Harvey, Emma L. – Fuller, Dorian Q. – Pal, J. N. – Gupta, M. C.

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E. L. Harvey / D. Fuller / J. N. Pal / M. C. Gupta

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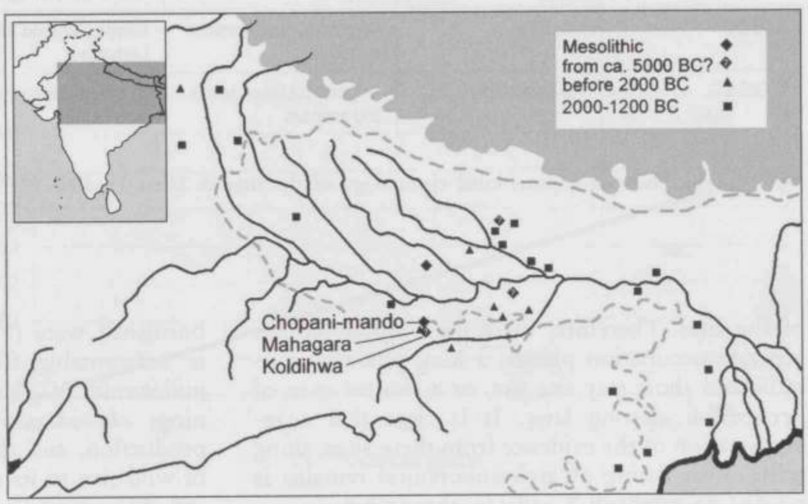

Fig. 1. Map showing the location of sites.

Introduction

The Neolithic sites located in the Belan Valley of North-Central India are surrounded with controversy over claims of early dates for rice domestication. Problems of chronology and a lack of thorough archaeobotanical sampling and analysis means a re-examination of these sites is necessary. This paper will report new evidence for early agriculture in the Vindhyan Neolithic-Chalcolithic. Systematic sampling by flotation for macrobotanical remains, and the collection of phytolith samples were carried out at Mahagara, Koldihwa, and Chopani-Mando in December 2001. This combination of two complimentary botanical methods provides a general picture of the Neolithic plant exploitation and a basis for assessing the extent to which early agriculture in this region was an indigenous development and the extent to which diffusion of crops from elsewhere played a role. Macro-remains indicate the importance of rice, a potential local domesticate, certain Indian native small millets and pulses as well as the presence of introduced crops during the sequence, such as barley and some pulses. The phytolith assemblage provides evidence for intensive processing of rice on-site and supports the inference of local cultivation.

The Prehistoric Traditions of the Belan River Valley

The Belan River Valley has a rich environment of raw materials and natural resources that were readily available for prehistoric people to exploit (see fig. 1). The Neolithic sites of Koldihwa and Mahagara were originally thought to have produced the earliest finds of rice in India dating to 6375 cal. BC (Sharma et al. 1980). However, these dates are still considered questionable[1], even with recent early dates from Landuradewa and Malhar in the Central Ganga Plain (Tewari et al. 2003). Dates of between 4th–3rd millennium BC are more likely for the beginnings of rice agriculture in the Belan River Valley (fig. 2). Continuous occupation from the 6th millennium BC would produce a large sequence of deposits but this is not present at any

1 Allchin/Allchin 1982; Possehl/Rissman 1986; Pandey 1988; Kajale 1991; Bellwood 1996; Glover/Higham 1996; Mandal 1997; Singh 2001; Fuller 2002.

Date	Phase	Phase characters	Belan-Son Late Prehistoric Tradition	Ganges Valley Late Prehistoric Tradition
	Chalcolithic	Black and red, slipped	**Koldhiwa**	
1500 BC	Neolithic	Dominated by rusticated	**Koldihwa, Mahagara,** Pachoh, Indari	
2000 BC	Neolithic (early)	Predominantly cord-impressed, rice husk and chopped straw temper	Kunjuhn II	
3500 - 3000 BC				
	"Advanced Mesolithic"	Dull red and brown grey wares, no temper	**Chopani Mando III**, Baghai Khor, Lekhahia III + IV, Ghagharia, Morahana Pahar	
	Mesolithic	No pottery, geometric microliths	**Chopani-Mando IIB, Lekhahia** II, Ghagharia,	Damdama, Sarai Nahar Rai, Mahadaha
9000 BC	Mesolithic	No pottery, non-geometric microliths	**Chopani Mando IIA**, Lekhahia I	
17,000 BC	Epi-palaeolithic	No pottery, blades, points and scrapers	**Chopani-Mando I**, Mahagara Gravels IV	

Fig. 2. Table showing a provisional chronology of the sites in Uttar Pradesh. Sites sampled are in bold.

of the sites. Therefore, there must either be two separate occupation phases, a long phase of sporadic and short stay site use, or a shorter span of occupation starting later. It is clear that a re-examination of the evidence from these sites, along with direct dating of archaeobotanical remains is needed to establish a reliable chronology.

The site of Chopani-Mando is located on a small tributary of the Belan River Valley, 77 km southeast of Allahabad. There are three main periods starting in c. 17,000 BC with an epipaleolithic phase producing blades, points and scrapers. Then there is a microlithic period with some huts, non-geometric and geometric microliths. Period 3 has the appearance of ceramics and the continuance of microliths. Wild rice grain impressions in pottery have been reported as well as a number of wild animal remains (Sharma et al. 1980) although impressions of any sort appeared rare in the sherds from our recent re-evaluation. This last period could be contemporary with the settled farming sites of the Belan River Valley.

Mahagara and Koldihwa are two of the early farming settlements that appeared in the Belan River Valley in the late prehistoric. This tradition is characterized from evidence of over 40 sites in the Belan, Adwa, Son, Rihand, Ganga, Lapari, and Paisuni valleys. The main characteristics of the Vindhya Neolithic culture are sedentism, characteristic pottery, rounded polished stone implements, Neolithic blades, and an economy based on domesticated cattle and rice agriculture (Pandey 1988; Allchin/Allchin 1997; Mandal 1997). This tradition has four types of pottery present; cord-impressed, rusticated, black burnished, and red burnished ware (Pal 1986). Sedentary agriculture is indisputable from at least the mid/late 3rd millennium BC, but what is at issue is the beginnings of sedentism, the beginnings of ceramic production, and the transition from the foraging of wild rice to its cultivation and the morphological domestication of rice.

The occupation mound of Mahagara is situated 3 km southwest of Chopani-Mando on the banks of the Belan River. There are 2.6 m of cultural deposits. Circular huts and cattle pens are present along with many artefacts including pottery, ground stone tools, and microliths. Rice has been reported from the original excavations (Sharma et al. 1980) but no systematic collection and flotation of archaeobotanical material was conducted at Mahagara, Koldihwa, or Chopani Mando until December 2001.

Koldihwa comprises Neolithic, Chalcolithic, and Iron Age levels. It is situated on the opposite bank of the Belan River to Mahagara and consists of a number of mounds. It produced similar Neolithic remains to those found at Mahagara, namely cord-impressed pottery, ground stone celts, and microliths. Domestic rice has been reported from rice tempered pottery found at this site (Sharma et al. 1980).

A lot of emphasis has been placed on the rice-based agriculture of these sites and of the culture as a whole. However, very little systematic archaeobotanical work has been conducted. This means that there is likely to be much more to the economy of the Vindhya Neolithic and how this relates to the advanced Mesolithic period at Chopani-Mando has yet to be established.

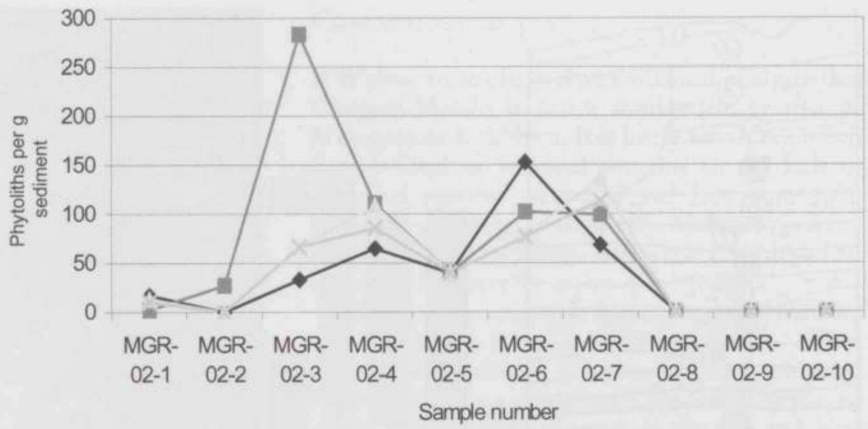

Fig. 3. Graph showing the number of different rice phytolith types per gram of sediment at Mahagara. Key: diamonds = double-peaked glume cell, squares = multi-celled glume, triangles = 'scooped' bilobe, crosses = fan-shaped bulliform.

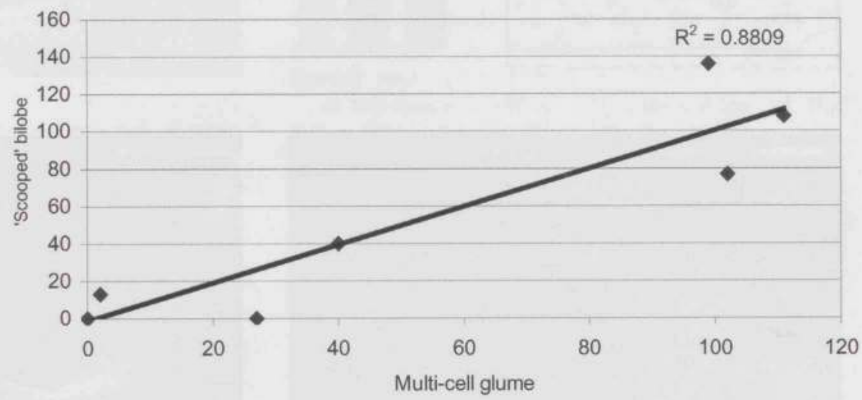

Fig. 4. Graph comparing 'scooped' bilobes of rice and multi-celled rice glume phytoliths. Correlation suggests the same input pathway to the site.

Research methods

A program of systematic sampling and flotation took place in December 2001 at Mahagara, Kolidhwa, and Chopani Mando. This was conducted to collect adequate sized botanical samples for thorough archaeobotanical analysis. The flotation samples were sorted and identified using standard archaeobotanical techniques.

Phytoliths are silica bodies, which are formed by living plants that when the plant decays are left in-situ. A wide variety of plants can be identified through phytolith analysis including economic plants such as rice and millets (Piperno 1988; Pearsall 2000). So far only phytolith samples from Mahagara have been analysed (Harvey 2002). A heavy liquid separation method (Miller-Rosen 1995) was used for processing the sediments and then a standard count was conducted of single- and multi-celled morphotypes including a quantitative method of weighing phytoliths to produce the number of phytoliths per gram of sediments (Albert/Weiner 2001). This meant that quantities of phytoliths could be compared between each sample allowing a greater depth of data analysis.

Preliminary results and interpretations

Phytolith analysis of the material from Mahagara has revealed on-site rice processing. This can be demonstrated by comparing the quantities of phytoliths from different parts of the rice plant (see figs. 3 and 4). In this case, 'scooped bilobes', which come from the leaves, are compared with multi-celled rice husk phytoliths (from the lemmas and paleas of the rice husk). This reveals that the quantities of these two types of phytoliths change by roughly the same amounts in each sample demonstrating they both come from the same input pathway to the site. Both leaves and husks of rice are being brought in to the site and therefore rice crops are being processed at the site of Mahagara.

Rice phytoliths are found at the bottom of the sequence at Mahagara (fig. 5) but are not found in the three latest layers. There are also some millet phytoliths present but further work is needed to determine which millet type and whether it was a cultivar. As well as crops, the phytolith analysis has found wetland weeds including reeds and sedges, which adds to the idea of wetland rice cultivation at Mahagara.

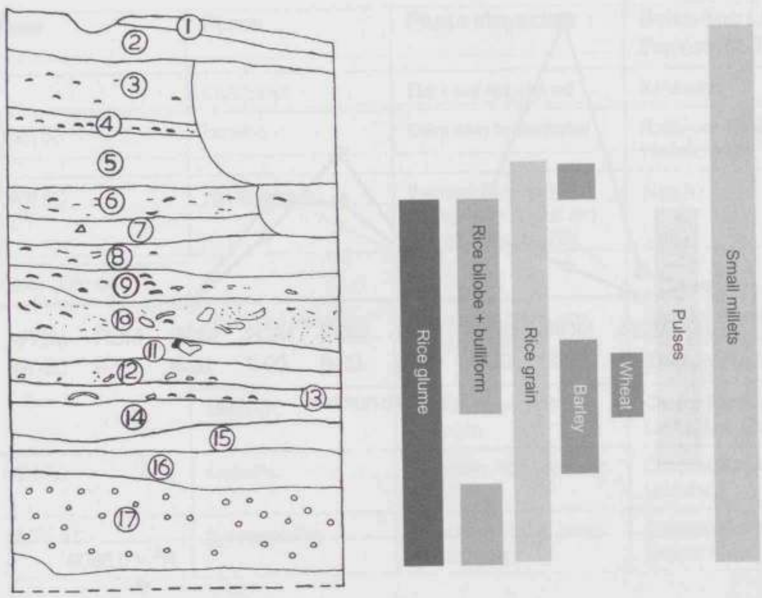

Fig. 5. Section of Mahagara deposits indicating when plants appear in this sequence. Level 12 corresponds with the Late Neolithic based on correlation with published Mahagara dates (calibrated) c. 1800 BC.

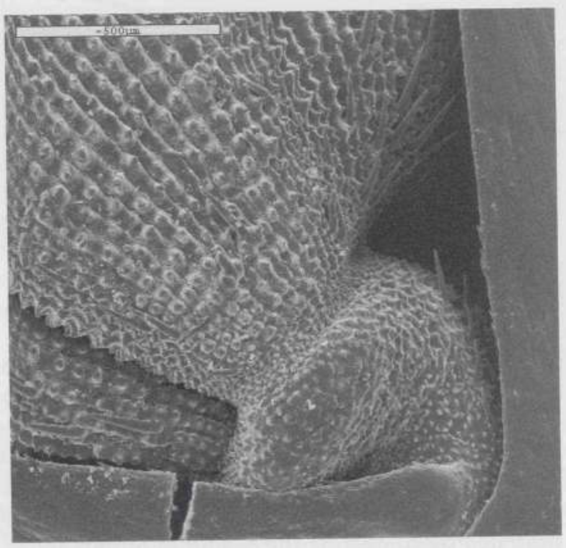

Fig. 6. SEM micrograph of *Oryza sativa* glume base and grain × 200.

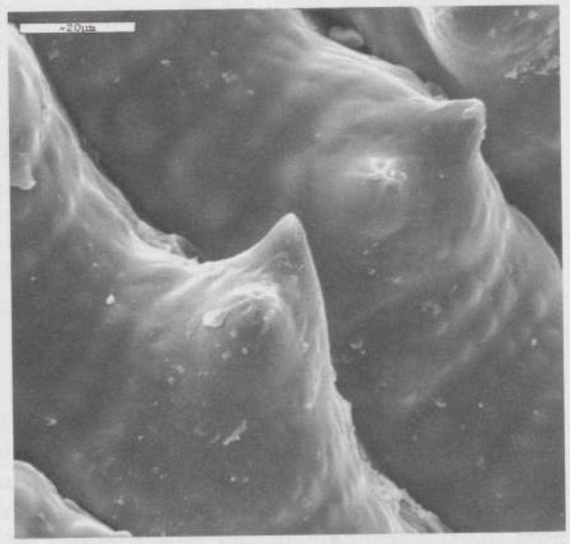

Fig. 7. SEM micrograph of *Oryza sativa* double-peaked husk cells × 1000.

Macroscopic plant remains have been sorted and identified from Mahagara, Koldihwa, and Chopani-Mando. Little or no macro-botanical remains were found in the samples from Chopani-Mando. This is extremely disappointing but further analysis is still to be conducted on the phytolith samples, which may reveal some information on the plants used at this site.

Macro-botanical remains of rice have been identified at both Mahagara and Koldihwa but many other plants were also present. Rice is present from the beginning of both the sequences sampled and both wild and possibly domestic types present. Further analysis of the rice grains will determine whether domestic species are present or not and whether there is a transition from wild to domestic types at these sites. As in the phytolith samples from Mahagara, rice macro-remains are not present in the latest three samples.

The other crops identified are barley, wheat (glume and free-threshing), pulses, sesame, and small millets. Weed seeds are also present at both sites such as sedges and wild grasses. The millets present included *Bracharia ramosa*, *Panicum sumatrense*, and *Setaria verticillata*, which is possibly domestic. The pulses include lentils, vignas (some possibly *V. radiata*), possible pigeonpea, and grasspea are all present. Millets are present in the majority of samples from Koldihwa and Mahagara and appear in the earliest samples. However, barley, wheat, and all the pulses are later additions to the crop repertoire of both sites.

Fig. 8. Transmitted light microscope photograph of a fan-shaped bulliform from the leaf of *Oryza sativa* × 50.

Rice identification

Another large part of this project is to refine the identification of rice species by comparing currently used methods for macro-remains and phytoliths. This will aid the analysis of samples from the Belan Valley sites and provide a clearer understanding of the Neolithic rice agriculture in the region.

Measurements of grains can be carried out to distinguish between *Oryza* species but this method is inaccurate due to natural variations and charring effects. Macro-botanical remains are more accurately identified in terms of domestication status by examining the abscission scar of the rice glume (Thompson 1996). Domestic species tend to have a rougher scar and a different shape to wild species (fig. 6). Unfortunately, charred rice glumes are rarely preserved archaeologically and therefore other forms of identification are needed. The archaeobotany has shown a wide variation in grain shape and size and it is hoped that this can be characterized using modern reference material.

Phytoliths can also potentially be identified to rice species. "Double-peaked husk" cells are measured and compared to measurements from modern species to distinguish between wild and domestic species (figs. 7 and 8). A comparison of methods developed by Zhao et al. (1998) and Wenxu (2002) is being carried out and applied to modern and ancient Indian rice phytoliths to assess the utility of these methods for identifying domestication in the Indian context.

Conclusions so far

It is clear from the archaeobotanical analysis that Chopani-Mando is not a similar site to that of Mahagara or Koldihwa. It is likely that it is a much shorter-lived or seasonal site due to the lack of botanical remains recovered and long time span covered by shallow stratigraphy. Mahagara is more clearly a sedentary village site, while Koldihwa had repeated intensive occupation periods.

The plant economy at Mahagara and Koldihwa was not solely based on rice cultivation. Other crops were exploited and possibly also cultivated by the prehistoric inhabitants. Small millets played a role in the early economy of the site and later the introduction of barley, wheat, and a variety of pulses led to a varied and nutritious diet. Thus, an understanding of the origins of agriculture in this region needs to consider the process of domestication or incorporation of a range of species and not just rice.

A re-examination of the chronology of the Belan River Valley sites and the tradition as a whole needs to be conducted to establish a clear sequence of events. This can only be achieved through detailed review of the existing evidence and new direct dating of archaeobotanical material. Only when this is achieved, can questions about the transition to agriculture in this region be answered.

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