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Carthamus L.: Origin, distribution and its archaeological records in India

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ABSTRACT

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This article reviews the current state of botanical and archaeological evidences that bears the origin, distribution, genetic diversity, and cultivation of the *Carthamus* sp. in Indian subcontinent and other parts of the world. This review provides an important compendium of evidences for *Carthamus* and related species in different geographical locations of the world through the ages as well as in the modern era. The archaeological records so far indicate that *Carthamus* sp. was established in northwestern India during the chalcolithic culture around 3rd–2nd millennium BCE in Indian subcontinent and then distributed to the other regions. However the origin and domestication of the crop has been recorded from the Middle East around ~4000 years ago. *Carthamus tinctorius* L. (safflower) is the cultivated representative of this genus and has a great economic importance as it is used for making different varieties of oil or dyes, today and in the past.

Key–words—*Carthamus* sp. L., Archaeobotany, Chalcolithic, Iron–Age, Indian subcontinent.

INTRODUCTION

CARTHAMUS TINCTORIUS L., commonly known as safflower, is an annual oilseed crop (Fig. 1A) belongs to the family Asteraceae (Compositae), tribe Cardueae (thistles) and subtribe Centaureinae (Bérvillé *et al.*, 2005). Safflower is known by many other names, such as kusum, kusumbo, kabri, kasumba, agnisikha, kusubi, su, sufir, ma, kar/karar, sendurgam, hebu, suban, etc. The Arabic usfur is thought to have been the root for the English name via a number of other terms such as asfrole, affore, asfiori, asfiore, astifore, zaffrole/zaffrone, saffiore to finally, safflower, while in China it is known as hung–hua or red flower (Chavan, 1961). Due to its resemblance with the saffron, this plant is also known as false saffron, dyer's saffron and thistle saffron, etc.

The genus *Carthamus* is found mainly in arid and semi–arid environments and is reported to be highly tolerant to drought stress (Quiroga *et al.*, 2001). *Carthamus tinctorius* L. probably evolved as a domesticated crop in the Middle East (Hanelt, 1961). Recent genetic studies (Chapman & Burke, 2007) suggest that *C. palaestinus*, a wild species restricted to the deserts of southern Israel and western Iraq (Zeven & Zhukovsky, 1975), is the progenitor of *C. tinctorius*. However, according to the European and Mediterranean plant diversity database, *C. palaestinus* is an invalid species name for *C. persicus* Willd. *C. persicus* has a wide distribution including Turkey, Syria, and the Levant, that was previously considered the Mesopotamian sub–region of the Irano–Turanian floristic region (Hanelt, 1961; http://www.bgbm.org/EuroPlusMed/query.asp). Knowles and Ashri (1995) suggested that safflower was first cultivated in this region, and Weiss (2000) further specified the area of cultivation as being in central Syria, near the river Euphrates. Hanelt (1961) and Kupcov (1932) reported that the use of the cultivated crop was preceded by the use of the wild species *C. persicus* in the Mesopotamian subregion, and *C. oxyacanthus* in the central sub–region of the Irano–Turanian floristic region, including northwest India. Knowles (1969) identified seven centres of safflower culture in the Old World: Far East (China, Japan, and Korea); India–Pakistan (India, Pakistan, and Bangladesh); Middle

East (Afghanistan to Turkey, Turkmenistan and Uzbekistan to the Indian Ocean); Egypt (bordering the Nile River north of Aswan); Sudan (bordering the Nile in southern Egypt and northern Sudan); Ethiopia; and Europe (southern Europe and northwest Africa). The types in each area are distinctive. Except for the Far East centre, each is well–represented in the USDA world collection.

Carthamus tinctorius is a multipurpose crop which has been grown for centuries in India and in other parts of world for various purposes. It is an extremely important plant as it provides the alternative source for the oil crop. The research and development on safflower still have not received great interest, although it has potential to grow in varied environmental conditions with very high yield potential and also has numerous uses of different plant parts. It was first grown for the pigment in its flowers that was used for colouring foods and dyeing cloth. Later it was grown for the oil in the seed. The largest hectarage of safflower is in south–central India. Safflower yields two types of oil. The standard polyunsaturated type is used in soft margarines, for cooking, and in surface coatings because of its high levels of linoleic acid. The oleic type, so named because of its high level of the monounsaturated oleic acid, is a high–quality frying oil and also has industrial uses. The meal, with or without the hulls, is fed to livestock.

GENERAL MORPHOLOGY OF PLANT

Carthamus tinctorius L. is an erect, herbaceous, highly branched, spiny, thistle–like annual plant that grows from 30 to 150 cm in height (Singh & Nimbkar, 2006; Kumar & Kumari, 2011) (Fig. 1B). Young safflower plants form a rosette and remain in this vegetative state for many weeks, during which leaves and a deep taproot system develop. Initially, the germination of the seed of safflower is comparatively slower process. This slow growing period is named as rosette period which can vary from 20 to 35 days, in which numerous leaves are produced at stem base. This deep taproot system, with abundant thin horizontal roots, allows the plant to extract water and nutrients from deeper layers of soil than many other crop plants (Li & Mündel, 1996; GRDC, 2010). The rosette stage is followed by rapid stem elongation, extensive branching then flowering, with leaves being arranged on both sides of the stem (Li & Mündel, 1996; Singh & Nimbkar, 2006). Each branch produces flowering heads commonly called capitula and has a composite type of inflorescence. Each capitulum consists of several flowers, with the number ranging from 20 to 250 (Fig. 1A). The flowering period in safflower lasts for a month.

The flowers of *Carthamus* are pale yellow to red–orange, tubular disk florets; there are no ray florets in this thistle–like head (Fig. 1B). Flowers are enclosed by bracts in circular order. Leaf size varies with variety and position on the plant, although typical leaves are 2.5–5 cm wide and 10–15 cm long (Fig. 1B). The leaf morphology is described as alternate, sessile and ovate–lanceolate (Teotia *et al.*, 2002). Upper leaves often develop hard spines (Fig. 1B), while those lower on the stem are usually spineless. These spines make the crop difficult to walk through, but act as a deterrent to larger animals such as pigs and kangaroos (GRDC, 2010). As plants mature they become stiff and woody and resistant to some environmental stressors such as hail and wind. The plant produces white, shiny and smooth seeds (fruits) (Fig. 2A) having thick pericarp, called achenes, each weighing from

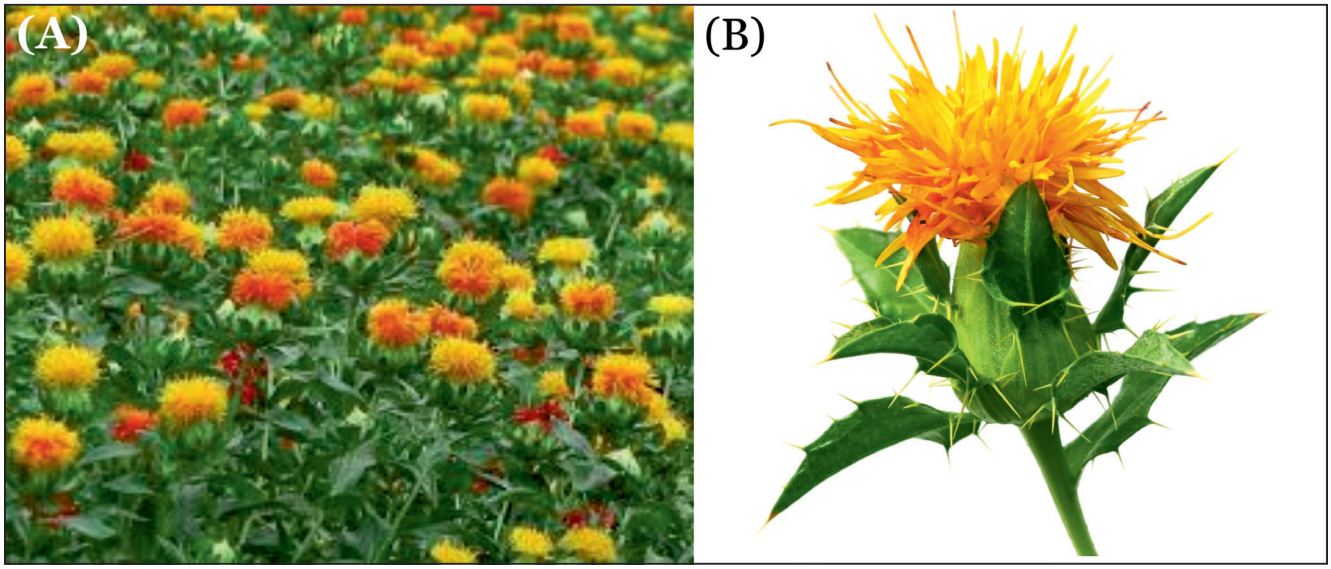

Fig. 1—Showing (A) agricultural field of *Carthamus tinctoius* L.; (B) floral morphology of the plant.

0.01 to 0.1 g. Safflower attains maturity in 30 to 35 days from the time when flowering ends. Safflower has a taproot system that elongates to 2 to 3 m in soils with adequate depth. The safflower has deep root system which helps to extract the water and nutrients from much deeper layers of soil, and thus make it an ideal plant for rain–fed cropping systems.

ORIGIN, GENETIC DIVERSITY AND GEOGRAPHICAL DISTRIBUTION

Carthamus is an ancient crop originated ~4000 years BP in the Fertile Crescent (Pearl *et al.*, 2014), ranges from southern Israel to western Iraq (Chapman *et al.*, 2010). Along with the native region of the *Carthamus*, India, China and northern Africa are the countries which have grown this crop for centuries for multiple uses. Seven 'centres of similarity' were identified by Knowles (1969) such as the Middle–East, India–Pakistan, Far–East, Europe, Egypt, Ethiopia and Sudan. However more centres were added by Ashri (1971) based on the similarity of plant type not on the diversity and origin of the plant. The different genotypes of the *Carthamus* retains a substantial amount of genetic diversity among genera. Patel *et al.* (1989) studied the 60 representatives of genotypes from different countries and observed that the characteristics of crop such as seed yield, seed weight, plant height and branching height were responsible for the maximum proportion of the diversity (~80%). He identified 14 clusters of genetic diversity which is not only based on the geographic isolation (Patel *et al.,* 1989).

Five genetic clusters were present in each regions namely Europe; Far East–India–Pakistan; Egypt–Ethiopia; Iran–Iraq–Afghanistan and Israel–Jordan–Syria based on the nuclear microsatellite analysis of accessions (Chapman *et al.*, 2010) (Table 1). It is believed that different species of *Carthamus* have single ancestor, possibly from Iraq and the north–western Iran. Except *Carthamus tinctorius* which is a cultivated species others are the wild weeds among them there are three species which are closely related such as *Carthamus flavescens* (*C. persicus*) is found in Syria, Turkey and Lebanon; *C. palaestinus* is found in the desert regions of Iraq, Israel and Jordan; *C. oxyacanthus* found in western Iraq to north–western India and southern Union of Soviet Socialist Republics. To produce fertile progeny the aforementioned species crossed with the *C. tinctorius* (OECD, 2020).

C. tinctorius (n = 12; Fig. 3) is the only species which has been reported as a domesticated oil crop, however all the remaining species are weeds, ranging from northwestern India westward to and around the Mediterranean Sea. Wild species of *Carthamus* falls into five chromosome groups with n = 10, 11, 12, 22, and 32 (Fig. 3). Five species with n = 12 are closely related to cultivated safflower (Hanelt, 1963; Fig. 3). *Carthamus palaestinus* Eig, a self–compatible species, occupies desert areas of western Iraq, Jordan, and southern Israel. *Carthamus persicus* Willd. (*C. flavescens* Spreng), inhabiting areas of Turkey, Syria, and Lebanon, is entirely self–incompatible.

Carthamus oxyacanthus M.B. (*C. oxyacantha* M.B.), distributed from northwestern India to central Iraq, is a mixture of self–incompatible and self–compatible types. *Carthamus gypsicolus* Iij., in the U.S.S.R., and *C. curdicus* Hanelt, in Iraq, have not been studied. Another species with n = 12, *C. nitidus* Boiss., found in Syria, Israel, Lebanon, Jordan,

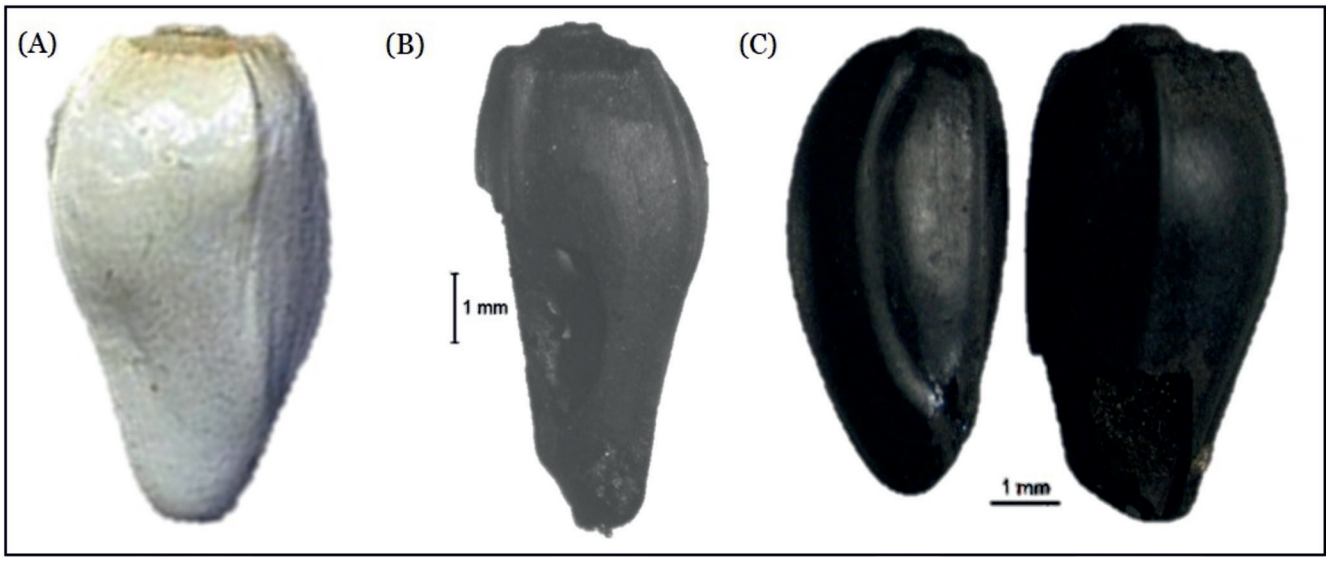

Fig. 2—Morphology of the seed of *Carthamus tinctorius* L. (A) Modern; (B) Carbonised seed recovered from the Chalcolithic archaeological site Ojiyana, Rajasthan, (C) Carbonised seeds recovered from the Iron age site Raja–Nal–Ka–Tila, Sonbhadra, Uttar Pradesh.

and Nubia and is self–compatible (Knowles & Schank, 1964). A large group of species with $n = 10$ is found in the Middle East, in southeastern Europe and northeastern Africa. They are closely related to one another and show variable self–incompatibility (Schank & Knowles, 1964). One exception, *C. leucocaulos* is entirely self–compatible. Most will cross with cultivated safflower, but the flowers are highly sterile. One species, *C.divaricatus* (Beg. and Vacc.) Pamp., from Libya, has 11 pairs of chromosomes. It is closely related to species with $n = 10$, and is self–incompatible (Estilai & Knowles, 1976). It will also cross with cultivated safflower, but the flowers are highly sterile. All species with $n = 22$ and 32 are self–compatible. *Carthamus lanatus* L., with $n = 22$, and C. *lanatus* ssp. *creticus* (L.) Holmb. [*C. baeticus* (Boiss et Reut.) Nym.], with $n = 32$, have extended the distribution of the genus to western Europe, northwestern Africa, and several other areas with a Mediterranean climate, including California and Australia. *Carthamus lanatus* ssp. *turkestanicus* (M. Popov) Hanelt (*C. turkestanicus* Popov), with $n = 32$, is in the area occupied by the genus east of central Turkey and the Near East (Fig. 3). Only *C. lanatus* has been crossed to cultivated safflower, giving a sterile flowers. The USDA Western Regional Plant Introduction Station, Pullman, WA 99164, maintains the World Collection of domesticated safflower (Dietz *et al.*, 1977).

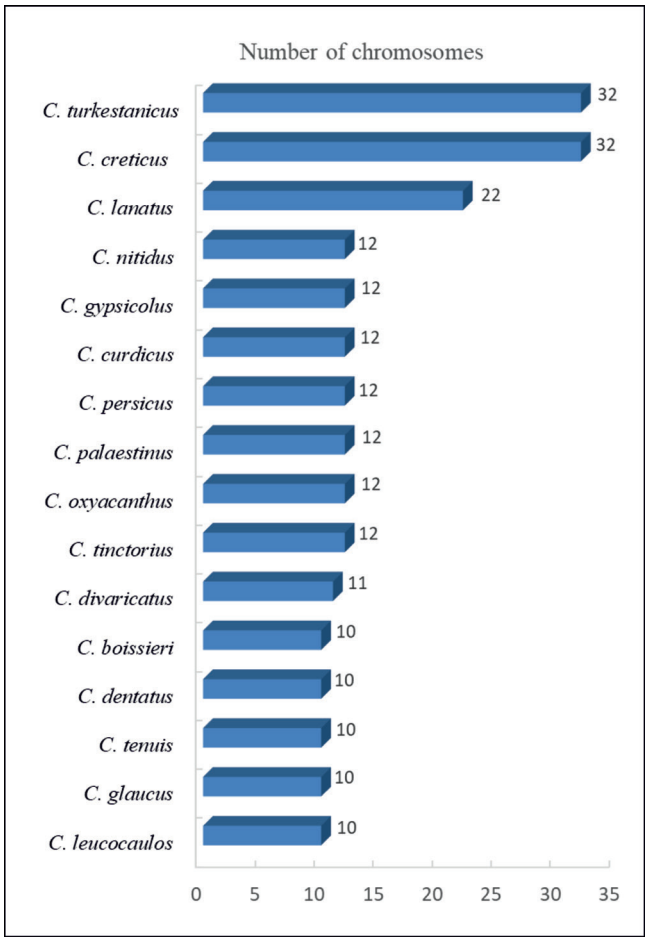

Fig. 3—Histogram showing the taxonomic groups of *Carthamus* sp. and their genetic diversity (proposed by López–González, 1990).

Distinct types of *Carthamus* species have been evolved during its early evolution at the different geographical locations such as Far East, South Asia, Egypt and Ethopia (Smith, 1996). Bérvillé *et al.* (2005) observed that several characters have been produced by the domestication of the *Carthamus* species. These characters include smooth seeds, reduced shattering, reduced seed dormancy, reduced duration of the early vegetative growth stage and restriction of branching to the upper part of the stem (Bérvillé *et al.*, 2005). After domestication several breeding programmes for safflower generated the disease resistant varieties of *Carthamus* with high oil content (GRDC, 2010).

As far as the cultivation of safflower in present era is concerned, India is the leading producer of *Carthamus tinctorius* L. (Table 1; Fig. 4), principally for the oil production and contributing one third of the world's production (Rowland, 1993; Kedikanetswe, 2012; Emongor *et al.*, 2013). Compared to the other countries in the world, India is using much more arable land for the cultivation of safflower. For instance, 429000 acres was used by the Bombay State in 1953–1954 (Argikar *et al.*, 1957). However 600000 acres of land were utilized by the Hyderabad State and 7000 acres by Madhya Pradesh (Fig. 4). Other than these states other parts of India were also growing safflower but in inconsequential quantity. Safflower is usually grown with the other crops in alternating cropping pattern or as a border around the fields.

ANCIENT AND MODERN USAGE OF CROP

Carthamus tinctorius L. is an ancient multipurpose crop, known for dyes, variety of oils, medicinal properties and feed values (Dajue & Mündel, 1996; Dwivedi, 2009; Emongor, 2010). *Carthamus* was conventionally grown for seeds, as medicines and dyeing materials for food and clothes (Weiss, 1971; Emongor, 2010). The use of safflower for colouring cotton and silk was also a part of tradition in religious ceremonies in Egypt (Gautam *et al.,* 2014). Gautam *et al.* (2014), reported that the seeds of *Carthamus* and garlands of florets have been recovered with the Egyptian mummies ~4000 BP. In France, Britain and Italy, the *Carthamus* was also used for dying cheese and flavour sausages while the dye named carthamin was extensively used for colouring cloth around 18th and 19th century respectively (Gautam *et al.*, 2014). It is recoded that the florets of *Carthamus* were widely used for colouring and flavouring soups, rice, medicines, ointments, etc. Due to purgative, laxative, pot herb and alexipharmic (antidote) properties of *Carthamus*, it has been used in the several regions such as Middle East, India

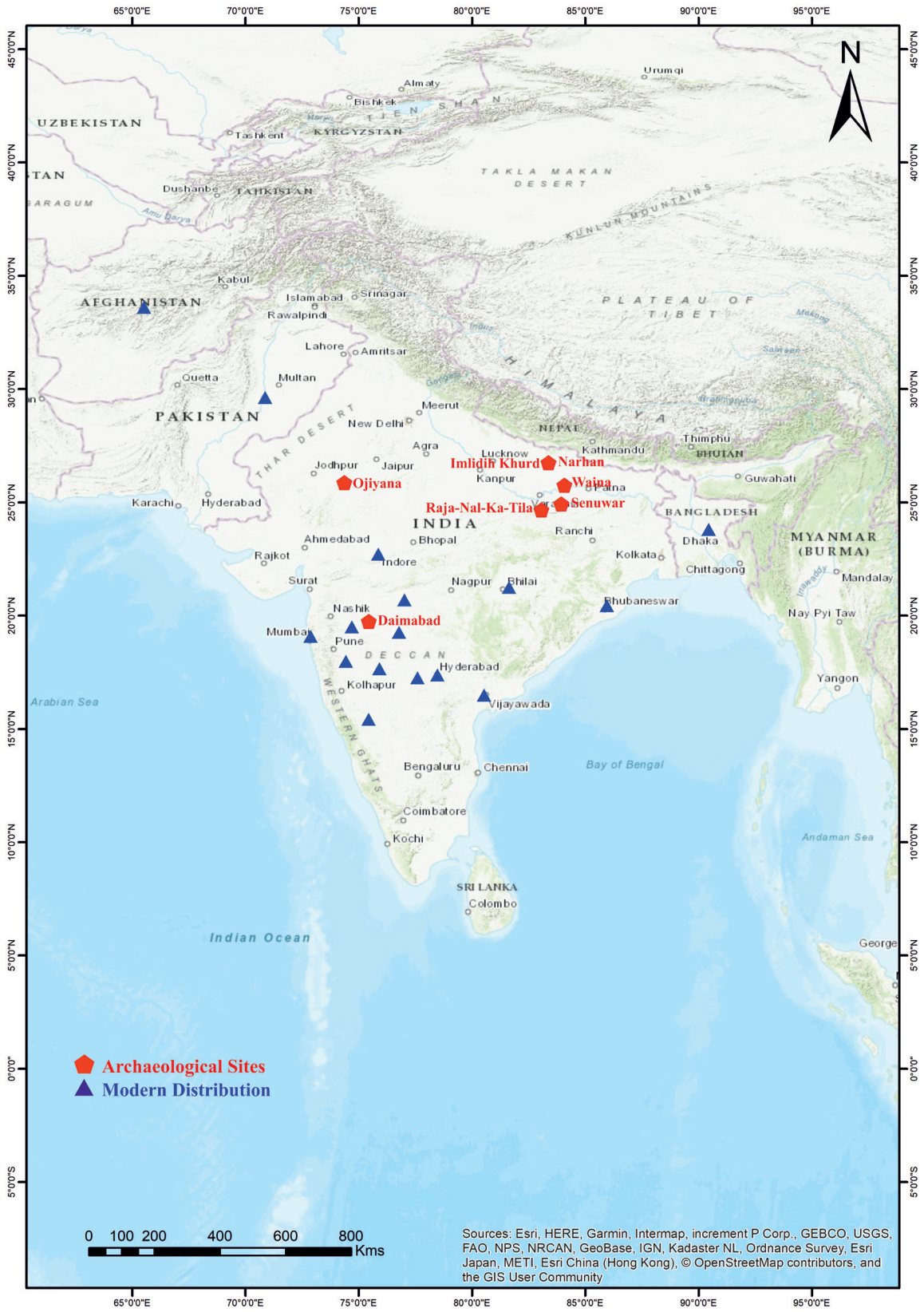

Fig. 4—Map showing the distribution of the *Carthamus tinctorius* L. in Indian subcontinent. The Red symbols indicate the ancient records of the *Carthamus tinctorius* and the blue symbols indicate modern distribution of the species.

Table 1—Geographical distribution of *Carthamus tinctorius* L. and related species in modern era. Adopted and modified from McPherson *et al.*, 2004; GBIF Backbone Taxonomy (2017).

Taxon	Geographical Distribution
***Carthamus* (*n* = 12)**	
C. tinctorius L.	Widely cultivated throughout the world such as India, Pakistan, Bangladesh, China, Japan, Korea, Afghanistan, Turkey, Southern U.S.S.R., Egypt, Sudan, Ethiopia, Europe
C. curdicus Hanelt	Iran only
C. gypsicolus Iljin	Iran, Iraq, Kazakhstan, Azerbaijan, Armenia, Lebanon, Turkey, Syrian Arab Republic, Uzbekistan
C. oxyacanthus Bieb.	Pakistan, Iran, Afghanistan, Iraq, Turkey, India, Uzbekistan, Azerbaijan, Armenia, Australia
C. palaestinus Eig.	Israel, Iraq
C. persicus Willd. (syn. *C. flavescens* Spreng.)	Israel, Turkey, Iraq, Syrian Arab Republic, Ethiopia, Lebanon, Jordan, Iran
C. nitidus Boiss	West Bank and Gaza Strip, Israel, Jordan, Syrian Arab Republic, Saudi Arabia, Lebanon, Egypt
***Carthamus* (*n* = 10, 11)**	
C. boissieri Halácsy	Greece, France, Cyprus2
C. dentatus Vahl	Australia, Greece, Turkey, Bulgaria, Cyprus, Hungary, Iran, Macedonia
C. divaricatus Beguinot & Vacc.	Libya
C. glaucus Bieb.	Israel, West Bank and Gaza Strip, Turkey, Syrian Arab Republic, Lebanon, Greece, Azerbaijan, Afghanistan, Egypt, Ukraine, Armenia, Jordan, Iraq, Russia, Australia
C. leucocaulos Sm.	Greece, Australia, United States, Germany, Turkey, Argentina
C. tenuis (Boiss. & Bl.) Bornm.	Israel, West Bank and Gaza Strip, Lebanon, Greece, Cyprus3, Jordan, Egypt, Syrian Arab Republic, Turkey
***Carthamus* (*n*= 22, 32)**	
C. creticus L.	Greece, Spain, United States, Portugal, Denmark, Morocco, New Zealand, Australia, France, Egypt, Iraq, Turkey
C. lanatus L.	Spain, France, Italy, Portugal, United States, Greece, Argentina, Ethiopia, Morocco, Turkey, Germany, Brazil, Netherlands, India, Pakistan, Australia
C. turkestanicus Popov	Afghanistan, Iran, Armenia, Turkey, Uzbekistan, Pakistan

and Africa etc. The evidence came from the Hebrew writings, described the usage of carthamin dye as a medicine, food colouring and rouge since the 2nd century (Gautam *et al.*, 2014). In Middle East, Indian subcontinent and the Eastern Europe, the safflower dyes were used in the carpet industries (Gautam *et al.*, 2014).

In the modern era *Carthamus* is mostly cultivated for its seeds for high quality edible and industrial oil and feed values (Knowles, 1989; Dajue & Mündel, 1996; Ekin, 2005; Emongor, 2010). The important usage of the seeds includes, transgenic pharmaceuticals, edible oil, biofuel and oleosin proteins (Lacey *et al.*, 1998; Velasco & Fernández–Maryinnez, 2004; McPherson *et al.*, 2004; Bergman & Flynn, 2009; Mündel & Bergman, 2009). Safflower oil is a non–allergenic, hence also used for the injectable medications (Smith, 1996). Its oil has promising role in margarine production compare to soy or canola oils. It is also used in frozen foods because of its highly stable and consistent nature at low temperature (Smith, 1996). In India, Pakistan and Burma, the leaves of *Carthamus* are also being used as a vegetable dish serve with rice (Gautam *et al.*, 2014). However in China, *Carthamus* is mainly grown for its flowers, used for preparations of medicines and tonic

Table 2—Evidence of the *Carthamus* sp. from the archaeological sites in India.

Archaeological site	Location	Identification	Period	References
Ojiyana	Rajasthan	*Carthamus tinctorius*	Chalcolithic (3rd–2nd millennium BCE)	Pokharia, 2008
Deccan region	West Central India	*Carthamus tinctorius*	Chalcolithic to the Early Historic (1500 BCE–300 AD)	Smith, 2006
Senuwar	Bihar	*Carthamus tinctorius*	Chalcolithic	Saraswat, 1992
Daimabad	Maharashtra	*Carthamus tinctorius*	Chalcolithic (Jorwe culture)	Kajale, 1977
Waina	Uttar Pradesh	*Carthamus tinctorius*	~1500–600 BCE	Saraswat & Pokharia, 2003
Imlidih–Khurd	Uttar Pradesh	*Carthamus tinctorius*	Narhan phase (1300–800 BCE)	Saraswat, 2005; Singh, 2008
Raja–Nal–ka–Tila	Uttar Pradesh	*Carthamus tinctorius*	Iron age (1300–700 BCE)	Pokharia *et al*., 2017

tea (Gautam *et al.*, 2014). *Carthamus* is an important ancient crop which has also gained attention in modern world for its production, breeding, genetic diversity, tissue culture and several other aspects (Dajue & Mündel, 1996; Ekin, 2005; Singh & Nimbkar, 2006; Mündel & Bergman, 2009; Emongor, 2010; Kisha & Johnson, 2012).

ARCHAEOBOTANICAL RECORDS OF *CARTHAMUS* SP.

Native area of *Carthamus* is known to be circumscribed by the eastern Mediterranean and Persian Gulf, Central Asia, Eastern Europe, Ethiopia and Eritrea (Vavilov, 1951; El–Bassam, 2010). As far as, the oldest evidence of the *Carthamus* sp. has been concerned, Syria has recorded the earliest evidence during middle Pre–Pottery Neolithic B (PPNB) c. 7500 BCE, however, huge number of records of cultivated species were also found more frequently from early Bronze Age ~3000 BCE in central Syria (Marinova & Reihl, 2009). The later appearance of *Carthamus tinctorius* out of central Syria indicates the dispersal of species to its contiguous regions, such as Near East including northwest India. The first archaeological finding of *Carthamus* has been evidenced from Europe during Neolithic since c. 5800 BCE (Marinova & Reihl, 2009). In Near East, the occurrence of *Carthamus* has been recorded from the early Bronze Age and it is found to be dominant in the area of Levant and upper Mesopotamia according to its regional pattern of precipitation. In later period (Bronze Age), the presence of the species outside the Near East indicates its introduction in the nearby flung areas such as modern Hungary, Serbia and Bulgaria (Kroll, 1990; Gyulai, 1993). In Bulgarian prehistory, the earliest record of *Carthamus* was found from Tell Karanovo, the eastern part of the Thracian plain during ~2800–2600 cal BCE (Gorsdorf & Bojadziev, 1996). The high variability of *C. tinctorius* fruits and the potential occurrence of C. *lanatus* in this region did not allow a convincible identification of the cultivated species. The evidence for the cultivation of *C. tinctorius* beyond the native region in southeastern Europe during Bronze Age (~2800–2600 BCE) suggests the broad cultural interactions between the eastern Mediterranean and neighbouring regions.

The seeds of *Carthamus* have been recovered from the Egyptian tombs around 4000 BP, and the use of seeds has also been reported in China since 2200 BP (Weiss, 2000). *Carthamus* fruits has also been recorded, along with the inflorescence of Asteraceae family, suggest that it has been used as a source of the dye material in the northern Syria (Van Zeist & Waterbolk–Van Rooijen, 1992; Marinova, 2004). However the evidence of *Carthamus* from Tell Karanovo indicates similarity with the residue remains left from the traditional oil extraction techniques suggests the use of safflower as an oil crop in the region (Knowles, 1967). Another record for the usage of safflower oil as a fuel was recorded from some studies (Bottema, 1984; Charles, 1998; Miller, 1984; Miller & Smart, 1984). Egypt has also recorded several evidences of *Carthamus* during Iron Age and the Roman and Byzantine periods. An exceptional finding of *Carthamus* from Switzerland has also been evidenced during ~100–200 AD (Vandorpe, 2006). The central India and westwards to, and around Mediterranean Sea including the countries of the Nile Valley have known to grow *Carthamus* for centuries. Southern Siberia and southern Russia were known as its ancient northern boundaries. *Carthamus* is a dryland oilseed crop, but was traditionally grown for the extraction of dyes

for textiles and for food (Weiss, 1971; Zohary *et al.*, 2012) throughout southern and central Asia and the Mediterranean (Weiss, 1971; Li & Mündel, 1996; Zohary *et al.*, 2012).

In Indian subcontinent, *Carthamus tinctorius* is known from Chalcolithic culture from the archaeological site Ojiyana in Bhilwara District, Rajasthan during 3rd–2nd millennium BCE (Pokharia, 2008) (Table 2). The site recovered a single achene (Figs 3B, 4) which has been found in the deformed state, due to carbonization. The achene was somewhat obovoid and four–angled, truncate on one end and it measures 7.50 mm in length and 3.50 mm in breadth (Fig. 2B). In all morphological characteristics the carbonized achene compares well with those of safflower belonging to the family Asteraceae (Pokharia, 2008).

The non–domesticated *C. tinctorius* from the Deccan region of the west central India has been recorded from the Chalcolithic to the Early Historic (~1500 BCE–300 AD) time periods (Smith, 2006). The botanical remains at Senuwar in Rohtas District (Table 2; Fig. 4), Bihar also evidenced the presence of *Carthamus tinctorius* along with the staples and other oil crops found from the Chalcolithic levels characterized by black and red ware industry (Saraswat, 1992). The agriculture was an important component at Daimabad in Maharashtra (Fig. 4). At Daimabad, succession of five Chalcolithic culture was recognized as Phase I–Savalda; Phase II–Late Harappa; Phase III–Daimabad; Phase IV–Malva and Phase V–Jorwe (Table 2) (Sali, 1986). The plant economy from the Daimabad site evidenced the occurrence of *Carthamus tinctorius* with another oil crop *Linum usitatissimum* from the Jorwe culture (Kajale, 1977). The investigations of the carbonised remains recovered through archaeological excavations at Waina (Uttar Pradesh; Fig. 4) also revealed the occurrence of safflower along with the a wide range of grains and seeds such as rice, two forms of wheat, jowar–millet, ragi–millet, Italian–millet, lentil, field–pea, chick–pea, green–gram, horse–gram, grass–pea, Indian mustard, linseed, cotton, and onion in the cultural deposits at different depths of occupation ~1500–600 BCE (Table 2) (Saraswat & Pokharia, 2003). The crop remains of *C. tinctorius* have also been evidenced from the Imlidih–Khurd (Fig. 4), Gorakhpur during ~1300–800 BCE (Saraswat, 2005; Singh, 2008). Another record of *C. tinctorius* (Fig. 2C) along with crops such as *Sesamum indicum*, *Brassica juncea*, *Linum usitatissimum*, *Gossypium arboreum*/*herbaceum* and *Cannabis sativa* from the Iron Age site Raja–Nal–ka–Tila (Table 2; Fig. 4) in Sonbhadra District of Uttar Pradesh emphasized the importance of the other oleiferous crops and textile production during 1300–700 BCE (Pokharia *et al.*, 2017).

CONCLUSION

The evidence of *Carthamus* sp. in Indian subcontinent and other parts of the world suggests its cultivation since ancient times. This emphasizes that the *Carthamus tinctorius* has been an economically important crop throughout the world and being used for its oil, dyes and medicinal properties, however, its ancient records have not gained much consideration till date. For instance, there are only few archaeological sites in India which recorded the occurrence of *Carthamus.* More detailed investigation and archaeological excavations are needed to explore its widespread distribution and dispersal in the subcontinent. The present review endorses that the *Carthamus* sp. was in use since 3rd–2nd millennium BCE in the Indian subcontinent. Although details about the regional distributions of crop and its cultivation require more investigation.

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