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Palaeodiet, palaeoecology and palaeoenvironment during 1200 BCE–300 CE in the Ganga Plain: A palaeoethnobotanical and palynological approach

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ABSTRACT

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This paper presents the results of plant macro–remain analysis from Iron Age–Historic settlement sites in Ganga Plain. The plant remains affirm the presence of distinct agricultural economy based on cereals (*Oryza sativa*, *Hordeum vulgare*, *Triticum aestivum*, *Triticum sphaerococcum*), pulses (*Lathyrus sativus*, *Vigna* sp., *Macrotyloma uniflorum*), oil–fibre yielding (*Sesamum indicum*, *Gossypium* sp.) and minor millets (*Panicum* sp., *Setaria* sp.). Relative dates based on ceramics from individual site provide secure chronology for the sites between 1200 BCE to 300 CE. Also analyzed pollen and non–pollen palynomorphs from Biland–Khera (200 BCE–300 CE) cultural sediment to investigate palaeovegetation and palaeoenvironment around the settlement.

Key–words—Palaeodiet, Palaeoecology, Archaeobotany, Palynology, Iron Age, Ganga Plain.

गंगा के मैदान में 1200 ईसा पूर्व–300 ईसवीं के दौरान पुरा आहार, पुरापारिस्थितिकी एवं पुरापर्यावरण : पुरामानव वानस्पतिक और परागाणविक दृष्टिकोण

अनिल के. पोखारिया, अंजलि त्रिवेदी, दीपिका त्रिपाठी, चंचला श्रीवास्तव, डी.पी. तिवारी, जया मेनन, सुप्रिया वर्मा, अल्का श्रीवास्तव एवं वैशाली

सारांश

यह शोध–पत्र गंगा के मैदान में लौह युग–ऐतिहासिक बस्ती स्थलों से प्राप्त पादप स्थूल–अवशेष विश्लेषण के निष्कर्ष प्रस्तुत करता है। ये पादप अवशेष (*ओरज़या सैटाइवा, होरडियम वलगारे, ट्रिटिकम ऐसटिवम , ट्रिटिकम स्फैरोकोक्कम*), दालें (*लेथाइरस सैटाइवस, विग्ना* जाति, *मैक्रोटाईलोमा यूनीफ्लोरम*), तैल–तंतु उपज (*सॅसामम इंडिकम, गौसिपियम* जाति) और बाजरा (*पेनिकम* जाति, *सेटारिया* जाति) पर आधारित विशिष्ट कृषि–संबंधी अर्थव्यवस्था की विद्यमानता अभिपुष्टि करते हैं। विशिष्ट क्षेत्र से प्राप्त मृत्तिका कला पर आधारित सापेक्षिक आयुनिर्धारण 1200 ईसा पूर्व से 300 ईसवीं के मध्य इन स्थलों हेतु सुनिश्चित कालानुक्रमण प्रदान करते हैं। इस बस्ती के इर्द–गिर्द पुरावनस्पति एवं पुरापर्यावरण अन्वेषित करने को बिलंद खेड़ा (200 ईसा पूर्व–300 ईसवीं) सांस्कृतिक अवसाद से प्राप्त पराग व गैर–पराग परागाणुसंरूप भी विश्लेषित किए।

सूचक शब्द—पुराआहार, पुरापारिस्थितिकी, पुरातत्ववनस्पतिविज्ञान, परागाणुविज्ञान, लौह युग गंगा के मैदान।

INTRODUCTION

THE emerging archaeological evidences in the subcontinent suggest that the sedentary lifestyle of Neolithic farming communities has been traced back to 7th millennium BC at Mehrgarh, Baluchistan in Pakistan and Lahuradewa, U.P., in India. Agriculture has been a mainstay of the prehistoric settlers as evidenced by the presence of winter crops *Triticum* sp. (wheat) and *Hordeum vulgare* (barley) at Mehrgarh (Jarrige & Meadow, 1980; Costantini, 1984; Costantini & Biasini, 1985) and indigenous summer crop *Oryza* sp. (rice), at Lahuradewa (Saraswat & Pokharia, 2004; Saxena *et al*., 2006; Tewari *et al*., 2006). The Indian subcontinent shows tremendous variations in its landforms, climatic patterns, rainfall, floral and faunal composition and diverse agricultural practices, coupled with cultural variability (Kajale, 1991). The archaeological sites all over the country are widely scattered, in time and space. Therefore information is fragmentary and sparse; the data related to the sequential development and the spread of agriculture is still insufficient to draw conclusion to know–how of diversification and diffusion of crops in time and space.

In recent times, the knowledge of early human has grown exponentially with the excavations of several sites in different regions of the country. The crops introduced from multiple regions such as West Asia, Eurasia and Africa along with indigenous ones, played a significant role in the plant based subsistence economy of the subcontinent.

The Gangetic plain is an important region for archaeobotanical studies as it was the region in which second urbanism emerged in India. The archaeobotanical and palynological studies pursued from and around the settlement sites in the Ganga Plain are meagre (Singh, 2000; Saxena *et al*., 2006; Chauhan *et al*., 2015; Trivedi *et al*., 2011, 2013, 2015) and have provided little database concerning the cultural succession and contemporaneous subsistence pattern the dwellers adopted in a particular environment. The presence of ruderal plant taxa around 9000 cal BP implies the ignition of cereal–based agrarian practice. However, abrupt decline in arboreal taxa from ~8700–4800 cal BP indicates that the forest groves became sparse in response to warm and less humid conditions due to decrease in monsoon precipitation (Chauhan *et al*., 2015).

The changing climatic conditions during early and middle phases of Holocene in the area might have played a significant role in the evolution of agrarian societies. Plant remains provide an extremely important source of evidence on human–plant interaction, environment, and the production and use of plants for food and other purposes. The information on archaeobotanical remains in the region from Iron Age onwards is limited. In order to understand the subsistence economy, palaeoecology and human–plant–environment

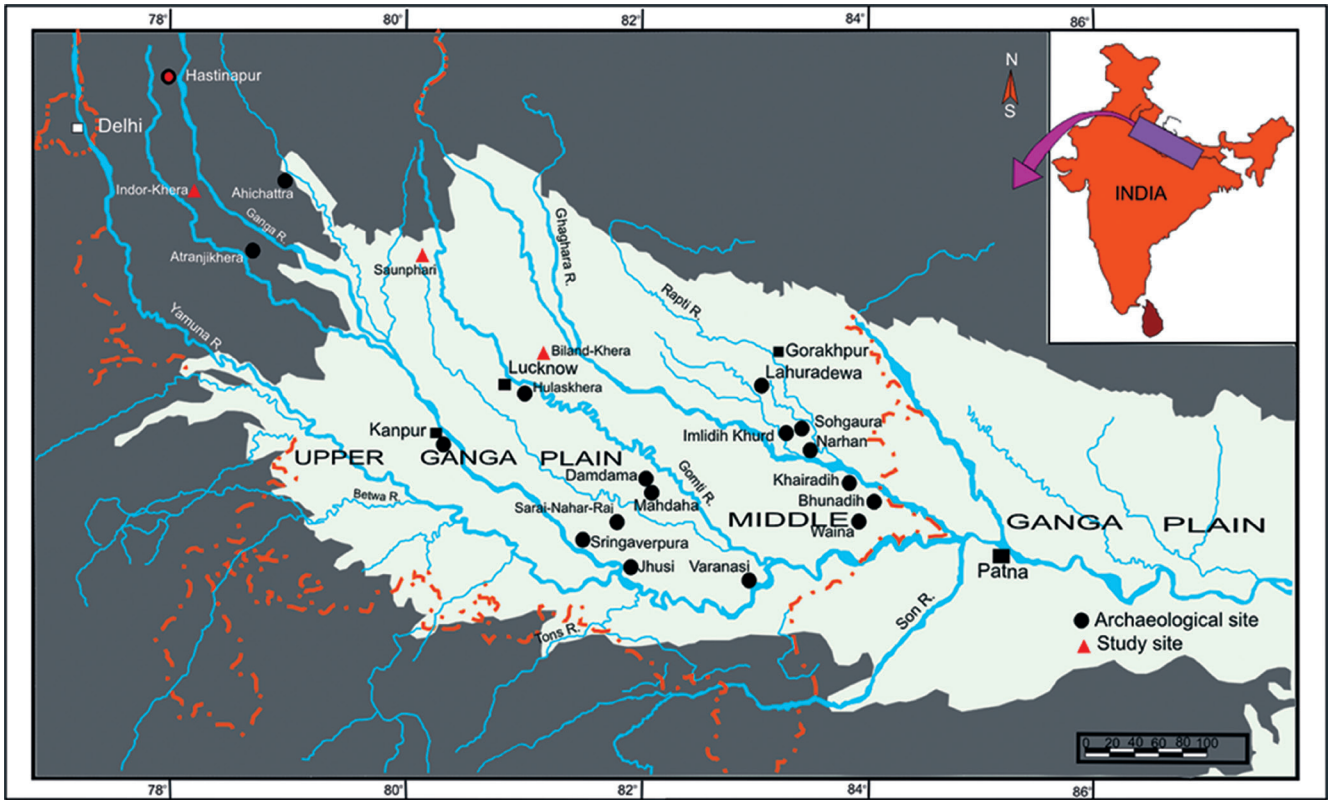

Fig. 1—Map of Ganga Plain showing archaeological sites.

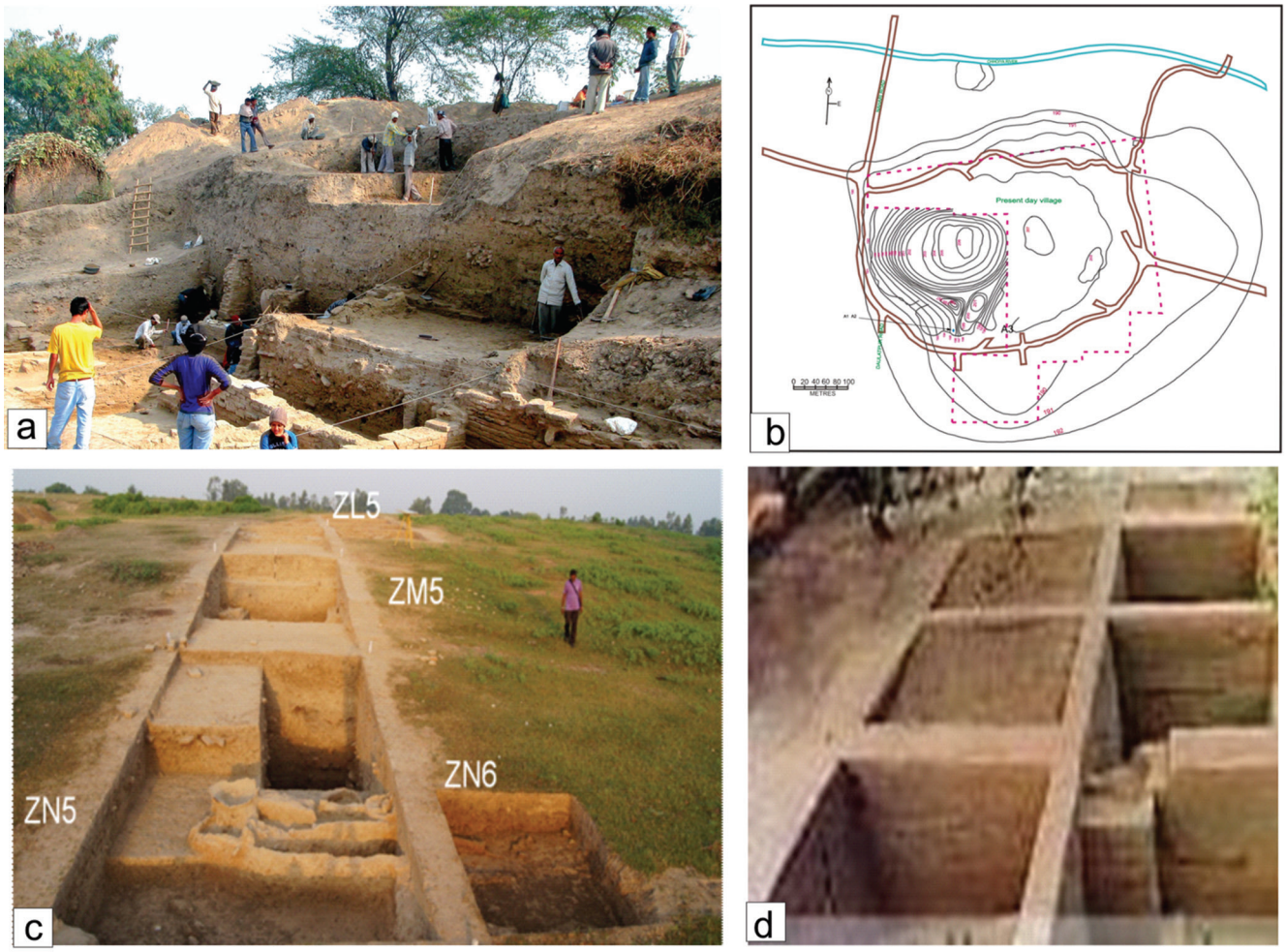

Fig. 2—a. General view of Indor–Khera archaeological site, b. Contour map of Indor–Khera mound, c. Biland–Khera archaeological site, d. Saunphari archaeological site showing excavated trenches.

interaction during proto–historic times in Ganga Plain, three archaeological sites ranging between 1200 BCE–300 CE were studied (Fig. 1). In the present communication, the cultural antiquity and the crops used by the settlers and environment around the site are dealt in detail, based on the meticulous investigations of Indor–Khera, Biland–Khera and Saunphari archaeological sites.

THE ARCHAEOLOGICAL SITE

Indor–Khera

Indor–Khera (28º14'5"N; 78º12'48"E) is a small site (about12 ha) with a number of small mounds, ranging from around 0.1–0.6 ha, with height of 1–2 m (Fig. 2a, b). Some of these small mounds lay on the other site of the river Chhoiya, but all the mounds in a radius of about 500–600 m were to the north and west of Indor–Khera mound. The site of Indor–Khera is located 0.5 km off the Aligarh–Anupshahr Road in Tehsil Debai, District Bulandshahr, Uttar Pradesh on the right bank of the eastern branch of the Chhoiyanadi, also called Nimnadi. Indor–Khera lies between the rivers Kali and the Ganga (Menon *et al*., 2008). Three test trenches (A1, A2 and A3) were opened at Indor–Khera in 2006. In 2007, one of the test trenches was reopened and a more extensive area (approximately 15 x 15 m) was excavated. On the basis of pottery, antiquities and bricks used in the structures at Indor–Khera, the entire cultural assemblage was divided into four cultural periods as under:

I. Black Slipped Ware (1200−1000 BCE)
II. Painted Grey Ware (1000−700/600 BCE)
III. Northern Black Polished Ware (700/600−200 BCE)
IV. Sunga–Kushana (200 BCE−300 CE)

Biland–Khera

Ancient site Biland–Khera (27º12'55" N; 80º31'40" E), a small village/hamlet in Kothawan Tehsil in Hardoi District

of UP is located 44 km East from the District Head Quarter Hardoi and 74 km from the State Capital Lucknow (Fig. 2c). The site lies in the circuit of 64 Kosiparikrama path of Naimisarnya Teerth where other mounds of archaeological interest still exist. On the basis of pottery, antiquities and bricks used in the structures at Biland–Khera, the entire cultural assemblage was divided into three cultural periods:

I. Sunga–Kushana Period (200 BCE–300 CE),
II. Gupta Period (400–600 CE)
III. Pre–Medieval Period (600–800 CE)

Saunphari

The mound of Saunphari (28º12'30"N; 80º15'05"E) lies in Khutra Tehsil of Shahjahanpur District of UP (Fig. 2d). It can be approached via Puwayan Tehsil of District Shahjahanpur across river Gomati. Topographically the area is plain and a part of Gangetic alluvium. In general, the area around the site of investigation is characterized by the presence of open type of vegetation, which comprises of scattered trees with grasses and other herbaceous elements; grasses mainly dominate the ground vegetation.

MATERIAL AND METHODS

Wet sieving or water floatation technique

In all seventy–six samples were collected by water floatation technique utilizing differences in density of organic and inorganic material to achieve separation of organic remains from the soil matrix during course of excavation from all the archaeological sites discussed in the manuscript. The wet–sieving enhances both the quantity and the range of botanical material that can be recovered archaeologically. The less dense organic material such as charred seeds, grains and charcoal will tend to float to the surface. The material that floats to the top (*light fraction*), is poured into a sieve (500 µm). The light fraction is then collected on the cloth and dried in sunlight and later examined under a low power microscope. Finally, grains, seeds and fruits were examined and sorted into categories of distinctive morphological types under LEICA Z6APO. These morpho types were then photo–documented, and identified taxonomically on comparison with modern reference material as well as published seed illustrations (Martin & Barkley, 1961; Musil, 1963).

Sediment collection and analysis

Samples were collected from Biland–Khera archaeological trench ZA1 ranging from cultural layers (1–13) belonging to Sunga–Kushana Period as evidenced by ceramics and artefacts. 10 g sample was treated with 10% aqueous KOH solution in order to deflocculate the pollen and spores from the sediment and to remove the humus followed by treatment of samples with 40% HF solution to dissolve the silica content. Thereafter, the standard procedure of acetolysis (Erdtman, 1943) was followed using acetolysing mixture (9 : 1, acetic anhydride and concentrated sulphuric acid). Finally, the samples were prepared in 50% glycerol solution with few drops of phenol for microscopic examination. The palynomorphs were identified and counted under Olympus BX 50 microscope at 40× magnification. Because of low number of pollen content, at least 3 microscopic slides were scanned in each sample. Identification of Pollen grains follows Moore *et al.*, 1991; Bennett *et al.*, 1994; Nayar, 1990 and sporotheck of BSIP supported by type slides. Recognition of cereal–type grains follows Andersen (1979) and Joly *et al.* (2007). A total of 53–98 pollen and fern spores were counted from each sample. The recovered taxa were categorised as arboreal (tree and shrub) and non–arboreal (terrestrial, marshy, herbs and ferns). Due to low number of pollen in each sample from the archaeological trench belonging to single culture (Sunga–Kushana) the representation is shown in tabular form instead of pollen spectra.

Cultural chronology

Due to financial constraints the AMS dating of the carbonized seeds was also not possible. However, the archaeological artefacts from these sites and cultural layers testify their cultural authenticity. Moreover, the archaeological relics and radiocarbon dates of archaeological sites Agaibir (Pokharia unpublished), Rajdhani and Sarethi (Pokharia *et al*., 2017, 2019) provide absolute dates of respective cultures in Ganga Plain.

RESULTS

Macroremains analysis

A total of 76 samples were analyzed from all the three sites. The plant remains (Figs 3, 4, 5) recorded and identified are listed in Tables 1, 2 and 3. Absolute count and ubiquity of plant taxa, were made to analyze the data (Table 4). The morphological description and information related to occurrence and use of these remains are discussed here.

Cereal, Pulses, Oil–fibre yielding taxa

Hordeum vulgare L. emend Bowden (barley)

A large number of elongated carbonized grains have been encountered. The grains are almost circular in cross view and some of them exhibit slight lateral twist. In the absence of husk, the grain appears naked. The characteristic transverse rippling on the smooth surface of the grains, more prominently on the cheeks along the shallow ventral furrow,

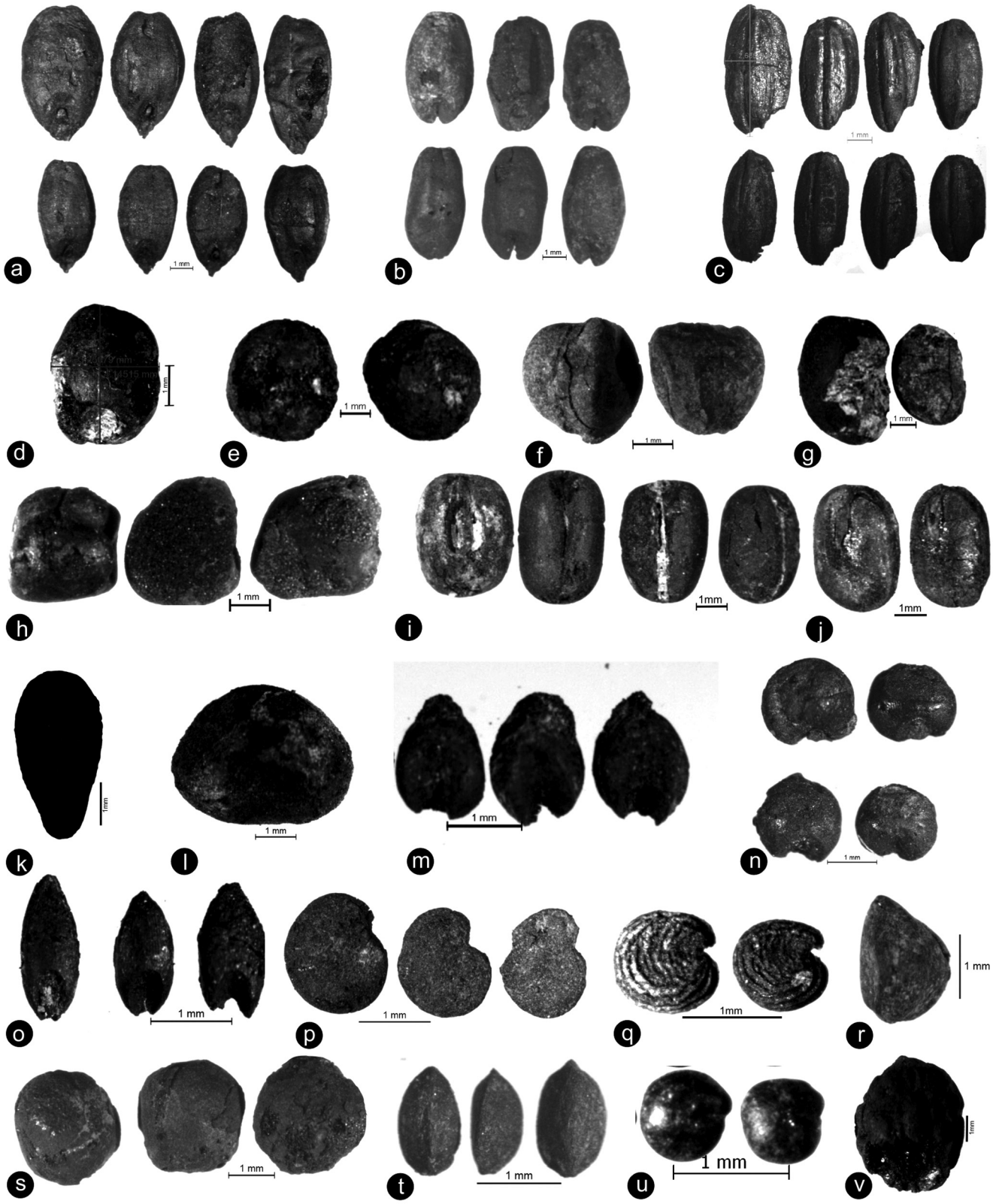

Fig. 3—Plant remains from Indor–Khera: a. *Hordeum vulgare*, b. *Triticum aestivum*, c. *Oryza sativa*, d. *Triticum sphaerococcum*, e. *Pisum arvense*, f. *Cicer arietinum*, g. *Macrotyloma uniflorum*, h. *Lathyrus sativus*, i. *Vigna* sp., j. *Vigna* sp. cotyledons, k. *Sesamum indicum*, l. *Gossypium arboreum/herbaceum*, m. *Setaria* sp., n. *Paspalum scrobiculatum*, o. *Andropogon* sp., p. *Solanum* sp., q. *Trianthema triquetra*, r. *Rumex* sp., s. *Vicia sativa*, t. *Cyperus* sp., u. *Chenopodium* sp., v. *Ziziphus* sp.

Fig. 4—Plant remains from Biland–Khera: a. *Hordeum vulgare*, b. *Oryza sativa*, c. *Vigna radiata*, d. *Vigna radiata* cotyledons, e. *Vigna aconitifolia,* f. *Paspalum scrobiculatum*, g. *Gossypium arboreum/herbaceum*, h. *Echinochloa* sp., i. *Setaria* sp., j. *Oryza rufipogon*, k. *Bombax* sp., l. *Andropogon* sp., m. *Commelina* sp., n. *Ziziphus nummularia*.

developed as a result of the contraction of the pericarp during drying of the grains.

Triticum aestivum L. (bread wheat)

Grains are elongated and narrower towards both ends and broader in the middle. Hilum is steeply placed on the slightly raised dorsal side. Cheeks along the deep ventral furrow are rounded. On the basis of morphological features the carbonized grains have been identified as belonging to bread wheat.

Triticum sphaerococcum L. (dwarf wheat)

Grains are somewhat rounded or oval–round in shape. Some of them exhibit broad and circular hump on their dorsal side. The grains are comparable to those of dwarf wheat.

Oryza sativa L. (rice)

The grains are elongated to oblong in shape, laterally flattened and prominently ribbed. The position of embryo is well marked in most of the grains. Differentiation between

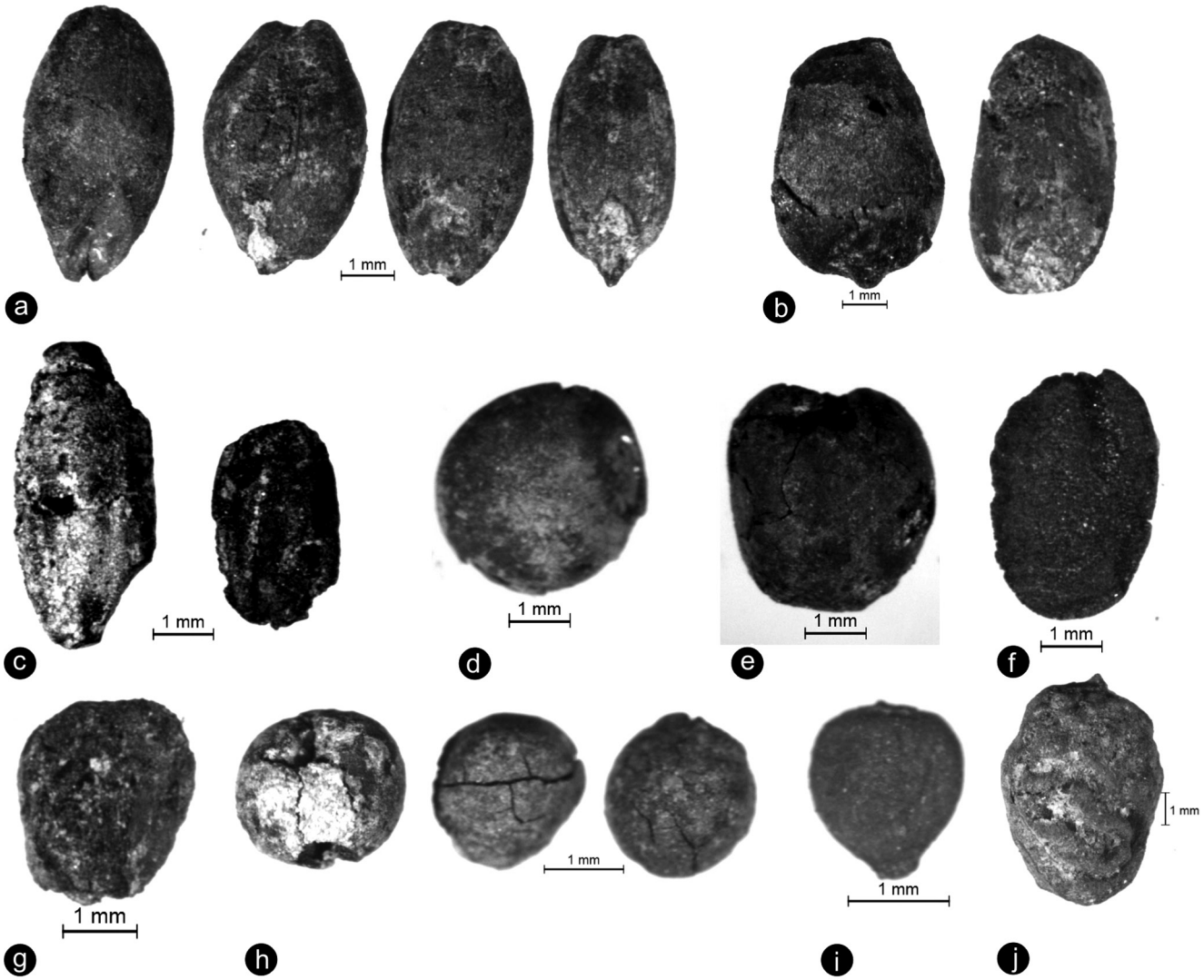

Fig. 5—Plant remains from Saunphari: a. *Hordeum vulgare*, b. *Triticum aestivum*, c. *Oryza sativa*, d. *Lens culinaris*, e. *Pisum arvense*, f. *Vigna mungo*, g. *Lathyrus sativus*, h. *Vicia sativa*, i. *Scirpus* sp., j. *Ziziphus* sp.

cultivated rice and the weedy and wild forms only on the basis of kernels without husk, is difficult to untangle as it shows enormous divergence in shape, size and other diagnostic features. Among several perennial and annual wild species of *Oryza*, which grow as weeds in the swampy cultivated fields of paddy crop, *Oryza rufipogon* is a highly variable perennial species closely resembling the cultivated forms of *Oryza sativa*. It is sporadically harvested along with the cultivated rice. Its grain is comparatively more slender than the carbonized rice grains recovered. However, the recorded bold grains have been identified as of cultivated *Oryza sativa*, moreover, by this time the cultivation of rice in this region was more prominent.

Vigna sp. L. (green/black gram)

A few complete seed and cotyledons in large numbers have been encountered. Complete seed, elongated and somewhat cylindrical in shape, cotyledons have angular to rounded ends. It's difficult to ascertain the peculiar features of hilum due to the carbonized state of the material, but under a stereo binocular microscope the hilum appears to be evenly flat at the level of seed–coat surface.

The carbonized seeds, on the ground of general morphology and shape, are similar to those of green–gram (*Vigna radiata*) and black–gram (*Vigna mungo*) as well. Under a stereo–binocular microscope, the presence of faint wavy ridges on seed surface (Kachroo & Arif, 1970), has led to refer the *Vigna* seed from these sites to *Vigna radiata*.

Further, in *Vigna mungo* the hilum, is raised above the level of seed surface.

***Lathyrus sativus* L. (grass–pea)**

The seed, varying from somewhat triangular to wedge–shape with small oval hilum has been identified as of grass–pea.

***Macrotyloma uniflorum* L. (horse gram)**

The seeds are flat, kidney–shaped or reniform. The hilum on the lateral side of the seed can be seen. It is widely cultivated as summer crop in India.

***Sesamum indicum* L. (sesame)**

The carbonized seeds have smooth/faint lines on the surface. Seeds of wild varieties of *Sesamum mulayanum* N.C. Nair found in northern and western India can easily be distinguished from those of cultivated sesame (*S. indicum*) in having reticulate–rugose surface. According to Martin & Barkley (1961), the seeds *in Sesamum indicum* are characterized by faint marginal lines and the equally faint central lines on both the flat sides.

***Gossypium* sp. L. (cotton)**

Seeds having one end rounded and the other end narrow and slightly angular in cross–view have been recorded in the collection. Ventral side of the seed is somewhat flattened and the dorsal side shows bulging.

Weeds and wild taxa

***Setaria* sp. (L) P. Beauv (foxtail–grass)**

Grains, small, ovoid to somewhat oblong have been found in conspicuous number in the samples. Hilum is conspicuously broad and about $^{1}/_{3}$ to ½ of the length of the caryopses. Carbonized grains compare with those of *Setaria* sp.

***Paspalum scrobiculatum* L. (kodo millet)**

Grains are ovate to elliptical with scutellum length closer to one–third of caryopsis length. The ventral surface is flattened, whereas dorsal surface is dome–like. Grains measuring 1.7–2.0 mm in length and 1.3–1.5 mm in breadth compare closely to *Paspalum*, an indigenous millet.

***Fimbristylis* sp. L.**

Nuts orbicular to ovate, stalked, surface cell quadrate, hexagonal and aligned in 8–9 longitudinal rows on each face of the nut.

***Andropogon* sp. L.**

Grains are somewhat rounded at lower end and gradually tapering towards upper end. Carbonized grains, show conspicuous hilum scar on the end of more or less evenly rounded dorsal side. These closely resemble with *Andropogon* sp. and have, therefore, been referred to the same.

***Vicia* sp. L.**

Carbonised seeds are globular in shape. Elliptical hilum is slightly depressed at the margins and raised along the median groove. These seeds are comparable to those of *Vicia sativa*, a common weed of the winter crops.

***Indigofera* sp. L.**

Several ovoid to elongate seeds have been recovered in carbonized state showing more or less circular hilum, nearly the central area on one margin.

***Scleria* sp. Berg.**

Nuts, ovoid to globose in shape and having reticulate surface. Remains of deciduous stigma could be seen. These nuts on morphological grounds are similar to *Scleria* sp.

***Solanum* sp. L.**

Seeds discoid in outline with a marginal scar and pitted surface, are comparable to *Solanum* sp. a weed of damp and waste places. Specific identity of the seeds is not possible in carbonized state of preservation.

***Scirpus* sp. L.**

Nuts ovate in outline and varying from triangular or plano–convex to lens shaped. The presence of blunt or pointed style base in these smooth surface nuts helps to distinguish *Scirpus* from nuts of other Cyperaceae. Sedge is adapted to bogs and marshes as well as saline conditions.

***Cyperus* sp. L.**

Trigonous nuts show minute and somewhat papillate cellular markings. On morphological ground, the ancient nuts are comparable to those of *Cyperus* sp. It grows in paddy field and swampy areas.

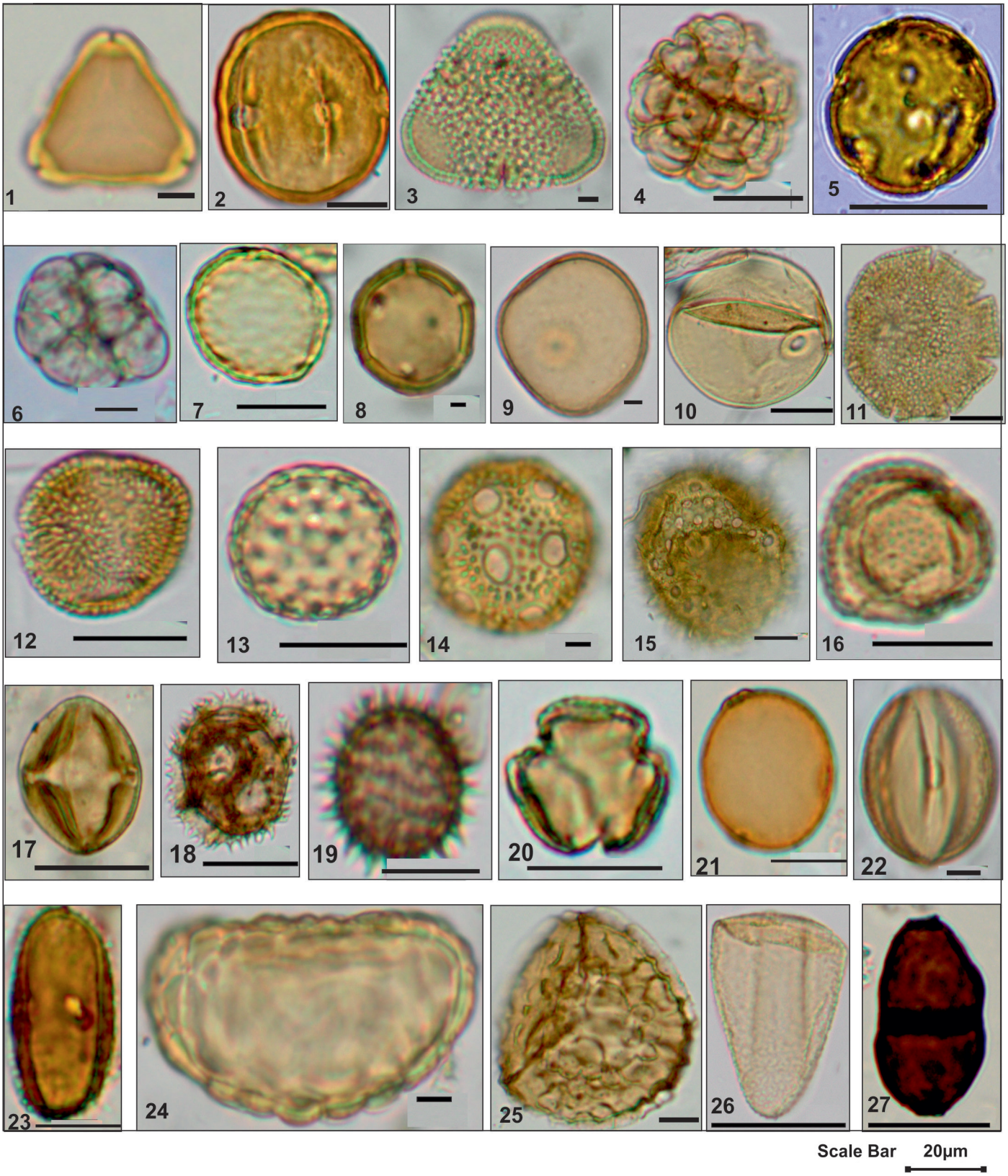

Fig. 6—1. Myrtaceae, 2. *Madhuca indica*, 3. *Bombax ceiba*, 4. *Acacia* sp., 5. *Emblica officinalis,* 6. *Mimosa pudica,* 7. *Holoptelea*, 8. *Aspidopteris,* 9. Poaceae, 10. Cerealia, 11. *Sesamum indicum*. 12. Brassicaceae, 13. Chenopodiaceae/Amranthaceae, 14. Caryophyllaceae , 15. Malvaceae, 16. *Xanthium strumarium,* 17, *Solanum*, 18. Cichorioideae, 19. Asteroideae, 20. *Artemisia*, 21. *Cannabis sativa*, 22. *Momordica charantia* 23. Acanthaceae, 24. Fern monolete, 25. Fern trilete, 26. Cyperaceae, 27. Fungal spore.

***Rumex* sp. L.**

Nut with smooth surface and angled closely resembles with *Rumex* sp. It occurs mostly as weed in moist places such as ditches and bunds of paddy field.

***Chenopodium album* L. (goosefoot)**

Seeds circular and compressed–lenticular having rounded margins and a distinctive marginal notch, measuring about 1.50–1.70 mm in diameter, are comparable to those of *Chenopodium album*.

***Desmodium* sp. L.**

Seeds are oval to elliptic and flattened. The carbonized seeds have been referred to *Desmodium*, without specific diagnosis.

***Polygonum* sp. L.**

Nuts triangular in cross view, compare closely with *Polygonum plebeium*, a tiny plant found abundantly growing on dried–up ponds and in the crop fields.

***Trianthema triquetra* Rottle. ex Willd. (lunki, lutanki)**

Seeds discoid, with concentric broken undulating raised lines, are characteristically beaked near the hilum. These seeds on morphological grounds closely compare with those of *T. triquetra.*

***Ziziphus* sp. (Burm. f.) W. & A. (jujube)**

Globose or somewhat oval stones in carbonized state have been recorded in the collection. Undulations and unevenness on their surface can easily be seen under low power microscope. These stones have been found comparable to those of jharberi.

Micro remains analysis

The thirteen samples (ZA1/1 to ZA1/13) procured from the excavated trench at Biland–Khera site characterized by the dominance of non–arboreal pollen taxa of the average value of 38.3 over arboreal (13.87) in the pollen assemblage (Fig. 6). Among arboreal taxa, namely *Madhuca indica*, *Shorea robusta*, *Bombax ceiba*, *Emblica officinalis* and *Acacia* are continuously exhibited in the pollen assemblage. Among non–arboreals, the cereal pollen is dominant, the other summer and winter crop taxa namely *Sesamum*, *Momordica charantia, Brassica* and Chenopodiaceae are also encountered in the pollen assemblage. The other non–arboreal taxa such as Cyperaceae, Carophyllaceae, Malvaceae, Acanthaceae, Asteraceae, *Cannabis* sp., *Xanthium strumarium*, *Solanum* sp., *Mimosa pudica*, *Artemisia* and *Polygonum* also recovered regularly in the pollen assemblage. Ferns both monolete and trilete also represent in trace value in the palynoassemblage.

DISCUSSION

Plant remains from Indor–Khera

In all 54 samples were analysed from the cultural sequences and a total of 2399 plant macro remains representing 37 different taxa were identified (Table 1). The cultivated plants during BSW include cereals and pulses. The most abundant among the crops was *Vigna* sp. (43%), followed by *Hordeum vulgare* (42%), and *Oryza sativa* (10%) (Fig. 7a). Besides crops, few weeds and wild taxa such as *Setaria* sp., *Ipomoea* sp., *Chenopodium* sp., *Commelina* sp., *Trianthema* sp. and *Ziziphus* sp., of cultivated field/wasteland were also encountered in the mixture.

The PGW plant economy is represented by cereals, pulses and Oil seeds. The most abundant among the crops was *Vigna* sp. (47%), followed by *Oryza sativa* (30%), *Hordeum vulgare* (17%), and *Sesamum indicum* (1%) (Fig. 7b). Besides crops, few weeds and wild taxa such as *Setaria* sp., *Chenopodium* sp., *Commelina* sp., *Andropogon* sp., *Vicia* sp., *Scleria* sp. and *Bombax* sp. were also encountered in the mixture.

The NBPW plant economy is represented by cereals and pulses. The most abundant among the crops was similar to BSW & PGW, viz. *Vigna* sp. (32%), followed by *Oryza sativa* (29%), *Hordeum vulgare* (15%), and *Macrotyloma uniflorum* and *Lathyrus sativus* (1% each) (Fig. 7c). Besides, few weeds and wild taxa such as *Chenopodium* sp., *Andropogon* sp., *Vicia* sp., *Medicago* sp., *Echinochloa* sp., *Polygonum* sp., *Indigofera* sp., *Desmodium* sp., *Oldenlandia* sp., *Fimbristylis* sp., *Solanum* sp., *Setaria* sp., *Paspalum* sp., and *Ziziphus* sp. of cultivated field/wasteland were also encountered in the mixture.

The Sunga–Kushana plant economy is represented by cereals, pulses and oil–fibre crop. Among the crops *Vigna* sp. (28%), followed by *Oryza sativa* (20%), *Hordeum vulgare* (17%), *Triticum aestivum* (5%) and *Gossypium* sp. (3%) (Fig. 7d) were recorded. Besides crops, weeds and wild taxa such as *Setaria* sp., *Paspalum* sp., *Ipomoea* sp., *Chenopodium* sp., *Commelina* sp., *Trianthema* sp., *Andropogon* sp., *Vicia* sp., *Commelina* sp., *Scleria* sp., *Medicago* sp., *Polygonum* sp., *Indigofera* sp., *Desmodium* sp., *Oldenlandia* sp., *Fimbristylis* sp., *Solanum* sp., *Clover* sp., *Ischaemum* sp., *Bombax* sp., *Echinochloa* sp., *Rumex* sp., *Cyperus* sp., *Sciprus* sp. and *Ziziphus* sp. of cultivated field/wasteland were also encountered in the mixture.

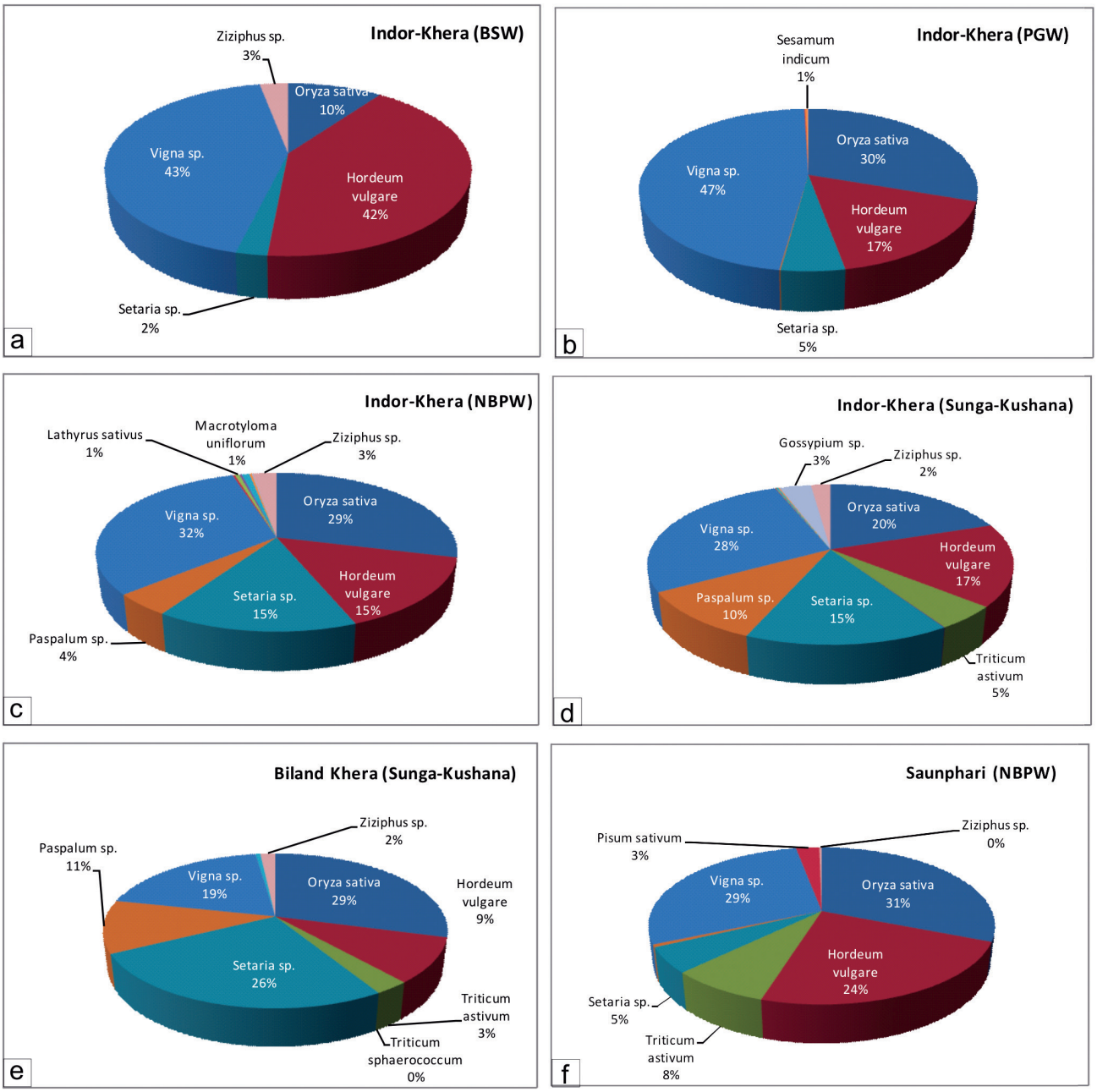

Fig. 7—Relative proportion of crop remains from Indor–Khera (a–d), Biland–Khera (e) and Saunphari (f).

Plant remains from Biland–Khera

A total of 10 samples were analysed for macrobotanical remains (Table 2). All the plant remains were charred. The most abundant cereal is *Oryza sativa* (30%), followed by *Triticum aestivum* (5%), *Triticum sphaerococcum* (>1%) and large amount of pulses especially *Vigna* sp. (20%) were recorded (Fig. 7e). Besides cereals & pulses, few weeds and wild taxa such as *Setaria* sp., *Paspalum* sp., *Ipomoea* sp., *Chenopodium* sp., *Andropogon* sp., *Vicia* sp., *Commelina* sp., *Medicago* sp., *Indigofera* sp., *Oldenlandia* sp., *Fimbristylis* sp., *Clover* sp. and *Eleocharis* sp. were also recorded.

Plant remains from Saunphari

The analyzed samples collected by the excavator from single trench during excavations yielded 786 carbonized macro remains belonging to 14 taxa during Sunga–Kushana time period (Table 3). All the plant remains were charred. The most abundant crops were *Hordeum vulgare* (53%), *Oryza*

Table 1—Botanical remains recorded at Indor–Khera.

S. No.	Archaeological Provenance		Cultural Horizon	Botanical remains identified
	Trench	Stratum/ Depth (cm)		
1	A3	(28)/596–606	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*
2		(28)/591–596	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*, *Setaria* sp. Fruits–*Ziziphus* sp.
3		(28)/586–591	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*
4		(27)/526–546	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Ipomoea* sp., *Aegilops* sp.
5		(26)/517–526	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Chenopodium* sp., *Commelina* sp.
6		(25)509–517	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Trianthema* sp., *Commelina* sp., *Ipomoea* sp.
7		(25)/506–509	Period–I (BSW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp.
8		(22)/454–471	Period–II (PGW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Oil seed–*Sesamum indicum* Fruits–*Ziziphus* sp.
9		(22)/443–454	Period–II (PGW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Pisum sativum* Oil seed–*Sesamum indicum* Weeds & Wild taxa–*Andropogon* sp., *Chenopodium* sp., *Vicia* sp., *Commelina* sp., *Scleria* sp., *Bombax* sp.
10		(9)270–280	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp.
11		(8)/258–270	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare, Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Oil seed–*Sesamum indicum* Fruits–*Ziziphus* sp. Weeds & Wild taxa –*Medicago* sp.
12		(7)/243–258	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa, Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Andropogon* sp., *Polygonum* sp., *Chenopodium* sp., *Indigofera* sp., *Vicia* sp., *Medicago* sp.

13		(6)/225–243	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Oil seed–*Sesamum indicum* Weeds & Wild taxa–. *Polygonum* sp., *Chenopodium* sp., *Desmodium* sp., *Oldenlandia* sp.
14		(6)/203–219	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sp., *Macrotyloma uniflorum* Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Oldenlandia* sp.
15		(4)/162–177	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare* , *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Oil seed–*Sesamum indicum* Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Fimbristylis* sp., *Polygonum* sp., *Vicia* sp., *Indigofera* sp., *Oldenlandia* sp., *Desmodium* sp., *Chenopodium* sp., *Medicago* sp.
16		(4)/ 155–170	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds &Wild Taxa–*Desmodium* sp., *Medicago* sp., *Chenopodium* sp., *Solanum* sp.
17		(4)/149–155	Period–III (NBPW)	Cereals & Millets–*Hordeum* vulgare, *Oryza* sativa, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild Taxa–*Indigofera* sp.
18	B1d	(3)/127–133	Period–IV (Sunga–Kushana)	Cereals &Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Commelina* sp., *Fimbristylis* sp., *Oldenlandia* sp.
19		(3)/117–127	Period–IV (Sunga–Kushana)	Cereals & Millets–*Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sp. Oil seed–*Sesamum indicum* Weeds & Wild taxa–*Chenopodium* sp., *Clover* sp., *Polygonum* sp., *Fimbristylis* sp., *Ipomoea* sp., *Oldenlandia* sp., *Vicia* sp.
20		(3)/112–117	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sp., *Macrotyloma uniflorum* (horse gram) Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Chenopodium* sp., *Medicago* sp.
21		(3)/93–108	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sp. Weeds & Wild taxa–*Trianthema* sp., *Polygonum* sp., *Fimbristylis* sp., *Cyperus* sp., *Chenopodium* sp., *Oldenlandia* sp., *Desmodium* sp., *Clover* sp., *Medicago* sp.

22		(3)/108–112	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare, Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Andropogon* sp., *Vicia* sp., *Commelina* sp., *Indigofera* sp., *Ipomoea* sp.
23		(3)/77–93	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum spharococcum*, *Oryza sativa* Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Vicia* sp.
24		(3)/68–85	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds &Wild taxa–*Trianthema* sp.
25		(3)/67–80	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Andropogon* sp., *Fimbristylis* sp., *Cyperus* sp., *Chenopodium* sp., *Ipomoea* sp., *Clover* sp.
26		(3)/62–70	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp. (10) Weeds & Wild taxa–*Andropogon* sp., *Fimbristylis* sp., *Trianthema* sp., *Ipomoea* sp.
27		(2)/56–62	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Weeds & Wild taxa–*Vicia* sp., *Indigofera* sp., *Scleria* sp., *Ipomoea* sp., *Medicago* sp.
28		(2)/50–68	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp. Weeds & Wild taxa–*Trianthema* sp., *Oldenlandia* sp.
29		(2)/50–67	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Chenopodium* sp., *Solanum* sp.
30		(2)/50–56	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds &Wild taxa–*Chenopodium* sp., *Solanum* sp., *Trianthema portulacastrum*, *Ischaemum* sp., *Commelina* sp., *Bombex ceiba*
31	B1c	(4)177–184	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Macrotyloma uniflorum* Fruits–*Ziziphus* sp. Weeds &Wild taxa–*Desmodium* sp., *Solanum* sp., *Chenopodium* sp., *Echinochloa* sp., *Vicia* sp., *Oldenlandia* sp.

32	(4)/157–170	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Paspalum* sp. Pulses–*Vigna* sp., *Cicer* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Andropogon* sp., *Desmodium* sp.
33	(4)/141–151	Period–III (NBPW)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp., *Pisum* sp., *Lathyrus* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Vicia* sp., *Solanum* sp., *Chenopodium* sp., *Oldenlandia* sp., *Medicago* sp.
34	(3)/119–127	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Vicia* sp., *Scleria* sp.
35	(3)/106–119	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Pisum sativum* Oil Seed–*Sesamum indicum* Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Andropogon* sp., *Desmodium* sp., *Chenopodium* sp., *Solanum* sp., *Echinocloa* sp., *Vicia* sp., *Rumex* sp., *Trianthema* sp.
36	(3)/96–106	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Chenopodium* sp., *Fimbristylis* sp., *Sciprus* sp., *Medicago* sp.
37	(3)/86–96	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Desmodium* sp., *Medicago* sp.
38	(3)/80–86	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Desmodium* sp., *Vicia* sp., *Medicago* sp.
39	(3)/72–80	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Vicia* sp.
40	(3)/64–72	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Macrotyloma* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Vicia* sp.
41	(3)/58–64	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Weeds & Wild taxa–*Medicago* sp.

42		(2)/46–58	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. (12), *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Chenopodium* sp., *Solanum* sp., *Vicia* sp., *Trianthema* sp., *Medicago* sp.
43	B1b	(3)/108–115	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp., *Medicago* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Solanum* sp., *Chenopodium* sp.
44		(3)/90–102	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Solanum* sp., *Vicia* sp., *Commelina* sp., *Ipomoea* sp., *Trianthema* sp., *Chenopodium* sp., *Medicago* sp.
45		(3)/75–80	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild texa–*Vicia* sp., *Chenopodium* sp., *Desmodium* sp.
46		(2)/56–75	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., Fibre Crop–*Gossypium* sp. Fruits–*Ziziphus* sp. Weeds & Wild texa–*Andropogon* sp., *Vicia* sp., *Solanum* sp., *Chenopodium* sp., *Trianthema* sp., *Medicago* sp.
47		(2)/56–68	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Lathyrus* sativus Fruits–*Ziziphus* sp. Weeds & Wild texa–*Commelina* sp., *Trianthema* sp., *Chenopodium* sp., *Solanum* sp., *Oldenlandia , Medicago* sp.
48	B1a	(3)/103–111	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild texa–*Rumex* sp., *Commelina* sp., *Medicago*
49		(3)/85–93	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Commelina* sp., *Trianthema* sp., *Solanum* sp.
50		(3)/71–76	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum astivum*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp., *Macrotyloma uniflorum* Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Commelina* sp., *Vicia* sp., *Trianthema* sp., *Solanum* sp., *Medicago* sp., *Clover* sp.

51		(1)/24–28	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Rumex* sp., *Trianthema* sp., *Chenopodium* sp., *Solanum* sp., *Medicago* sp.
52	B2c	(1)/33–43	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa* Pulses–*Vigna* sp. Weeds & Wild taxa–*Trianthema* sp., *Chenopodium* sp.
53	B2b	(1)/13–21	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza* sp., *Setaria* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Commelina* sp., *Polygonum* sp., *Trianthema* sp., *Chenopodium* sp., *Oldenlandia* sp.
54	C2b	(1)/21–50	Period–IV (Sunga–Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Trianthema* sp., *Oldenlandia* sp.

sativa (19%), *Vigna* sp. (18%), *Triticum aestivum* (5%) and *Pisum sativum* (2%) (Fig. 7f). Besides crops, few weed and wild taxa such as *Setaria* sp., *Ipomoea* sp., *Trianthema* sp., *Andropogon* sp., *Vicia* sp., *Solanum* sp. and *Cyperus* sp. were also recorded.

Palaeodiet and Palaeoecology

The Ganga Plain, one of largest alluvial tracts of the country, is densely inhabited fertile terrain. This region has been continuously under human settlement right from the advent of sedentism, most likely since the commencement of the Holocene and the termination of harsh Great Ice Age, i.e. Pleistocene. Despite being the flood prone, this region has been under intensive agricultural practice by the inhabitants to cope with the expanding populace. The archaeobotanical investigations from different sectors of this region have rendered valuable database concerning the early crop economies and cultivation approaches during different cultural settlements and the major crops used in subsistence (Saraswat, 1992, 2004, 2005; Saraswat *et al.*, 1994; Pokharia, 2008, 2012; Pokharia *et al.*, 2009, 2011, 2015, 2017). In addition, the crop remains have also unfolded the dissemination of crops from one region to another in context to cultural contacts as well as alterations in cropping pattern in response to climate variability in the past. The archaeobotanical evidences from Neolithic sites, viz. Lahuradewa, Senuwar and Mahagara (Saraswat, 2004; Tewari *et al*., 2006; Harvey *et al*., 2005) in the region of Ganga Plain and Vindhyan region indicate that the earliest crop assemblages were composed of only native species (*Oryza* sp. and pulses), whereas non–native cereals and pulses were added later. Dissemination of these non–native species which are the main nutritional traits of Harappans in the northern and north western India, suggest direct or indirect cultural contacts. Direct dates of barley from Lahuradewa, Jhusi, Damdama, Mahagara and Senuwar by 2400–1800 BC (Harvey *et al*., 2005; Saraswat, 2004, 2005; Tewari *et al*., 2006) suggest that during this time period the Harappan crops became culturally popular in the rice growing zone.

The cereals in the collection comprise rice (*Oryza sativa*), barley (*Hordeum vulgare*), bread–wheat (*Triticum aestivum*) and dwarf–wheat (*Triticum sphaerococcum*). Leguminous crops are represented by the seeds of field–pea (*Pisum arvense*), grass–pea (*Lathyrus sativus*), horse–gram (*Macrotyloma uniflorum*) and green–gram (*Vigna radiata*). Oleiferous and fibre crops are represented by the seeds of sesame (*Sesamum indicum*) and cotton (*Gossypium arboreum/herbaceum*). Rice, horse–gram, green–gram, sesame and cotton of Indian origin, are grown in the warm rainy season, whereas barley, bread–wheat, dwarf–wheat, field–pea and grass–pea of near–eastern complex are grown in the winter season. The relics of crop plants of diverse origins illustrate the practice of rotation of crops, known since Neolithic times in Ganga Plain (Saraswat, 2004, 2005; Pokharia, 2008; Pokharia *et al*., 2009).

Similar status of agriculture has also been recognized from other sites in the Ganga Plain and Vindhyan region during Neolithic, followed by transitional Neolithic–Chalcolithic, Chalcolithic and Iron Age cultures (Saraswat, 1992, 2004, 2005; Saraswat *et al.*, 1994; Pokharia 2008, 2012; Pokharia *et al*., 2009, 2011, 2015, 2017). The presence of winter–cultivated crops such as barley, wheat, and field–pea, into the rice growing zone, spread from the early cultures in the NW regions.

The crop remains from the present studied sites ranging from 1200 BCE to 300 CE represent a small amount of plant resources utilized by the ancients, however are demonstrative

Table 2—Botanical Remains recorded at Biland-Khera.

S. No.	Archaeological provenance		Cultural Horizon	Botanical Remains identified
	Trench	Depth (cm)		
1	XN4	288-312	(Sunga-Kushana)	Pulses–*Vigna* sp. Fruits–*Ziziphus* sp.
2	XN4	260-288	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Fimbristylis* sp., *Chenopodium* sp., *Vicia* sp., *Medicago* sp.
3	XN4	230-260	(Sunga-Kushana)	Cereals & Millets–*Setaria* sp. Pulses–*Macrotyloma* sp. Weeds & Wild taxa–*Andropogon* sp.
4	XN4	200-230	(Sunga-Kushana)	Cereals–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp.
5	XN4	156-180	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Setaria* sp.
6	XN4	121-156	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Paspalum* sp. Pulses–*Vigna* sp. Fruits–*Ziziphus* sp. Weed & Wild taxa–*Commelina* sp., *Fimbristylis*, *Eleocharis* sp., *Indigofera linifolia*, *Vicia* sp., *Clover* sp.
7	XN4	90-121	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Chenopodium* sp., *Oldenlandia* sp., *Commelina* sp.
8	XN4	72-90	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Fibre Crop–*Gossypium* sp. Weeds & Wild taxa–*Andropogon* sp., *Clover* sp.
9	XN4	5-72	(Sunga-Kushana)	Pulses–*Vigna* sp.
10	ZA1	540	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp., *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Aegilops* sp., *Indigofera* sp., *Ipomoea* sp.

of double cropping. Similarly, in the early phase of PGW culture (1500–800 BCE) and later phase of Early Mitra Panchal Period (300–100 BCE), the food grains were relatively less in numbers and diversity. However, the rich assemblage of crop plants was found in the late phase of PGW Period (800–400 BCE) (Pokharia *et al*., 2015). Limitations in the data are inevitable as they survived the preservation by accidental charring. The occurrence of plant remains in the deposits relies to a large extent not only upon their being present on the site, but upon the secondary process of carbonization. Therefore, plant remains inevitably provide an incomplete picture of man–plant relationship. Based on the present investigated sites, the Black Slipped Ware (BSW) culture shows the dominance of barley whereas Painted Grey Ware (PGW) culture onwards shows dominance of rice. The crop economy was much prosperous during Sunga–Kushana (100 BCE–300 CE) Period as marked by relatively rich assemblage of food grains comprising the cereals such as *Oryza sativa* (rice), *Hordeum vulgare* (barley), *Triticum aestivum* (bread–wheat) and *Triticum sphaerococcum* (dwarf–wheat); legumes, viz. *Pisum arvense* (field–pea), *Vigna radiata* (green gram) and *Gossypium arboreum/herbaceum* (cotton) as oil/fibre crop.

Table 3—Botanical remains recorded at Saunphari.

S. No.	Archaeological provenance		Cultural Horizon	Botanical Remains Identified
	Trench	Depth (cm)		
1	A-1	100-110	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa*, *Setaria* sp. Pulses–*Macrotyloma uniflorum* Weeds & Wild taxa–*Vicia* sp.
2	A-1	110-120	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa*, *Setaria* sp.
3	A-1	130-140	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp., *Macrotyloma* sp. Weed & Wild taxa–*Andropogon* sp., *Vicia* sp. (4), *Solanum* sp., *Ipomoea* sp.
4	A-1	140-150	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa* Pulses–*Vigna* sp., *Macrotyloma uniflorum* Weeds & Wild taxa–*Andropogon* sp., *Vicia* sp.
5	A-1	150-160	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa* Pulses–*Vigna* sp.
6	A-1	160-170	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa, Setaria* sp. Pulses–*Vigna* sp., *Macrotyloma uniflorum* Weeds & Wild taxa–*Andropogon*, *Vicia* sp.
7	A-1	170-180	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Triticum aestivum*, *Oryza sativa*, *Paspalum* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Vicia* sp., *Cyperus* sp.
8	A-1	180-190	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp.
9	A-1	190-200	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa* Pulses–*Vigna* sp.
10	A-1	200-210	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Setaria* sp. Pulses–*Vigna* sp., *Macrotyloma uniflorum* Fruits–*Ziziphus* sp. Weeds & Wild taxa–*Ipomoea* sp., *Trianthema* sp., *Vicia* sp.
11	A-1	225-230	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Weeds & Wild taxa–*Vicia* sp.
12	A-1	230-240	(Sunga-Kushana)	Cereals & Millets–*Hordeum vulgare*, *Oryza sativa*, *Setaria* sp. Pulses–*Vigna* sp. Weeds & Wild taxa–*Vicia* sp.

In all, the summer crops were more widespread throughout in contrast to winter crops most likely in response to more pronounced summer monsoon rainfall.

Among minor cereals *Setaria* sp. and *Paspalum* sp. have been recorded at all the sites. The abundance of *these* grains suggests that they did not arrive only as contaminants, but were gathered or stored from the crop harvested. *Setaria* might have been cultivated in association with rice. The practice of mixed cultivation, in which small–seeded millets and pulses to large–seeded job's tear are cultivated along with rice is reported from SE Asia (Harris, 1977). The record of crop remains show the occupants practiced self–sufficient

Table 4—Abundance and ubiquity of plant remains recorded from archaeological sites.

Site	**Indor-Khera**												**Biland-Khera**			**Saunphari**		
Cultural Period	**Period-I (BSW)**			**Period-II (PGW)**			**Period-III (NBPW)**			**Period-IV (Sunga-Kushana)**			**Sunga-Kushana**			**Sunga-Kushana**		
No. of Sample	7			2			11			34			10			12		
Taxa	**Absolute count**	**(%) sample**	**Ubiquity (%)**	**Absolute count**	**(%) sample**	**Ubiquity (%)**	**Absolute count**	**(%) sample**	**Ubiquity (%)**	**Absolute count**	**(%) sample**	**Ubiquity (%)**	**Absolute count**	**(%) sample**	**Ubiquity (%)**	**Absolute count**	**(%) sample**	**Ubiquity (%)**
Oryza sativa	30	4	57	327	2	100	240	11	100	303	33	97	53	6	60	119	10	83
Hordeum vulgare	125	7	100	183	2	100	124	11	100	256	31	91	17	8	80	328	12	100
Triticum astivum	0		0			0			0	73	11	32	0	0	0	30	6	50
Triticum sphaerococcum	0		0			0			0	1	1	3	0	0	0			0
Setaria sp.	7	3	43	55	2	100	125	10	91	234	28	82	47	6	60	20	7	58
Paspalum sp.	0		0	1	1	50	37	10	91	159	20	59	20	4	40	2	1	8
Vigna sp.	130	4	57	512	2	100	262	11	100	423	33	97	35	8	80	110	9	75
Pisum sativum	0		0	1	1	50	2	1	9	1	1	3	0	0	0	10	5	42
Lathyrus sativus	0		0			0	4	2	18	1	1	3	0	0	0			0
Cicer sp.	0		0			0	2	1	9			0	0	0	0			0
Macrotyloma uniflorum	0		0			0	7	2	18	3	3	9	1	1	10			0
Sesamum indicum	0		0	3	2	100	2	2	18	2	2	6	0	0	0			0
Gossypium sp.	0		0			0	1	1	9	52	9	26	0	0	0			0
Ziziphus sp.	9	5	71	1	1	50	21	10	91	32	19	56	3	3	30	1	1	8
Ipomoea sp.	5	2	29			0			0	19	6	18	2	1	10	5	2	17
Aegilops sp.	2	1	14			0			0			0	8	1	10			0
Chenopodium sp.	1	1	14	9	1	50	11	5	45	40	16	47	2	2	20			0

Commelina sp.	2	2	29			0			0	8	5	15	0	0	0			0
Trianthema sp.	1	1	14			0			0	94	16	47	0	0	0	1	1	8
Andropogon sp.	0		0	5	1	50	8	2	18	22	5	15	2	2	20	3	3	25
Vicia sp.	0		0	5	1	50	9	4	36	25	14	41	2	2	20	154	8	67
Commelina sp.	0		0	4	1	50			0	5	4	12	2	2	20			0
scleria sp.	0		0	1	1	50			0	2	2	6			0			0
Medicago sp.	0		0			0	24	5	45	32	14	41	1	1	10			0
Polygonum sp.	0		0			0	3	3	27	4	3	9			0			0
Indigofera sp.	0		0			0	3	2	18	3	2	6	2	2	20			0
Desmodium sp.	0		0			0	19	5	45	33	4	12			0			0
Oldenlandia sp.	0		0			0	20	5	45	22	6	18	1	1	10			0
Fimbristylis sp.	0		0			0	1	1	9	14	6	18	2	2	20			0
Solanum sp.	0		0			0	5	3	27	45	11	32			0	1	1	8
Clover sp.	0		0			0			0	11	4	12	3	2	20			0
Ischaemum sp.	0		0			0			0	1	1	3			0			0
Bombax ceiba	0		0	42	1	50			0	1	1	3			0			0
Echinochloa sp.	0		0			0	8	1	9	1	1	3			0			0
Rumex sp.	0		0			0			0	4	3	9			0			0
Cyperus sp.	0		0			0			0	5	2	6			0	2	1	8
Sciprus sp.	0		0			0			0	1	1	3			0			0
Eleocharis sp.	0		0			0			0			0	1	1	10			0
Total	**312**			**1149**			**938**			**1932**			**204**			**786**		

Table 5—Pollen taxa identified at Biland-Khera from Sunga-Kushana Period (200 BCE-300 CE).

Pollen Type	**ZA1/ 1**	**ZA1/ 2**	**ZA1/ 3**	**ZA1/ 4**	**ZA1/ 5**	**ZA1/ 6**	**ZA1/ 7**	**ZA1/ 8**	**ZA1/ 9**	**ZA1/ 10**	**ZA1/ 11**	**ZA1/ 12**	**ZA1/ 13**	**Vegetation type**
Madhuca indica	0	0	0	0	0	1	4	2	1	3	4	2	1	Moist forests, open area
Shorea robusta	1	0	0	0	0	2	3	1	0	2	3	1	0	Moist forest, open area
Bombax ceiba	1	0	1	0	1	2	0	0	0	2	0	0	0	Moist forest, open area
Syzygium sp.	1	0	0	0	0	2	2	1	0	2	2	1	2	Moist forest, open area
Murraya sp.	1	0	0	0	0	0	1	0	1	1	0	0	0	Moist forest, open area
Holoptelea integrifolia	3	2	3	4	3	1	0	0	1	1	0	0	1	Dry forests, open area
Emblica officinalis	5	2	0	1	0	2	0	0	1	2	0	0	1	Dry forests, open area
Acacia sp.	3	5	2	1	1	3	1	0	1	3	1	0	1	Dry forests, open area
Sum of Arboreals	**15**	**9**	**6**	**6**	**5**	**13**	**11**	**4**	**4**	**16**	**12**	**4**	**6**	Average 11.65
Cerealia	10	8	6	6	6	10	8	8	17	10	12	10	8	Agricultural field, cropland weed
Brassica sp.	2	2	2	1	2	2	4	4	5	8	6	5	5	Agricultural field, crop plant
Sesamum indicum	0	0	0	0	1	0	1	2	1	0	1	2	3	Agricultural field, crop plant
Momordica charentia	0	0	0	0	0	0	0	1	1	1	0	0	0	Agricultural field, crop plants
Chenopodiaceae	5	5	9	6	5	9	2	12	10	12	11	17	16	Agriculture field, crop plant, ruderal places
Cannabis sativa	2	4	2	2	4	3	3	4	2	3	2	1	1	Agriculture field, ruderal plant
Xanthium strumarium	2	3	4	5	5	6	8	5	4	4	6	3	4	Cropland weed
Solanum sp.	0	0	0	2	1	0	3	2	2	1	1	1	1	Cropland weed
Caryophyllaceae	1	0	1	0	1	1	0	1	1	1	6	5	5	Cropland weed

Malvaceae	1	0	1	1	1	1	0	1	1	2	1	1	1	Ruderal places
Artemesia sp.	3	2	2	1	0	1	0	0	0	6	7	8	8	Pastures, ruderal places
Asteroideae	3	1	2	1	0	1	0	2	1	8	5	5	1	Pastures, ruderal places
Cichrioideae	2	1	2	2	1	2	0	1	1	3	0	5	1	Pastures, ruderal places
Poaceae	10	17	14	24	16	5	8	6	6	5	4	6	5	Broad ecological amplitude, generally drier open habitats
Mimosa pudica	1	5	1	0	4	1	2	0	1	2	1	0	2	Broad ecological amplitude, generally drier open habitats
Acanthaceae	1	0	0	0	0	2	0	1	1	0	1	1	2	Broad ecological amplitude, generally drier open habitats
Cyperaceae	0	0	0	1	0	1	2	2	2	6	9	6	1	Broad ecological amplitude, generally drier open habitats
Polygonum plebeium	0	0	1	0	0	2	1	0	1	6	4	5	0	Broad ecological amplitude, generally drier open habitats
Fern monolete	0	0	0	0	1	0	3	4	4	2	2	1	1	Broad ecological amplitude, generally drier open habitats
Fern trilete	0	0	0	0	0	1	2	1	3	2	1	2	2	Broad ecological amplitude, generally drier open habitats
Sum of the non-arboreals	**43**	**48**	**47**	**52**	**48**	**48**	**47**	**57**	**64**	**82**	**79**	**84**	**67**	Average 38.6
Total Sum	**58**	**57**	**53**	**58**	**53**	**61**	**58**	**61**	**68**	**98**	**91**	**88**	**73**	

arable agriculture system consisting of winter and summer crops.

Weeds of frequent occurrence around the settlement, in the crop fields, ditches, along water course, moist places such as *Echinochloa* sp., *Polygonum* sp., *Rumex dentatus*, *Oldenlandia* sp., *Fimbristylis* sp., *Andropogon* sp., *Chenopodium* sp., *Commelina* sp., *Desmodium* sp., *Cyperus* sp., *Scirpus* sp., *Trianthema* sp., *Indigofera* sp., *Ipomoea* sp., *Solanum* sp., *Ischaemum* sp. and *Vicia sativa*, may have turned up in the collection with/without human interference or as an admixture with crop–remains. Ephemeral growth of these grasses, sedges and herbs follows the rain and may be regarded to subsist in the well–watered and marshy areas around the ancient mounds. *Ziziphus* fruits may have been collected and consumed by the settlers.

PALAEOVEGETATION AND PALAEOENVIRONMENT

In general the generated pollen data from Biland–Khera archaeological site during 200 BCE–300 CE indicate a tropical mixed deciduous open land vegetation comprising *Madhuca indica*, *Shorea robusta*, *Emblica officinalis*, *Holoptelea integrifolia*, and *Bombax* sp., which are suggestive of the warm and humid climatic conditions (Champion & Seth, 1968). The presence of *Syzygium* pollen observed in the pollen assemblage is indicative of good rainfall in the region. The abundance of Cerealia pollen along with *Sesamum* sp., *Brassica* sp., *Cannabis* sp., *Solanum* sp. and Chenopodiaceae, noticed regularly suggest agricultural and anthropogenic activity in the vicinity. The presence of Cyperaceae and *Polygonum* sp. are indicative of the annual and perennial water logged condition in response to rainfall. Pollen grains of Asteraceae together with *Xanthium* sp. and *Artemisia* sp. are commonly connected with grazed grasslands (Behre, 1981; Gaillard, 2007). Apart from the pollen grains the presence of monolete and trilete fern spores are observed which are suggestive of the local origin and reflect warm and humid climatic condition in the region. The generated pollen data is well supported with the macroremain data.

CONCLUSION

The recorded field–crop taxa shows the ancients practiced self–sufficient arable agriculture system consisting of winter and summer crops, portraying probably the rotation of crops in the Ganga Plain. A large number of weeds and wild taxa, occurring in crops–fields, marshy places and along the ditches, ponds and streams reveal that these crops were cultivated by the site occupants and palaeoecology of the surrounding area was moist. Further, the evidence has contributed to a much broader understanding of the ways in which ancient inhabitants exploited useful plants, and to reconstruct the agricultural model in time and space. The direct/indirect contacts with the contemporary cultural communities and favourable climatic conditions may have favoured the development of agriculture since 1200 BCE onwards. These evidences if, taken together, show that the rice cultivation was in practice along with barley and wheat from 1200 BCE to 300 CE. The present attempt has shown that the food plants, especially staple cereals, pulses, oil–seeds and fibre crops played important role in the food economy of the ancient settlers. The seed and pollen data allow a more secure interpretation of ecological conditions. Further, the palynological data indicate open land, moist habitat, agricultural activities and pastoralism, around the study site from the 200 BCE to 300 CE. The Ganga Plain is vast, and the scope of future studies is immense. Hence, the studies on the macro–and microbotanical remains are much needed to reconstruct human–environment relationship in a definite time frame.

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