Record of macrobotanical remains from the Aravalli Hill, Ojiyana, Rajasthan: Evidence for agriculture-based subsistence economy

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Analysis of 29 samples of carbonized plant material from Chalcolithic Ojiyana, Rajasthan, dated to 3rd–2nd millennium BC is presented. The unusual location of this site on the hill slope makes it unique among other sites of this culture in the region that flourished in river valleys. Comprehensive information on agriculture-based subsistence economy on any of the Chalcolithic sites in Rajasthan has been lacking so far. The results are discussed in the context of other archaeobotanical investigations from the Ahar culture sites in Rajasthan.

Keywords: Archaeobotany, Chalcolithic site, macrobotanical remains, subsistence economy.

OJIYANA (lat. 25°53′N, long. 74°21′E) in Bhilwara District, Rajasthan, is a small village located about 30 km, southwest of Bewar and 11 km, north of Badnor, on the Beawar–Bhilwara road (Figure 1). The ancient site lies on the slope of a small hill situated in the northwest of the present village. The hill running from southwest to northeast rises up to the height of about 523 m asl[1]. The unusual location of this site makes it unique among all other sites of this culture that flourished in river valleys. In Rajasthan, during the 3rd millennium BC, while the Harappan Civilization was flourishing to the north of the Aravalli region, to south of it, in the valley of River Banas an indigenous rural culture originated and flourished. Mooring of this indigenous culture is not precisely known, but it has evidenced intimate contacts with Harappans, in material economy. Due to the concentration of this culture in the Banas valley, it is also called the Banas Culture[2]. To delve into this less known and lesser-studied indigenous Ahar Culture of Rajasthan, the Jaipur Circle of the Archaeological Survey of India decided to carry out systematic excavations at this site from January to April 2000 and again from January to June 2001. A systematic collection of fragile plant remains was made, dispersed in the cultural deposits measuring about 7.50 m thick. The entire habitational deposit consisting 26 distinct strata belongs to a single culture and is divided into three phases, based on pottery and other artefacts. The data embodied in this article are, however, expected to narrow down some gaps in the information based on plant remains in sufficient quantity.

The botanical remains discussed here were segregated from 29 samples. Majority of plant remains recovered from Ojiyana, turn to be a mixture of carbonized grains, seeds and fruits of cultivated and wild plants along with a bulk of wood charcoal pieces. These could survive in the carbonized form by being exposed to heat or fire. Remains of cereals, pulses, oil-seeds and other economically important cultivated plants are a source of information about ancient agriculture and food economy. Remains of wild plants furnish information on the past vegetation cover in the region. The plant remains are likely to have resulted in the deposits from certain human activities. However, it is difficult to mention with certainty how and through what sort of activity the material got carbonized and came into the deposits.

The water floatation technique was used for collecting the botanical material from different cultural horizons. In water floatation, a difference in density of organic and inorganic materials is utilized to achieve separation of organic remains from the soil matrix, which greatly enhances both the quantity and range of the botanical material that can be recovered archaeologically. Identification is based on morphological details preserved in carbonized remains. The grains, seeds and fruits that did not actually catch fire during conflagration but burnt slowly, retained their shape and fine morphological details, and could be identified satisfactorily under a stereomicroscope; these have been described in this article.

Five radiocarbon dates of charcoal samples from layers 26, 20B, 19, 7 and 2 are available. Their calibrated values in BP and BC are given in Table 1. It can be seen from Table 1, that two out of five radiocarbon dates (BS-2283; BS-2342) appear consistent to some extent. However, the discrepancies in other dates may be due to disturbances by some unreported human activities in the past or mixing of older or more recent wood charcoal with the plant remains of the period to be dated. The aberrant dates cannot be relied upon for finding out the age of a culture or site. There has to be a cluster of dates for the chronology to be reliable. My main objective is to present the botanical findings. However, based on radiocarbon dates of other

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Table 1. ^{14}C radiocarbon dates of charcoal samples from Ojiyana

Depth (cm)	Layer	Lab no. BSIP	^{14}C date (yrs BP)	Calibrated date (BP)	Calibrated date (BC)
717–683	26	BS-2271	6280 ± 170	7418–6952	5468–5002
544–534	20B	BS-2283	3330 ± 130	3695–3400	1745–1450
497–484	19	BS-2342	3240 ± 100	3627–3361	1677–1411
204–180	7	BS-2343	5920 ± 200	6992–6495	5042–4545
70–50	2	BS-2281	2700 ± 90	2916–2749	966–799

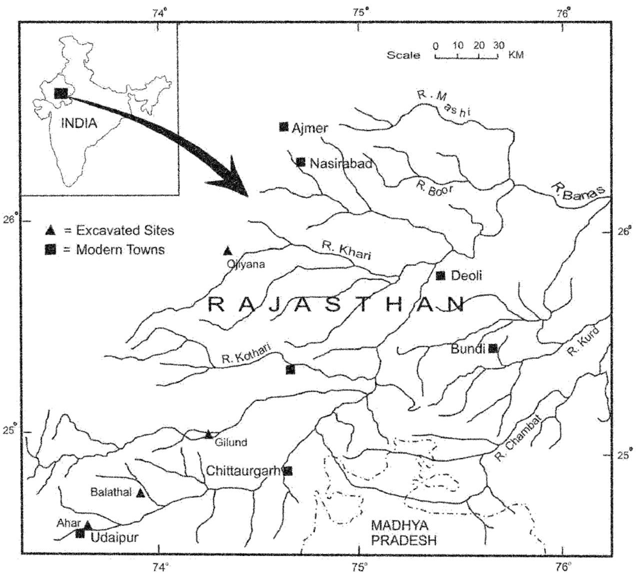

Figure 1. Map showing Ojiyana and excavated archaeological sites in Rajasthan (modified after Meena and Tripathi[1]).

Chalcolithic (Ahar Culture) sites in the region[3,4], the botanical remains from this site have been discussed within a time range 3rd–2nd millennium BC.

Majority of the remains described here collectively include the complete grains, seeds and fruits. The results of the study are discussed under different categories as below.

Cereals

Hordeum vulgare L. emend. Bowden (hulled barley; Figure 2 a)

A large number of elongated, carbonized grains measuring 9.50–4.50 mm in length, 4.50–2.50 mm in breadth and 2.50–2.00 mm in thickness have been encountered in the mixture. Few grains were recovered in broken state. The hull is found dislodged in most kernels. The characteristic veins in the form of longitudinal striations on the surface of hulled grains are more distinctly observed on the ventral cheeks along the shallow furrow, which arises from the base and gradually widens towards the upper end of the grains. The embryo lies on a pointed end at the dorsal side. The grains reveal a mixture of larger and straight ones having a distinct bulge in the middle, and smaller, somewhat asymmetrical ones with ventro-lateral twists. The twisted asymmetrical grains suggest their derivation from the lateral florets in a six-rowed form of hulled barley[5,6]. The larger, straight grains with bulge are derived from the middle floret on the node of the spike axis. Barley, both wild and cultivated, belongs to the same potentially interfertile population and is grouped under one species, *Hordeum vulgare* L. emend. Bowden[7,8].

H. vulgare L. emend. Bowden var. nudum (naked barley; Figure 2 b and c)

Grains measuring 6.00–5.00 mm × 4.00–3.00 mm × 2.50–2.00 mm ($L \times B \times T$) appear to be much broader in relation to their length than kernels of hulled barley. The grains are almost circular in cross view and some of them exhibit slight lateral twist. In the absence of husk, the grains appear naked. The characteristic transverse rippling on the smooth surface of the grains, more prominently on the cheeks along the shallow ventral furrow, developed as a result of the contraction of the pericarp during drying of the grains. They compare well in all respects with those of the six-rowed form of naked barley[5].

Triticum aestivum L. (bread wheat; Figure 2 d)

Grains measuring 6.00–4.00 mm × 3.50–2.50 mm × 2.50–1.50 mm ($L \times B \times T$) 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 and classification by Zohary[9], the carbonized grains have been identified as belonging to bread wheat.

T. sphaerococcum Perc. (dwarf wheat; Figure 2 e)

Grains measuring 4.00–3.00 mm × 4.00–2.50 mm × 2.50–2.00 mm ($L \times B \times T$) are broad and 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; Figure 2 f)

Grains elongate to narrowly oblong, laterally flattened and prominently ribbed are without husk. They measure

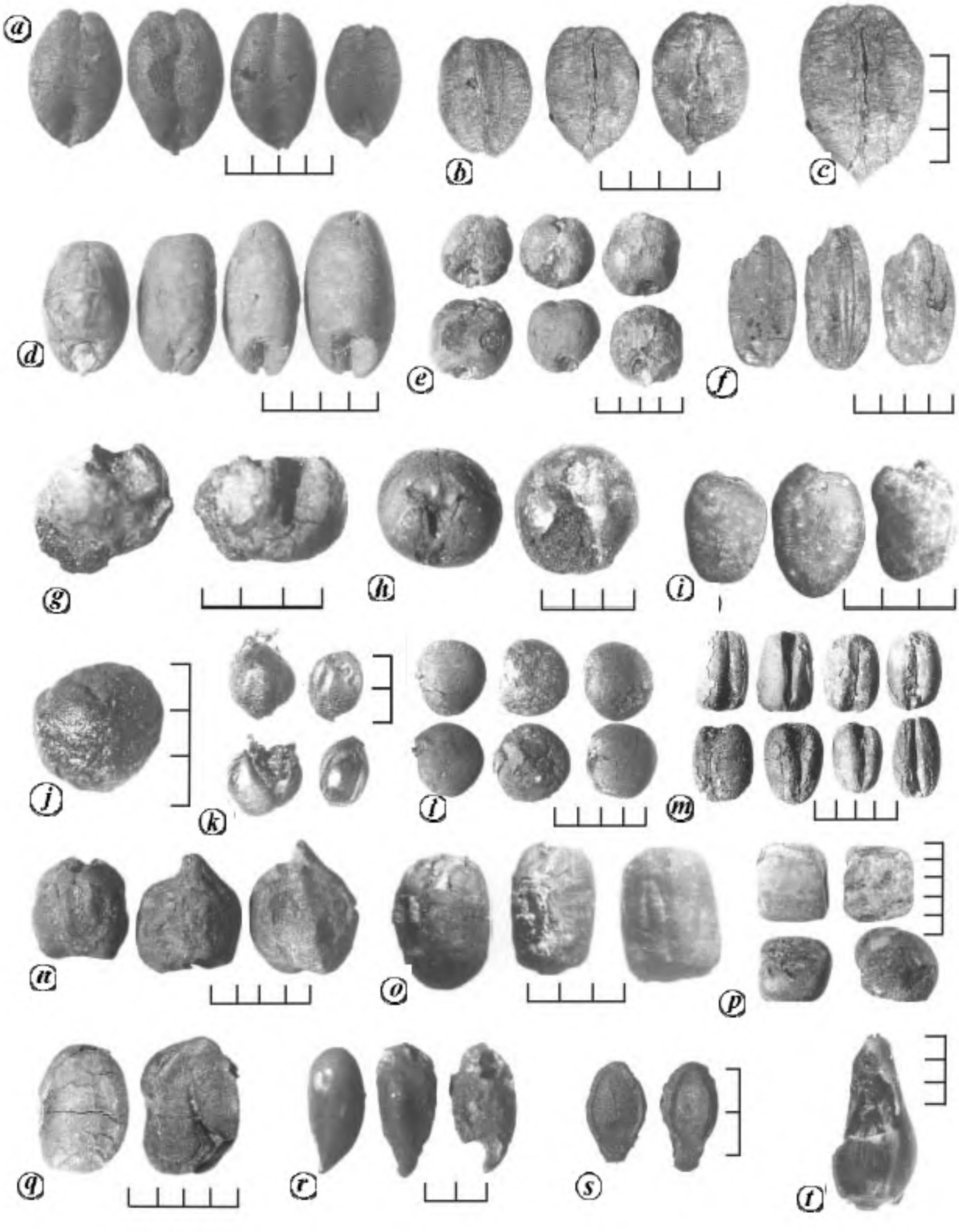

Figure 2 ***a–t***. ***a***, *Hordeum vulgare* (hulled barley); ***b***, ***c***, *H. vulgare* var. *nudum* (naked barley); ***d***, *Triticum aestivum* (bread wheat); ***e***, *T. sphaerococcum* (dwarf wheat); ***f***, *Oryza sativa* (rice); ***g***, *Sorghum bicolor* (jowar millet); ***h***, *Pisum arvense* (field-pea); ***i***, *Vigna aconitifolia* (moth bean); ***j***, *Eleusine coracana* (ragi millet); ***k***, *Setaria italica* (Italian millet); ***l***, *Lens culinaris* (lentil); ***m***, *Vigna radiata* (green gram); ***n***, *Cicer arietinum* (chickpea); ***o***, *V. mungo* (black gram); ***p***, *Lathyrus sativus* (grass pea); ***q***, *Macrotyloma uniflorum* (horse gram); ***r***, *Linum usitatissimum* (linseed); ***s***, *Sesamum indicum* (sesame); ***t***, *Carthamus tinctorius* (safflower). (Scale in mm.)

5.80–4.50 mm × 3.00–2.00 mm × 1.00–1.50 mm ($L \times B \times T$). Differentiation between cultivated rice and the weedy and wild forms only on the basis of kernels without husk, is intricate, owing to gross variations in the shape and size of grains. Continuous intercrossing among the wild perennial, wild annual and annual cultivated *Oryza* has resulted in enormous diversity in the weed races. Bold grains of weedy *O. rufipogon*, which is a highly variable perennial form of wild rice, give the appearance of cultivated rice. It is occasionally harvested along with the cultivated crop. Its grains are comparatively more slender than the carbonized rice grains recovered. Oblong grains comparable to ancient ones, are produced by an annual wild *O. nivara*, but these are somewhat cuneate in shape. The kernels recovered from Ojiyana are comparable to some forms of cultivated rice (*O. sativa*).

Sorghum bicolor (L.) Moench. (jowar millet; Figure 2 g)

Only three carbonized grains oblong to somewhat obovate and dorso-ventrally symmetrical measure 3.00–2.50 mm × 3.00–2.50 mm × 2.00–1.50 mm ($L \times B \times T$). Oval–round hilum scar is one-third to half as long. Taking into account the shape of the grains and the nature of the hilum scar, these are referred to jowar millet.

Eleusine coracana (L.) Gaertn. (ragi-millet; Figure 2 j)

Single globose to sub-globose grain with embryonal position in inverted *V*-shaped outline has been recovered in the mixture. The grain measures 3.00 mm × 2.50 mm ($L \times B$). Under a stereobinocular microscope, rugose ornamentation could be observed at places on the surface of its pericarp. A few granules fuse together, to give an appearance of faint and wavy horizontal rows. In contrast to the elliptic grains showing obliquely striate ornamentation of *E. indica*, which is a common wild grass, the grain is globose with finely striate punctuate ornamentation. Thus it has been identified as belonging to the cultivated ragi/finger-millet.

Setaria italica Beauv. (Italian millet/foxtail millet; Figure 2 k)

Carbonized grains oval to somewhat elliptical, thickest about midway and sloping towards the apical side and base have been encountered. The grains measure 2.50–1.50 mm × 1.50 mm × 2.00–1.00 mm ($L \times B \times T$) and are enclosed in closely spaced glumes. The surface of the glume (lemma) is finely tubercled. In all morphological aspects these grains compare well with those of Italian millet.

Pulses

Lens culinaris Maedik. (lentil; Figure 2 l)

Seeds circular and flattened with keeled margin, measure about 3.50–2.50 mm in diameter and 1.50–2.00 mm in thickness. Some seeds are puffed enough due to carbonization, but still retain their lenticular appearance. Small and acutely lanceolate hilum scar is present on the keeled margin. These seeds in all morphological respects are comparable to those of lentil.

Pisum arvense L.-syn. Pisum sativum var. arvense (L.) Poir (field pea; Figure 2 h)

The lot comprises seeds spherical to hemispherical, measuring about 4.50–3.50 mm in diameter. Faintly preserved oval hilum is seen on the smooth seed surface. Seed coat is blurred and broken at places due to carbonization and puffing. Seeds resemble those of field pea.

Cicer arietinum L. (chickpea; Figure 2 n)

Three complete seeds are squat and somewhat triangular in shape, pointed at one end, and broad and lobed on the other. The seed coat is rough-textured and undulating. The seeds measure about 5.00–4.50 mm × 4.50–3.50 mm × 4.00 mm ($L \times B \times T$). Due to carbonization the shape of hilum could not be seen, yet there is no doubt about its presence in a depression near the pointed end. The chalazal plate on the ventral side is noticeably broad. Seeds are comparable to those of chickpea.

Lathyrus sativus L. (grass pea; Figure 2 p)

Seeds approximately wedge-shaped, with end planes somewhat triangular, measure about 6.00–3.00 mm × 5.00–3.00 mm × 4.00–2.00 mm ($L \times B \times T$). Small and oval hilum is located in one of the wider angles at one end. Seed coat is rough-textured. These seeds compare well with those of grass pea.

Vigna radiata (L.) Wilczek (green gram; Figure 2 m)

More than two dozen complete and broken seeds have been encountered. Complete seeds, elongated and somewhat cylindrical in appearance, measure 3.50–3.00 mm × 3.00–2.00 mm × 3.00–1.50 mm ($L \times B \times T$). Cotyledons are 3.50–3.00 mm × 3.00–2.00 mm × 1.25–1.00 mm ($L \times B \times T$). Both seeds and cotyledons are characterized by angular to somewhat rounded ends. Elliptical hilum, about 1.00 mm in length, could also be noticed in some seeds, which appeared evenly flat at the level of seed-coat surface. The carbonized seeds have therefore been referred to as green gram.

Vigna mungo (L.) Hepper (black gram; Figure 2 o)

A few sub-cylindrical to oblong, complete seeds slightly larger than those of green gram have been encountered in the collection. The seeds measure 4.00–3.50 mm in length, 2.50–2.00 mm in breadth and 2.00–1.50 mm in thickness. Although the hilum, does not reveal distinctly the hard corky tissue, it is raised above the level of seed surface. In view of these characteristics, the seeds comparable to *Vigna* sp. in this lot, have been referred to as black gram.

Vigna aconitifolia (Jacq.) Marechal. (moth bean; Figure 2 i)

Three complete seeds, more or less uniform in shape with rotund to truncate ends, measure 3.50–3.00 mm in length, 2.50–2.00 mm in breadth and 1.50–1.00 mm in thickness. Hilum scar could not be distinctly seen due to carbonization. The carbonized seeds exhibit striking similarities in their shape with those of moth bean.

Macrotyloma uniflorum (Lam.) Verdc. syn.-Dolichos biflorus L. (horse gram; Figure 2 q)

The lot is represented by complete and broken, ellipsoidal to somewhat kidney-shaped, laterally flattened seeds and cotyledons. Seed surface is smooth. Seeds measure 5.50–3.50 mm × 4.00–2.50 mm × 2.00–1.00 mm ($L \times B \times T$). Hilum is small and elliptical, about 1.00 mm long and 0.50 mm broad. Seeds are comparable to those of horse gram.

Oilseeds

Linum usitatissimum L. (linseed/alsi; Figure 2 r)

Eight partly broken seeds except one seed are flattish, elliptic to elliptic–ovate and with one end much narrower. They measure 4.00 mm × 2.00 mm × 1.00 mm ($L \times B \times T$). The seeds are comparable to linseed and therefore identified as the latter.

Sesamum indicum L. (sesame/til; Figure 2 s)

Eight flattish–ovate seeds, having one end narrow and the other rounded, measure 3.00–2.00 mm in length, 1.50 mm in breadth and 1.00 mm in thickness. The seed-coat surface appears to be smooth. A wild species *S. mulayanum* N. C. Nair also occurs in the northwestern regions of India, but it can be distinguished from the cultivated *S. indicum* by having reticulate–rugose seed surface. The carbonized sesame seeds with smooth surface have, therefore, been regarded as belonging to the cultivated sesame.

Carthamus tinctorius L. (safflower; Figure 2 t)

Single achene has been found in the deformed state, due to carbonization. The achene is somewhat obovoid and four-angled, truncate on one end. The achene measures 7.50 mm in length and 3.50 mm in breadth. In all morphological characteristics the carbonized achene compares well with those of safflower, family Compositae. In extant material the truncate end has four bosses at the top, which is, however, not distinctly visible in the carbonized achene.

Weeds and wild taxa

Vicia sativa L. (common vetch; Figure 3 a)

Seeds vary in shape from globose or compressed–globose to somewhat wedge-shaped. Variation in their sizes is also noticed. Small elliptical hilum is noticed in some seeds, slightly depressed at the margins and raised along the median groove. Seeds about 1.70–2.30 mm in diameter, compare well with those of *V. sativa* L., a common weed in winter crops of cereals and pulses.

Coix lachryma-jobi L. (Job's tear; Figure 3 b and c)

Evidence is furnished by the remains of involucres, small pieces of bracts and seed. Involucres, false fruits and pseudocarps connote the bead-like oval–cylindrical structures of *Coix* grass formed from the hard, shell-like bracts or metamorphosed leaf sheaths which enclose the female spikelets[6,10,11]. Seed is orbicular and ventrally furrowed, measuring about 4.00 mm × 4.50 mm ($L \times B$).

Setaria Beauv. (foxtail, bristlegrass; Figure 3 f)

Grains, ovoid to somewhat oblong with narrow upper end, measure 1.25–2.00 mm in length, 1.00–1.25 mm in breadth and 0.80–1.00 mm in thickness. Dorsal side is curved. Hilum is conspicuously broad and occasionally covers up to half the length of the grains. Seeds are comparable to those of *Setaria* sp. Two species, *S. intermedia* and *S. verticillata* occurs in the Indian desert[12].

Rumex dentatus L. (jangli palak; Figure 3 e)

Trigonous nuts with pointed upper ends, smooth surface and acute angles, measuring 1.50–1.80 mm × 1.50 mm ($L \times B$) are comparable to those of *R. dentatus.*

Polygonum L. (smartweeds/knotweed; Figure 3 h)

Complete nuts of varied sizes in the collection are triangular in cross-view. Two of the sides are almost equal and the third side is broader. The nuts are exceptionally large-sized with one end tapering and measure 2.00–1.50 mm in length and 1.25–1.75 mm in breadth. The nuts

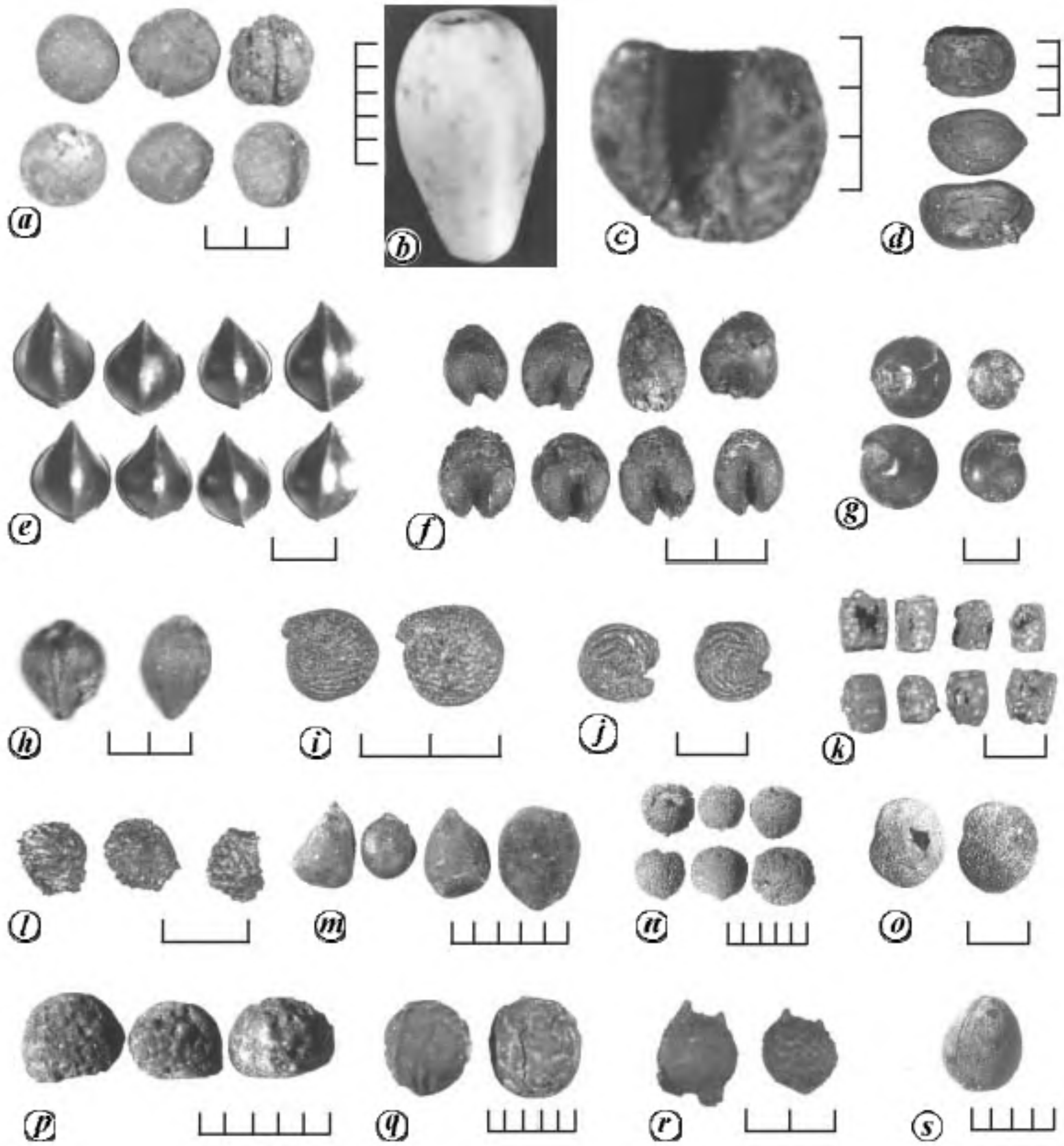

Figure 3 ***a–s.*** ***a***, *Vicia sativa*; ***b***, ***c***, *Coix lachryma-jobi*; ***d***, *Acacia* sp.; ***e***, *Rumex dentatus*; ***f***, *Setaria* sp.; ***g***, *Chenopodium album*; ***h***, *Polygonum* sp.; ***i***, *Trianthema portulacastrum*; ***j***, *Trianthema triquetra*; ***k***, *Indigofera* sp.; ***l***, *Dactyloctenium aegyptium*; ***m***, *Ipomoea* sp.; ***n***, Caryophyllaceous type; ***o***, *Solanum* sp.; ***p***, *Grewia* sp.; ***q***, *Ziziphus nummularia*; ***r***, *Scleria* sp.; ***s***, *Bombax* sp. (Scale in mm).

have been identified as belonging to *Polygonum* sp., a common plant on moist soil.

Chenopodium album L. (goosefoot, bathua; Figure 3 g)

Shiny, circular to lenticular seeds with rounded margins, measure 1.00–1.50 mm in diameter. A characteristic notch is present on the margins. The seeds have been identified as belonging to *C. album*, a common weed in winter crops.

Indigofera L. (indigo; Figure 3 k)

The carbonized seeds are rectangular, broadly pitted on all sides and measure 1.75–2.00 mm in length and 1.25–1.75 mm in breadth. About ten species occur in the region. It is not possible to identify the carbonized seeds to specific level. They have been identified as *Indigofera* sp.

Trianthema triquetra Rottle. ex Willd. (lunki, lutanki; Figure 3 j)

Seeds discoid, with concentric broken undulating raised lines, measure 1.25 mm in length and 1.00 mm in breadth.

They are characteristically beaked near the hilum. These seeds on morphological grounds closely compare with those of *T. triquetra*.

Trianthema portulacastrum L. (Santo; Figure 3 i)

Seeds reniform with faint wavy ribs, measure 1.50 mm in length, 1.25 mm in breadth and 0.50 mm in thickness. They are characteristically beaked near the hilum. Seeds closely compare with those of *T. portulacastrum*.

Dactyloctenium aegyptium (L.) P. Beauv (crowfoot grass; Figure 3 l)

Four ovoid caryopses with rugose surface, measuring about 1.00 × 1.00 mm have been encountered. The carbonized grains on morphological grounds compare closely with those of *D. aegyptium*.

Ipomoea L. (morning glory; Figure 3 m)

Seeds are somewhat flattened dorso-ventrally and ovoid–lanceolate in shape. The back slopes distinctly to the apex and base forms a bulge in the central portion. Seeds measure 3.00–4.50 mm in length and 2.00–3.50 mm in breadth. About seventeen species are reported in the region[12]. Several species produce such types of seeds. Therefore, identification of ancient seeds of *Ipomoea* up to species level could not be determined.

Solanum L. (Nightshade; Figure 3 o)

Seeds discoid in outline with a notch and marginal scar and pitted surface, measuring 1.50–2.50 mm in diameter, are comparable to *Solanum* sp. Five species of *Solanum* occur in the Indian desert[12]. Specific identity of the seeds is not possible in carbonized state of preservation.

Scleria Berg. (Figure 3 r)

Four nuts, ovoid to globose in shape and having pitted reticulate surface, measure 1.60–2.30 mm in length and about 1.80 mm in breadth. Remains of deciduous stigma in broken state could be seen. These nuts on morphological grounds have been identified as belonging to *Scleria* sp.

Bombax sp. L. (semal; Figure 3 s)

Single ovoid to almost globose and smooth-surfaced seed, measuring 4.50 mm in length and about 3.50 mm in breadth, is comparable to *Bombax ceiba*. A single species has been reported in the Indian Desert[12].

Grewia L. (phalsa; Figure 3 p)

Five circular to somewhat oval round and plano-convex stones measure about 4.50–5.50 mm in length and 4.00 mm in breadth. Outer convex side is roughened with coarse tuberculations. They closely compare with the stones of *Grewia* sp., family Tiliaceae. There are several species of *Grewia*, growing wild and cultivated for its fruits. Specific identification of the seed is not possible in the carbonized state, and so it has been identified as *Grewia* sp.

Ziziphus nummularia (Burm. f.) W. & A. (jharberi; Figure 3 q)

Globose or somewhat oval stones and spherical fruits in carbonized state have been recorded in the collection. Stones with characteristic tubercled surface measure about 8.00–5.00 mm in diameter. Globose fruits measuring approx 9.00–12.00 mm in diameter show typical undulations and unevenness on their surface. These stones and fruits have been found comparable to those of jharberi.

Acacia L. (babul; Figure 3 d)

Seeds are compressed, sub-orbicular, and measure 5.00–3.50 mm in length and 4.50–3.00 mm in breadth. The faces are marked by an oval line more or less concentric with the outline of the seed. In all the morphological features the carbonized seeds exhibit close conformity with seeds of *Acacia* species. Several species of *Acacia*, viz. *jacquemonti* Benth., *leucophloea* (Roxb.) Willd., *nilotica* (L.) Del., *senegal* (L.) Willd, and *pennata* (L.) Willd. commonly occur in the region. In view of variation in their seed sizes, it is difficult to refer the unknown seeds to a particular species.

Caryophyllaceous type (?) (Figure 3 n)

Eight carbonized seeds were recovered from phase-III. These tubercle seeds were all roundish and flat with radiating grooves or furrows. Although it is not possible to identify their generic level, they have been identified on morphological grounds as close to family Caryophyllaceae.

Investigating human–plant relationship during the Dark Ages is one of the central questions in archaeobotany. The plant remains recovered from Ojiyana, provide direct evidence that apparent plant food staples of the Aharians during the 3rd–2nd millennium BC, were adapted to a particular environment and revealed affinities with other agricultural settlements in Rajasthan and beyond. The remains of crop plants of diverse origin (Table 2) from a wide range of deposits in all the three occupational phases are demonstrative of practice of rotation of crops. Rice (*O. sativa*), black gram (*V. mungo*), green gram (*V. radiata*), moth bean (*V. aconitifolia*), horse gram (*M. uniflorum*) of Indian origin coupled with African jowar (*S. bicolor*) and ragi (*E. coracana*) millets and also Eurasian Italian millet (*S. italica*) were grown during the warm, rainy season. Barley (*H. vulgare*), bread wheat (*T. aestivum*), dwarf wheat (*T. sphaerococcum*), lentil (*L. culinaris*), field pea (*P. arvense*), grass pea (*L. sativus*) and chickpea (*C. arietinum*) of Near-Eastern Complex, which are important founder crops in the Harappan agriculture and also recorded immensely from widespread Neolithic–Chalcolithic settlements, were grown during winter season. Presence of oeliferous crops such as sesame (*S. indicum*), linseed (*L. usitatissimum*) and safflower (*C. tinctorius*) affirms the importance of oilseeds for their diverse uses to the Aharians.

Conventionally, the presence and absence of carbonized remains lead to change in the exploitation of resources. Although biases introduced by differential preservation of botanical remains by carbonization are of prime concern, a considerable number of varieties of field-crops, weeds and wild taxa have constituted the largest number of botanical finds ever reported in the archaeological context of Chalcolithic Aharians in Rajasthan. Comprehensive information on any of the Ahar Culture sites was not available earlier. The work based on incidentally recovered remains, however, made considerable contributions to our knowledge, but the present trend of collaborative work made at Ojiyana is bound to construct upheavals in the understanding of the past man–plant relationships in the Aravalli in Rajasthan.

Remains of foodgrains support well-founded inferences about the agriculture-based subsistence economy during 3rd–2nd millennia BC. Although a large number of grains occur in carbonized condition, there is also evidence for uncarbonized (silicified) remains such as shell remains of *C. lachryma-jobi*. Only few archaeological sites of the Ahar Culture in the region of Rajasthan have been studied for plant economy[13–15]. The Ahar–Banas people were agriculturists[3]. Evidence of wheat, barley, rice, millets (jowar, bajra, ragi, Italian), pulses (pea, green gram, black gram, horse gram) etc., recorded from earlier as well as the present site supports well-founded, agriculture-based subsistence economy. Remains of *Oryza* and *Sorghum* in the form of impressions have been reported by Vishnu-Mittre[13] from the archaeological site at Ahar. The present study at Ojiyana has provided important information on the early history of agriculture and food habits of Aharians in Rajasthan. The stratigraphic sequence of the carbonized remains offers a clear record of the crop plants from the lowest stratum to the upper-most level of occupational deposits of the Ahar culture. One cannot definitely conclude that plants not represented from the upper-most levels of occupational deposit were absent. Biases in the preservation are thus of considerable concern, in the reconstruction of the agricultural economy from the earliest phase-I to the subsequent phases of occupation in phases-II and III. The collective evidence, however, indicates that the agricultural regime in this region was a static element in the early half of the 3rd millennium BC. Winter and summer cultivation of crops is well apparent at ancient Ojiyana, with a shift towards greater dependence on a multi-cropping system. There is ample evidence of these crop remains from a number of sites of Early and Mature phases of Harappan culture in the northwestern region of the subcontinent, indicating intimate contacts with Harappans in material economy.

Cultivation of rice, the crop of the Ganga Valley region, in the economy of the Aharians of Rajasthan is also considerably important. Evidence of rice cultivation has not only been reported from Rajasthan but also from its contemporaneous Early, Mature and Late Harappan cultures[16–21] in Haryana, Punjab and Gujarat dated to 2860–1800 BC. Similarly, Harappan crops in the northwestern region of the country such as barley, wheat, jowar millet, ragi millet, lentil, field pea, grass pea, chickpea, green gram, black gram, horse gram and sesame, make a bulwark, in the agriculture of Neolithic and Chalcolithic cultures of Ganga Valley, up to the distant eastern region of Bihar and peninsular India[22–30]. Thus there is evidence of the spread of foodgrains, in a vast region from the northwestern to the eastern regions of Ganga Plain and vice versa, during 3rd–2nd millennium BC, as a consequence of the direct and indirect contacts and movement of archaeologically unrelated cultural groups.

S. italica (Italian millet) is thought to have been domesticated in the Chinese and has been reported from a number of Yang-shao sites, about 6000 yrs BP[31]. It is believed to have been domesticated from green-bristle grass (*Setaria viridis*). This is a crop suited to tracts with low rainfall. Apart from Ahar Culture in Rajasthan, it has been recorded from a number of Harappan sites in Gujarat, Punjab and Haryana[32–35].

Cultivation of oeliferous crops at this site is evidenced by the remains of sesame (*S. indicum*), linseed (*L. usitatissimum*) and safflower (*C. tinctorius*). These oilseeds affirm the importance of the seeds and oil to the Aharians due to their varied uses. Sesame represents African crops, while linseed and safflower belongs to Near-Eastern group of crops.

Remains of seeds and fruits of weeds and other wild taxa (Table 2) are the source of information about ground vegetation in the cultivated and uncultivated soil around the settlement. An overall approach of study is helpful in assessing how the ancient settlers may have familiarized themselves with the environmental conditions in which they lived and the relative importance of the different resources in their economy. The associated remains of weeds and wild taxa are represented by *V. sativa*, *C. lachryma-*

Table 2. Botanical remains recorded from Chalcolithic Ojiyana, Bhilwara District, Rajasthan

	PHASE-I									PHASE-II														PHASE-III					
Stratum/depth (m) → / Plant taxa ↓	(26); 7.17–6.83	(25); 6.83–6.54	(24); 6.54–6.34	(23); 6.34–6.02	(22); 6.02–5.69	(21); 5.69–5.44	(20); 5.44–4.97	(20A); 5.40	(20B); 5.44–5.34	(19); 4.97–4.84	(18); 4.84–4.62	(17); 4.62–4.44	(16); 4.44–4.27	(15); 4.27–3.90	(14); 3.90–3.60	(13); 3.60–3.28	(12); 3.28–3.00	(11); 3.00–2.77	(10); 2.77–2.56	(9); 2.56–2.32	(8); 2.32–2.04	PSB (8); 2.24–2.04	(7–8); 1.75	(7); 22.04–1.80	(6); 1.80–1.38	(5); 1.38–1.15	(4); 1.15–1.00	(3); 1.00–0.77	(2); .77–0.55
Hordeum vulgare	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Hordeum vulgare var. *nudum*	+					+		+							+			+											
Triticum aestivum					+	+	+	+	+	+	+	+	+		+			+	+					+		+			+
Triticum sphaerococcum						+					+	+			+														
Oryza sativa	+	+	+	+	+	+	+		+		+	+		+	+			+		+	+			+				+	
Sorghum bicolor								+																					
Eleusine coracana															+														
Setaria italica						+			+																				
Lens culinaris	+	+			+	+			+		+	+	+	+	+			+		+	+		+	+					
Pisum arvense	+	+			+	+	+		+		+	+	+		+				+	+				+					
Cicer arietinum												+			+														
Lathyrus sativus						+						+		+	+				+										
Vigna radiata		+				+	+		+		+	+				+		+	+	+						+		+	
Vigna mungo						+																							
Vigna aconitifolia						+										+													
Macrotyloma uniflorum							+					+	+	+	+						+	+	+	+	+	+		+	+
Sesamum indicum						+	+			+			+							+					+	+			
Linum usitatissimum						+	+					+																	
Carthamus tinctorius																							+						
Vicia sativa	+	+			+	+			+		+			+		+		+		+	+			+					+
Setaria sp.															+	+			+						+				+
Coix lachryma-jobi							+											+		+				+					
Rumex dentatus				+	+	+	+																						
Polygonum sp.						+	+						+							+									+
Chenopodium album		+							+	+			+	+				+						+					
Dactyloctenium aegyptium						+																							
Trianthema triquetra			+			+															+								
Trianthema portulacastrum			+																										
Scleria sp.			+			+										+													
Grewia sp.													+	+	+														
Ziziphus nummularia	+	+		+	+		+				+	+	+		+	+		+	+	+	+	+						+	+
Indigofera sp.		+					+							+															
Ipomoea sp.	+					+	+								+	+						+							+
Bombax sp.						+																							
Acacia sp.						+										+													+
Solanum sp.							+																						

(+), Presence in the particular stratum.

jobi, *Setaria* sp., *R. dentatus*, *Polygonum* sp., *C. album*, *Indigofera* sp., *T. triquetra*, *T. portulacastrum*, *D. aegyptium*, *Ipomoea* sp., *Solanum* sp., *Scleria* sp., *Bombax* sp., *Grewia* sp., *Z. nummularia*, *Acacia* sp. and Caryophyllaceous type.

V. sativa occurs as the most frequent weed in pulse crops. It is a forage legume of rich protein value, eaten by cattle and also used as hay. This species spread in the Indian region from Europe, through the north temperate zone in the Old World.

C. lachryma-jobi and *S. italica* would have been a common component in the diet of ancient people. *C. lachryma-jobi* is a tall, erect grass commonly growing along water courses, ditches, etc. *S. italica* occurs in grasslands, is self-sown and sometimes cultivated also as a kharif crop on uplands or hilly regions[11].

D. aegyptium, *Ch. album*, *R. dentatus*, *Polygonum* sp., *Indigofera* sp., *Ipomoea* sp., *Solanum* sp. and *Ipomoea* sp. are common in moist soil and occur as weed in cultivated fields. Ephemeral growth of these grasses and herbs follows the rains and may be regarded to subsist in the well-watered and marshy areas around the ancient settlement and along the river course. *T. triquetra* and *T. portulacastrum* are common weeds of waste places in shade, sun, saline and nonsaline areas, gardens as well as in cultivated fields. *Scleria* sp. occurs frequently in shady places and rocky hills; young tops and fruits are eaten. Leaves are used for making mats and for polishing wood. *Bombax* sp. is a large deciduous tree, common on the hills and also planted in gardens and on roadsides.

Grewia fruits are edible and often sold in the market; decoction of the wood is used as a remedy against cough. It is the most common shrub growing amongst *Euphorbia* bushes on low hills. About four species occur in the Indian desert[12]. *Z. nummularia* commonly occurs in open sandy ground. Fruits are edible and sold in the market. Five species occurs in the region and this is the most common species of the area. It is a component of scrubby vegetation.

Acacia sp. are thorny trees or shrubs growing in dry and arid regions. While tannin, gum and timber are its derivatives, pods and leaves of some species are regularly used as fodder, especially for sheep and goat. The habitats of the weeds recovered from the Ojiyana excavation, throw considerable light on the ecological conditions. A good number of species came from marshy and moist regions, while a few reflect on the ground vegetation in grassy and scrubby places. Traditional uses of some of the plants have also been discussed, which the ancient settlers would have not ignored in their day-to-day activities.

The studies of plant remains have brought to light the economic exploitation of vegetational resources by ancient inhabitants in Aravalli. Agriculture was their rewarding economy.

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