiah, 2002). There is substantial evidence to suggest that it was grown in India since long time and was associated with Hindu religious ceremonies for decoration and coloring, essentially a similar use as in Mexico. Besides an ornamental crop, it is known as insect repellent and is being used as border or mixed crop in India for biological control of nematodes for centuries (Khan *et al*., 1971).

***Tamarindus indica* L., Tamarind**

Tamarind is of West African origin, but it has spread to India at an early date (Burkill, 1997). There are many references to the tamarind tree in Hindu mythology. Salim *et al*. (1998) noted its reference in *Brahma-Samhita* (1200-200 BC) discovered by Lord Chaitanya and in Buddhist literature of around 650 AD. Absence of Egyptian finds suggests that it travelled along the Sabaean Lane. Indian traders introduced it to Southeast Asia. In Sanskrit, it has been referred to as *Amlika*, *Sucukrika*, *Tintrini* and *Yamadutika*. Charcoal remains of tamarind tree have been identified from Narhan site of the middle Gangetic Plains (Saraswat *et al*., 1994) dating back 1300 BC.

***Trifolium alexandrinum* L., Berseem**

Berseem is a native of Egypt. As per common belief, it was introduced into North India in the early 19th century. But the ancient cultural and trade contacts between Egypt and India, its reference in Sanskrit writing as *Tripatra*, and finding of three seeds in archaeobotanical remains from mature Harappa phases (Saraswat and Pokharia, 2002) negate this presumption and indicate its ancient introduction/ cultivation.

***Trigonella foenum-graecum* L., Fenugreek**

A native to eastern Mediterranean region, fenugreek was brought into cultivation in the Near East as indicated by the charred fenugreek seeds recovered from Tell Halal in Iraq dating back to 4000 BC. It is found wild in Kashmir, Punjab and the upper Gangetic Plains suggesting its naturalization to India. It came to cultivation either through very early introduction or through another independent geographical domestication. In Sanskrit, it is referred to as *Medhika, MethikA, Chandrika* and several other names, confirming its ancient cultivation. Find of single partly broken-seed, somewhat oblong with a deep groove between the radicle and the cotyledon has been identified as *Trigonella* cf. *foenum graecum*. Occurrence of seeds have also been recorded in Early and Mature Harappa phases at Kunal and Banawali in Haryana, and Rohira in Punjab (Saraswat, 1986; Saraswat *et al*., 2000; Saraswat and Pokharia, 2003). It is used as leafy vegetable, seed-spice, and in *Ayurveda* compositions.

***Triticum - T. aestivum* L. ssp. *aestivum*, Common Hexaploid Wheat**

Common wheat was first domesticated in Western Asia (Fertile Crescent—upper reaches of the Tigris-Euphrates drainage basin) round 11,700 years BP. Its cultivation began to spread after about 8000 BCE (9,000 years back) and reached India, where it evolved further. For this reason, the north-western end of Indian Subcontinent is regarded as the secondary center of origin, leading to origin of *T. sphaerococcum* (dwarf wheat). Excavation at Mehrgarh revealed species, *T. monococcum*, *T. dicoccum* and *T. durum* or *T. aestivum*, suggesting that Baluchistan was a very early center of wheat cultivation. In Sanskrit, it has been referred to as *Godhuma*, *Sumana*, *DhUma*, *Kanika*, etc. Carbonized wheat grains discovered at Mohenjo-Daro are dated to 1755 BC. From the Indus basin wheat moved to Gangetic Plains, reaching Chirand in Bihar 3500 BC through the vast plains of Ganga and Yamuna. This spread is corroborated by post Harappa discovery of wheat at Atranjikherain Etah, UP (ca. 2000-50 BC) (Chowdhury *et al*., 1977), with grain resembling *T. compactum* from period III (ca. 1200-600) and one resembling *T. aestivum* and

T. sphaerococcum from period IV (ca. 550-50 BC). It was also discovered from post Harappa Chalcolithic sites at Nevadatoli – Maheshwar (1600-1450 BC) (Sankalia *et al*., 1958; Sankalia, 1959): from Kayatha culture (ca. 1900 BC) at Ujjain in MP; at Sonegaon (1340-1290 BC), Inamgaon (1370-1025 BC) and Ter (ca. 200 BC) in Maharashtra (Vishnu-Mittre, 1974). This suggests that wheat from north moved to central and south India around 2nd century before the beginning of Christian era.

Triticum durum Desf., Macaroni wheat and *T. dicoccum* Schrank ex Schübler, Emmer or Khapli, Tetraploid wheat

Wild emmer is native to Fertile Crescent of the Middle East. The oldest evidence of domesticated emmer wheat was found near Damascus, Syria dating 7650 to 8200 BC. It probably reached India by 6500 BCE, as small quantities of emmer were present during period I of Mehrgarh (7000-5000 BC) and found at Kunal (Saraswat and Pokharia, 2003). In Sanskrit, it is referred to as *Samita* and *Godhuma*. Hard seeded, naked *T. durum* or *T. turgidum* subsp. *durum* was developed by selection in the domesticated emmer wheat in India.

Vigna unguiculata (L.) Walp., Cowpea

Cowpea is indigenous to West-Central Africa (Panella *et al*., 1993). Its long-time cultivation in India led to a belief for its Asian origin. Absence of cowpea in intermediate sites between Africa and India suggests that it was carried to India by sea around 2000 BP during the Neolithic period (Pant *et al*., 1982). In Sanskrit, it has been referred to as *Harimanth*, in writings dated to 150 BC (Steele and Mehra, 1980) and *Bhava Prakash Nighantu*, confirming its presence in India before the Christian era. Archaeobotanical remains have been found at Daimabad in Maharashtra ca.1700-1500 BC, Hulas in upper Gangetic Plains 2200-1500 BC (Fuller, 2000) and in Khairadih and Raja-Nala-Ka-Tila in middle Gangetic Plains (Saraswat, 2005). Hulas is a remote site almost in the foot hills of Himalayas, hence it must have left Africa later than 4000 BP.

Vitis vinifera L., Grapes

A native of Eurasia, grapes is thought to have been domesticated first in Southwestern Asia during the Neolithic period. In Asia, the earliest evidence of cultivation of grapes for wine making is from Iran and Baluchistan, dated before 2000 BC, wherefrom cultivation slowly spread to India and China with the beginning of Christian era. It is not mentioned in *Vedic* literature, but listed in *Ayurveda* with Sanskrit names, *Draksha*, *Drdkrfi* and a few more in *Bhava Prakash Nighantu*. Two pyriform seeds in carbonized state have been found at Balu and Kunal from mature Harappa stage (Saraswat and Pokharia, 2002; 2003).

Zea mays L., Maize

Maize is generally believed to have been introduced into India by the Portuguese during the 17th century. However, the discovery of Sikkim Primitive 1 and 2, from Sikkim (Dhawan, 1964; Gupta and Jain, 1973) with astonishing resemblance to the progenitor of maize reconstructed by Mangelsdorf, then any other primitive type known or found in central America, demonstrate that maize was present in India in ancient Era and was cultivated much before the turn of Christian Era. Zeven and de Wet (1982) considered Himalayan region a secondary center of diversity. Fifth century AD literature also suggests its much earlier presence. Watt (1889) provided words denoting 'maize' in Sanskrit, *Sasyam*, *Stambakari*, *Sasyavisesha*, besides *Yavanala* (Chopra *et al*., 1956; Torkelson, 1999). References to maize fields are found in the inscriptions of Assam (*kostha makkhi-yana*). Sculptures of maize-ears were found in many Hindu, Jain, and Buddhist temples and also in the Hoysala Empire temples in Karnataka between11th-13th centuries (Johannessen and Wang, 1998; Sorenson and Johannessen, 2004).

Table 1 summarizes the above evidences for respective crop/plant species, providing a bird's eye-view, confirming their ancient presence and justifying their inclusion in the present review.

Discussion and Conclusion

The above set of evidences (archaeobotanical remains; sculptural or graphic depiction of plants, flowers, fruits and cobs in caves and temples; ancient literature and Sanskrit names) supports ancient introduction of many of crops/plants into India, dispelling common perceptions regarding the period of their introduction and center of origin and diversity. These include several crops perceived to have been introduced by

colonial powers during the medieval period (8th to 18th century CE) such as cashew nut (Sauer, 1993), custard and sugar apple (Watt, 1989), *Cucurbita* species (Merrick, 1995), chilies, tobacco, guava, maize, etc., and more recently, berseem and sunflower.

Similarly, there are several crop species for which India, besides the possibility of ancient introduction, can be another probable center of origin. For example, okra, tartary buckwheat, sweet clover**,** fenugreek, etc., where the presence of possible ancestral wild relatives or forms, or their extended distribution into India, and the significant amount of distinct diversity, support the argument for India being another independent geographic center of origin/ diversity. Such an explanation can also be extended to *Chenopodium album*, which naturally occurs in Europe and East Asia; and also occurs as weed in wheat fields of North India and Nepal, and cultivated on marginal scale as leafy vegetable in vegetable fields/gardens near urban areas. It is mentioned in *Vedas*, *Charak Samhita* and *Sushruta Samhita*. Compressed seed of Chenopodium have been found in excavation at Kunal in Haryana (Saraswat and Pokharia, 2003). Whereas, in case of sword bean, suggested to be of American origin (Vavilov, 1935), occurrence of wild forms and finding of seeds in an archaeological site in India dated to 1600 BC, led to visualization of the possibility of the same voyagers who carried lima bean from Peru to India, also brought sword bean (Sorenson and Johannessen, 2004). Though, further investigations are needed for conclusive inference.

The evidence for some other crops suggests for a case of trans-domestication, where the ancestral wild species/forms were introduced into India by either the natural forces or settlers or the traders, and the intellect or experiences of the local Indian communities led to their domestication or re-domestication or diversification and regular cultivation for the same or diverse use. These include safflower domestication as an oilseed, tosa jute as textile fiber, kenaf, musk melon and sorghum into cultivar development (Haaland 1996; 1999), kodo millet, castor and bottle gourd for diverse purposes and tamarind for culinary and medicinal use.

Additionally, there are crops, in whose case circumstantial evidence, such as wide and long time cultivation and use, suggests ancient introduction without hard data to support, such as amaranth, buckwheat and mulberry which are cultivated in the Himalayan region.

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