International Research Journal of Biological Sciences _____ ISSN 2278-3202
Vol. **9(4),** 83-94, November **(2020)** *Int. Res. J. Biological Sci.*

Review Paper

Exotic plant invasion in India through the lens of archaeobotanical evidences: An overview

Patil D.A.
Post-Graduate Department of Botany, S.S.V.P. Sanstha's L.K. Dr. P.R. Ghogrey Science College, Dhule-424005, MS, India
dapatil_10aug@yahoo.com

Available online at: www.isca.in, www.isca.me
Received 5th July 2020, revised 16th October 2020, accepted 11th November 2020

Abstract

The present author looked at archaeobotanical evidences particularly with the objective of plant invasion in India either through introduction and domestication of plant species and naturalisation of other wild species. India had religious and cultural contacts with other countries abroad in ancient period. The native Indian people appropriated, absorbed or bioprospected potentially beneficial exotic plant species and thereby made integral part of Indian culture. A literary survey was done knowing occurrence of exclusively exotic cultivated plant species revealed or depicted in archaeological sites and structures. Their exotic status has been verified by comparing relevant literature to decipher their respective nativity. Significant comments in botanical perspective are made. The exotic species appeared to have adapted for dietary needs, medicine, beautycare and even socio-religious purposes. Present attempt included total 74 exotic cultivated or wild taxa pertaining to 68 genera and 30 angiospermic families. These are evaluated for their nativity consulting recent and relevant literary sources. Apart from proximal Asian countries, exotic taxa from distant continents such as America, Africa, Europe and Australia predominated exotic flora of India in ancient past. Plant invasion in India in ancient period is discussed based on evidences borrowed from archeobotanical dataset. Ancient Indians inducted and domesticated plant species from different parts of the Old and New worlds for the concrete purposes. These have been also appropriated for religious purposes and thus also find place in Indian bioculture.

Keywords: Plant Invasion, Archaeobotany, Exotic Species, Bioculture, India.

Introduction

Archaeobotany is a sub-discipline of archaeology. It is a resourceful study to reveal ancient plants, whether wild or cultigens. It also helps to connect the people to ancient bioculture and agriculture and provide evidences for plant dispersals, trade and economy of a region in past. It is thus a composite field of study combining archeological materials with botanical knowledge. This area of study informs about plant remains in the form of carbonized and silicified seeds, fruits, wood charcoals, phytoliths, husk, glumes, fibres, imprints on pottery and burnt mud-clods, etc. recovered from archeological settlements.

India is one of the most diverse country in terms of relationship between environment and mankind through the ages. It has also a strategic position between the East and West. Its cultural and natural interconnectivity suffices explanation for cultural diversity of its inhabitants. Moreover, its varied and unique climate associated with biodiversity have the great bearing on the culture and life-style. India has remained in past as an ideal region for plant domestication[1,2,3]. Indian subcontinent has attracted attention of many archaeologists because of a potential area for domestication of useful species. Moreover, India was a connecting link for various countries. Although, Indian territory has been fairly studied archaeologically in view of biodiversity elements, it has not provided explicit status with particular emphasis on exotic floral elements domesticated or naturalised to date. The present is an attempt to shed more light on exotic species playing economic and environmental role in this region.

Methodology

India is a biodiversity-rich country and has strategic geographical position in between in the West and East. It has also importance for trade and has a facourable climate for domestication of plants, apart from its biocultural heritage. At this backdrop, Indian subcontinent has been investigated fairly archaeobotanically. The past investigations although revealed biodiversity of India in ancient period, they have not explicitly and satisfactorily illustrated exotic status of the various floral elements invaded in past. The present author re-examined such archaeobotanical reports and evaluated them from the invasion standpoint in ancient period.

The results of such re-investigation are projected in the Table-I incorporating plant species (along with synonyms if any), plant parts or remains unearthed, respective archaeological site and state or region in India, their habit, besides status regarding wild or cultivated. Their nativity is pointed out consulting relevant

literary sources. The results of this re-investigation are dilated pertinently in this communication.

Results and discussion

Accumulation of archaeobotanical data gathered from various sites in Indian states with particular emphasis on exotic plant species in shortlisted in the Table-I. The data belongs to different periods and eras. Agricultural and overall conditions in India suited to the crop and useful species hailed from various regions throughout. Plant dispersal towards and within India provide clues for the conditions, routes, trade and plant economy in the ancient period. A total of 74 exotic plant angiospermic species found place and settled in Indian territory. They belong to total 68 genera (52 dicotyledonous and 16 monocotyledonous). It thus appeared that major share, in plant invasion is due to dicotyledonous species. Majority of genera shared a single species each except few e.g. *Annona*, *Allium*, and *Brassica*. Of these, 50 exotic species are found under cultivation for food, spices, oils, etc., whereas 21 species run exclusively as wild ones. Three species are grow wild and also cultivated in India. Their habital categorisation revealed trees (12 species), shrubs (05 species), climbers (04 species) and herbs (53 species). The herbaceous taxa played a major role in plant introduction *vis-a-vis* plant invasion. Relevant literature on their exotic status showed that these species are introduced or naturalised in India from different continents, countries and geographical areas of both, the New and Old worlds. They belong to continents *viz*., America (20 species) and Europe (13 species). Few countries and geographical regions shared a few exotic species e.g. Mediterranean region (04 species), Australia and Arabia (03 species each) and subtropical and warm temperate zone (02 species). Others *viz*., Chile, Peru, Balkan Peninsula, Italy, Fertile Crescent, East Indies, China and Molluccas shared a single species each. Carbonized, charred or silicified plants or plant parts found on different archaeological sites in India are cloves, flowers, fruits (achenes, caryopsis, stones), seeds (or grains), spikelets, timber and charcoal. Few exotic species are painted or sculpted on temples or caves. The archaeological sites belong to different Indian states e.g. (i) Uttar Pradesh: Ballia, Waina, Raja-Nala-Ka-Tila, Tokwa, Narhan, Malhar, Imlidih Khurd and Atranjikhera Etah. (ii) Madhya Pradesh: Bharut Stupa, Nevadatoli-Maheshwar. (iii) Himachal Pradesh: A Temple, (iv) Punjab: Sanghol, Rohira, (v) Haryana: Balu, Kunal, Farmona, Banawali and Maharana, (vi) Kashmir Valley, (vii) Gargetic Plains: Hulas, Senuwas, Khairdah, (viii) Gujarat: Rangpur, Patan, Rojdi, Surkhotoda, Kanmer, (ix) Bihar: Kaimar Ranges, (x) Maharashtra: Inamgaon Daimabad, Sonegaon, Ter, Ajanta, Ellora, (xi) Karnataka: Hoysala, Hallur, Tekkalkota, (xii) Orissa (Odisha): Udaigir, (xiii) Tamil Nadu: Tiruchirapalli.

Food is the premier necessity of mankind worldwide. This most important human need was met with hunting and gathering of plant parts or animals in ancient period. However, eventually man adapted for sedentary life-style and hence agricultural activity. This activity was/is sufficed through domestification of local species available in the wild. Unavailability of food resources because of famines, floods and such other natural calamities or climatic variabilities, sometimes seer necessity compelled mankind to adopt crops/plant species from other regions of the world. During this process, some essential exotic species are brought in his area of habitation. The seeds or propagules sometimes also contained seeds of wild species of other regions. These also naturalised around human habitations. These wanted and unwanted species of ancient period were normally preserved in carbonized or silicified forms. Their area of occurrence now we call archeological sites. Thus the most direct or hard evidence for agriculture and naturalization of wild species in the past comes from archaeobotany. India provides interesting prospects for archaeobotanical research about early agriculture. The ecological and topographical diversity in India provide the home for a wide diversity of edible and non-edible plants. The exotic species occupied a space in diet and subsistence in the then India. Apart from cultigens, 21 exotic species associated with them are still found in India and are integral part of Indian biodiversity. They run either as crop weeds or weeds on waste places and routes.

After food, medicine is the first discovery and need of mankind. The exotic species have been appropriated as medicinal resources even in the indigenous system of medicine (Ayurveda)[4]. Singh earmarked 26 alien plant species prior to the 8thcentury. He also derived evidence from archaeobotanical studies in India. The exotics have been depicted as paintings or stone sculptures in temples or caves. These also provide proof of evidences supporting cultivation of exotic plants in ancient times in India. For example, (i) flowers and fruits of *Anacardium occidentale* are depicted at Jambukeshwara temple, Tiruchirupalli, Tamil Nadu built before 2500 years[5]. (ii) Fruits of *Annona squamosa* carved at Bharut Stupa and Sanchi, Madhya Pradesh[6-8] and depicted at Ajanta caves[9] and Durga temple, Aihole, Karnataka[10]. (iii) Likewise, representation of hands and feet dyed by *Lawsonia inermis* find place in ancient Upinishad as during 800 BCE to 300 BCE[11]. (iv) Fruit of *Ananas comosus* are sculpted as 'Vanamala' of Lord Vishnu (a Hindu God) in his 'Varah Avatara' and Udaygiri temple, Madhya Pradesh (5th century AD.) and also depicted at Moti-Shahka-Tuk, Shatrunjaya Hills Complex, Palitana, Gujarat[5]. Many exotic plant species have been mentioned in ancient Sanskrit scriptures in Vedic and Post-Vedic period of India[11], in the epic Ramayana[8], Garuda Purana[12] and Tantrasarah[13]. The origins of common plant names in various Indian languages and Sanskrit are also traced[14]. Exotic species are also intertwined with bioculture in India[15]. Carriage of plant propagules, seeds or grains are possible through terrestrial route (Silk route) on the northern side of India. However, decisive evidences of transoceanic carriage of some species are provided e.g. *Ananas comosus*, species of *Annona*, *Anacardium occidentale*, *Capsicum annuum*, *Macroptilium lathyroides*, *Nicotiana tabacum*, species of *Phaseolus*, *Zea mays* of the present account[16]. A pivotal evidence particularly for transfer of custard

apple (*A.squamosa*) during pre-Columbian period is also on record[17]. All the species included in Table-I have invaded Indian subcontinent obviously during pre-Columbian period.

The above resume indicates that fundamental changes in bioculture and heritage of modern mankind emerged with cultivation practices and sedimentary life. The ancient plant remains help provide most direct and hard evidence. In India, beginning of agriculture is reported in *viz*., South India, Orissa (Odisha), The Middle Ganges, Saurashtra (In Gujarat) and the Himalayan Foothills of the Punjab region before the introducing exogenous crops and cultivation systems[18]. The present study clearly proved that exogenous crops or wild plant species from all continents of the world were settled in all these above stated five Indian regions of early agriculture and domestication. The dominance in representing exotic species from Asian region may be due to proximity of the region. It is, however, notable that the distant continents or countries like America, Africa, Europe and Australia have also predominated exotic floral elements in India. This is probably due to seer necessity of the ancient Indians for their sustenance which cannot be met with the Asian exotic species, besides indigenous ones.

Table-1: Plant Species Revealed From Archaeological Evidence.

Plant Name & Family	Part Disclosed & Reference	Archaeological Site	Habit	Wild (W) / Cultivated (C)	Nativity & Reference
Acacia nilotica (L.) Willd. ex Del. Mimosaceae	Seeds 96	Kanmer, Gujarat	Tree	W	North Africa & Arab 24, 56
Albizia lebbeck Mimosaceae	Timber Remains 92	Eastern Region (Rajasthan, Punjab, Haryana & UP)	Tree	W/C	North Australia & Tropical Asia 60
Allium cepa L. Liliaceae	Plant Remains 62	Middle Gangetic plains-Wainna, Ballia & Raja-Nala-Ka-Tila, Uttar Pradesh	Herb	C	Western Asia, Persian & Adjacent regions 19
Allium sativum L. Liliaceae	Three Cloves Carbonized 63	Harrappa site Balu, Haryana	Herb	C	Western Temperate Asia & Europe 19
Anacardium occidentale L. Anacardiaceae	Flowers & Fruits 64,65	Jambukeshvara Temple, Tiruchirapalli, Tamil Nadu	Tree	C	Tropical America 20, 21
Ananas comosus (L.) Merr. Bromeliaceae	Fruit 64	Udaygiri Cave Temple, Madhya Pradesh	Shrub	C	South America 22
Annona cherimolia Mill. Annonaceae	Fruit 66	Wall of Hoysala Dynasty Temple, Karnataka	Tree	C	Mesoamerican Region 23
Annona reticulata L. Annonaceae	Fruits, Seeds 65, 17	Bharut Stupa, Madhya Pradesh; Sanghol, Punjab; Tokwa & Raja-Nala-Ka-Tila, Uttar Pradesh	Tree	C	Tropical America 16, 30 West Indies 20
Annona squamosa L. Annonaceae	Fruits, Fruit pieces & Seeds 64, 65, 67	Bharut Stupa, Madhya Pradesh; Ajanta Caves, Maharashtra; Sanghol, Punjab	Tree	C	Tropical America 19
Argemone mexicana L. Papaveraceae	Charred Seeds 88, 89	Sanghol, Punjab; Narhan, Uttar Pradesh	Herb	W	South America 41

Avena sativa L. Poaceae	Seeds 97	Hulas, Gangetic plains	Herb	C	Mediterranean Region 47
Blainvillea acmella (L.*f.*). Philipson Asteraceae	Seeds 88	Rojdi (Saurashtra) Gujarat	Herb	W	Tropical America 41
Boerhavia diffusa L. Nuctasinaceae	Seeds 88	Rojdi (Saurashtra) Gujarat	Herb	W	Tropical Africa 48
Brasica juncea (L.) Koch Brassicaceae	Seeds 89	Sanghol, Punjab	Herb	C	Europe 44, 45
Brassica campaestris L. Brassicaceae	Plant Remains 53	Rojdi (Saurashtra) Gujarat	Herb	C	Europe 44
Cannabis sativa L. Cannabinaceae	Seeds & Charcoal of wood 69, 75	Kunal, Haryana; Senuwar, Middle Gangetic Plain	Shrub	W	Central Asia 42 Caspian Sea Region &Caucasus Mountains 43
Capsicum annuum L. Solanaceae	Plant with flowers, fruits &leaves 64	Jambukeshvara Shiva Temple, Tiruchirapalli, Tamil Nadu.	Shrub	C	Chile 19
Carthamus tinctorius L. Asteraceae	Achenes (Fruits), Grains 68	Imlidih-Khurd, Uttar Pradesh; Savlda, Maharashtra	Herb	C	South-West Asia 21
Chenopodium album L. Chenopdiaceae	Seeds 89	Sanghol, Punjab	Herb	W	Europe 59
Cicer arietinum L. Papilionaceae	Grains 68	Savalda, Maharashtra; Imlidih-Khurd, Uttar Pradesh; Balu, Kunal, Haryana	Herb	C	South Europe 20
Citrullus lanatus (Thunb.) Matsum & Nakai Cucurbitaceae	Seeds 68	Imlidih-khurd, Uttar Pradesh, Balu, Haryana	Climber	C	South Africa 21, 24, 25
Cleome viscosa L. Capparidaceae	Seeds 100, 101	Narhan, Middle Gangetic Plains	Herb	W	Tropical Africa 41
Coriandrum sativum Apiaceae	Seeds 89	Sanghol, Punjab	Herb	C	South Europe 19
Cucumis melo L. Cucurbitaceae	Seeds 62,63, 68, 69	Imlidih-khurd, Uttar Pradesh; Balu, Kunal, Haryana	Climber	C	Asia (Excl. India) 26, 27
Cuminum cyminum Apiaceae	Fruits 89	Sanghol, Punjab	Herb	C	Mediterranean Region 24, South Europe 35

Cymbopogon martinii (Roxb.) Wats. Poaceae	Seeds 88	Rojdi (Saurashtra), Gujarat	Herb	W	Afro-Asian 40 Africa 35
Dactyloctenium aegyptium (Linn.). Beauv. Poaceae	Plant Remains 88	Rojdi (Saurashtra) Gujarat	Herb	W	Warmer Regions of the Old World 54
Digera muricata (L.) Mart. Amaranthaceae	Seeds 88	Rojdi (Saurashtra) Gujarat	Herb	W	South-West Asia 41
Echinochloa crus-galli (L.) Beauv. Poaceae	Earopsis Fruits 89	Sanghol, Punjab	Herb	W/C	Tropical America 46 South America 48, 58
Eleusine coracana (L.) Gaertn. Poaceae	Carbonised Seeds, Grains &Caryopsis 62, 68, 70, 71	Malhar, Uttar Pradesh & Gansetic Plains; Hallur, Karnataka	Herb	C	Tropical Africa 27, 28
Gossypium herbaceum Malvaceae	Seeds 69, 90, 91	Kunal, Haryana; Sanghol, Punjab; Hulas, Gangetic Plains; Hullur, Karnataka	Herb	C	Arabia & Asia Minor 19 Africa & Asia 24
Helianthus annuus L. Asteraceae	Sunflower 64, 66	Rani Gumpha cave, Udaigir, Orissa; Hoysala Temple, Karnataka	Herb	C	Central America & Peru 29
Hordeum vulgare L. var. *nudum* Hook. *f.* Poaceae	Seeds 63, 69	Harappa site, Balu & Kunal, Haryana	Herb	C	Europe & North America 30
Indigogera linifolia (L.*f.*) Retz. Papilionaceae	Plant Remained 88	Rojdi (Saurashtra) Gujarat	Herb	W	Tropical South America 41, 51, 52
Ipomoea pes-tigrides L. Convolvulaceae	Seeds Fruits 103	Senuwar, Kaimur Ranges, Bihar	Climber	W	Tropical East Africa 41, 51, 52
Lablab purpureus (L.) Sweet (Syn.*Dolichos lablab* L.) Papilionaceae	Plant Remains 94	Maharana, Punjab	Climber	C	Tropical Africa 46
Lathyrus aphaca L. Papilionaceae	Seeds & Fruits 100, 101, 106	Narhan, Gorakhpur District, Middle Gangetic Plains	Herb	W	Europe 40, 56
Lathyrus sativus L. Papilionaceae	Seeds 62, 63, 68	Malhar, Uttar Pradesh ; Balu & Kunal, Haryana &Gangetic Plains	Herb	C	Balkan Peninsula 31
Lawsonia inermis L. Lythraceae	Paintings, Seed 72, 73	Ajanta & Ellora Caves, Maharashtra; Sanghol, Punjab	Shrub	C	North America & Australia 61

Lens culinaris Medik. Papilionaceae	Seeds 62, 63, 65	Malhar, Uttar Pradesh; Balu & Kunal, Haryana, Gangetic Plains	Herb	C	Western Temperate Asia 32
Linum usitatissimum L. Linaceae	Seeds 68, 69, 74	Harappan Site & North Inidia	Herb	C	Mediterranean Region 32
Lolium temulentum L. Poaceae	Seeds & Fruits 100, 101, 106	Narhan, Gorakhpur District, Middle Gangetic Plains	Herb	W	Europe 16, 33
Macroptilium lathyroides (L.) Urb. (Syn.*Phaseoluslathyroides* L.) Papilionaceae	Grains 99, 99, 100	Inamgarh & Daimabad, Maharashtra	Herb	W	Tropical America 55
Macrotyloma uniflorum (Lam.) Verdc. (Syn.*Dolichos biflorus*) Papilionaceae	Carbonized Plant Remains 93	Rohira, Punjab	Herb	C	South-East Asia 47
Malvastrum coromandelianam (L.) Garcke Malvaceae	Seeds 100, 101	Narhan, Middle Gangetic Plains	Herb	W	Tropical America 41
Medicago sativa L. Papilionaceae	Seeds 66	Kunal, Haryana	Herb	C	West Temperate Asia 20
Myristica fragrans Houtt. Myristicceae	Remains of Nutmeg 100	Khairadih, Uttar Pradesh	Tree	C	Moluccas 50
Nicotiana tabacum L. Solanaceae	Hooka 4	Temple, Himachal Pradesh	Herb	C	Tropical America 28 America 19, 24
Panicum miliaceum L. Poaceae	Crop Remains 62	Raja-Nala-Ka-Tila, Uttar Pradesh	Herb	C	Asia (Excl. India) 33
Paspalum scrobiculatum L. Poaceae	Spikelets 75	Malhar, Uttar Pradesh	Herb	C	Tropical Africa 27
Pennisetum americanum L. [Syn.*P.glaucum* (L.) R.Br.] Poaceae	Crop Remains 68, 70, 71	Harappa Site, Rangpur, Gujarat; Narhan, Uttar Pradesh	Herb	C	Tropical America 28 Tropical Africa 34
Phaseolus lunatus L. Papilionaceae	Grains 98, 99, 76	Inamgaon & Daimabad, Maharashtra	Herb	C	America 27
Phaseolus vulgaris L. Papilionaceae	Plant Remains 76, 77	Patan, Gujarat Inamgaon & Diamabad, Maharashtra; Tekkalkota, Karnataka	Herb	C	America 28 South America 30

Phoenix dactylifera L. Arecaceae	Stone Remains 63	Rohira, Punjab; Balu, Haryana	Tree	C	Arabia & North Africa 31
Phragmites karka (Retz.) Trin ex Steud. Poaceae	Carbonized Seeds 104, 105	Surkotada, Run of Kutch Gujarat	Herb	W	Africa 16
Pisum arvenes L. Papilionaceae	Seeds 62, 63, 69, 78, 79	Gangetic Plains, North India; Tokwa, Uttar Pradesh	Herb	C	Italy 25
Pisum sativum L Papilionaceae	Plant Remains 68	North-West India & Gangetic Plains	Herb	C	West Asia 20
Ricinus communis L. Euphorbiaceae	Plant Remains 62, 68, 80, 81	Hulas, Gangetic Plains	Tree	C	Africa 19, 24 Tropical Africa 35
Rumex dentatus L. Polygonaceae	Seeds 89	Sanghol, Punjab	Herb	W	Africa & Europe 33
Saccharum spontaneum L. Poaceae	Remains of Cuticles 100,101, 102, 106, 107,108,109	Narhan, Gorakhpur District, Middle Gangetic Plains	Herb	W	Tropical West Asia 51, 52
Setaria italica Beauv. Poaceae	Plant Remains 92	Rojdi (Saurashtra) Gujarat	Herb	C	Near East (China) 27
Solanum melongena L. Solanaceae	Plant Remains 95	Farmana (Rohtak District)	Shrub	C	East Indies 50 America 28
Sorghum bicolor (L.) Moench. Poaceae	Carbonized Plant Remains 99	Rohira, Punjab	Herb	C	North-Eastern Quadrant of Africa/Ethiopia 27
Tamarindus indica L. Caesalpiniaceae	Charcoal Remains 68	Narhan, Middle Gangetic Plains	Tree	W/C	Tropical Africa 24
Trianthema portulacastrum L. Aizoaceae	Charred Remains (Seeds) 96	Kanmer, Gujarat	Herb	W	Tropical America 16
Trifolium repens Linn. Papilionaceae	Carbonized Seeds 105, 106	Surkotada, Run of Kutch Gujarat	Herb	W	Europe (Incl.British) 53
Trigonella foenum-graecum L. Papilionaceae	Seeds 69, 82, 83	Kunal & Banawali, Haryana; Rohira, Punjab	Herb	C	South Europe 20

Triticum aestivum L. Poaceae	Grains 84, 85, 86	Atraniikherain Etah, Uttar Pradesh; Navadatoli-Maheshwar, Ujjain, Madhya Pradesh; Sonegaon, Ter & Inamgaon, Maharashtra	Herb	C	Fertile Crescent, Middle East 37
Vicia sativa L. Papilionaceae	Seeds, Fruits 100	Sensuwar, Kaimur Ranges, Bihar; Narhan, Gangetic Plains	Herb	C	Mediterranean Region &West Asia 25
Vigna unguiculata (L.) Walp. Papilionaceae	Plant Remains 62, 87	Daimabad, Maharashtra; Hulas, Gangetic Plains; Khairadih & Raja-Nala-Ka-Tila, Middle Gangetic Plains	Herb	C	Central Africa 47
Vitis vinifera L. Vitaceae	Carbonized seeds 63, 69	Balu & Kunal, Haryana	Climber	C	South-East Europe to West Indies 38, 38
Zea mays L. Poaceae	Sculptures of ears 66, 77	Hoysala Temples, Karnataka	Herb	C	Central America 39
Ziziphus jujuba Mill. Rhamnaceae	Seeds 97	Madhya Pradesh	Tree	C	Subtropical & Warm Temperate zone 49
Ziziphus mauritiana Lam. Rhamnaceae	Fruit Remains 92	Rojdi (Saurashtra) Gujarat	Tree	C	Australia 57

Conclusion

The archaeobotanical information so far available from various centres of agriculture in Indian subcontinent help understand the role of alien crop species in Indian economy, crop diversity, distribution and cultural change. It is wheat and barley represented generally throughout India. Crops of different seasons were suitable to the amiable environment and soil conditions of India in past. Few crop species also appeared adapted in view of drought-resistancy. Apart from dietary necessity, health, beautycare and religions aspects have been also supported in past after appropriation of such useful alien species. The review is targeted revealing domestication and nativity of cultigens in India in various ancient periods of time for the sake human welfare. Still, there are other cultigens need to be studied on this line in future.

Acknowledgements

I am thankful to the authority of S.S.V.P. Sanstha, Dhule, for library facilities.

References

1. Sauer C.O. (1952). Agriculture Origins And Dispersals. American Geographical Society, New York, USA.

2. Harris D. (1973). The prehistory of tropical agriculture: An ethnoecological model. In: The explanation of Culture Change: Models In Prehistory. pp. 397-417.

3. Vavilov N.I. (1949). The Origin, Variation, Immunity and Breeding of Cultivated Plants. *Chronica Botanica*, 13.

4. Singh A.K. (2016). Exotic ancient plant introductions: Part of Indian 'Ayurveda' medicinal system. *Plant Genetics Resources: Characterization and Utilization*, 14(4), 356-369. DOI:10.1017/S1479262116000368

5. Gupta S.M. (1996). Plants in Indian Temple Art. B.R. Publishing Corporation, Delhi, India.

6. Brown P. (1965). Indian Architecture-Buddhist and Hindu Periods. D.B. Taraporewala Sons & Co. Pvt. Ltd., Bombay, India.

7. Marshall J. & Foucher A. (1940). The Monuments of Sanchi. Vols. 3, Probsthain, London, UK.

8. Patil D.A. (2018b). Some comments on exotic floral elements as hailed from epic Ramayana. *Sch. Acad. J. Biosci*., 6(2), 146-150.

9. Watt G. (1889-1893). A Dictionary of The Economic Products of India. Periodical Expert, Shahadara, Delhi, India. Vol.1-6.

10. Pokharia A.K., Sekar H., Pal J. & Srivastava A. (2009). Possible evidence of pre-Comumbian transoceanic voyages based on conventional LSC and AMS 146 dating of associated charcoal and a carbonized seed of custard apple (Annona squamosa L.). *Radiocarbon*, 51(3), 923-930. https://doi.org/10.10/750033822200033993

11. Patil D.A. (2017b). Alien plant species recorded in Vedic and Post-Vedic period of India: An assessment. *Sch. Acad. J. Biosci*., 5(11), 812-819. DOI:10.21276/sajb.2017.5.11.8

12. Patil D.A. (2018). On some alien plant species: Gleanings from Garuda Purana. *Sch. Acad. J. Biosci*., 6(2), 163-166. DOI:10.21276/sajb.2018.6.2.5

13. Patil D.A. (2019). Plant invasion in India as revealed from Tantrasarah. *Journal of Emerging Technologies and Innovative Research*, 6(3), 16-21.

14. Patil D.A. (2019). Origins of common names of aliens: A comparative study of Indian biodiversity. I3 Biodiversity, 4, 402-412. https://biodiversity.I3 press.fi.

15. Patil D.A. (2019). Scientific history of some alien plants in India: Origin, implications and culture. *Plantae Scientia*, 1(5), 66-75. DOI: https://doi.org/10.32439/ps.vlio 5.66.75.

16. Sorenson J.L. (2005). Ancient voyages across the ocean to American: From 'Impossible' to 'Certain'. *Journal of Book of Mormon Studies*, 14/1:4-17, 124-125.

17. Saraswat K.S., Rajagopalan G. & Prasad Ravi (2008). A pivotal evidence of custard apple: Evocative of some pre-Columbian network contact between Asia and America. *Pragdhara*, 18, 283-308.

18. Fuller D.Q. (2015). Finding plant domestication in the Indian Subcontinent. *Athropology*, 52(4), 347-362.

19. Bailey L.H. (1949). Manual of Cultivated Plants. Rev.Ed., The Macmillan Co., New York, USA.

20. Patil D.A. (1995). Exotic elements in the flora of Dhule district (Maharashtra-II). *Biojournal*, 7(1-2), 1-8.

21. Patil D.A. (2003). Flora of Dhule and Nandurbar District (Maharashtra). Bishen Singh Mahendra Pal Singh, Dehradun, India.

22. Sharma B.D. & Pandey D.S. (1984). Exotic Flora of Allahabad District. *Bot. Surv. India*, Calcutta, India.

23. Qureshi H., Arshad Muhammad & Yasmin Bibi (2014). Invasive flora of Pakistan: A critical analysis. *Int. J. Biosci*., 4(1), 407-424.

24. Purseglove J.W. (1968). Tropical Crops: Dicotyledons-1&2. Longmans, London, UK.

25. Shetty B.V. & Singh V. (1987). Flora of Rajasthan. *Bot. Surv. India*, Calcutta, India. Vol. I.

26. Stewart R.R. (1972). An Annonated Catalogue of The Vascular Plants of West Pakistan and Kashmir. Fakhri Press, Karchi, Pakistan.

27. Singh A.K. & Nigam S.N. (2017). Ancient alien crop introductions integral to Indian agriculture: An overview. *Proc. Indian Natn. Sci. Acad*. 83(3), 549-568. DOI:10.16943/ptinsa/2017/48970

28. Gaikwad S.P. & Garad K.U. (2015). *Flora of Solapur District*. Laxmi Book Publications, Solapur, Maharashtra, India.

29. Coats A.M. (1956). Flowers and Their Histories. Hulton Press Ltd., London, UK.

30. Dar G.H., Bhagat R.C. & Khan M.A. (2002). Biodiversity of the Kashmir Himalaya. Valley Book House, Srinagar, India.

31. Kislev M.E. (1989). Origins of the cultivation and Lathyrus sativus and L. cicera (Fabaceae). *Economic Botany*, 43(2), 22-270.

32. De Candolle A. (1959). Origin of Cultivated Plants. Rev. 2nd Ed., Hafner Publishing Co., London, UK.

33. Kaul M.K. (1986). Weed Flora of Kashmir Valley. Scientific Publishers, Jodhpur, India.

34. Purseglove J.W. (1972). Tropical Crops: Monocotyledons. Vols. 2, Longmans, London, UK.

35. Yadav S.R. & Sardesai M.M. (2002). Flora of Kolhapur District, Maharashtra, India. Shivaji University Kolhapur, (Maharashtra) India.

36. Graf A.B. (1980). Exotica: Pictorial Cyclopedia of Exotic Plants from Tropical and Near-Tropic Regions. Roders Company INC. USA. 10th Ed.

37. Simmons S.R. (1987). Growth, Development and Physiology. In: Wheat and Wheat Improvement. (Ed.Heyne, E.G.) 2nd Ed. ASAINC, CSSA, INF and SSS of America INC. Madison Wisconsin, USA, pp.77-104.

38. Ugemuge N.R. (1986). Flora of Nagpur District, Maharashtra. Shree Prakashan, Shankarnagar, Nagpur, India.

39. Backer C.A. & Brink Jr. R.C.B. (1963-1968). Flora of Java. Vol.1-III. Wolters - Noordhoof, Gronengen, Netherland.

40. Naik V.N. (1988). Flora of Marathwada. Vol.I-II. Amrut Prakashan, Aurangabad, Maharashtra, India.

41. Patil D.A. (2017). Invasive alien species in Khandesh region (Maharashtra: India): Diversity, Implications and measures. *Sch. Acad. J. Biosci*., 5(12), 867-876. DOI:10.21276/sajb.2017.5.12.8

42. Cooke T. (1958). Flora of the Presidency of Bombay. Vol.I-III., Bot. Surv. India, Calcutta, India, Repr.Ed.

43. Watt G. (1908). The Commercial Products of India. John Murray, London, UK.

44. Naqshi A.R. & Javeid G.N. (1987). Tribe Brassiceae (Brassicaceae) in Kashmir Himalaya. *J. Econ. Tax. Bot*. 9, 89-96.

45. John Cameron (1891). Catalogue of Plants in The Botanical Garden, Bangalore and Its Vicinity. 2nd Ed.. Mysore Government Central Press, Bangalore, India.

46. Debnath A. & Debnath B. (2017). Diversity, invasion status and usages of alien plant species in Northeastern Hilly State of Tripura: A confluence of Indo-Barman Hotspot. *American Journal of Plant Sciences*, 8, 212-235.

47. Patil D.A. (2019). Food Crops: Evolution, Diversity and Advances. Scientific Publishers, Jodhpur, India.

48. Panda T., Mishra N., Pradhan B.K. & Mohanty R.B. (2018). Expansive alien flora of Odisha, India. *Journal of Agriculture and Environment for International Development*, 112(1), 43-64.

49. Martin F.W., Campbell C.W. & Ruberte R.M. (1987). Perennial Edible Fruits of The Tropics: An Inventory. U.S. Department of Agriculture, Agriculture Handbook No. 642, 222p illus.

50. Singh N.P., Lakshminarsimhan P. & Karthikeyan S. (2001). Flora of Maharashtra State: Dicotyledons. Vol. II. Bot. Surv. India, Calcutta, India.

51. Reddy C. Sudhakar (2008). Catalogue of Invasive Alien Flora of India. Forestry and Ecology Division, National Remote Sensing Agency, Balanagar, Hyderabad-500037, India. http://1sj.224.edu.en

52. Chandra Sekar K. (2012). Invasive alien plants of Indian Himalayan Region: Diversity and implication. *American Journal of Plant Sciences*, 3, 177-184. http://dx.doi.org/10.4236/ajps.2012.32021

53. Clapham A.R., Tutin T.G. & Warburg E.F. (1968). Excursion Flora of the British Isles. Cambridge University Press, Cambridge, UK.

54. Bhandari M.M. (1978). Flora of Indian Desert. Scientific Publishers, Jodhpur, India.

55. Prabhukumar K.M., Jagadeesan R., Gangaprasad A. & Mathew Sam P. (2016). Macroptilium (Leguminosae: Faboideae), a new genus record for Kerala. *Devgiri Journal of Science*, 2(1), 142-145.

56. Rajagopal T. & Panigrahi G. (1965). Aliens' naturalised in the flora of Allahabad. *Proc. Nat. Acad. Sci. India*. Sect. B., 35(4), 411-422.

57. Veerasamy A. & Arumugan R. (2014). Diversity in invasive plant species in Boluvampatti forest range. Southern Western Ghats, India. *Biodiversity Journal*, 5(3), 377-386.

58. Srivastava S., Dvivedi A. & Shukla R.P. (2014). Invasive alien species of terrestrial vegetation of North-Eastern Uttar Pradesh. *International Journal of Forestry Research*, Article ID959875 pp.1-9.

59. Khuroo Anzar Ahmad, Irfan Rashid, Zafar Reshdi, Dhar G.H. & Wafai B.A. (2007). The alien flora of Kashmir Himalaya. *Bio Invasions*, 9, 269-292. DOI 10.1007/ S10530-0114-9981-2.

60. Kshirsagar S.R. & Patil D.A. (2002). Exotic floral elements in the flora of Jalgaon district (Maharashtra). *J. Econ. Tax. Bot*., 26(3), 529-532.

61. Patil D.A. (1990). Exotic elements in the flora of Dhule district (Maharashtra). *J. Econ. Tax. Bot*., 14(3), 721-724.

62. Saraswat K.S. (2005). Agriculture background of the early farming communities in the Middle Gangetic Plain. *Praghdhara*, 15, 145-177.

63. Saraswat K.S. & Pokharia A.K. (2002). Harappan Plant economy at ancient Balu, Haryana. *Pragdhara*, 12, 153-172.

64. Gupta S.M. (1996). Plants in Indian Temple Art. B.R. Publishing, Delhi, India.

65. Cunnigham A. (1879). The Stupa of Bharut: A Buddhist monument ornamented with numerous sculptures illustrative of Buddhist legend and history in the third century BC. London (Repr. 1962) Indological Book House, Varanasi, India.

66. Johannesen C.L. & Wang S. (1998). American crop plants in Asia before AD 1500. *Pre-Columbiana*: *A Journal of Long-Distance Contacts*, 1, 9-36.

67. Watt G. (1889). A Dictionary of the Economic Products of India. Department of Revenue and Agricultural, Calcutta, India.

68. Saraswat K.S., Sharma N.K. & Saini D.C. (1994). Plant economy at ancient Norhan (ca. 1300 BC-300/400 AD). In: Excavations at Narhan (1984-1989) (Ed.Singh, P.). Banaras Hindu University, Varanasi, India, pp.255-346.

69. Saraswat K.S. & Pokharia A.K. (2003). Palaeobotanical investigations at early Harappan Kunal. *Pragdhara* 13, 105-139.

70. Fuller D.Q. (2003). African crops in prehistoric South Asia: A critical review. In: Food, Fuel and Fields: Progress In African Archaeobotany (Ed.Neumann, K. et al.) Africa Prehistorica 15 Heinrich-Barth Institute, Cologne, pp.239-271.

71. Herman C.P. (1997). Harappan Gujarat the archaeology-chronology connection. *Paltorient*, 22, 77-112.

72. Vankar P.S. (2007). Handbook on natural dyes for Industrial Applications. National Institute of Industrial Research, New Delhi, India.

73. Mohd. Yusuf, Mohd. Shabbir & Mohammad Faqeer (2017). Natural colourents: Historical processing and sustainable prospects. *Nat. Prod. Bioprospeet,* 7(1), 123-145.

74. Kajale M.D. (1996). Palaeobotanical investigations at Balathal: Preliminary results. *Man Environ,* 11, 98-102.

75. Saraswat K.S. (2004). Plant economy in ancient Malhar. *Pragdhara,* 14, 137-172.

76. Vishnu-Mittre, S. A. (1976). Chanchala (1986). Ancient plant economy at Daimabad. Daimabad, 1979, Memoirs of the Archaeological Survey of India (Ed. Dali, S.A.). Government of India Central Publication Branch, Calcutta, India, 588-626.

77. Sorensen J.A. & Johannessen C.L. (2004). Scientific evidence for pre-Columbian transoceanic voyages. Sino-Platonic Papers. Department of East Asian Languages And Civilizations. University of Pennsylvania, Philadelphia, USA. pp.273.

78. Saraswat K.S. (1992). Archaeobotanical remains in ancient culture and socio-economical dynamics of the Indian subcontinent. *Palaeobotanist,* 40, 514-545.

79. Pokharia A.K. (2008). Palaeoethnobotanical record of cultivated crops and associated weeds and wild taxa from Neolithic site, Tokwa, Uttar Pradesh, India. *Curr. Sci*., 94, 248-254.

80. Saraswat K.S. (1993). Plant economy of late Harappan at Hulas. *Pragdhara,* 23, 1-12.

81. Kajale M.D. (1988). Plant economy. In: Excavations at Inamgaon, (Ed.Dhavalikar, M.K. et al.) Vol.1, Part 2. Deccan College Post-Graduate and Research Institute, Pune. pp. 727-821.

82. Saraswat K.S. (1986). Ancient crop economy of Harappan from Rohira, Punjab (ca.200-1700 BC). *Palaeobotanist* 35, 32-38.

83. Saraswat K.S., Srivastava C. & Pokharia A.K. (2000). Palaeobotanical and pollen analytical investigations. In: Indian Archaeology (1994-95): A review. ASI, New Delhi, India, pp.96-97.

84. Chowdhury K.A., Saraswat K.S. & Buth G.M. (1977). Ancient Agriculture and Forestry In North India. Asia Publishing House, New Delhi, India.

85. Sankalia H.D., Subbarao B. & Deo S.B. (1958). The excavations at Maheshwar and Nevadatoli 1952-1953. The Deccan College Post-Graduate And Research Institute, Poona And Maharaja Sayaji Rao University, Baroda, Gujarat, India.

86. Vishnu-Mittre A. (1974). The beginnings of agriculture: Palaeobotinical evidence in India. Evolutionary Studies in World Crops (Ed.Hutchnison, J.B.). Cambridge University Press, London, U.K. pp 3-30.

87. Fuller D.Q. (2000). Fifty years of archaeobotanical studies in India: Laying a solid foundation. In: Indian Archaeology In Retrospect. III. Archaeology And Interactive Disciplines (Ed. Settar, S. and R.Korisettar). Oxford and IBH, New Delhi, India pp.317-390.

88. Weber S.A. (1991). Plants and Harappan Subsistence: A Example of Stability and Change from Rojdi. Oxfort & IBH Publ. Co.Pvt.Ltd., New Delhi, Bombay and Calcutta, India.

89. Pokharia A.K. & Saraswat K.S. (1999). Plant econmomy during Kushana period (100-300 AD) at ancient Sanghol, Punjab. *Pragdhara,* 9, 75-104.

90. Saraswat K.S. (1997). Plant economy of Barans at ancient Sanghol (ca.1900-14 BC.) Punjab. *Pragdhara*, 7, 97-114.

91. Fuller D.Q., Boivin N. & Korisettar R. (2007). Dating the Neolithic of South India: New radiometric evidence for key economic, social and ritual transformations. *Antiquity* 81, 755-778.

92. Pokharia A.K. & Srivastava C. (2013). Current status of archaeobotanical studies in Harappan civilization: An archaeological perspective. *Heritage,* 1, 118-137.

93. Saraswat K.S. (1988). Pre-Harrappan crop economy of ancient Rohira (ca.2000-1700 BC.), *Palaeobotanist,* 35, 32-38.

94. Saraswat K.S. (1991). Crop economy at ancient Maharana, Punjab (2100-1900 BC.). *Pragdhara*, 1, 83-88.

95. Weber S., Kashyap A. & Mounce L. (2011). Archaeobotany at Farmana: New insights into Harappan plant use strategies. In: Excavations at Farmana, District Rohtak, (Ed. Shide V. et.al.). (2006-2008). Indus Project, RIHN, Kyoto, Japan, pp.808-825.

96. Pokharia, A. K., Kharakwal, J. S., Rawat, R. S., Osada, T., Nautiyal, C. M., & Srivastava, A. (2011). Archaeobotany and archaeology at Kanmer, a Harappan site in Kachchh, Gujarat: evidence for adaptation in response to climatic variability. Current Science, 100(12), 1833-1846.

97. Vishnu-Mittre & Savithri R. (1982). Food economy of the Harappans. In: Harrappan Civilization (Ed.Possehl Gregory L.) Oxford & IBH Publ.Co., New Delhi, Calcutta, India pp.205-221.

98. Kajale M.D. (1977). On the botanical findings from excavations Daimabad-a Chalcolithic site in Western Maharashtra. *Curr.Sci*., 46(26), 818-819.

99. Kajale M.D. (1988). Plant economy. In: Excavations at Inamgaon (Dhavalikar, M.K. et al.). 1(2), 727-820. Deccan P.G. & Res. Inst. Pune, India.

100. Sharma N.K. (1989). Palaeoethnobotanical studies at Narhan, District Gorakhpur, U.P. (C.1000 BC-400 AD). Ph. D. Thesis (Unpublished). Birbal Sahni Institute of Palaeobotany, Lucknow, India.

101. Saraswat K.S., Sharma N.K. & Saini D.C. (1988). Ancient remains of the crop plants from Narhan excavation. Ed.Singh, P. & O.P. Tandon. Bharat Kala Bhavan, Varanasi, India.

102. Saraswat K.S., Sharma D.C. & Chanchala (1990). Palaeobotanical & Pollen analytical investigations. *Indian Archaeology: A review*, 1985-86, 122-125.

103. Singh B.P. (1990). Early farming communities of Kashmir foot-hills. *Purattattva*, 19, 6-18.

104. Savithri R. (1976). Studies In Archaeobotany Together With Its Bearings Upon Socio-Economy & Environment of Indian Proto-Historic Cultures. Ph.D. Thesis, University of Lucknow (Unpublished).

105. Vishnu-Mitre & Savithri R. (1978). Palaeobotanical & pollen analytical investigations. Indian Archaeology: A Review, 1972-73. Archaeological Survey of India, New Delhi, India. pp. 67-68.

106. Saraswat K.S., Sharma N.K. & Saini D.C. (1991). Plant economy at ancient Narhan, Gorakhpur. In:Indian Archaeological Heritage, Ed.Margabandhu, C.et al.. Agam Kala Prakashan, Delhi, India. Pp 199-209.

107. Saraswat K.S. & Sharma N.K. (1986-87). Annual Report: 47-48. Birbal Sahni Institute of Palaeobotany, Lucknow, India.

108. Saraswat K.S., Saini D.C. & Sharma N.K. (1987-88). Annual Report: 49-50. Birbal Sahni Institute of Palaeobotany, Lucknow, India.

109. Saraswat K.S. & Sharma N.K. (1985). Plant economy at ancient Narhan (C.700 BC-400 AD). In: Bharati Bulletin, Department A.I.H.C. & Archaeology. Series-3. Banaras Hindu University, Varanasi, India pp.165-174.