

TABLE 7. CROPS OF PROBABLE AFRICAN ORIGIN, BOTANICAL AND ARCHAEOBOTANICAL SUMMARY

Crop	Common names: English, Hindi, others	Frequent synonyms	Region of origin (references)	Early finds, region of Origin	Early finds, South Asia
<i>Sorghum bicolor</i> (L.) Moench.	Sorghum, Great Millet, Jowar	numerous specific epithets in the older literature are all merged as one species (De Wet and Huckabay 1967).	Sudanic Africa (wild), c. 6000 BC	Nabia Playa, S. Egypt Hulas (Saraswat 1993), (Wasylikowa and Kubiak- Martens 1995), Khartoum Neolithic (wild) c. 3000 BC (Stemler 1990); Qasr Ibrim, Nubia, 100-400 AD (domestic) (Rowley-Conwy 1991; Conwy et al. 1997)	Rajdi C (Weber 1991); Daimabad (Kajale 1977c); 2000-1700 BC (Kajale 1977c); Nevasa 1500- 1200 BC, T. Garhi, c. 1500 BC (Kajale 1988a); ? Inamgaon, c. 1200 BC (Vishnu-Mittre and Savithri 1976)
<i>Eleusine coracana</i> (L.) Gaertn.	Finger Millet, Ragi (Kan. and Him.), Umi, mandal, mandua		East Africa: Ethiopia-Uganda	Axum, Ethiopia, c. 600 AD (S. Boardman, pers. comm.)	all reports need confirmation of identification? Harappan Rajdi c. 2600- (Weber 1991), Kuntasi (Dhavalikar 1995), Shikarpur, Gujarat, 2500- 2000 BC; Senwar, Bihar 2000-1800 BC (Saraswat et al. 1995) Babar Kot (Reddy 1994), Harappa (Weber 1998)
<i>Pennisetum glaucum</i> (L.) R. Br.	Pearl Millet, Bajra	<i>P. americanum</i> (L.) Lecke, <i>P.</i> <i>typhoides</i> Rich	West Africa Mauritania	Mauritania, c. 1000 BC (Anblard and Pernes 1989); Khartoum Neolithic, c. 3000 BC (wild?) (Stemler 1990)	Daimabad, 2000-1700 BC (Kajale 1977c); Nevasa, c. 1500 BC; Rangpur IIC 1800-1700 BC (Ghosh and Lal 1963)
<i>Labiab purpureus</i> (L.) Sweet	Hyacinth Bean, Bonaivist, Sem, avarai (Tamil)	<i>Dolichos lablab</i> L., <i>L. niger</i> Medik.	East Africa (?) (Verdcourt 1970, 71)	Qasr Ibrim, Nubia, 300- 500 AD (A. Clapham, unpublished)	Maharana, Punjab, 2300-2000 BC (Saraswat and Chanchala 1994); Chalcolithic Maharashtra, 2nd M. BC (Kajale 1991), Southern Neolithic, Late 3rd/2nd M. BC (Fuller et al. n.d.)

(contd.)

Crop	Common names; English, Hindi, others	Frequent synonyms	Region of origin (references)	Early finds, region of Origin	Early finds, South Asia
<i>Vigna unguiculata</i> (L.) Walp.	Cow Pea, lobia, chowli, karamani (Tamil)	<i>Dolichos biflorus</i> L., but <i>not D.</i> <i>biflorus</i> in archaeobot. Litt.	West Africa: (Valencourt and Weeden 1992 Panella et al. 1993)	none; but one report from Old Kingdom Egypt (as wild/weed?)	Hulus, 2000-1700 BC (Saraswat 1993); Daimabad, c. 2nd M. BC (Vishnu-Mittre et al. 1986)
<i>Cyamopsis</i> <i>tetragonolobus</i> (L.) Taubert	Cluster Bean, Guar, gaur	<i>C. psoraloides</i>	East Africa? (S.C. Hiremath, pers. comm.; also Kajale 1991: 174)	none.	none.
<i>Psophocarpus</i> <i>tetragonolobus</i> (L.) DC.	winged bean, goa bean; claudhari- phali, charkoni-sen		no conspecific wild, relative identified. Ethiopia? (Smartt 1990)	none.	none.
<i>Ricinus communis</i> L.	Castor, arand		Africa? (De Candolle 1886; Rehm and Espig 1991)	none (?)	uncarbonized fragments, Hulus, 1800-1300 BC (Saraswat 1993)
<i>Gossypium herbaceum</i> L.	Short staple Cotton, 'Asiatic Cotton', Kapas		Africa (?)	Nubia, c. 3000 BC (but not cultivated?) (Chowdhury and Buth 1971)	? See <i>G. arboreum</i> in Table 9 for early identifications of this genus

its variants in the Indian subcontinent (Phillipson and Bahuchet 1996). Indeed, the genetic evidence of Hilu (1995), although of limited sampled size, could indicate that some of the most 'primitive' genotypes of the crop come from Tanzania.

The origins of finger millet differ from the sub-Saharan savanna origins suggested by the wild distribution of *Sorghum bicolor* and *Pennisetum glaucum* (Harlan 1971, 1992, 1995a). The origins of *Sorghum* have generally been assigned to the eastern savannas, such as those in Sudan (Harlan 1971, 1992, 1995a), although Ethiopia has also been suggested (Doggett and Prasada Rao 1995). Although the standard interpretation sees the domestication of *Sorghum* between c. 5000 BC and 3000 BC (Harlan 1992, 1995a), recent genetic evidence from modern *Sorghum* and archaeological specimens from Qasr Ibrim in Egypt has been used to argue that domestication was quite late, perhaps as late as c. AD 0 (Rowley-Conway et al. 1997; Deakin et al. 1998). It can be objected, however, that the genetic locus utilized showed so little variation between modern domesticated and wild varieties (i.e. lacking polymorphism) that they are unlikely to be informative when it comes to assessing phylogenetic divergence between *Sorghum* lineages. In addition, despite a number of questionable reports of *Sorghum* from prehistoric India and Arabia (Willcox 1992; Rowley-Conway et al. 1997; Section 4.2.1, above), there remain a few finds which appear to have secure archaeological contexts in the second millennium BC and are clearly of domesticated *Sorghum* types. This argues either for an early domestication of sorghum, or else the Haaland (1995) hypothesis whereby wild-type sorghum was transmitted to ancient India and there evolved into the fully domesticated *durra* type.

Recent genetic evidence puts the origins of Pearl Millet/Bajra in the far west of Africa, distantly separated from *Sorghum* (Tostain 1994, 1998); it is argued that Pearl Millet may have been domesticated as early as 6000 BC, although the earliest evidence, in both Africa and India, dates to the mid-second millennium BC (see Table 7).

There are four important pulses in regular cultivation in India today that are of probable African origin, although only two of them have any archaeobotanical record. Guar (*Cyamopsis tetragonoloba*) and winged bean (*Psophocarpus tetragonolobus*) are both of African origin and cultivated in India today, although the former primarily for its seeds' gum. Neither of these two species has yet been recorded archaeobotanically. Cowpea (*Vigna unguiculata*), despite its pan-African wild distribution, appears to have been domesticated from a quite restricted geographical sample of the known genetic populations, approximately restricted to modern Nigeria (Rawal 1975; Vailancourt and Weeden 1992; Panella et al. 1993; Ng 1995). The assemblage of *Vigna unguiculata* illustrated from Daimabad (Vishnu-Mittre et al. 1986, see Section 4.3, above), suggests that a range of varieties of this species were introduced to India quite early. Hyacinth bean (*Lablab purpureus*) is also argued to occur wild in Africa (Verdcourt 1971; Smartt 1990), and as no wild populations have been clearly established in India (cf. Hooker 1872-97; Smartt 1990), it is likely to have originated in eastern Africa. The high diversity of this crop in India (Vavilov 1992 [1950]; Liu 1996), often cited in favour of its origin there, should therefore be seen as the result of an early and extensive radiation in South Asia, and

possibly multiple introductions. Nevertheless, *Lablab* appears to have arrived in India relatively early (late third millennium BC) and rapidly became widespread in peninsular India where it has been found on numerous Chalcolithic sites (Kajale 1991) and recently on sites of the Southern Neolithic (Fuller et al. n.d.; Section 5.3.1).

### 5.3 South Asian Domesticates

Although not included in the revised centres (or non-centres) of Harlan (1971), there is clear evidence for a number of crop origins in South Asia, most notably amongst tropical pulses as well as several localized millets, tree cotton and possibly sesame (Table 8). Although these crops share origins in the Indian subcontinent, this begs the question as to where more specifically they were domesticated. Unfortunately the modern botanical-geographical evidence is often inadequate to localize these regions with certainty. In addition there are cases in which it seems likely that the wild progenitor has become extinct in its primary habitat due to the extensive spread of agriculture and anthropogenic environmental change on the subcontinent. A possible candidate for such a situation is horsegram (correctly *Macrotyloma uniflorum* (Lam.) Verdcourt, based on *Dolichos uniflorum* Lam., but not *D. biflorus* Linn, nor *Vigna unguiculata*<sup>3</sup>). This pulse is well represented by archaeological finds across India, from the mid-third millennium BC, but is of unclear regional origin since wild populations are not reported in any regional floras. It is also cultivated in Africa, but has not been noted as wild there (Verdcourt 1971; Smartt 1990). Other species of *Macrotyloma* are recognized in Sri Lanka (Maxwell 1991) and Africa (Verdcourt 1971) although it is not clear if they have a close relationship to the domesticated species. Archaeobotanically, *Macrotyloma* is widely reported from Chalcolithic and Neolithic sites, with candidates for the earliest occurrences being Khujhun, in the Vindhyan plateau (Kajale 1991; Saraswat 1992), the Harappan site of Burthana Tigrana in Haryana (Willcox 1992), and Southern Neolithic sites of Andhra and Karnataka (Fuller et al. n.d.; Kajale 1991, 1998), pending more accurate chronology.

An important group of Indian crops is that of three pulses in the genus *Vigna*, a genus which includes two other domesticated species from East Asia.<sup>4</sup> Mungbean, *V. radiata* (L.) R. Wilczek, and Black Gram, *V. mungo* (L.) Hepper,<sup>5</sup> can now be considered to have distinct geographical origins. Formerly they were both considered to derive from the same wild progenitor *Phaseolus sublobatus* Roxb.<sup>6</sup> (syn. *P. trinervius* Heyne, cf. Cooke 1903; Gamble and Fisher 1921-35; Ignacimuthu and Babu 1987), although this has been shown to include two non-hybridizing forms each of which easily crosses with one of the two cultigens and can be linked to the cultigens as wild progenitor on the basis of a wide range of morphological, anatomical, biochemical and genetic data (Arora et al. 1973; Lukoki et al. 1980; Miyazaki 1982; Chandel et al. 1984; Smartt 1985b, 1990; Lawn 1995; Kaga et al. 1996). However, much more work on the ground, collecting these wild taxa, is needed before their primary distribution will be clear. Both occur in the western Himalayan foothills in 'secondary habitats' and the Western Ghats on the Peninsula (Arora et al. 1973). Nevertheless, the primary distribution of wild Green Gram (*V. radiata* var.

TABLE 8. CROPS OF PROBABLE SOUTH ASIAN ORIGIN, ESPECIALLY PENINSULAR, CENTRAL OR NORTHERN INDIA: BOTANICAL AND ARCHAEOBOTANICAL SUMMARY

Crop	Common names: English, Hindi, others indicated	Frequent synonyms (References)	Region of origin (References)	Early finds, region of origin	Other early finds, South Asia
<i>Paspalum scrobiculatum</i> L.	Kodo Millet, kodon, kodu, kodhra, varagu (Tamil), Kodo (Munda)		Peninsular India (De Wet et al. 1983; M'Riba and Hilu 1996)	see next column	Senuwar IB, Bihar, 1800-1200 BC (Saraswat et al. 1995); Rojdi C, Gujarat, 2000- 1700 BC (Weber 1991); Daimabad, 1500-1000 BC (Vishnu-Mittre et al. 1986); Narhan, c. 1200 BC (Saraswat et al. 1994)
<i>Panicum sumatrense</i> Roth.	Little Millet, shavan, samai (Tamil), gondli nom illeg. (Munda)	<i>Panicum miliare</i> (De Wet et al. 1983a; Hiremath et al. 1990; M'Riba and Hilu 1996)	Peninsular India; ? N. Andhra, (De Wet et al. 1983a; Hiremath et al. 1990; M'Riba and Hilu 1996)	Southern Neolithic sites, 3rd M. bc (?) (author's data; Fuller et al. n.d.).	Harappan Rojdi from c. 2500 BC (Weber 1991), Babar Kot, Oriyo Timbo, Gujarat; 2000-1700 BC (Reddy 1994); Balathal?, by 2000 BC (Kajale 1996a); Inmangaon 1200-900 BC (Kajale 1988b)
<i>Echinochloa colona</i> (L.) Link. ssp. <i>frumentacea</i>	Sawa millet, shama, sanwa, sawank	<i>E. frumentacea</i> (Roxb.) Link (this species has been used also for the domestic form of <i>E. crus-galli</i> )	Peninsular India, multiple domestications (De Wet et al. 1983c; Hilu 1994)	Southern Neolithic sites, 3rd M. bc (?) (author's data; Fuller et al. n.d.).	Narhan (?), c. 1200 BC (Saraswat et al. 1994)
<i>Setaria pumila</i> (Poir.) Roem. and Achult.	Yellow Foxtail Millet, bandhira, Korali (Telugu)	<i>Setaria glauca</i> nom illeg.	Cult. and Domes., India only (De Wet et al. 1979; De Wet 1995a)	caryopsis not yet clearly distinguished from other <i>Setaria</i> species. Study in progress.	<i>S. pumila</i> /S. <i>verticillata</i> present on Southern Neolithic sites from mid. 3rd M. bc (author's data; Fuller et al. n.d.). Numerous sites with early find of <i>Setaria</i> (dating the 2500-1800 BC, could be <i>S. pumila</i> , including Balathal, Senuwar IA, Sanghol, Babar Kot, Surjolada
<i>Brachiaria ramosa</i> (L.) Stapf.	Browntop Millet, Pedda Sama (Tel.?)	<i>Urochloa ramosa</i> (L.) Nguyen	Cult. and Domes., India only (De Wet 1995a)	none	none

(contd.)

Crop	Common names: English, Hindi, others indicated	Frequent synonymy	Region of origin (References)	Early finds, region of origin	Other early finds, South Asia
<i>Vigna mungo</i> (L.) Hepper	Black Gram, Urid, ulundu (Tamil)	<i>Phaseolus mungo</i> L., <i>not V. angularis</i> (Wild.) Ohwi and Ohashi	South Asia: ? Himalayan foothills (Lawn 1995)	see next column	Rodji A. (Weber 1991), Balathal (Kajale 1996a), Burthana (?) and Mitathal (?) (Willcox 1992), 2500-2200 bc; Koldihwar, after 2000: Maharashtra sites
<i>Vigna radiata</i> (L.) Wilczek	Green Gram, Mung, hesaru (Kann.)	<i>Phaseolus radiatus</i> L., <i>P. aureus</i> Roxb.	South Asia, Western Ghats (?) (Lawn 1995)	Southern Neolithic sites, 3rd M. bc (?) (author's data; Fuller et al. n.d.).	Balathal, by 2000 bc (Kajale 1996a); after 2000 bc; Chalcolithic Maharashtra (Kajale 1991); Rojdi C, 2000-1700 bc (Weber 1991)
<i>Vigna aconiifolia</i> (Jacq.) Marechal	Golden Gram, Math, Matki		South Asia: ? (Lawn 1995)	see next column	Narhan, 1000-800 bc (Saraswat et al. 1994); Senuwar, after c. 1200 bc (Saraswat et al. 1995)
<i>Cajanus cajan</i> (L.) Millsip.	Pigeonpea, Red Gram, Tuvar, Athar		India: S. Orissa, Bastar, from <i>C. cajanifolia</i> (Haines) van der Maeson (1986; 1995)	closest finds in next column	Peddamediyam, 1300-1700 bc; T. Garhi c. 1500 bc; Sanganakallu, Karnataka, mid 2nd M. bc? (author's data, Fuller et al. n.d.)
<i>Macrotyloma uniflorum</i> (Lam.) Verdcourt	Horsegram, Kulthi	<i>Dolichos biflorus</i> nom. illeg., <i>D.</i> <i>uniflorus</i> Lam.	South Asia: ? (Verdourt 1970; Smart 1985a)	see next column	Harappa Burthana and Mitathal (Willcox 1992); Kunjun c. 2500 bc (Kajale 1991); Rojdi C, 2000-1700 bc (Weber 1991); Chalcolithic Maharashtra sites; Southern Neolithic sites, 3rd M. bc (?) (author's data, Fuller et al. n.d.)
<i>Sesamum indicum</i> L.	Sesame, Til, ellu (Tamil)		South Asia: ? Pakistan (Bedigian and Harlan 1986)	Harappan Makran (Tengberg 1998); Harappa (c. 2500-2000 bc)	See previous column. Also, Sanghol, Punjab, 1900- 1400 bc (Saraswat and Chanchala 1997); Senuwar ii, 1200-600 bc (Saraswat et al. 1995); Narhan, from c. 1200 bc (Saraswat et al. 1994)
<i>Gossypium arboreum</i> L.	Trec Cotton, rapas, rui		South Asia: Gujarat/Sindh? (Santhanam and Hutchinson 1974)	? Mehrgarh Baluchistan? 5000 bc	See prev. (?); Mohenjodaro, Mature Harappan (cloth) 2500-2000 bc (Gulati and Turner 1929; Marshall 1931: 33); Hulas (seed), Late Harappan 1800-1300 bc (Saraswat 1993); Nevasa (thread) 1500-1200 bc (Gulati 1961). (see Janaway and Coningham 1995)

*sublobata*, formerly *Phaseolus sublobata* Roxb. in part) clearly extends throughout the Western Ghats and into Sri Lanka (Saldhana 1984; Maxwell 1991). Truly wild Black Gram may turn out to be restricted to northern India, although published botanical data is insufficient. Moth Bean (*V. aconitifolia*) also has not been adequately mapped in terms of its wild and weedy distribution, although it is *not* considered native to southern India (Cooke 1903; Gamble 1935; Saldhana 1984), and thus may be northern. Moth may have been a secondary domesticate, evolving from a weed of other crops, as there is no early evidence for it (prior to the later first millennium BC).

Several crops, including two major pulses, have been alternatively attributed to Indian or African origins, although it is now possible to provide more secure origins for some of them. Pigeonpea (*Cajanus cajan*. Hindi: *Tuvar*, *arhar*) has often been referred wrongly to an African origin (e.g. De Candolle 1886; Blench 1991; Langer and Hill 1991; Sundararaj and Thulasidas 1993) on the basis of mistaken botanical evidence and a disputed find of a single archaeological specimen from Egypt. Its wild progenitor, *Cajanus cajanifolia* (formerly *Atylosia cajanifolia*) is now well established through morphological and genetic study and occurs over a very limited area in Bastar and south-eastern coastal Orissa (De 1974; van der Maeson 1980, 1986, 1990, 1995; Smartt 1985a, 1990; Jha and Ohri 1996). Pigeonpea (*Cajanus cajan*) seeds, which appear in a later level at Sanganakallu, show numerous characteristics of putative wild ancestors (Fuller et al. n.d.). This occurrence together with that from Peddamudiyam, Cuddapah district (Venkatasubbaiah and Kajale 1991) and Tuljapur Garhi, Maharashtra (Kajale 1988a, 1996b), suggests that Pigeonpea began to spread out of its region of origin toward the mid-second millennium BC. This could suggest a domestication in the first half of the second millennium. Hyacinth Bean (Hindi *sem*), *Lablab purpureus* (formerly *Dolichos lablab*) has often been suggested to be of Indian origin (e.g. Kajale 1991; Sundararaj and Thulasidas 1993), although current botanical evidence, as inadequate as it is, suggests derivation from East African wild populations (Verdcourt 1970, 1971; Smartt 1985a, 1990).

The geographical origins of cotton and sesame remain disputed. One of the cotton species, *Gossypium arboreum* L. is now considered most likely of South Asian origin. Although disagreement continues to surround the history of the two Old World cotton species, a South Asian origin is supported by a weedy/wild form that is distributed there, although it may no longer be preserved in primary habitat and has perhaps spread together with the early cultivar (Zohary and Hopf 1993; Wendel 1995). This current hypothesis is opposite to the suggestions of De Candolle (1886) who suggested an Indian origin for *G. herbaceum*, now thought to come from Africa, and an African origin for *G. arboreum*. Another crop, now argued by many to have originated in South Asia is sesame, *Sesamum indicum* L. (Bedigian and Harlan 1986; Zohary and Hopf 1993), although doubts persist, with an African origin still preferred by some experts (cf. Nayar 1995). Potentially complicated plant exchanges between India and Africa are highlighted by the example of the vegetable Okra, *Abelmoschos esculentus* (L.) Moench. which appears to be of hybrid origin, with one genome possibly from India (Uttar Pradesh, *A. tuberculatus* Pal and

Singh) and the other from African *A. ficulneus* (cf. Joshi et al. 1974; Hamon and van Sloten 1995). Seeds of an *Abelmoschus* sp. have now been identified from widely separated early third to second millennium BC sites in India (Weber 1991; Venkatasubbaiah and Kajale 1991; Kajale 1996a).

### 5.3.1 South Indian Neolithic: a Centre of Domestication?

One candidate for domestication in India is the Southern Neolithic, or Ashmound Tradition, which flourished from the beginning of the third millennium BC therefore pre-dating the early Maharashtra villages by at least three to four centuries (Liversage 1991; Possehl and Rissman 1992; Allchin and Allchin 1982, 1997). This chronological priority would make it a candidate area to investigate the initial domestication of several of the indigenous crops. There are still few systematic archaeobotanical collections from this region and period, although the author has recently been involved in a programme to fill this gap (Fuller et al. n.d.; Korisettar et al. in Vol. I of this series). Remains from a number of sites, including Hallur in the west, Sanganakallu and Tekkalakota in the Bellary district, and sites in the Cuddapah district, show the presence of small millets and tropical pulses, with the later addition of *Lablab*, wheat and barley, perhaps in the mid-second millennium BC. The remains appear to be dominated by *Setaria*, perhaps *S. pumila* or *S. verticillata*. *Echinochloa colona* is also tentatively identified from a number of contexts. Small *Panicum* has also been found at a few sites, and is likely to be *P. sumatrense*. The evidence of pulses has implications for the domestication of these crops. *Macrotyloma* and *Vigna* are the most ubiquitous species, and they occur in the early levels at these sites. It is possible that the earliest agriculture in south India relied on grain legumes, like *Macrotyloma* and *Vigna*, and root crops, since parenchyma tissue (as yet unidentified) is also present in Southern Neolithic samples. Most *Dioscorea* spp., of south India are concentrated in the forested hilly tracts along the west and east coasts, the same areas where wild *Cajanus cajan* and *Vigna radiata* were probably located. Thus a tuber and pulse subsistence system is likely to have spread from hilly, forested regions, such as the Western Ghats, onto the drier, savanna grasslands of the Deccan. In these grasslands wild millets would have been readily available and these may then have become the focus of cultivation.

### 5.4 CHINESE CROPS

In addition there are important crops in India that came from centres of origin in South-East Asia or China (Table 9). Early agriculture in China can be divided into two very different crop complexes. That from south China was based around rice (Wenming 1991; Glover and Higham 1996; Chen and Jiang 1997; Crawford and Shen 1998; Higham and Lu 1998), but this may represent an independent rice culture from that in India (see below). That from north China (the Wei and lower Yellow River Valleys) which included the two best known 'Asian' millets, Proso Millet (*Panicum miliaceum*) and Common



Foxtail Millet (*Setaria italica*) (Bray 1981; Chang 1986: 92; Higham and Lu 1998), but evidence does not suggest that they necessarily diffused together as a package.

Both of the Chinese millet species are widely grown in India today. *S. italica* in South Asia represents one of the three morphological races of the crop (race *indica*) and may derive from mixing between the other two races, *moharia* of South-West Asia and *maxima* of China (Rao et al. 1987; Li et al. 1998). *P. miliaceum* in India falls into the race *patentissimum* which also occurs in Afghanistan, China and the former USSR; it is suggested to have come to India via central Asia or Afghanistan (De Wet 1995a). It is still unclear when, and by what route, these two crops entered the subcontinent. Although both Chinese millets have been identified on Late/Post-Harappan sites in Gujarat, it is unclear how these species were definitively distinguished from indigenous congeneric species, such as the edible *S. verticillata* and *S. pumila* (the latter also domesticated) and the little millet (*Panicum sumatrense*). The work by Weber (1991) and Reddy (1994) appears to have relied on differences of size alone, although no statistical studies of modern samples nor the effects of experimental charring are reported to these support these metrical criteria. *Panicum miliaceum* has positively been identified from Kashmir from the Indo-Greek period, i.e. late first millennium BC (Lone et al. 1993). *Setaria* probably to be identified with *S. italica* also comes from roughly the same period and region (ibid.). *Panicum miliaceum* is present at Shortugai in Afghanistan but only from the second millennium BC, i.e. after those levels with Harappan affinities, while *S. italica* is absent (Willcox 1991).

The origins of Asian domestic rice, *Oryza sativa*, have been placed by various authorities in India, south China and South-East Asia. The systematics and nomenclature of rice has been subject to a certain amount of confusion, and the taxonomy of Vaughn (1989a) is followed here. In this system two wild species with close affinities to the crop are recognized, *O. rufipogon* Griffith, a perennial, and *O. nivara* Sharma et Shastri, an annual (see also Crawford and Shen 1998). Although Vavilov (1992 [1950]) attributed rice to his Indian centre of origin, wild varieties can also be found across a broad band extending eastwards through South-East Asia and south China (T. Chang 1989, 1995; Oka 1988). Within the crop, three varieties are generally recognized, *japonica* (also called *sinica*), *indica* and *javanica* (sometimes lumped with *japonica* as a tropical offshoot of short-grained rice). The latter is confined largely to South-East Asia while the other two are widespread. The two main divisions can be distinguished on the grounds of morphology and generally ecology (Oka 1988; T. Chang 1989, 1995; Crawford and Shen 1998), with *indica* having long grains and *japonica* possessing short grains. It has long been recognized that crosses between *indica* and *japonica* are usually wholly or partly sterile, although both will readily hybridize with *javanica* (Wan and Ikehashi 1997). While this has long suggested to some authorities two domestications (cf. Chang 1989, 1995), some have also seen these varieties as a rapid divergence after domestication (Oka 1988; White 1989). However, it is now clear that there are a number of substantial genetic distinctions between *indica* and *japonica* (Sano and Morishima 1992; Chen et al. 1993, 1994; Wan and Ikehashi 1997; Crawford and Shen 1998; Sato et al. 1991). Most significant is the

TABLE 9. SELECTED CROPS OF VARIED ASIAN ORIGIN, INCLUDING EAST AND SOUTH-EAST ASIA, AND NORTH-EASTERN INDIA

Crop	Common names: English, Hindi, others indicated	Frequent synonyms	Region of origin (References)	Early finds, region of origin	Other early finds, South Asia
<i>Oryza sativa</i> L.	Rice, vrili		cv. <i>Indica</i> and <i>japonica</i> / <i>sinica</i> separate origins: South China, Yangzi; and ? second centre (could be NE India or Myanmar?) Assam, Aurangial Pradesh (NE India), Myanmar	Peiligang culture, Jiahu, Henan province, China, 7000-6000 bc (Chen and Jiang 1997); Mijialing culture, Hemudu, SE China, 5000 bc (Glover and Higham 1996)	wild rice at Chopani-Mando, 4th M. bc; domesticated at Mahadaha, 3000-2000 bc? (Sharma et al. 1980), See Sections 5.4, 5.7.4
<i>Coix lacryma-jobi</i> L.	Job's Tears, Gurlu, Giral, Garahedua, Kasi (Munda)			none	(as weed?): Balathal, 2350- 1800 bc (Kajale 1996a); Sunuwar IB, 1800-1200 bc (Saraswat et al. 1995); Inangaon, 1200-900 bc (Kajale 1988b), Bhaginohari, 1st M. bc (Kajale 1989c)
<i>Digitaria cruciata</i> (Nees) A. Camus	Raishan (Khasi)		Khasi Hills, Assam (NE India)	none	none
<i>Setaria italica</i> (L.) Beauv.	Common Foxtail Millett, Kangni, kangu, kakun, thennai (Tamil)		North China and ? South-East Europe (De Wet et al. 1979) De Wet 1995c)	6th M. bc Peigang and Chishan culture, N. China (Lu 1998); 5th-4th M.; Yangshao culture, N. China (K. Chang 1986)	Harappa (?); Gujarat: Surkotada 2500-2000 bc (Vishnu-Mittre) 1990); Balathal (?), 2000-1700 bc (Reddy 1994); Daimabad (?), c. 1500 bc See <i>S. pumila</i> (Table 8)
<i>Panicum mitaceum</i> L.	Proso Millet, Chin, Morha, Anu, panivaragu (Tamil)		North China (De Wet 1995a; Zohary and Hopf 1993)	5th-4th M. bc, Georgia sites; 4th M. bc; Yangshao culture, N. China (K. Chang 1986)	?Babar Kot by 2000 bc; ?Prak after 2000 bc
* <i>Echinochloa</i> <i>crusgalli</i> var. <i>utilis</i> Ohwi and Yabuno	Barnyard Millet [not cultivated in India; wild form present as weed/wild]	formerly lumped with domesticated <i>E. colona</i> as <i>E. frumentacea</i> (see Yabuno 1962; Hilt 1994)	Japan? and/or North China (Yabuno 1987; Crawford 1992	Middle Jomon culture, Japan, 2000 bc (Crawford 1992, 1997)	none as cultivar (?); Rojdi C, 2000- 1700 bc (Weber 1991)
<i>Saccharum</i> <i>officinarium</i> L.	sugarcane, gamma		New Guinea and/or South China (Daniels and Daniels 1993)	none	none, but <i>Saccharum</i> sp. fibres from Chirand, 3 M. bc (Vishnu- Mittre 1972); Hastinapur, 1st M. bc (Chowdhury and Ghosh 1955)
<i>Cenabis sativa</i> L.	Hemp, ganja, bhang		Central Asia/Afghanistan?	in N. China by 2500 bc (Li 1974; K. Chang 1986: 143; Crawford 1992)	Senuwar IB (charcoal) 1800- 1200 bc;

evidence for a sequence deletion in the chloroplast DNA of *indica* cultivars and in wild annual '*O. rufipogon*' (i.e. *O. nivara* in the taxonomy used here), but absent from *japonica* cultivars, perennial *O. rufipogon*, and other wild species (Chen et al. 1993): this evidence indicates clearly that *indica* and *japonica* have distinct phylogenetic origins. It is therefore plausible that they have distinct geographical origins, although it remains to be determined where. Until more detailed genetic markers are recognized and screened for across the range of wild populations, the best evidence comes from archaeobotany. There is strong archaeological evidence for at least one early rice domestication in southern China around the middle Yangzi river area, where on sites of the Hemudu Culture and southern Peiligang Culture of central China, rice is found from seventh and sixth millennia BC (Wenming 1991; Bellwood et al. 1992; Glover and Higham 1996; Chen and Jiang 1997; Anping 1998; Zhao 1998; Crawford and Shen 1998; Higham and Lu 1998). Despite a tradition of distinguishing *japonica* and *indica* within this material on the basis of length:width ratios, these are unlikely to be reliable on charred grains, at least not until we better understand the effects of the charring process (Glover and Higham 1996; Crawford and Shen 1998; see Section 4, above).

#### 5.4.1 Rice Domestication in the Ganga Plains: Evidence and Problems

Plausible botanical arguments for a separate rice domestication in India can be made, although reliable archaeobotanical evidence is still lacking. The wide distribution and diversity of wild rice in India, especially of annual, long-grain *O. nivara* type in northern and north-eastern India, has long suggested that *indica* cultivars may have originated in India and spread from there to South-East Asia and China (Vavilov 1992 [1950]; Shastri and Sharma 1974; Kumar 1988). There is still no convincing archaeobotanical evidence for an in situ domestication, and systematic sampling should be taken up at early sites in regions with large stands of wild rice.

An argument has been put forward for the domestication of rice in the central Ganga Valley, from sites in the Vindhyan plateau (Sharma et al. 1980; Vishnu-Mittre 1989). Unfortunately, the plant remains were not collected systematically by flotation and have been inadequately reported in terms of quantitative and morphometric trends. There is no clear temporal sequence suggesting a move from wild to domestic type rice which would indicate in situ selection for domestic morphology. The Koldihwa material was offered as evidence as both 'wild' and 'domestic' kinds occur together. Initially 'wild' rice was reported (Vishnu-Mittre and Savithri 1979a), but the stratigraphic sequence of rice finds as summarized later (Vishnu-Mittre and Savithri 1979c: 88; Vishnu-Mittre 1989; R. Singh 1990: 30; Kajale 1991: 169-70) has only *O. sativa* in the lower stratum (level 10) while *O. sativa* co-occurs with '*O. rufipogon*' (or a *spontanea* hybrid weed?) and *O. nivara* in levels 8 and 9 above. Thus, in this sequence wild finds actually post-date the earliest reported domesticate (assuming they have been correctly identified). Co-occurrence cannot be used to suggest domestication, since wild species and *spontanea*

hybrids often occur as weeds of rice fields (cf. Kumar 1988; Vaughn 1989). This is demonstrated by the co-occurrence of wild and domestic rice in pottery from Late Harappan Hulas, c. 1800 BC (Vishnu-Mittre and Sharma 1983; Saraswat et al. 1992) as well as numerous Chalcolithic to Iron Age sites in Uttar Pradesh (Vishnu-Mittre et al. 1984: 106). Indeed at Mahagara, contemporary or later than Koldihwa, domesticated and wild rice continue to co-occur as tempering material, including another rice weed, *Ischaemum rugosum* (Vishnu-Mittre et al. 1984). Thus the evidence from impressions at Koldihwa and Mahagara would appear to indicate only that crop-processing waste from rice cultivation was used as tempering; it says nothing about the evolution of rice cultivation. Burnt clay from Chopani-Mando III (mid-fourth millennium BC) contains charred remains of wild rice (Vishnu-Mittre 1989) which does seem to suggest the utilization of wild grains since querns are also found on the site (Sharma et al. 1980:75). How wild rice use relates to cultivation and later domestication requires research. Recent reviews of the evidence have been skeptical (e.g. Glover and Higham 1996). On the basis of the dearth of finds before the mid-second millennium, Glover and Higham (1996) suggest that cultivation in India did not start prior to this time. However, their compilation of finds by millennium fails to take into account sampling factors. There are very few sites with an archaeobotanical record at all prior to the third millennium in rice-growing areas, while later sites are abundant. This may in itself be significant, indicating that there were few settlements of this period large enough to have been easily detected archaeologically. The occurrence of rice at Harappan sites in Haryana, c. 2500-2000 BC (Willcox 1992), at Harappa after c. 2200 BC (Fujiwara et al. 1992; Weber 1997; M. Madella: personal communication), Lothal and Rangpur (back to c. 2500 cal. BC), suggests that rice must have been cultivated for some time prior to its adoption in Harappan areas which are largely outside its natural range.

Sites in the Vidhyan plateau area have also yielded additional crop species, although these have not drawn much interest. If rice is to be hypothesized as having been domesticated in this area then these other species should be studied as possible companion crops. A *Vigna* pulse, identified as Black Gram *Vigna cf. mungo*, and Horsegram (*Macrotyloma uniflorum*) have been reported from Kunjhun and Koldihwa, respectively (see Kajale 1991; Saraswat 1992). More archaeobotanical work in this region is clearly called for. It will also be necessary to systematically reinvestigate the absolute chronology of this region which has been surrounded by controversy and contradiction (cf. Sharma et al. 1980; Sharma and Sharma 1987; Chakrabarti 1988; Possehl and Rissman 1992; Allchin and Allchin 1982, 1997).

#### 5.5 THE PROBLEM OF MAIZE IN INDIA

A controversial issue which emerged during the first era of archaeobotany and has to some extent continued to the present, is that of the antiquity of maize in South Asia (Achaya 1994: 231). Vishnu-Mittre (1968b; 1974) believed that the evidence indicated a pre-colonial adoption of maize (*Zea mays* L.) in India. Earlier suggestions that maize in

South Asia might pre-date Columbus were supported by the fact that some forms of maize, notably popcorn and green vegetable corns, were cultivated by 'primitive peoples' in 'ethnological back corners', such as Assam (Stonor and Anderson 1949: 355). Aside from a flawed view of changeless peoples cut off from modern contact, these arguments hinged on the apparent divergence between maize in Nepal and Assam and elsewhere, especially in the New World (Stonor and Anderson 1949; Nickerson 1953; Jeffreys 1955, 1971). This deep genetic divergence was suggested on the basis of morphological measurements in a period before the availability of direct genetic evidence. In fact, at that time the origins of maize were obscure and Stonor and Anderson (1949) even speculated that maize could have originated in Asia and might be related to *Sorghum*. Today the origins of maize are far better understood and its New World origins are not in doubt (see Goodman 1995; Piperno and Pearsall 1998). Its wild ancestor is almost certainly the grass Teosinte which is indigenous to central America and genetic evidence, breeding experiments and archaeobotanical evidence all indicate its domestication and evolution in central America from c. 5000 BC.

Nevertheless, the high diversity in Himalayan maize varieties is remarkable:

Some primitive Himalayan strains appear to have been isolated from the main stream of maize evolution for a very long time, and the possibility of introduction before the discovery of America by Columbus can not be ruled out. (Hutchinson 1976: 133)

However, population bottlenecks in novel environmental settings could explain this diversity. In addition, it is likely that numerous genetic strains from the New World were transported to Asia during the early centuries of European transoceanic voyaging. And for at least one of these 'primitive' maize types, from Sikkim, a precursor population has been found in South America (Sachan and Sarkar 1986). On the other hand, the genetic diversity in maize from the plains of India (including the peninsular region) is so low as to be certainly of post-Columbian introduction (Sarkar et al. 1974; Hutchinson 1976). Nonetheless, Vishnu-Mittre, citing the diversity noted by Nickerson for *Himalayan* maize, argued for pre-Columbian maize *from the plains* on the basis of maize cob impressions decorating pottery from the late Medieval site of Kaundinyapura, Maharashtra. While his replication experiments strongly support the identification of maize, his argumentation for dating relied on an unsubstantiated assertion of a *terminus ante quem* of AD 1435 on the basis of a coin of this date reported from another contemporary site; in fact this coin can only be considered a *terminus post quem*, since it is unclear how long the coin would have circulated before burial. The inaccuracies of dating these archaeological deposits, however, suggest that a date in the sixteenth century is plausible. In addition, large grass pollen from late in the sequences in Kashmir was attributed to maize on morphometric grounds and suggested to date to the thirteenth or fourteenth centuries (Vishnu-Mittre and Sharma 1966). However, given that there were no absolute dates for this pollen sequence, no reliability can be granted such chronological guesswork. Moreover, some Indian *Coix* spp. were later shown to overlap in size with maize, suggesting that these pollen grains could be native (Vishnu-Mittre and Sharma 1983). Maize pollen from

sequences elsewhere in Asia, such as Sulawesi (Indonesia) are also undated (Gremmen 1990).

Other arguments for pre-Columbian maize in peninsular India have been put forward more recently on the basis of supposed artistic depictions of maize in Hoysala temple scenes in Karnataka (Johannessen 1988; Johannessen and Parker 1989; Achaya 1994: 233). These depictions are far from convincing, especially as they lack the distinctive tassels of maize, amongst other incongruencies, such as linguistic evidence in which terms for maize refer to its similarity to the more ancient *Sorghum* (Payak and Sachan 1988; 1993; cf. Veena and Siagamani 1991). Textual evidence from the temples in question and other contemporary written sources do not include the plant name for maize (Payak and Sachan 1993). The Hoysala temple depictions could just as easily be stylized representation of *Sorghum* or may not even be cereals. Payak and Sachan (1993) suggest that the depictions represent a mythical flower made of pearls, known in Sanskrit as *muktaphala*. The introduction of maize to South and South-East Asia remains a fascinating process to explore, but has so far been subject to more speculation than collection of botanical and archaeobotanical evidence. The hard evidence needed will be lacking until systematic archaeobotany is taken up on later historic sites, and well-dated pollen sequences are available.

#### 5.6 PALYNOLOGICAL INDICATORS FOR THE BEGINNINGS OF AGRICULTURE

Before turning to the evidence of archaeological seeds, for tracing the history of agriculture in South Asia (Section 5.7), some comments on the use of pollen proxy indicators of agriculture is in order. Although the study of pollen from natural deposits, such as lake beds or bogs, are generally analysed in order to reconstruct palaeoecological sequences they can also provide insights into human modification of the landscape (for general reviews, see Faegri and Iversen 1975; Godwin 1975; Behre 1986; Moore et al. 1991; for a discussion of pollen from archaeological sites, see Section 6.3). Perhaps the most significant human landscape modifications came about with agriculture, which cleared and replaced plant communities with arable fields. The first pollen studies that attempted to document the advent of agriculture were conducted in Europe (e.g. Iverson 1949; also Godwin 1956, 1975). Guinet (1963, 1966) and Vishnu-Mittre were the first workers in South Asia to draw attention to palynological indicators for the advent of agriculture (Vishnu-Mittre 1966, 1968a, 1974; Vishnu-Mittre and Sharma 1966; Vishnu-Mittre et al. 1962). As is now becoming apparent from the confrontation of the archaeological and palynological data bases in Europe, the signature of agriculture in pollen record may consistently post-date the actually beginnings of cultivation but reflect instead a subsequent period of agricultural intensification or the crossing of an environmental impact threshold (Willis and Bennett 1994; M. Jones et al. 1996: 93-6).

The biggest difficulty with studying early agriculture through palynological evidence is the recognition of reliable indicators. The most obvious indicator of cultivation would

be the presence of pollen that could be identified to domesticated plants, although identification to this level is generally highly problematic. One traditional indicator in Europe is 'cereal' pollen (taken to include cultivated *Hordium*, *Triticum*, *Avena* and *Secale* as well as some large-grained wild grasses). In general, however, few grass genera let alone species can be separated with certainty on the basis of pollen: grass pollen is all relatively large, single-pored, thin-walled and with relatively-smooth surfaces (Faegri and Iversen 1975; Godwin 1975: 405; Behre 1981; Edwards 1989; Moore et al. 1991). Standard criteria rely on size distinctions in terms of overall pollen grain diameter and pore size (Leroi-Gourhan 1969; Vuorela 1973; Godwin 1975: 405; Andersen 1979; Dickson 1981; Edwards 1989). However, for any given species there is always a range of pollen sizes and the differences that are generally relied are modal tendencies and rarely absolute distinctions. The attribution of pollen to cereals on the basis of size is problematic because of the large pollen of species of wild polyploid grasses in India such as *Coix* spp. (Vishnu-Mittre 1976a, 1976b, 1981a, 1985; Vishnu-Mittre and Guzder 1975; Vishnu-Mittre and Sharma 1983; see also Maloney 1990). Such large grains are known from pollen diagrams in Kashmir and Nepal from the Terminal Pleistocene (Vishnu-Mittre and Sharma 1966; Vishnu-Mittre 1978), which certainly do not indicate domesticates since according to other sources of evidence agriculture does not enter this region until the third millennium BC (cf. Burzahom archaeobotany, Lone et al. 1993). A recent review of the literature on grass pollen studies shows that a large number of genera and species that are common in India have not been taken into account for developing the standard criteria used in European and Near Eastern studies (Bower 1997). Some of these other large-pollen-producing species, however, may be recognized by surface patterning of the pollen and therefore ruled out, such as *Coix* which has distinctive exine (Maloney 1994). In general, further examination of exine sculpturing with a scanning electron microscope may allow specific (or generic) identifications for a number of cultivars, but this technique would seldom be practical for application to pollen cores samples as part of a routine analysis. A further serious problem with identification of cereal pollen in India is that several of the important cereal crops, notably all the small-seeded millets, *Sorghum* and rice, have pollen that falls below the western Eurasian 'cereal' size range and overlaps with a wide range of wild grasses (Vishnu-Mittre 1974, 1975; Vishnu-Mittre and Guzder 1975; Maloney 1990). There are, however, a few other cultivars, e.g. amongst fruit trees, that may be identified in the pollen records (for a review of species utilized in South-East Asia, see Maloney 1994).

The other approach to recognizing early agriculture is by identification of associated weed taxa and inferred forest clearance (Vishnu-Mittre 1968a, 1974; Vishnu-Mittre and Guzder 1975). This approach relies on assuming ecological preference of particular species and plant associations, specifically with crops, can be extended into prehistory. Inevitably such an approach raises difficulties of uniformitarian assumptions; it must assume that plant associations observed today would have held in the past, which may not be the case (Behre 1981; Huntley 1990). Indeed archaeobotanical macrofossils suggest rather the opposite, that arable weed floras have been evolving in response to changes in irrigation,

tillage and weeding technologies (M. Jones 1988a, 1988b; Kuster 1991). Also many of the indicator species often used in Europe were present during Pleistocene interglacial long prior to agriculture (Godwin 1975); similar observations were made in Kashmir and the Nilgiri Hills by Vishnu-Mittre (1976a, 1976b, 1978). As Edwards (1979) and Behre (1981) warn, palynologists have been somewhat overzealous in identifying pastoralism and cultivation on the basis of indicator species which often have a range of possible ecological interpretations. A pollen sequence researched in the 1960s from the Nilgiri Hill-station of Ootacamund (Tamil Nadu) initially suggested a period of clearance, attributed to the impact of pastoralism (see Vishnu-Mittre 1968a), although once it was dated it was found to be Pleistocene and was reinterpreted as natural vegetation change and disturbance (Vishnu-Mittre and Gupta 1971; Vishnu-Mittre 1976b). Nevertheless, if used cautiously, evidence for decreasing forest cover and increases in taxa which flourish under regimes of tillage or fallowing can be suggestive of widespread agriculture in a region.

Pollen evidence has been collected from other parts of northern India and the Himalayan region. Vishnu-Mittre discussed the pollen sequence from Kashmir in relation to the origins of agriculture. The decline of forest tree species and the increase in non-tree pollen types together with species associated with disturbed agricultural habitats is often taken as a proxy indicator for agriculture. Vishnu-Mittre attributed the presence of weeds like *Plantago lanceolata*, Chenopodiaceae, as weeds of wheat/barley cultivation. Work in the Kumaon region of the Himalayas (Vishnu-Mittre et al. 1967; Gupta 1975a) correlates well with the Kashmir sequence and indicates a similar phase of agricultural impact on the landscape. In the middle of Zone A of this sequence there is some evidence for burning, but without evidence for 'cereal' type pollen, so Gupta (1975a) attributes this evidence to natural fires. More certain evidence for agriculture comes from Zone C with greater occurrences of 'cereal' sized pollen, herbs of disturbed ground, decreasing tree pollen and charcoal. However, these earlier studies remain difficult to utilize for understanding human prehistory as they lack a fixed absolute chronology. More recent work from Sharma and Chauhan (1988) on two lakes in Himachal Pradesh which spans from c. 4000 BP to the present has been interpreted to indicate agriculture throughout this period. A Holocene pollen sequence is now available from the Garhwal region, between Kumaon and Himachal Pradesh (Sharma and Gupta 1997). This sequence is poorly dated, however, because there is only one radiocarbon date and dates for rest of the sequence must be extrapolated. In Zone II defined by this study there is an apparent increase in non-arboreal pollen as well as several anthropogenic herb groups, some of which were absent from the previous pollen zone. The decline in oak and associated forest elements during the period extrapolated as 4000-3500 BP is interpreted in terms of the local climate cooling, although intensive agriculture is also suggested for this region on the basis of anthropogenic indicators, charcoal and 'Cereal' -size pollen (ibid.).

Another pollen sequence which has been interpreted in terms of agriculture comes from the salt lakes of Rajasthan (Singh 1971; Singh et al. 1974). The climatic implications of Rajasthan pollen profiles and their implications for understanding the rise and fall of



Harappan Civilization, continue to be debated but will not be dealt with here (Singh 1971; Vishnu-Mittre 1976; Vishnu-Mittre and Savithri 1979c: 109; Meher-Homji 1980; Bryson and Swain 1981; Meadow 1989; Shaffer and Lichtenstein 1989; Agrawal 1992; Kajale and Deotare 1997; also see Fuller and Madella in Vol. IV of this series). On the basis of the occurrence of a few large grass pollen grains (40-50 microns) and an increase in microcharcoal in 'climatic phase' III (8000-4000 cal. bc) Singh (1971) suggested that scrub burning was carried out for 'primitive cereal agriculture'. If accepted, this might be contemporary with or later than the Mehrgarh. Although it is difficult to accept uncritically the attribution of this pollen to domesticated cereals. Given that large quantities of cereal pollen are probably only released through crop processing (Vuorela 1973; Robinson and Hubbard 1977; Behre 1981; Bower 1992), an agricultural hypothesis would suggest human agriculture or settlement very close to the lakes. In the absence of such evidence, as appears to be the case for Rajasthan, a wild source for the pollen seems likely. The *single* occurrence of a supposed anthropogenic weed can not be considered indicative of agriculture (Vishnu-Mittre 1976). The evidence for burning, from microcharcoal in the sediment core, is also ambiguous and could indicate hunter-gatherer management of vegetation to encourage game (Vishnu-Mittre 1985) or an increase in natural burning. The latter position may be supported by the fact that the charcoal level remains consistently high throughout the remaining sequence. This is not accompanied by significant pollen indicators of deforestation (Vishnu-Mittre and Guzder 1975). There is an increase in cereal-sized pollen in latter levels contemporary to Pre-Harappan/Harappan period. The evidence from this phase is more generally accepted as indicating cultivation because of several clearance herbs (anthropogenic indicators) and larger amounts of cereal-size pollen (Vishnu-Mittre and Guzder 1975).

Additional pollen sequences in South Asia that may have a bearing on agriculture, come from peninsular India. An offshore sequence from the west coast of India is reported by Caratini et al. (1991, 1994). These pollen sequences are assumed to reflect vegetation in the Western Ghats and the adjacent plains carried by rivers to be deposited on the continental shelf. This sequence indicates a dramatic decrease in tree species and an increase in grassland and herbaceous types. While Caratini et al. (1994) prefer to attribute these changes to a climatic change, a weakening of the monsoon and aridification, c. 3500 BP (1900-1700 cal. bc), some, if not all, of these changes could be due to forest clearance, for grazing and agriculture, the explanation advocated by Meher-Homji (1996) and Subash Chandran (1997). Certainly, from the emerging archaeobotanical evidence from the Southern Neolithic and the published record for the Maharashtra Chalcolithic (see Sections 5.3.1 and 5.7.5), the early second millennium bc witnessed the proliferation of agricultural villages, and in the case of the Southern Neolithic the adoption of winter crops from external sources, implying agricultural intensification (chronology is still to be resolved). This evidence tends to support an anthropogenic factor. If, however, the change found by Caratini et al. could be shown to have a tight chronological correlation with vegetational changes in other regions (e.g. Rajasthan), then a climatic explanation would gain support. In general, most of available palynological data for the Holocene

suffer from the ambiguity of equi-finality with marked changes that could be due to climatic variables or human impact. More discussion of strategies for disentangling these confounding factors should be incorporated in future work. The total quantity of pollen evidence for the Holocene of South Asia is still extremely small and warrants further research, however, there is a need for placing pollen evidence into its broader landscape context by trying to consider archaeological evidence for the scale of settlement and archaeobotanical evidence for agriculture.

#### 5.7 CROP DIFFUSION IN SOUTH ASIA:

##### A CURRENT SYNTHESIS

Starting from the geographical sources of crops outlined earlier (Section 5.5), it is possible to trace in general terms their directions and period of spread in the subcontinent. Liversage (1989) proposed a simple classification of four Neolithic regions in South Asia which can be hypothesized to have had distinct prehistoric agricultural traditions that were based around different but overlapping suites of crops. These regions include Baluchistan, the Indus Valley, the Ganga Valley and a large west-central Indian region that extends from the Aravalli Hills in the north-west down through the peninsula (Deccan). Liversage sees these Neolithic 'complexes' as unified by similar ecological conditions and presumed cultural interaction; a broadly similar division was already discussed by Allchin and Allchin (1968) and Hutchinson (1976). The two river valleys differ from their adjacent regions by the presence of regular alluvial flooding. Liversage suggested that the Indus region formed something of a large, ecological frontier zone where the spread of South-West Asian crops was delayed before spreading into tropical India. As more evidence becomes available these regions are likely to require revision and perhaps a certain amount of subdivision, in particular of the rather large and heterogenous Southern Neolithic. An alternative framework for discussing the Neolithic geography of India is based on the definition of Neolithic cultures as defined by distinctive artefact styles, through which seven Neolithic zones are recognized (Thapar 1974, 1978; Saraswat 1992). There remains a need to evaluate these regional classifications on the basis of archaeobotanical evidence for similarities and differences in ancient agriculture. Some preliminary observations of the geographical distribution of crops in the past on the basis of archaeology are offered below.

The extent to which any or all of these Neolithic zones represent either the independent development of cultivation or the spread of agriculture from elsewhere by migration or diffusion, remains to be determined. A major problem facing Indian archaeologists interested in agricultural origins is an Early Holocene gap in the archaeological record. For the subcontinent as a whole there are very few well-dated sites between the end of the Pleistocene (c. 10,000 BC) and the regional Neolithic cultures, which largely appear to date after 3000 BC. While microlithic, 'mesolithic' cultures are assumed to fill this gap, there are still few well-excavated sites that have been sampled archaeobotanically and accurately dated. The filling of this gap is essential, if the roots of Indian agriculture are

to be truly understood. Some very promising data that contributes towards filling this gap are the Mesolithic charred assemblage studied by Kajale from Damdama, a Vindhyan plateau site (Kajale 1990a, 1991), in addition to some Mesolithic plant remains from Sri Lanka (Kajale 1989b). More early and pre-neolithic plant assemblages are badly needed.

### 5.7.1 Spread of South-West Asian Crops

It is conceivable that wheat, barley and four South-West Asian pulses spread together into the subcontinent, although the evidence from the Greater Indus Valley region is too highly fragmentary at present to be sure (Fig. 3). Although the South-West Asian pulse species have not been reported from the early periods at Mehrgarh (Costantini 1984), this cannot be taken to indicate their actual absence as the evidence for wheat and barley comes from pottery and mud-brick impressions, a category of remains which one would not expect to include leguminous crops, since straw, cereal chaff, or dung are the ceramic tempering agents usually documented ethnographically. It is clear however that in regions east and south of the Indus Valley all or most of these crops co-occur in their earliest occurrences which suggests that they spread as a winter crop package. The spread of these crops, usually found together as a package, shows a clear trajectory from the north-west to the east and south, with a discernible delay around the eastern fringes of the Harappan province. Wheat (*Triticum* spp.), barley (*Hordeum vulgare* L.), peas (*Pisum sativum* L.), lentils (*Lens culinaris* Med.), grass pea (*Lathyrus sativus* L.) and chick pea/bengal gram (*Cicer arietinum* L.) are present in the upper Ganga Basin during the Ochre Coloured Pottery phase in the early to mid-second millennium BC (for the dating see Possehl and Rissman 1992; Allchin and Allchin 1997: 214-18, 225-6), e.g. at the sites of Hulas (Saraswat et al. 1992; Saraswat 1993); Atranjikhhera (Chowdhury et al. 1977) as well as Lal Qila (excluding *Lathyrus* and *Lens*, Kajale and Deotare 1993; Kajale 1995) and Sringaverapura (excluding *Lathyrus*, *Lens* and *Pisum*, Kajale 1991). In the Ganga Valley these crops were probably adopted into a cultural system in which rice had already been cultivated since at least 2500 cal. BC (Bellwood et al. 1992), and possibly in earlier millennia (Koldihwa and Chapni-Mando: Sharma et al. 1980; Chang 1989; Vishnu-Mittre 1989; Saraswat 1992; but see critical discussion of dating in Possehl and Rissman 1992). In peninsular India they were merged with an agricultural system that utilized summer pulses and millets of peninsular origin.

An unclear aspect of the history of the South-West Asian crops, is the story of different wheat types. As discussed above (Section 4.1), attribution of archaeobotanical material to *Triticum sphaerococcum* has not been reliable. Thus previous reviews of the history of wheat in India (e.g. Vishnu-Mittre 1968c, 1974; Zeven 1978; Randhawa 1980; Kulshrestha 1985; Buth et al. 1987) which emphasize the former dominance of *T. sphaerococcum* should be disregarded until evidence from chaff remains becomes available. Most of the reported evidence for wheat comes from charred caryopses, which are generally inadequate for specific level identifications and the likely presence of free-threshing tetraploid wheat

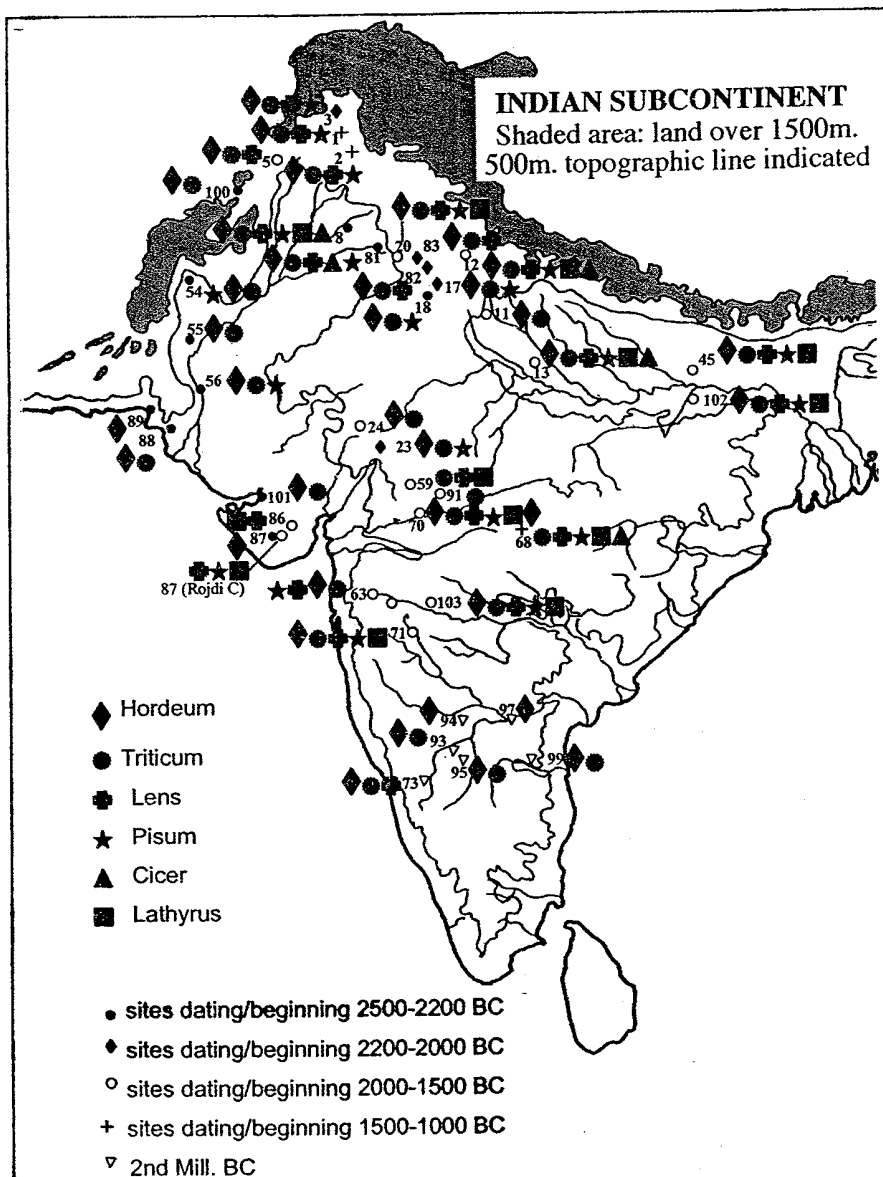


Fig. 3. Map showing the dispersal of the South-West Asian crop suite across South Asia. The representatives of this package (pulses and cereals) are shown next to selected sites plotted according to their approximate archaeological period. Note that only the earliest finds and sites in each region are shown. Site numbers can be found in Tables 2 and 3.

(*T. durum* sensu lato) has been largely ignored (see Section 4.1; Willcox 1992). Thus Vishnu-Mittre's (1986c) suggestion that diploid and tetraploid wheats were introduced to India only in recent times is unfounded. Nevertheless, the bulk of these finds do suggest the widespread presence of free-threshing types (whether hexaploid or tetraploid) in the past, while glume wheats, in particular emmer, would appear to be fairly uncommon. This is perplexing, given the traditional importance of emmer in Karnataka and Tamil Nadu (Pal 1966; Kajale 1974a). Plant impressions in pottery from a few sites have been studied, and as these often include 'chaff' it is possible to suggest plausible specific identifications. For example, glume wheats are present amongst impressions from Pre-Harappan Mehrgarh in Pakistan (Costantini 1983) and from Harappan Kalibangan (cf. Vishnu-Mittre and Savithri 1975). Charred grains of emmer, including in one instance an attached rachis, have come from Rohira, Punjab in the Post-Urban Harappan phase (Saraswat 1986). While in neither case are the illustrated examples adequate for certain identification, there seems a reasonable likelihood for the presence of at least one hulled wheat type, most probably emmer. Other illustrated assemblages, of charred wheat grains, do include specimens that could be emmer (e.g. Early Historic Ter, Vishnu-Mittre et al. 1971: pl. 1.1), although the presentation of the data is usually inadequate to confirm this. It seems plausible that emmer and a free-threshing tetraploid (*T. durum* sensu lato) spread together into peninsular India as part of the 'Harappan package' which included barley and the pulses of South-West Asian origin. The history of *T. sphaerococcum* remains obscure. In the early decades of this century it was cultivated in Punjab, Sindh, parts of Uttar Pradesh and Madhya Pradesh and in pockets of Baluchistan (Ellerton 1939), while today it is more or less extinct (Pal 1966; Kulshrestha 1985). It is not clear whether it represents a relatively recent mutation which has always been of limited local importance, or if indeed it is very ancient and was once more widespread. It showed superior drought resistance in comparison to other wheat types (Percival 1921; Ellerton 1939), which favours the hypothesis of the long history, at least in the north-western part of South Asia. However, this does not provide any reason to expect its more widespread distribution, such as into the Ganga Valley (e.g. Chirand, Bihar; Neolithic Kashmir), as the older archaeobotanical literature suggests. Attempts to estimate the date of its origin, such as a suggestion of 3500 BC (Kulshrestha 1985) seem unwarranted in light of our current knowledge.

Whether flax also spread in South Asia as part of the above-mentioned crop package is unclear, due in part to a sparser archaeological record. The earliest flax evidence came from Late/Post Harappan contexts (i.e. post 2000 BC), at Pirak, Baluchistan (Costantini 1979b) and Rojdi, Gujarat (Weber 1991). Several of these records come from textile fibres, which must be regarded cautiously as evidence for local cultivation as they could be imports. Subsequently, evidence for flax occurs on Chalcolithic sites in Maharashtra from at least the Early Jorwe phase, c. 1500 BC (Janaway and Coningham 1995; dating after Possehl and Rissman 1992). Thus, flax appears to lag behind the other South-West Asian crops.

### 5.7.2 African Crops and the Hypothesis of a Summer Crop Revolution

Discussion of African crops in India has focused almost exclusively on millets, to the exclusion of pulses for which there is an equally good archaeobotanical record (Fig. 4). Much interest has been shown in the potential role of African millets in transforming the subsistence systems of ancient India, especially of the Harappan Civilization. Several authors have argued for a 'revolution' in agriculture with the adoption of summer crops, both from East Asia and Africa, around the Harappan sphere in the Late Harappan period, i.e. end of the third/early second millennium BC (Costantini 1981; Costantini and Biasini 1985; Possehl 1980: 33, 1986, 1997, 1998; Jarrige 1985, 1997; Meadow 1989, 1996; Franke-Vogt 1995: 32-4; Willcox 1992). This was seen as an agricultural transformation, particularly around the fringes of the Harappan Civilization which corresponds in general to the era of de-urbanization. This *kharif* (monsoon-season) crop revolution opened up new zones to extensive agriculture as opposed to the intensive, presumably irrigated, Harappan system (Possehl 1980: 33, 1997; Meadow 1989, 1996; Franke-Vogt 1995: 32-4). However, this Late Harappan agricultural shift needs to be reconsidered in light of the possibility that earlier dates for the African millets have been overestimated and that *Setaria* and *Panicum* reports relate to indigenous crop species in these genera. The earliest millets cultivated in India are likely to have been entirely indigenous (cf. Weber 1998; Fuller et al. n.d.), and are species that are probably native to the savanna grasslands of the peninsula. This transformation is to be seen, the source of the crops, at least for some regions, such as Gujarat (e.g. Rojdi, Babor Kot, Kuntasi, Surkotada), and at Harappa (Weber 1997, 1998) is likely to have been from the east in inner India, with African crops playing a later and secondary role. The status of east Asian millets, and the possibility of rice coming into northwestern Pakistan from China rather than India in the early second millennium BC (see Jarrige 1997) remain to be critically assessed.

In Gujarat, on the fringes of the Indus Civilization, African millets appeared in India, not as a single package but at different times (Weber 1990, 1991, 1998). Finger millet, *E. coracana*, is the earliest and most widely reported. Although most of these reports are problematic, as discussed earlier in Section 4.2, and some are certainly misidentified. The other African millets are usually thought to arrive by the beginning of the second millennium BC although many early reports are problematic. *Pennisetum* has been reported from a number of Chalcolithic (Malwa Culture) sites in Maharashtra (Kajale 1977c, 1990c, 1991) as well as in Gujarat at Rangpur, Period III, c. 1500-1000 cal. BC (Ghosh and Lal 1963; chronology after Possehl and Rissman 1992). A single grain, unidentifiable to species, from Babor Kot in Gujarat (Reddy 1994, 1997) is ambiguous evidence. The timing of the adoption of *Sorghum* is controversial with some doubt being cast as to whether *Sorghum* had even been domesticated before the late first millennium BC (Willcox 1992; Rowley-Conwy et al. 1997). Some tentative reports of *Sorghum* require confirmation, such as those at Pirak and Ahar referred to above (Section 4.2.1). Nevertheless, there are a number of other reports of *Sorghum*, dated on contextual grounds to the first half of the second millennium BC which may constitute support for the earlier origin of

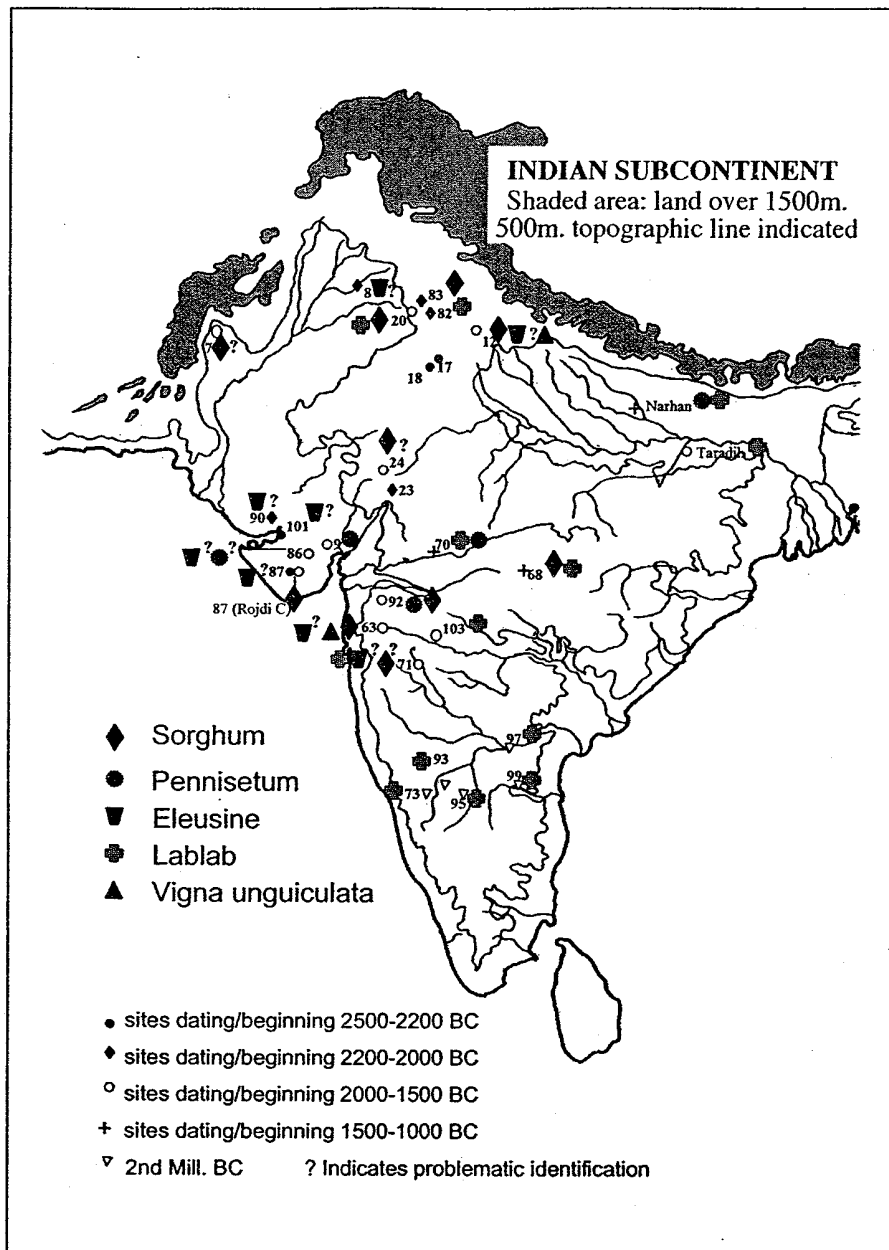


Fig. 4. Map showing the archaeological distribution of African pulses and millets in South Asia. Taxa are shown next to selected sites plotted according to their approximate archaeological period. Questionable identifications are included and indicated by question marks. For discussion of problems with *Eleusine* and *Sorghum* identification, see text, Sections 4.2 and 4.2.1. Site numbers can be found in Tables 2 and 3.

domestic *Sorghum*. These data suggest the introduction of *Sorghum* across parts of Gujarat and the northern Deccan, as well as perhaps between the Sutlej and Yamuna rivers in northern India (e.g. Rojdi C: Weber 1991; Kaothe: Kajale 1990c; Daimabad: Kajale 1977c; Rohira: Saraswat 1986). These finds would seem to argue against accepting the hypothesis of Rowley-Conwy et al. (1997; Deakin et al. 1998) for a late domestication of *Sorghum*.

As with reported *Pennisetum* and *Sorghum*, the African pulses have a distinctly extra-Harappan distribution on the basis of finds from the early second millennium BC (see Fig. 4). *Lablab* and *Vigna unguiculata* have both been recorded, although *Lablab* is much more widely reported. This is in keeping with the idea that *Lablab* diversified relatively quickly into various South Asian agricultural regimes. Taken together as a whole, the evidence of African millets and pulses, casts serious doubt on the notion that these crops were introduced from Africa as part of the long-distance trade of the Harappan Civilization, although it is clear that contact between peninsular India and Africa must have been established, in at least an indirect way, early in the second millennium BC. The lack of contemporary archaeological evidence from the west coast of India and from areas in eastern Africa limits our understanding of this diffusion process.

### 5.7.3 South Asian Pulses and Millets

The record for pulses of South Asian origin may begin in the second half of the third millennium BC (Fig. 5), although the first well-dated evidence at present is from the start of the second millennium BC. As noted in Section 5.3.1, the earliest evidence for several of these pulses may come from the Southern Neolithic of Karnataka and Andhra Pradesh, although these finds remain to be accurately dated (Fuller et al. n.d.). Other potentially early finds of horsegram, *Macrotyloma uniflorum* (although the absolute dating controls are inadequate), also come from Senuwar in Bihar, Kunjhun in the Vindhyan Hills, Burthana Tigrana and Mitathal in Haryana (Willcox 1992) and Rohira in the northeastern Harappan region (Saraswat 1986; Kajale 1991; Saraswat et al. 1992). In the first half of the second millennium BC, horsegram (*Macrotyloma uniflora*) occurs in the regions between the south and the Vidhyas, namely in the upper levels at Rojdi, the lower levels at Inamgaon and Apegaon, and the second and third phase at Daimabad (Weber 1991; Kajale 1977a, 1988b, 1991; Vishnu-Mittre et al. 1986a). This could indicate either northern or southern origins for horsegram (or both!). A similar situation seems to hold for *Udid*/black gram, *V. mungo*, although the suspicion of this author is that it originated somewhere in the north. Possible early finds come from Burthana Tigrana (specific identification uncertain, Willcox 1992), and Rojdi phase A, possibly as early c. 2600-2200 BC (accepting the Weber/Possehl dating; recently supported by Herman [1997], although others argue that this site begins only at the end of the third millennium or the start of the second, i.e. Late Harappan, see Chakrabarti 1995).

The pulses which are more clearly of southern origin are so far only recorded from the second millennium BC. Mung, *Vigna radiata*, however, is widely found on Southern Neolithic sites which await dating but could push its origin back into the early or mid-



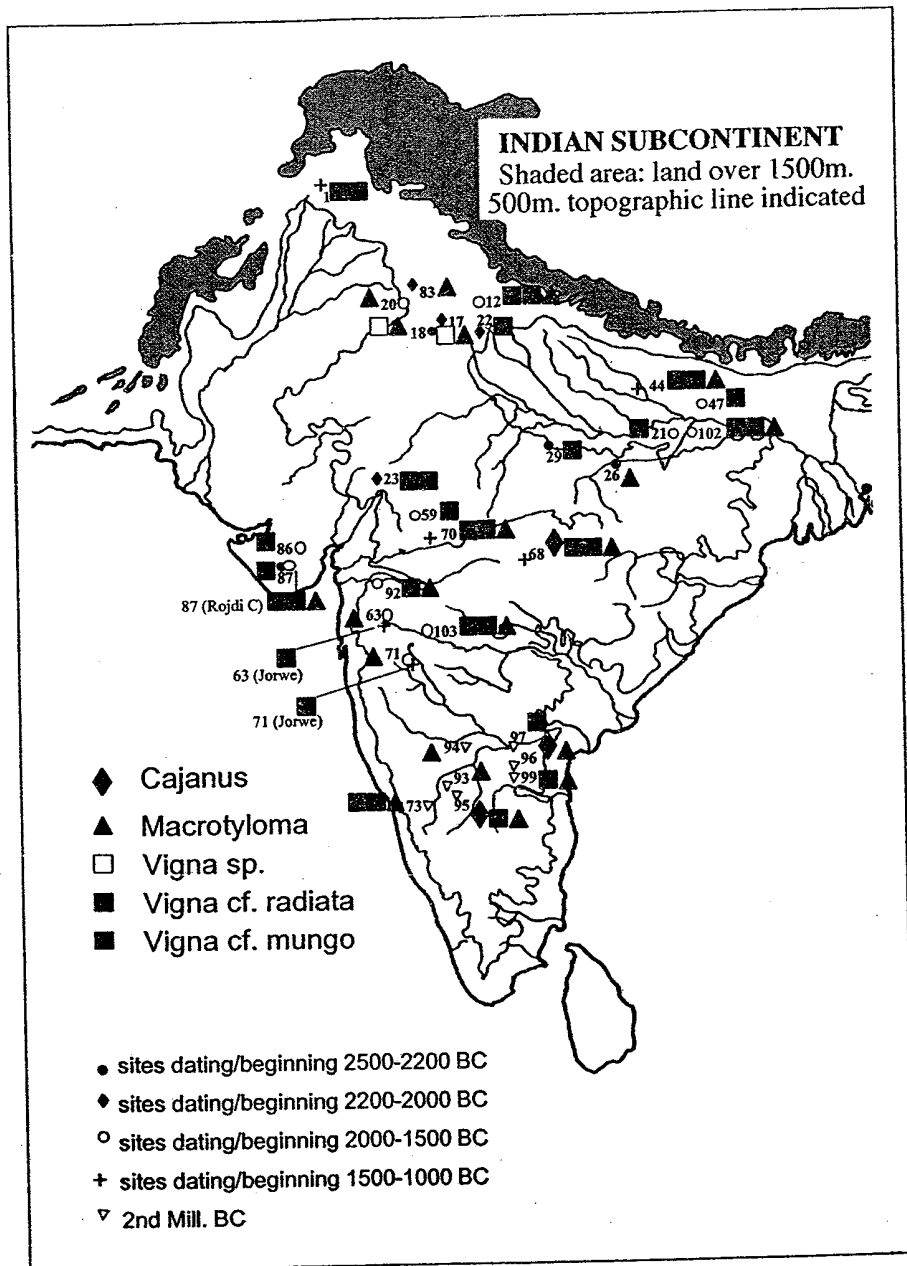


Fig. 5. Map showing the prehistoric distribution of pulses of South Asian origin. Taxa identifications as reported are shown next to selected sites plotted according to their approximate archaeological period. Although *Vigna* finds are reported to species level, it should be recognized that this level of identification is not certain in all cases and requires further confirmation. Site numbers can be found in Tables 2 and 3.

third millennium BC along with horsegram. Otherwise mung comes from Malwa phase Apegaon (Kajale 1991), Rojdi level C (Weber 1991), or Hulas in the Ganga-Yamuna Doab region (Saraswat et al. 1992), all dating between 2000 and 1700 BC. The earliest pigeon-peas (*Cajanus cajan*) yet reported come from Peddamudiyam in Andhra Pradesh, c. 1700-1300 BC (Kajale and Venkatasubbaiah 1991) and the Jorwe period (c. 1200-900 BC) at Thūljapur Garhi, Maharashtra (Kajale 1988b, 1996b). This would tend to suggest a later start for agriculture in the eastern peninsular region around Bastar and southern Orissa, although archaeobotanical evidence from this region itself is lacking.

South Asian millets are more difficult to trace in part due to difficulties with identifying to species level, as well as distinguishing wild use from domesticated varieties (Fig. 6). However, *Panicum* probably, *P. sumatrense* (syn. *P. miliare* nom. illeg.), is now widely reported from the late third millennium BC, including Southern Neolithic sites, Harappan Rojdi, and later Harappa, after c. 2200 BC (Fuller et al. n.d.; Weber 1991, 1997, 1998). *Setaria* reports could be wild *S. verticillata*, or domesticated *S. pumila* (syn. *S. glauca* nom. illeg.), or even *S. italica*, and further morphometric documentation is needed. The author's ongoing work on Southern Neolithic material argues strongly against *S. italica* in the south. Other finds of large quantities of *Setaria* (e.g. Surkotada, Rojdi, Babor Kot, Oriyo Timbo) may similarly turn out to be indigenous species. Similar difficulties surround reports of *Echinochloa*, since clear criteria for distinguishing *E. crus-galli*, almost certainly a weed, and *E. colona*, either a weed or a crop, need to be developed. Kodo millet is fairly straightforward to recognize and has been reported from the Bihar Neolithic c. 2000 BC (Saraswat et al. 1992), Rojdi C, 2000-1700 BC (Weber 1991; although the small quantity could suggest it to have been a weed) and from Chalcolithic Daimabad, 1500-1000 BC (Kajale 1977c; the first evidence from further south dates to the Iron Age, c. 500 BC, as at Veerapuram (Kajale 1984). Browntop Millet, *Brachiaria ramosa*, remains undocumented archaeologically.

#### 5.7.4 Cotton

Early evidence for cotton is generally rare, as is the case for other fibres and oilseeds. The earliest reported cotton to date is that from Mehrgarh Phase II, c. 5000 BC (Costantini 1984), although actual antiquity of this find may need revision. The cotton seeds were apparently not charred, as one would expect to have been necessary for preservation in most areas. However, the association of these seeds with charred wheat and barley may argue for their antiquity. In addition, textile impressions, of an unidentified fibre, were reported from roughly contemporary levels (Lechevallier and Quivron 1981: 80). Well-dated cotton fibre fragments from northern Arabia, c. 4400 BC (Betts et al. 1994), however, do suggest that cotton must have been cultivated in the early-mid fifth millennium BC. Cotton seems more likely to have reached Arabia from South Asia than from East Africa, since the limited cotton evidence from Africa (Nubia) does not imply textile production in prehistory (cf. Chowdhury and Buth 1971). Evidence for cotton cloth in South Asia

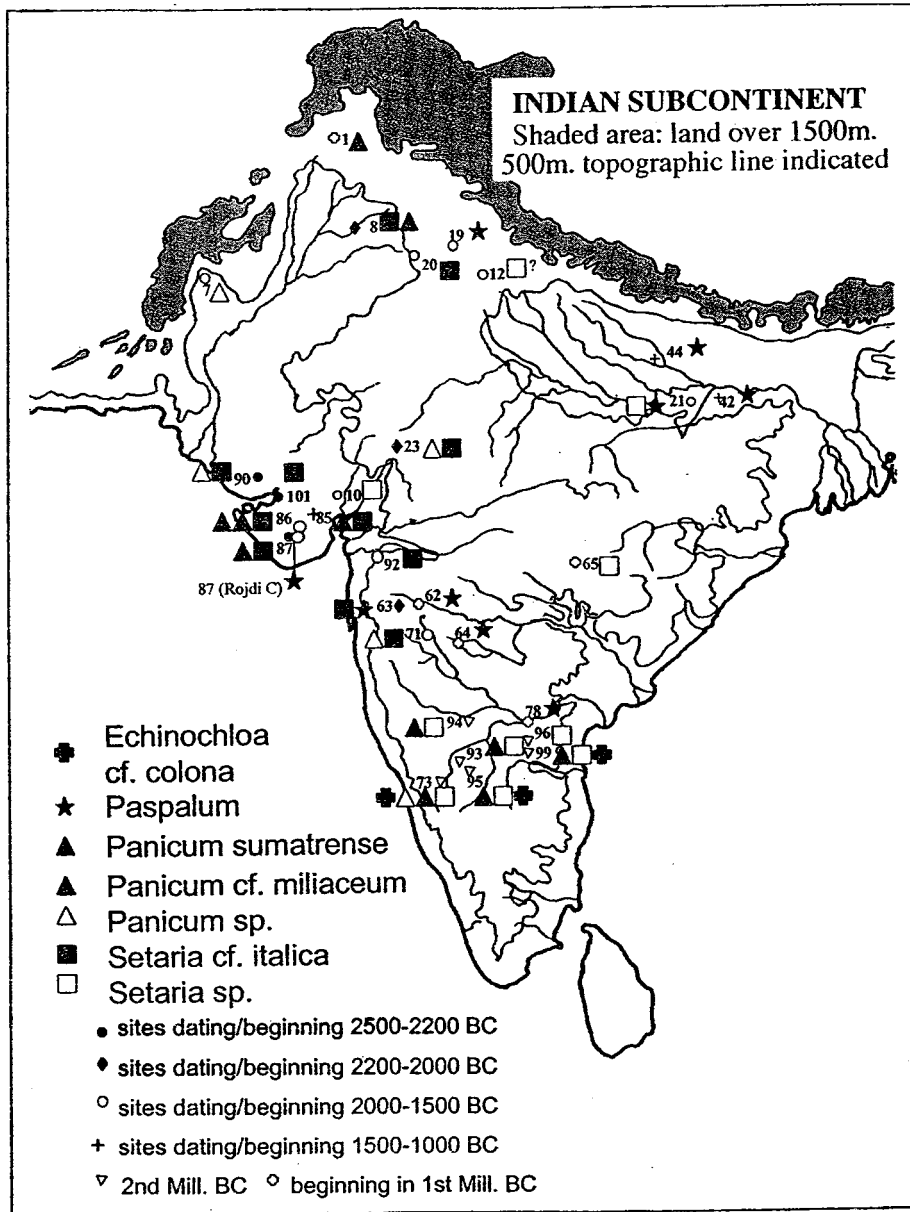


Fig. 6. Map showing the prehistoric distribution of the Asian millets, including those of South Asian and East Asian origins. Reported millet taxa are shown next to selected sites plotted according to their approximate archaeological period. Although reported to species level, it should be recognized that this level of identification is not certain in all cases and requires further confirmation. Site numbers can be found in Tables 2 and 3. ? indicates uncertain identification.