PART I
INTRODUCTION
The modern man, as revealed by the palaeontological evidence, appeared on the Earth about 40,000 to 30,000 years B.P. and within a period of 10,000 to 20,000 years spread throughout the world. It was also about this time that humans added fire-making to their cultural heritage. In the course of evolution man marked his progress by evolving a succession of tools in response to his need for mastering the environment, which primarily meant the quest for food. As a result of human hunting a "Pleistocene overkill" occurred between 15,000 and 12,000 B.P. when many of the large mammals became extinct. Such types of interactions with hunted animals, along with fire, constitute some
of the first major impacts on ecosystem (Barghoorn 1971).

By about 10,000 B.P. mankind achieved an important milestone through the development of agriculture and undoubtedly assumed an ecological role without parallel in the history of this planet. Through the cultivation of plants man developed a more dependable source of food which led to an ever increasing growth of population. The sedentary existence associated with cultivation practices also led to the development of village communities (Struever 1971, Hutchinson et al 1977; Moore 1982, 1985; Rindos 1984).

Our knowledge about the beginnings and progressive development of agriculture has greatly been advanced by the archaeological evidence. This has resulted in the development of a new branch of study known as "Palaeoethnobotany" which constitutes the study of plant remains, utilized by man in ancient times that have survived in archaeological context, leading to the understanding of origin, domestication and exploitation of plants. Such studies in addition to revealing man-plant relationships over time are frequently of importance in plant breeding as the genes
and gene complexes existing in ancestral forms and nearest relatives of cultivated plants may be used in hybridization for plant improvement.

Palaeoethnobotanical studies started and continued to capture the interest of botanists, agriculturists and archaeologists since 1826 when C. Kunth studied the desiccated fruits and seeds found by Passalacqua in the tombs of ancient Egypt. Then Heer (1866) worked out the material from waterlogged villages of Switzerland. In 1870's and 1880's Heer and Messikomer worked on the materials from Alpine Lakeside settlements; Deiniger, Staub and Shroeter in Central Europe at Lengyel, Aggtelak and Butmir; Wittmack in Germany, Greece, Anatolia and Peru and Unger, Braun and Schweinfurth in Egypt. These works have been consolidated by Buschan (1895) and Neuweiler (1905).

In the first half of this century some excellent works were carried out in Europe by Neuweiler, Netolitzky, Arnaudov, Maly, Hoffman, Schulz, Fietz, Werneck, Sarauw, Halt, Jesson and Schiemann which have been summarized by Bertsch and Bertsch (1949). Tackholm et al (1941) comprehensively
brought together the work carried out during this period in Egypt. The possibility of using palaeoethnobotanical evidence in the study of origin of crop plants was brought to light by de Candolle (1884) and this aspect was further elaborated by Schiemann (1951).


In the New World palaeoethnobotanical studies were started by Saffary (1876) followed by Wittmack (1880-87), Costantin and Bois (1910), Safford (1917), Harms (1922), Glimore (1931), Yacovleff and

The study on coprolites was started by Jones (1936) followed by Fonner (1957), Callen (1969) and Buth (1970).


In the Indian subcontinent palaeoethnobotany started in 1930's (Stapf 1931, Luthra 1936, Burt 1941, Vats 1941). Further works have been carried out by Vishnu Mittre (1962, 1966, 1968a, b, c, d, e, 1969, 1971, 1972, 1974, 1976); Chowdhury and Ghosh

Over past few years palaeoethnobotanists have made an increasing effort to apply their data to the question of cultural processes like the evolution of cultivation strategies; long term stability of subsistence strategies; process of agricultural intensification and alike. Several
papers (Asch and Asch 1975; Asch et al 1979; Dennel 1976; Ford 1979; Pearsall 1979, 1980, 1983, 1986; Minnis 1981) have emphasized caution in the interpretation of archaeological plant assemblages. The lack of direct correlation between raw seed counts or percentages and dietary importance of the plant has been well understood by most ethnobotanists who routinely include in their analyses cautions about the bias produced by differential preservation of botanical materials archaeologically. A variety of quantitative means have been applied to palaeoethnobotanical data to circumvent this problem (Pearsall 1983).

The very location of Kashmir in Central Asia has helped it to secure elements from different cultures of various countries falling in Central Asia ranging from Neolithic, which is the earliest known culture of Kashmir, to the Medieval times. These cultures melted, reacted and the valley became a culture compound of its own type at various stages of human development. Inspite of the fact that the valley of Kashmir is rich in archaeological sites little work has been done on the plant remains from various sites.
The present investigation is based on the systematic excavations conducted at Semthan in Anantnag district between 1979 and 1982. The object of the study has been to identify the remains of agricultural and forest products that the inhabitants had used and then evaluate from these the state of their economy. It has also been included in the present study to find out how best the inhabitants utilized the natural resources that were available to them in the environment they settled down. It also fell within the scope of this study to deal with the origin, domestication and source of the plant remains; diffusion of plants, probable uses of plants to ancient man, past vegetation and climate, ecological and environmental interaction between biological species and human culture and progressive development of Kashmir agriculture. Various statistical and quantitative approaches have been used, wherever possible, to the problem of determining the behaviour of various plant taxa, stability of subsistence strategies through time and drawing various palaeoecological implications.
THE SITE AND ITS ENVIRONMENT
Semthan (75°-9' E longitude; 33°-48' N latitude), in district Anantnag is situated 44 km almost south of Srinagar on the Jammu-Srinagar National Highway about 2 km from tehsil headquarters of Bijbehara (Fig.1,2). The site is located on the ancient lake bed of the valley floor and the serpentine Vitsta known as "Veth" in Kashmiri closely and calmly flows past. It comprises of six low and high mounds namely Tshradakut, Kuta, Rajmateng, Chakdhar, Guda, Sonakhuta and the overall perimeter of ancient Semthan is between 1.5 to 2 km. At places the mounds rise to a height of 60 m above the surrounding ground level.
The surrounding lowland is highly fertile. Rice (*Oryza sativa* L.) is the main cereal cultivated today. Wheat (*Triticum* spp) is also cultivated to a limited extent. The pulses cultivated include *Phaseolus vulgaris*, *P. aureus* Roxb, *P. mungo* L. and *Pisum sativum* L. Cash crops like *Brassica compestris* L. and to a lesser extent *Linum usitatissimum* L. and *Sesamum indicum* L. are also grown. Orchards comprising the trees of *Malus sylvestris* Host, *Juglans regia* L. and *Prunus amygdalus* Baill. have been raised on the higher grounds. Also grown in the surrounding lowlands are the trees and shrubs like *Populus* spp; *Salix* spp, *Ulmus* spp, *Robinia pseudoacacia* L. *Praxinus excelsior* L. etc.

The climate is similar to that of the rest of Kashmir being essentially of temperate type. The seasons in the year are more or less well marked and can be placed under four distinct periods, namely, Winter (December to February), Spring (March to May), Summer (June to August) and Autumn (September to November). The rainfall (Fig.3) is light and variable. The average rainfall is never more than a foot even in the month of January. The temperature
(Fig. 4) falls below freezing in winter and the highest temperature recorded in summer is never more than $35^\circ$C.

The site has been excavated by the Archaeological Survey of India. The cultural sequence revealed the occurrence of following occupational phase (Fig. 5):

**Period I: Pre-N.B.P. Phase:**

It is represented by a deposit of yellowish brown compact and sticky clay. It is distinguished by a type of ceramics most of which shows strong but remote genetic relationship with the late phase of the post-Harappan pottery of Banawali–Bara phase of the plains of Punjab and Haryana where it might be dated to c.1500-1100 B.C. (Bisht 1977). The phase has revealed few sherds of thick gritty red ware, a few of thick grey burnished ware, a sizable quantity of Bara type pottery and a red ware that has apparently something to do with the Chalcolithic culture (Bisht and Gaur 1982).

The site was not totally deserted by the inhabitants of this period before the arrival of
their successors since there was a cultural overlap between the two, evidenced by the continuation of the early in the later and thereby a sort of fusion at a stage.

**Period II : N.B.P. Phase**

The inhabitants of this phase had their own distinct material culture including a remarkable class of pottery known as the N.B.P. (Northern Black Polished Ware) along with the typical associated grey and red ware. A noticeable feature with regard to the construction is the use of mud clods, especially in making floor. A rubble of stone wall could also be revealed. The use of iron is evident. Beads of terracotta, semiprecious stone and crystalline quartz were also recovered. This period lasted from 600 - 200 B.C.

**Period III : Indo-Greek Phase**

Sandwiched between N.B.P. and Kushan horizons, a comparatively thin deposit consisting of various mud floors and horizontally running streaks yielded a very distinct class of pottery which is reddish pink slipped and thin in fabric. It seems
to be associated with the Indo-Greeks. This period has never been found in the valley earlier and lasted from 200 to 1 B.C.

**Period IV : Kushan Phase :**

This period is represented by a deposit of brownish compact earth and characterized by a red ware wheel turned pottery. Some burnt bricks have been met with. Floor levels paved with stones were also encountered. The time bracket of this period is from 1-500 A.D.

**Period V : Hindu Rule Phase :**

The pottery of this phase is wheel turned with fine grained fabric and lustrous red slip. This corresponds to a period when the temple-building activity was achieved by the Hindu rulers in the valley and dates back to 600-1000 A.D.
MATERIALS
The soil from various levels of each phase of the site was collected and plant remains retrieved using following methods (Buth et al 1986 b).

1) **Hand sorting or hand picking**

The loose soil was spread over sheets of paper and the large sized plant remains visible to the naked eye and under hand lens were picked up with the help of forceps.

2) **Mesh screening**

After hand picking the soil was screened through mesh screens of various sizes (Mesh 2057, Mesh 1698, Mesh 1000 and
Mesh 500). This facilitated recovery of quite a large size range of seeds and charcoal pieces.

3) **Floatation**

In order to recover smaller seeds and other artefacts which could not be retrieved through mesh screens, the soil was subjected to water floatation. A simplified version of floatation set up developed by Streuver (1968) was used. The soil was poured in a tub of water under constant stirring. The plant remains that floated on the surface were scooped off with the help of a strainer.

After the first round of floatation was over, the water was decanted off the tub and replaced with constant stirring to retrieve any other plant matter present.

4) Sometime the materials were found embedded in the burnt or unburnt mud clods from which they were retrieved using the method developed by Chowdhury and Ghosh (1954-55). The details of the procedure followed are as follows:
Burnt mud was soaked in tap water for about 6 hours and examined under a binocular dissecting microscope. Bits of the plant material were picked up and treated with 2% acetic acid and centrifuged. Later, they were washed carefully in 10 to 20% alcohol.

The plant remains thus recovered were dried in shade. All the plant materials were in carbonized form.
METHODS OF STUDY
The materials were cleaned with the help of soft camlin hair brushes using 0.5 to 1% acetic acid. After cleaning the first step has been to examine the material under stereomicroscope and take down notes on macroscopic morphological features. For this purpose the material was placed in a dish full of sand so that the material could be rolled to any position and examined under the low power binocular microscope.

Cleaned material was later treated for different anatomical procedures like peeling, maceration, section cutting and scanning. Of these section cutting was done of the solid plant parts such as wood, grains etc while peeling method for
material which was not suitable for cutting sections. Finally the maceration was done of the tissues which were delicate or too small for the application of the first two methods.

**Peeling**

Artschwager's (1930) method after further modification (Chowdhury et al 1977) was employed which gave fairly good results. The pieces of caryopses were passed through grades of ethyl alcohol from 20% to 95% keeping in each grade for about 10 minutes. The material was then passed to equal parts of ethyl alcohol and ether in a flat bottomed watch glass and kept for about 10 minutes. 4% celloidin was then poured on to the material. As soon as the celloidin formed a thin layer it was taken off with forceps. Detailed structure of peeling improved considerably when kept in xylol for two minutes before mounting. However, the structure of the peelings was much clear under scanning electron microscope.

**Section cutting**

To prepare an archaeological object for section cutting, it had to be embedded in some media
which hold the tissues and cells together while cutting is done. Double embedding with celloidin and paraffin was adopted in the present study. The processes used by Chowdhury (1934) and Chowdhury and Ghosh (1954-55) were employed.

**Maceration**

2-3% acetic acid was first used for maceration. With hard material this treatment had little effect. Concentrated nitric acid plus few crystals of potassium chlorate (Chamberlain 1932) was tried for an hour and the results were fairly satisfactory.

**Scanning Electron Microscopy**

For cereals whole caryopses or removed peelings were mounted on aluminium stubs and coated with 20-30 nm of gold-palladium in a sputtering device. The coated specimens were examined under scanning electron microscope. For millets and smaller seeds whole seeds were coated and scanned. In case of charcoals well preserved pieces were individually held between two fingers and snapped. The surfaces thus exposed indicated the features which could guide in further snapping in such a way as to obtain transverse and longitudinal surface views.
Small pieces of charcoal snapped along transverse and longitudinal surfaces were mounted on aluminium stubs, coated with 30-60 nm of gold-palladium and scanned. In other cases thin sections were cut on a rotatory microtome after embedding in paraffin wax. These sections were mounted on aluminum stubs and examined immediately under SEM. No interference was encountered and gold coating was not applied. Both the procedures gave fairly good results.

**Background laboratory and field studies**

Identification of plant remains of fossil and of recent past is possible only when these remains completely or nearly so match with the extant counterparts. It is customary to use morphology and anatomy for this purpose. In the present study, intensive morphological and anatomical survey of living plants which were likely to match with the ancient remains was made. The background studies included collection of various species of cereals, pulses, stone fruits, millets, weed seeds and wood specimens from various sources like U.S. Department of Agriculture, Indian Agricultural Research Institute, New Delhi, Kashmir University herbarium and various
local fields. The laboratory studies included artificial carbonization of extant grains and seeds in order to know about the changes caused due to carbonization by baking them in an electric oven at 200°C for 12 hours (Renfrew, 1973); morpho-anatomical study of various species of cereals, pulses, endocarps and weed seeds under stereo-, light and scanning electron microscopes; preparation of a seed bank for comparison of weed seeds and wood anatomy of various tree species growing in Kashmir for comparison with archaeological charcoals. Keys for identification were also prepared.

Statistical Analyses

For statistical analyses the data recovered from equal number of flotation samples of equal volume from each phase were used.

Chi-square values were determined using the formula:

\[ x^2 = \frac{(X_{ob} - X_{Ex})^2}{X_{Ex}} \]

Where \( X_{ob} \) = Observed number of seeds/charcoals of a taxon

\( X_{Ex} \) = Expected number of seeds/charcoals of the taxon.
Intensity of occupation was calculated as the total count of charred wood summed by phase.

For species diversity Shannon-Weaver (1949) information index for finite populations ($H$) was calculated in each phase as:

$$H = - \sum \left( \frac{N_i}{N} \right) \ln \left( \frac{N_i}{N} \right)$$

Where $N_j =$ total number of charcoals of a taxon in the phase

$N =$ total number of charcoals in the phase

$\ln =$ natural log.

Species richness was measured after Marglef (1957) as

$$r = \frac{(S-1)}{\ln N}$$

and species evenness after Shannon and Weaver (1949) as

$$e = \frac{H}{\ln S}$$

Where

$S =$ total number of species present in a phase

$N =$ total number of charcoals in the phase

$H =$ species diversity.
Standard scores or standard deviation units (Z) were calculated after Blalock (1972) as

\[ Z = \frac{x - \bar{x}}{s} \]

Where

- \( \bar{x} \) = occurrence of a seed taxon in a phase
- \( x \) = mean occurrence of taxon in all the phases
- \( s \) = standard deviation of taxon from the mean.

Coefficient of similarity 'S' between pairs of phase was computed after Wolda (1981) as

\[ S = \frac{2C}{A + B} \]

Where A and B are the total species recorded at each of the given pair of phases and C, the total number of species recorded at both the phases.

Co-efficient of similarity 'T' was computed after Thibodeau and Nickerson (1985) as

\[ T = \sum \frac{\left(\frac{N_{ja} + N_{jb}}{2} - \frac{N_{ja} - N_{jb}}{2}\right)}{(Na + Nb)} \]
Where \( a \) and \( b \) are subscripts labelling two phases between which similarity is to be determined; all other notations being as described above.
I) ARTIFICIAL CARBONIZATION

The changes in dimensions resulting from artificial carbonization, of grains and seeds of various species, are presented in the form of histograms in Figs. 6 to 21 as *Triticum monococcum* L. (Fig. 6), *T. dicoccum* Schuble (Fig. 7), *T. turgidum* L. (Fig. 8), *T. sphaerococcum* Perc. (Fig. 9), *T. aestivum* L. (Fig. 10), *Hordeum spontaneum* Koch. (Fig. 11), *H. distichum* L. (Fig. 12), *H. hexaploidum* L. (Fig. 13), *H. vulgare* L. (Fig. 14), *Oryza sativa* L. Cultivar China 1039 (Fig. 15), *O. sativa* Cultivar Noon Beoul (Fig. 16), *Avena fatua* L. (Fig. 17), *A. sativa* L. (Fig. 18), *Phaseolus*
II) **RESULTS OF BOTANICAL STUDY**

On visual observation the plant remains recovered from various phases of the site could be grouped into following categories:

I) CEREALS
II) MILLETS
III) PULSES
IV) WEED SEEDS
V) ENDOCARPS
VI) WOODS

I) **CEREALS**

Majority of the charred seed and fruit remains recovered consist of caryopses typical of family Poaceae. On macroscopic examination the caryopses turned out to be a mixture of more than one type showing marked differences in shape, size and other morphological features. They have, therefore, been grouped into four lots viz. 'A', 'B', 'C' and 'D'.
LOT A

Morphology (Fig. 22, 23, 24)

This lot comprises a total of 170 caryopses of which 105 are complete and 65 broken. The caryopses are puffed, oblong to oval in shape. Their length varies from 4.3 to 5.5 mm and breadth from 1.9 to 2.7 mm. The grains are ribbed and the number of ribs varies from two to four (usually three). The embryo is lost but its position on the lateral side is clear in all the grains. A few grains have portions of husk (lemma and palea) well preserved at places.

Anatomy (Fig. 25)

The cross sections of the caryopses do not reveal any helpful anatomical structure. Various tissues of the caryopses are not distinguishable due to its transformation into black mass during carbonization.

SEM (Fig. 26, 27)

Grains partially covered with husk were scanned under electron microscope. The SEM of the surface shows somewhat thick and sinous walled cells.
The SEM of the husk shows that it is composed of regular squares of characteristic chess-board pattern. At places hair bases are also visible.

**Identification**

The lateral position of embryo and ribbed grains lead to genus *Oryza*. This is further confirmed by the presence of chess-board pattern on the husk, which is helpful in separating genus *Oryza* from rest of the genera belonging to grass family (Chowdhury and Ghosh 1954–55; Buth 1970; Chowdhury et al 1977).

*Oryza* has been classified into different species and subspecies based on morphological and cytogenetic characters. These are, no doubt, useful for identification of fresh material but not for the archaeological remains in which all the parts are not always available. The cultivated rice includes two taxonomically distinct species: *Oryza sativa* L. found throughout the world especially in southeast Asia and *O. glaberrima* Steud limited to west and central Africa from Senegal to Sudan (de-Candolle 1884; Chatterjee 1951; Kihara 1959;
Darlington 1964; Riccharia and Govindaswami 1966; Buth 1970; Buth and Saraswat 1972; Chowdhury et al 1977; Second 1982; Buth et al 1986 a). Considering the age of the present archaeological material, the possibility of the African species is rather remote. Thus the rice remains are placed under Oryza sativa L.

*O. sativa* has been usually classified into three subspecies namely subsp *indica* Kato; subsp *japonica* Kato and subsp *javanica* Kato (Purseglove 1974). The distinction between the subspecies are not absolute but are based on morphological characters and adaptions to temperature and photoperiod conditions prevailing in different rice regions of the world (Ghose et al. 1960).

However Vishnu Mittre (1974) provided *L/(BxT)* indices for different species of *Oryza* as follows

\[
\begin{align*}
Q. \text{perennis} & \quad 2, 20, 2.21 \\
Q. \text{officinalis} & \quad 2.36 \\
Q. \text{rufipogon} & \quad 2.64 \\
Q. \text{sativa var. indica} & \quad 1.71 \\
Q. \text{sativa var. japonica} & \quad 1.70 \\
Q. \text{sativa var spontanea} & \quad 1.77, 1.79
\end{align*}
\]
The size statistics of modern rice grains and the rice grains from Semthan is given in Table 1 and 2 respectively. On comparison it is clear that the rice grains of the ancient material approach very close to *O. sativa* complex with respect to various statistical ratios. However, the material does not fit exactly in any one of the three subspecies *indica*, *japonica* and *spontanea*.

Hector (1937) classified *O. sativa* into four groups on the basis of size alone. These are:

(a) Long  
Length 4–7 times the breadth
(b) Fine  
Length 3–4 times the breadth
(c) Coarse  
Length 2–3 times the breadth
(d) Round  
Length two times the breadth

Ghose et al (1960) also presented a classification for *O. sativa* of Indian origin as follows:

(a) Coarse  
2.75 mm and more breadth
(b) Fine  
2–3.75 mm breadth
(c) Superfine  
2 mm and less breadth.

On comparison it is clear that the rice grains of the ancient material come under the group 'Coarse' of Hector. By Ghose's classification the material comes under 'Fine' group.
Table 1: Size Statistics of Rice Grains from Semthan.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (L) in mm</td>
<td>4.7</td>
<td>4.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Breadth (B) in mm</td>
<td>2.1</td>
<td>1.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Thickness (T) in mm</td>
<td>1.4</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>L/B ratio</td>
<td>2.2</td>
<td>2.3</td>
<td>2.1</td>
</tr>
<tr>
<td>L/T ratio</td>
<td>3.5</td>
<td>3.58</td>
<td>3.06</td>
</tr>
<tr>
<td>B/T ratio</td>
<td>1.5</td>
<td>1.58</td>
<td>1.5</td>
</tr>
<tr>
<td>T/B ratio</td>
<td>0.66</td>
<td>0.63</td>
<td>0.66</td>
</tr>
<tr>
<td>L/(BxT)</td>
<td>1.60</td>
<td>1.88</td>
<td>1.13</td>
</tr>
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</table>

Table 2: Size Statistics of Modern Rice Grains

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (mm) L</th>
<th>Breadth (mm) B</th>
<th>Thickness (mm) T</th>
<th>L/B</th>
<th>L/T</th>
<th>B/T</th>
<th>I/(BxT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oryza perennis</td>
<td>8.12</td>
<td>2.29</td>
<td>1.61</td>
<td>3.54</td>
<td>5.04</td>
<td>1.41</td>
<td>2.21</td>
</tr>
<tr>
<td>O. officinalis</td>
<td>4.25</td>
<td>2.12</td>
<td>0.85</td>
<td>2.0</td>
<td>5.0</td>
<td>2.49</td>
<td>2.36</td>
</tr>
<tr>
<td>O. rufipogon</td>
<td>7.0</td>
<td>2.65</td>
<td>1.0</td>
<td>2.64</td>
<td>7.0</td>
<td>2.65</td>
<td>2.64</td>
</tr>
<tr>
<td>O. sativa ssp.</td>
<td>8.82</td>
<td>2.55</td>
<td>1.95</td>
<td>3.45</td>
<td>4.52</td>
<td>1.30</td>
<td>1.77</td>
</tr>
<tr>
<td>javanica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O. sativa ssp.</td>
<td>6.50</td>
<td>2.75</td>
<td>1.38</td>
<td>2.36</td>
<td>4.71</td>
<td>1.27</td>
<td>1.71</td>
</tr>
<tr>
<td>japonica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O. sativa ssp.</td>
<td>2.25</td>
<td>1.88</td>
<td>1.22</td>
<td>2.79</td>
<td>4.30</td>
<td>1.54</td>
<td>1.70</td>
</tr>
<tr>
<td>indica</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
Phase Wise Distribution

The distribution of rice as recorded in different phases of the site is as follows:-

<table>
<thead>
<tr>
<th>Phase</th>
<th>No. of Caryopses</th>
<th>Complete</th>
<th>Broken</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre-N.B.P.</td>
<td></td>
<td>17</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td></td>
<td>25</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td></td>
<td>9</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td></td>
<td>38</td>
<td>19</td>
<td>57</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td></td>
<td>16</td>
<td>7</td>
<td>23</td>
</tr>
</tbody>
</table>

LOT B

A total of 179 caryopses could be grouped together within this lot. On macroscopic observation these have further been divided into two subgroups - 'B₁' and 'B₂'.

Lot B₁

Morphology (Fig. 28, 29, 30, 31, 32)

There are a total of 165 caryopses of which 69 are complete and 96 broken. The grains are oval to subglobular in shape rather plump, varying in length from 3.7 to 5.2 mm and in breadth from 2 to
3.5 mm. The two cheeks of the grains are fairly wide and flat. The position of the embryo or embryo itself is at the base of the dorsal surface. The dorsal surface is raised and a fairly deep furrow is present on the ventral side. The caryopses are naked. Some of them are partially or completely covered with a thin layer of pericarp.

**Anatomy** (Fig. 33)

The cross sections of the caryopses do not reveal much useful anatomical data. After carbonization the cells of the caryopses inside have been distorted. The black mass formed shows little detail of the structure of individual cells. The only preserved tissue appears to be endosperm and the remains of vascular tissue in the furrow.

**SEM** (Fig. 34, 35)

The scanning electron micrograph of the surface reveals characteristic cell alignment and relief. The pericarp is made up of horizontally placed parenchymatous cells.

**Identification**

Attempt has been made to compare the structure
of thin layer of pericarp of carbonized caryopses with that of extant caryopses of members of grass family. It has been found to be similar to that of the inner layer of the extant caryopses of *Triticum* spp. This has further been corroborated by the morphology of the caryopses.

Wheat being one of the most important present day food plants, extensive and arduous research has been carried out on it from different points of view. Based on the number of chromosomes the genus is grouped under diploid (2n=14); tetraploid (2n=28) and hexaploid (2n = 42) groups. The genus exhibits an extraordinary variability and as such a number of workers have made substantial contributions to the understanding of its affinities (Percival 1921, Mackay 1954, Paterson 1965 and Sears 1965). Zohary (1971) has classified the genus as presented in Table 3.
Table 3: Wheats: main morphological types based on cytogenetic affinities.

<table>
<thead>
<tr>
<th>Types</th>
<th>Description</th>
<th>Collective Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Diploid einkorn wheats,</td>
<td>2n=14 (genome A)</td>
<td><em>T. monococcum</em> L.</td>
</tr>
<tr>
<td>ii) Tetraploid emmers,</td>
<td>durums and turgidums, 2n=28 (genomes AB)</td>
<td><em>T. turgidum</em> L.</td>
</tr>
<tr>
<td>iii) Tetraploid timopheevii wheats</td>
<td>2n = 28 (genomes AG)</td>
<td><em>T. timopheevii</em> Zhuk.</td>
</tr>
<tr>
<td>iv) Hexaploid wheats,</td>
<td>2n = 42 (genomes ABD)</td>
<td><em>T. aestijum</em> L.</td>
</tr>
</tbody>
</table>

1. *T. boseicum* Boiss emend Schiem (wild, brittle, hulled).
3. *T. dicoccoides* (Kornicke Aarons) (wild, brittle, hulled).
5. *T. durum* Desf. (cultivated, free threshing).
8. *T. polonicum* L. (cultivated, free threshing).
14. *T. compactum* Host (cultivated) free threshing.
Morphologically (Helbaek 1960; Paterson 1965), wheat is divided into two groups; if the Kernel has glumes attached to it at maturity it is termed as "Glume wheat" and if glumeless it is termed as "Naked wheat". The mode of fracturing of rachis in glume wheats is also used in identifying the species (Watkins 1930; Helbaek 1964; Paterson 1965). The present material falls in the category of "Naked" wheats.

A look at Table 3 shows a total of 16 conventional species. Of these six namely, T. persicum; T. polonicum; T. araraticum; T. timopheevii, T. macha and T. vavilovii can be easily taken out because these species are strictly confined to certain regions of the world and none is reported to be distributed in Indo-Pak region (Chowdhury et al. 1977). The hulled wheats namely T. boeoticum, T. monococcum, T. dicocoides, T. dicoccum and T. spelta can also be discarded as the Semthan wheat is naked. Thus the T. durum, T. turgidum, T. aestivum, T. compactum and T. sphaerooccum are left.

In the absence of other morphological features the shape and size has proven very useful in determining the identity of archaeological wheat.
There seems to be a gradual variation in both shape and size as one comes across diploid, tetraploid and hexaploid wheats. On this basis one can differentiate between tetraploid T. durum, T. turgidum and hexaploid T. aestivum, T. compactum and T. sphaerococcum because the former are long and slender while the later are short and plump. The Semthan wheat belongs without any doubt to hexaploid group as they are slightly shorter, comparatively plump and considerably wider near the embryo.

Size statistics of some extant hexaploid species is given in Table 4 and that of wheat grains from Semthan in Table 5. Matching the different ratios, the prehistoric wheat comes very close to T. aestivum and T. compactum while differing considerably from T. sphaerococcum.

Comparative SEM study of pericarp of the extant Triticum caryopses has been carried out (Buth 1982) which revealed that various species could be identified on the basis of surface relief and cell alignment. Comparing the scanning electron micrograph of carbonized material, it resembles T. aestivum (Fig.35).
Table 4: Size statistics of modern wheat grains

<table>
<thead>
<tr>
<th>Species</th>
<th>L/B</th>
<th>L/T</th>
<th>B/L</th>
<th>T/L</th>
<th>T/B</th>
<th>Calculated I(BxT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. aestivum</td>
<td>2.68</td>
<td>3.07</td>
<td>0.37</td>
<td>0.32</td>
<td>0.87</td>
<td>1.32</td>
</tr>
<tr>
<td>T. compactum</td>
<td>2.44</td>
<td>3.07</td>
<td>0.40</td>
<td>0.32</td>
<td>0.79</td>
<td>1.26</td>
</tr>
<tr>
<td>T. sphaerococcum</td>
<td>1.76</td>
<td>1.62</td>
<td>0.56</td>
<td>0.61</td>
<td>1.09</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Table 5: Size statistics of wheat (T. aestivum) from Semthan.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length in mm</td>
<td>4.8</td>
<td>3.7</td>
<td>5.2</td>
</tr>
<tr>
<td>Breadth in mm</td>
<td>2.4</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Thickness in mm</td>
<td>1.9</td>
<td>1.6</td>
<td>2.4</td>
</tr>
<tr>
<td>L/B</td>
<td>2.0</td>
<td>1.85</td>
<td>1.48</td>
</tr>
<tr>
<td>L/T</td>
<td>2.52</td>
<td>2.31</td>
<td>2.16</td>
</tr>
<tr>
<td>B/L</td>
<td>0.5</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td>T/L</td>
<td>0.20</td>
<td>0.43</td>
<td>0.46</td>
</tr>
<tr>
<td>T/B</td>
<td>0.79</td>
<td>0.8</td>
<td>0.68</td>
</tr>
<tr>
<td>I(BxT) index</td>
<td>1.05</td>
<td>1.15</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Hexaploid wheats have further been classified by Mackay (1954) and Sears (1956). Taking Mackay's classification, the species T. aestivum (L) em Thell. includes sub species T. spelta (L) Thell; T. macha (Dek et Men) Mackay, T. vavilovii (Tuman ) Sears, T. vulgare (Vill) Host Mackay and T. sphaerococcum (Perc.) Mackay. While working on archaeological material of naked wheats Helbaek (1966, 1969) included only T. vulgare; T. compactum and T. sphaerococcum under T. aestivum. In view of this the Semthan material is placed under T. aestivum (L) em Thell complex.

Lot B₂

Besides the wheat grains referred to T. aestivum above, a total of 14 grains of which 10 are complete and 4 broken were also recovered which no doubt belong to wheats but are certainly not those of T. aestivum. The results of their study are given below:

Morphology (Fig. 36, 37, 38)

The caryopses are oval to subglobular in shape;
comparatively shorter and rounded, rather plumpy when viewed from ventral side. They vary in length from 3 to 4.7 mm and in breadth from 2.2 to 3.3 mm. The position of embryo or embryo itself is at the base of dorsal surface. Some of the caryopses are covered partially or completely by a thin covering of pericarp.

Anatomy and SEM (Fig. 39, 40)

The serial sections of the caryopses do not reveal any useful anatomical data. The scanning electron micrograph of the surface shows resemblance in respect to relief, cell-pattern and cell alignment with that of T. sphaerococcum (Fig. 40).

Identification

As indicated above the caryopses show resemblance with T. sphaerococcum. The size statistics of these caryopses is given in Table 6. Comparing the various indices with those of extant wheat species (Table 4) it is seen that the material approaches very close to T. sphaerococcum.
Table 6: Size statistics of wheat (*T. sphaerococcum*) from Semthan.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length in mm</td>
<td>3.7</td>
<td>3.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Breadth in mm</td>
<td>2.7</td>
<td>2.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Thickness in mm</td>
<td>2.6</td>
<td>2.1</td>
<td>3.0</td>
</tr>
<tr>
<td>L/B</td>
<td>1.37</td>
<td>1.36</td>
<td>1.42</td>
</tr>
<tr>
<td>L/T</td>
<td>1.43</td>
<td>1.43</td>
<td>1.56</td>
</tr>
<tr>
<td>B/L</td>
<td>0.73</td>
<td>0.74</td>
<td>0.70</td>
</tr>
<tr>
<td>T/L</td>
<td>0.70</td>
<td>0.70</td>
<td>0.69</td>
</tr>
<tr>
<td>T/B</td>
<td>0.96</td>
<td>0.95</td>
<td>0.90</td>
</tr>
<tr>
<td>I*(BxT)* index</td>
<td>0.53</td>
<td>0.65</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Hence these caryopses are placed under

T. sphaerococcum Perc.

**Phase wise Distribution**

The occurrence of T. aestivum and T. sphaerococcum as recorded in various phases of the site is as follows -

<table>
<thead>
<tr>
<th></th>
<th>T. aestivum</th>
<th>No of caryopses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>Complete</td>
<td>Broken</td>
</tr>
<tr>
<td>I. Pre N.B.P.</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>16</td>
<td>48</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>46</td>
<td>25</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>4</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>T. sphaerococcum</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>5</td>
</tr>
<tr>
<td>II. Kushan</td>
<td>5</td>
</tr>
</tbody>
</table>

**LOT C**

**Morphology (Fig. 41, 42, 43, 44)**

The lot comprises of 280 caryopses of which 118 are complete and 162 broken. The grains vary
from 5 to 6.5 mm in length and 2 to 3.5 mm in breadth. Some of the caryopses have a distinct bulge in the centre whereas a few have a prominent twist at the anterior end. The grains are flat on the dorsal side and somewhat pointed at both the ends. A shallow dorsal furrow and a comparatively deeper ventral furrow are prominent. The position of the embryo or embryo itself is present at the base of dorsal surface in all the caryopses. The embryo has a pointed beak. All the caryopses are partially or completely enclosed in a thick covering which shows longitudinal ridges under binocular microscope.

**Anatomy (Fig. 45)**

The serial sections of the caryopses show nothing but a black mass of tissue. However, the furrow, low domed lobes and remains of vascular tissue are visible.

**SEM (Fig. 46, 47, 48, 49)**

The caryopses were scanned under an electron microscope at various places. The scanning electron micrographs have shown that the surface shows a
characteristic cell alignment and relief. Pericarp shows a layer of somewhat thick walled parenchymatous cells. Short cells and silica bodies are also seen in the husk.

**Identification**

The morphological features like shape, size, beaked embryo and pericarp with longitudinal ridges etc. clearly indicate that the caryopses belong to *Hordeum* sp.

Genus *Hordeum* has been classified into two main groups based on the number of fertile florests present per node (Bor 1960, Helbaek 1960, Backer et al 1968). These are: the two-rowed barley and the six rowed barley. In the two-rowed species, there are three florets per node, only median floret develops into a fruit, the two lateral florets being sterile. Thus there is only one row of caryopses on either side of the spike. In six-rowed species all the three florets are fertile resulting in three caryopses on either side of the spike. The median caryopses of six rowed barley has usually a distinct bulge in the middle whereas the lateral caryopses show a prominent twist.
on the ventral side. Both the types of grains are found in the present archaeological material indicating that they belong to the six-row group.

The genus has once again been divided into two main groups. Those varieties in which the caryopses are completely hidden within lemma and palea are termed "hulled" and those in which the kernels are free at maturity are termed "naked". In the hulled form lemma and palea are stuck to the caryopses by secretion of pericarp (Helbaek 1960, Chalan and Venkateswarlu 1965, Chowdhury et al 1977) and are characterized by longitudinal ridges. On the caryopses of naked barley no such ridges are present and instead the pericarp shows ripple markings. From the description of the ancient material from Semthan it becomes quite evident that it belongs to the hulled form of six rowed species.

Comparative study of the size statistics of the ancient and extant species of Hordeum is presented in Table 7 and 8. Comparison of various indices makes it evident that the ancient material approaches very close to Hordeum vulgare complex.
Table 7: Size statistics of barley grains from Semthan.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (L) mm</td>
<td>5.8</td>
<td>5.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Breadth (B) mm</td>
<td>2.8</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Thickness (T) mm</td>
<td>2.1</td>
<td>1.55</td>
<td>2.25</td>
</tr>
<tr>
<td>L/B</td>
<td>2.07</td>
<td>2.5</td>
<td>1.85</td>
</tr>
<tr>
<td>L/T</td>
<td>2.76</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>B/L</td>
<td>0.48</td>
<td>0.4</td>
<td>0.53</td>
</tr>
<tr>
<td>T/L</td>
<td>0.36</td>
<td>0.31</td>
<td>0.34</td>
</tr>
<tr>
<td>T/B</td>
<td>0.75</td>
<td>0.77</td>
<td>0.64</td>
</tr>
<tr>
<td>L/(BxT)</td>
<td>0.95</td>
<td>1.6</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Table 8: Size statistics of extant barleys

<table>
<thead>
<tr>
<th>Species</th>
<th>L/B</th>
<th>L/T</th>
<th>B/L</th>
<th>T/L</th>
<th>T/B</th>
<th>L/(BxT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. vulgare (hulled)</td>
<td>2.14</td>
<td>2.43</td>
<td>0.46</td>
<td>0.41</td>
<td>0.87</td>
<td>0.67</td>
</tr>
<tr>
<td>H. vulgare (naked)</td>
<td>2.28</td>
<td>2.60</td>
<td>0.43</td>
<td>0.38</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>H. hexaploidum</td>
<td>5.4</td>
<td>5.5</td>
<td>0.18</td>
<td>0.18</td>
<td>0.98</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Further it has been suggested that all the hulled varieties of barley be placed under *H. vulgare* complex (Chowdhury 1963, Harlan and Zohary 1966, Chowdhury et al 1977). In view of this the present material is placed under *Hordeum vulgare* L. hulled, six-row form.

**Phasewise Distribution**

The distribution of barley as recorded in various phases of the site is as follows:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Complete caryopses</th>
<th>Broken caryopses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre N.B.P.</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>N.B.P.</td>
<td>63</td>
<td>81</td>
<td>144</td>
</tr>
<tr>
<td>Indo Greek</td>
<td>15</td>
<td>31</td>
<td>46</td>
</tr>
<tr>
<td>Kushan</td>
<td>25</td>
<td>31</td>
<td>56</td>
</tr>
<tr>
<td>Hindu Rule</td>
<td>11</td>
<td>16</td>
<td>27</td>
</tr>
</tbody>
</table>

**LOT D**

**Morphology** (Fig. 50,51,52,53)

A total of 19 caryopses consisting of 14 complete and 5 broken are quite distinct from those referred to *Oryza*, *Triticum* and *Hordeum* above. The grains are thinner and elongate, 3.8 to 5 mm long.
and 1 to 1.8 mm broad. The dorsal surface is smooth and a shallow furrow is seen on the ventral surface. The caryopses are partially or wholly covered with a thin layer of pericarp. The position of the embryo is dorsal.

**Anatomy (Fig. 54)**

Serial sections of the caryopses do not reveal any characteristic features except a black mass of charred tissue.

**SEM (Fig. 55, 56, 57, 58)**

The scanning electron micrograph of the caryopses show that the pericarp is made of a thin layer of parenchymatous cells comparable in structure to that of extant *Avena fatua* and *A. sativa*.

**Identification**

The shape of the caryopses bring the material very close to *Avena* which is further confirmed by the structure of pericarp.

Based on the number of chromosomes oat
species have been classified into three groups (Martin and Leonard, 1967). These are:

A) Diploid group (2n = 14) including short oat (*Avena brevis* Roth); desert oat (*A. wiestii* Steud); sand oat (*A. strigosa* Schreb) and small seeded naked oat (*A. nudbrevis* Vav.).

B) Tetraploid group (2n = 28) including slender oat (*A. barbata* Brot.) and Abyssinean oat (*A. abyssinica* Hochst.)

C) Hexaploid group (2n = 42) including common wild oat (*A. fatua* L.); common white oat (*A. sativa* L.); large seeded naked oat (*A. nuda* L.); wild red oat (*A. sterilis* L.) and cultivated red oat (*A. byzantina* Koch).

Taking into consideration the present day distribution of the oats, the diploid and the tetraploid oats do not have an area of distribution in Kashmir. Of the hexaploid ones the common ones are *A. fatua* and *A. sativa*. In the absence of detailed morphological characters size and shape have proven useful in the classification of oats as there
is considerable difference in size of wild and cultivated oats (Renfrew 1969). The dimensions and the proportional indices of the Semthan oats are presented in Table 9. Similar indices for the extant *Avena* spp. are presented in Table 10. Comparing the different indices, it becomes evident that concordance exists between the living and the ancient oats but the proportional indices of the later do not match exactly with those of any particular species. However based on differences in size alone, the smaller ones are referred to *Avena fatua* L. and the larger ones to *A. sativa* L. (Renfrew 1969, 1973). Structure of pericarp further confirms the identification.

**Phase-wise Distribution**

The occurrence of oats as recorded in different phases at Semthan is as follows:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Complete caryopses</th>
<th>Broken caryopses</th>
<th>Total caryopses</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>II. N.B.P.</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td><em>Avena</em> sp.</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td><em>A. fatua</em></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-</td>
<td>1</td>
<td><em>A. sativa</em></td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td><em>A. fatua</em></td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>3</td>
<td>-</td>
<td>3</td>
<td><em>A. sativa</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>4</td>
<td><em>A. sativa</em></td>
</tr>
</tbody>
</table>
Table 9: Size statistics of oat grains from Semthan.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>4.55</td>
<td>3.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Breadth (mm)</td>
<td>1.5</td>
<td>1.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>1.1</td>
<td>0.8</td>
<td>1.5</td>
</tr>
<tr>
<td>L/B</td>
<td>3.03</td>
<td>3.8</td>
<td>2.7</td>
</tr>
<tr>
<td>L/T</td>
<td>4.13</td>
<td>4.75</td>
<td>3.33</td>
</tr>
<tr>
<td>B/L</td>
<td>0.32</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>T/L</td>
<td>0.24</td>
<td>0.21</td>
<td>0.30</td>
</tr>
<tr>
<td>T/B</td>
<td>0.73</td>
<td>0.80</td>
<td>0.83</td>
</tr>
<tr>
<td>L/(BxT)</td>
<td>2.75</td>
<td>4.75</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Table 10: Size statistics of extant *Avena* spp.

<table>
<thead>
<tr>
<th>Indices</th>
<th>L/B</th>
<th>L/T</th>
<th>B/L</th>
<th>T/L</th>
<th>T/B</th>
<th>L/(BxT)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Avena fatua</em></td>
<td>4.50</td>
<td>6.02</td>
<td>1.31</td>
<td>0.16</td>
<td>0.76</td>
<td>3.43</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>4.84</td>
<td>5.30</td>
<td>1.09</td>
<td>0.18</td>
<td>0.90</td>
<td>2.55</td>
</tr>
</tbody>
</table>
II. MILLETS

A few seeds (Fig. 59) recovered from the site, on comparison show resemblance with the extant millets. Macroscopic observation revealed them to be of two types. Therefore, they are described below as Lot 'A' and Lot 'B'.

LOT A (Fig. 60, 61)

This lot consists of a total of four seeds of which two are complete and two broken. The complete seeds are oval with smooth and shining surface measuring 2.9 to 3.1 mm in length and 1.5 to 2 mm in breadth. The dorsal side is slightly convex. The scanning electron micrograph of the surface shows that it is made up of smooth walled parenchymatous cells (Fig. 61).

LOT B (Fig. 62, 63)

This lot consists of a total of three seeds of which two are complete. The complete seeds are oval, longer than broad, glumed with tubercles on the surface. The seeds measure about 2.5 mm in length and 1.5 mm in breadth. The scanning electron
micrograph of the surface shows that it is made of somewhat sinous walled cells (Fig. 63).

**Identification**

Morphological features of some extant millets are presented in Table 11. A comparison with extant millets revealed that lot A shows maximum resemblance with *Panicum* sp. and lot B with *Setaria* sp.

**Phasewise Distribution**

The millets were recorded from the following phases of the site.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Millet</th>
</tr>
</thead>
<tbody>
<tr>
<td>III. Indo Greek</td>
<td><em>Panicum</em> sp.</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td><em>Setaria</em> sp.</td>
</tr>
</tbody>
</table>
Table 11: Morpho-anatomical features of some species of Millets.

<table>
<thead>
<tr>
<th>Species</th>
<th>Shape &amp; surface</th>
<th>Epidermis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eleusine coracana</td>
<td>Circular hulled, ventral surface longitudinally depressed, glumes absent.</td>
<td>Smooth walled, cells longer than broad.</td>
</tr>
<tr>
<td>2. Panicum milliaceum</td>
<td>Oval, lemma &amp; palea smooth/roughened by fine tubercles on dorsal convex side.</td>
<td>Smooth/sinuous walled cells encrusted with silica bodies, lumen narrow.</td>
</tr>
<tr>
<td>4. Setaria glauca</td>
<td>Oval, convex on the dorsal side tightly enclosed with lemma and palea. Tubercles transversely oriented on dorsal surface.</td>
<td>Deeply sinuous walled cells</td>
</tr>
<tr>
<td>5. Setaria italicca</td>
<td>Longer than broad, oval glumed, lemma flattened, palea convex, tubercles on the dorsal side.</td>
<td>Dentate, longer than broad cells.</td>
</tr>
<tr>
<td>7. Sorghum bicolor</td>
<td>Rounded, bluntly pointed obovate, obtuse base, glumed and no tubercles.</td>
<td>Smooth, longer than broad cells.</td>
</tr>
</tbody>
</table>
III. **PULSES**

About thirty seeds recovered from different levels of the site show characteristics of pulses (the cultivated leguminous seeds). Based on shape, size and gross morphological features these were divided into lots 'A', 'B', 'C', 'D' and 'E'.

**LOT A**

**Morphology** *(Fig. 64, 66)*

This lot consists of seven seeds of which four are complete and three broken. The complete seeds are oblong in shape covered with a thin and smooth seed coat. The seeds are 4.0 to 4.8 mm long and 2.5 to 3.0 mm broad. The hilum is lateral in position surrounded by a raised border which partially covers it.

**Anatomy** *(Fig. 68)*

Palisade cells are rather short varying in height from 58 to 67 μm. They are bulbous towards the inner end and narrow towards the outer end.
LOT B

Morphology (Fig. 64, 65, 67).

This lot consists of ten seeds of which three are complete and seven broken. Complete seeds are avoid to oblong in shape covered with a smooth seed coat. They are 3.2 to 3.7 mm long and 2.5 to 2.6 mm broad. The hilum is lateral in position, oblong to oval in shape.

Anatomy (Fig. 69)

Palisade cells are rather short varying in height from 42 to 75 μm. They are bulbous at the inner end and narrow towards the outer end as in lot A.

LOT C

Morphology (Fig. 70)

This lot comprises of two almost complete and one broken seed. The seeds are very much compressed, oblong to oval in shape, 3.3 to 5.1 mm long and 2.5 to 2.9 mm broad. The seed surface is smooth. Hilum is lateral in position.

Anatomy (Fig. 71)

Palisade cells are short, 45 to 82.5 μm in
height, bulbous at the inner end and narrow towards the outer end. The bulbous part of the cells has somewhat dense contents.

LOT D

Morphology (Fig. 72,73)

Nine seeds of which seven are complete belong to this lot. The seeds are large, round to ovoid in shape, 4.5 to 8.5 mm in diameter. The seed surface is smooth and thin. The position of the hilum is clear and lies in level with the seed surface. It is oblong in shape and 1.6 to 2.8 mm in size.

Anatomy (Fig. 74)

The palisade cells are rather long varying from 67.5 to 83 μm in height. The inner end of the cells is corrugated and broad while the outer end is narrow and smooth.

LOT E

Morphology (Fig. 75,76)

Six seeds of which three are complete are placed in this lot. The seeds are flat and circular, 3-4 mm in diameter and 1.6 - 2.0 mm in thickness. The
surface of the seeds is smooth. The hilum is lateral, 1 mm in size, oval and in line with the seed surface.

Anatomy (Fig. 77)

The palisade cells are short varying in height from 25-34 µm. They are bulbous at the inner end and narrow towards the cuticular end.

Identification

Corner (1951) has emphasized that seed coat having outer palisade and hour-glass cells below it is "apparently identifiable as Leguminous". The present materials, on maceration, have revealed palisade cells typical of pulses (Buth, 1970, Chowdhury and Buth 1970), therefore, belong to family Leguminosae.

Now, Leguminosae family is divided into three sub-families viz. Mimosoidae, Caeselpinoidae and Papilionoidae (Corner 1951). Musil (1963) has pointed out that Papilionaceeous seeds can be distinguished from those of the other two sub-families as the hilum is more conspicuous in the former. The seeds of all the above described lots
show conspicuous presence of hilum and therefore, belong to subfamily Papilionoidea.

Chowdhury and Buth (1970) have made a comprehensive study of the seed coat anatomy of Indian pulses and provided a key based on size, shape and surface of seeds; size and position of hilum; shape and height of palisade cells and the characteristic structure of cuticle. The palisade cells have been divided into three types: Type I, Type II and Type III. The present material shows palisade cells Type II in the lots A, B, C and E and Type III in lot D.

Palisade cells type II lead to four species namely Lens culinaris Medic; Phaseolus aconitifolius Jacq., P. mungo L. and P. aureus Roxb. The seeds of lot A show a conspicuously raised border partially covering the hilum which is characteristic of Phaseolus mungo. Those of lot B are slightly smaller in size than those of lot A and are referred to P. aureus. Those of lot C are compressed and show resemblance with P. aconitifolius. Those of lot E are flat and circular and resemble Lens
culinaris. This is further confirmed by comparing the morpho-anatomical characteristics with those of extant pulses (Fig. 78).

Palisade cells Type III lead to Cicer arietinum L. Lathyrus sativus L, Vicia faba, L. and Pisum sativum L. Comparing the shape, size and other morpho-anatomical characters with the extant pulses (Fig. 78) it is seen that the seeds of lot D resemble Pisum sativum.

In view of this the pulses are identified as follows:

Lot A  Phaseolus mungo L.
Lot B  P. aureus Roxb.
Lot C  P. aconitifolius Jacq.
Lot D  Pisum sativum L.
Lot B  Lens culinaris Medic Syn. L. esculenta Moench.

Phasewise distribution

The pulses as recorded in various phases of the site are presented in text Fig.1.
Text Fig. 1: Phasewise distribution of Pulses.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Species</th>
<th>No. of seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>Phaseolus aureus</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Lens culinaris</td>
<td>2</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>Phaseolus mungo</td>
<td>4 (2)</td>
</tr>
<tr>
<td></td>
<td>P. aureus</td>
<td>5 (5)</td>
</tr>
<tr>
<td></td>
<td>P. aconitifolius</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Pisum sativum</td>
<td>4 (1)</td>
</tr>
<tr>
<td></td>
<td>Lens culinaris</td>
<td>1</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>Phaseolus mungo</td>
<td>2 (1)</td>
</tr>
<tr>
<td></td>
<td>P. aureus</td>
<td>2 (1)</td>
</tr>
<tr>
<td>IV Kushan</td>
<td>Phaseolus mungo</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>P. aureus</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>P. aconitifolius</td>
<td>2 (1)</td>
</tr>
<tr>
<td></td>
<td>Pisum sativum</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Lens culinaris</td>
<td>4</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>Pisum sativum</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Lens culinaris</td>
<td>1</td>
</tr>
</tbody>
</table>

Numbers in parenthesis indicate broken seeds.
IV. WEED SEEDS

More than eighty seeds recovered from various phases of the site have been found to belong to plants classified as weeds (Alexander, 1969). Their macroscopic observation revealed variability in them and have, therefore, been described under different lots.

LOT A

Morphology (Fig. 79, 80, 81)

A total of 19 seeds comprise this lot. The seeds are ovoid - truncate with a ridge on one side and a broad flatish scar at the base, 2 to 3 mm long and 1.5 to 2 mm broad. The surface of the seeds is papillate.

Scanning electron micrograph shows that the seed surface is papillate provided with 'spines'. The papillae are 70 to 150 μm long and 37 to 50 μm broad. The surface of the seed as well as that of 'spines' is roughened with tubercles.

Identification

On comparison with the extant weed seeds it becomes clear that the seeds under investigation
belong to nutlets of *Lithospermum arvense* L.

**LOT B**

**Morphology** (Fig. 82, 83, 84, 85).

Seeds grouped in this lot are 44 in number. These are globose to remiform and hollow centered 1.5 to 2.5 mm in diameter. Some of them are bristly.

Scanning electron micrographs of the surface revealed two types of seeds. Some have a smooth surface (Fig. 83) while others are papillate (Fig. 84, 85). Those with papillae could further be divided into two types: those having scarce papillae (Fig. 84) and others having dense papillae (Fig. 85).

**Identification**

Remiform shape and hollow centered seeds clearly lead to *Galium* spp. An examination of the extant species of *Galium* growing in Kashmir and comparison of ancient seeds with them revealed that the seeds belong to three different species as follows:

- Seeds with smooth surface - *G. tricorne* With
- Seeds with scarce papillae on the surface - *G. aspernoides* Edgew.
Seeds with dense - G. aparine L. papillae on the surface

LOT C

A total of 13 seeds of which 6 are complete and 7 are broken are characterized by the presence of a clear position of hilum on the seed surface and thus belong to subfamily Papilionoidae of family Leguminosae (Musil 1963). On visual and macroscopic observations they have been divided into three groups C₁, C₂ and C₃.

Lot C₁

Morphology (Fig. 86,87)

The seeds are 10 in number of which 3 are complete and 7 broken. They are small, globose to rounded in shape, 2-3 mm in diameter. The position of the hilum is clear on the seed surface. The surface of the seed is smooth.

Identification

On comparison with the extant leguminous seeds the unknown show close resemblance with Vicia spp. and Lathyrus spp. As Martin and
Barkley (1961) have pointed out, these two genera cannot be distinguished satisfactorily by their seeds. Probably they belong to Vicia sp.

Lot C₂

Morphology (Fig. 88)

Two seeds are half moon shaped with rounded ends. They are compressed falcate 2.5-3 mm long. The position of the hilum is clear on the lateral side.

Identification

On comparison with the extant weed seeds the unknown show closest resemblance with Medicago sp. in respect to shape, size and morphological features.

Lot C₂

Morphology (Fig. 88)

One seed is compressed ovoid with small circular hilum on an edge near one end. It is truncate at the broader end, 2 mm long and 1 mm broad.

Identification

On comparison with the extant seeds it show
maximum resemblance with *Melilotus albus* Desf.

**Phasewise Distribution**

Phasewise distribution of weed seeds is given in Text Fig. 2.

**Text Fig. 2: Phasewise distribution of weed seeds.**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Species</th>
<th>No. of seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>II. N.B.P.</td>
<td><em>Vicia/Lathyrus</em> sp.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><em>Lithospermum arvense</em></td>
<td>6</td>
</tr>
<tr>
<td>III. Indo - Greek</td>
<td><em>Vicia / Lathyrus</em> sp.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><em>Lithospermum arvense</em></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Unidentified leguminous seed</td>
<td>1</td>
</tr>
<tr>
<td>IV Kushan</td>
<td><em>Galium tricorne</em></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td><em>G. asperuloides</em></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td><em>G. aparine</em></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td><em>Lithospermum arvense</em></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td><em>Medicago</em> sp.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><em>Vicia/Lathyrus</em> sp.</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Unidentified</td>
<td>2</td>
</tr>
<tr>
<td>V Hindu Rule</td>
<td><em>Galium tricorne</em></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><em>Lithospermum arvense</em></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><em>Melilotus albus</em></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unidentified</td>
<td>1</td>
</tr>
</tbody>
</table>
V. ENDOCARPS

More than 80 small and large pieces of carbonized endocarp pieces belonging to various fruit trees were recovered from different levels of the site. On visual and macroscopic observations they have been grouped into three lots viz. A, B and C.

LOT A

**Morphology** (Fig. 89, 90)

This lot comprises of 17 pieces. None of them is large enough to suggest the shape of the complete endocarp. The pieces are 5 to 18 mm long. The outer surface of the endocarps is roughened by reticulate markings formed by canal like structures or grooves and is irregularly pitted. The inner surface is rough due to raised projections.

**Anatomy** (Fig. 91, 92)

The sclereids are of two types. Majority of them are branched, somewhat star shaped with thick and wavy walls - the Asterosclereids. Others are small somewhat isodiametric with smooth walls -
the Brachysclerids. The sclereids vary from 50 to 102µm in diameter.

**Identification**

Though the shape of the endocarp pieces is not clear yet the very look at their outer surface and other morpho-anatomical features, as provided above, lead to *Juglans* spp. Two species of *Juglans* namely - *J. nigra* L. and *J. regia* L. are found in Kashmir (Stewart 1972). *J. nigra* has deeply ridged stones whereas in *J. regia* stones are shallow ridged and reticulate. Therefore, the present material belongs to *Juglans regia* L.

**LOT B**

**Morphology** (Fig. 93, 94)

Endocarp pieces in this lot are 8 in number. The endocarps are globose to rounded in shape, 3 to 8 mm in diameter. The sides of the endocarp are raised. The outer surface shows finely reticulate markings with wavy margins. The inner surface is smooth. The endocarp is somewhat papery.

**Anatomy** (Fig.95,96)

The sclereids are small, roughly isodiametric -
Brachysclereids, 10 to 62 μm in diameter with thick walls which are wavy in some cases. The lumen is narrow and somewhat star shaped.

**Identification**

The globose shape, papery nature of the stone and finely reticulate markings with wavy margins on the outer surface are characteristic of *Celtis* sp. This is further confirmed by the shape and size of the sclereids.

Two species of *Celtis* are common in the valley: *Celtis australis* L. Syn. *C. alpina* Royle and *C. eriocarpa* Donn Syn. *C. australis* var. *eriocarpa* Donn (Stewart 1972). On comparison with the two species, the present material closely resembles *Celtis australis* L. Syn. *C. alpina* Royle.

**LOT C**

The number of endocarp pieces within the lot is about 65. Based on morphological characters this lot could be further divided into three groups *C₁*, *C₂* and *C₃*.

**Lot C₁**

**Morphology** (Fig. 97,98)

This group is characterized by the presence
of small ripples on the outer surface. These are 22 in number varying in length from 2 to 17 mm. Some pieces represent nearly half of the full stone and depict the ovoid shape of the complete endocarp. The inner surface is smooth.

**Anatomy (Fig. 99, 100)**

Two types of sclereids have been retrieved after maceration. Most of them are small isodiametric, 50 to 62 μm in diameter - Brachysclereids. Others are elongate, columnar 112-165 μm long and 15 to 60 μm wide - Macrosclereids. The walls of the sclereids are thick and smooth and lumen is narrow.

**Lot C2**

**Morphology (Fig. 101, 102)**

This group is characterized by smooth outer surface which is devoid of any ripples, grooves or pits. These are 36 in number 2 to 10 mm long. None of them is large enough to depict the shape of the entire endocarp. The inner surface is smooth.

**Anatomy (Fig. 103, 104)**

Majority of the sclereids are long, columnar
and elongate - Macrosclereids, 102 to 162 \( \mu m \) long and 17 to 55 \( \mu m \) wide. Some of the sclereids have pitted walls. The lumen is narrow.

Lot C_3

**Morphology** (Fig. 105)

The characteristic feature of this group is the presence of deep ridges on the outer surface. The total number of such endocarp pieces is 7. Though none is complete yet some pieces are fairly large, upto 31 mm long, and ovoid in shape. Others are small 2 to 5 mm in length. The stones are somewhat compressed but very thick. The inner surface is smooth.

**Anatomy** (Fig. 106, 107)

The sclereids are of two types. Some are large, elongate and columnar 125 to 187 \( \mu m \) in length and 8 to 65 \( \mu m \) in width - Macrosclereids, whereas others are roughly isodiametric 48—87 \( \mu m \) in diameter - Brachysclereids. The walls are medium to thick and smooth. The lumen is narrow.
Identification

The shape and morphological features resemble those of Prunus spp. Attempt has been made to compare the morpho-anatomical characteristics of the three types with the extant endocarps. The morpho-anatomical characteristics of extant species are presented in Table 12. A comparison shows that the endocarps of group C1 characterized by the shallow sculptured outer surface belong to Prunus armeniaca L. those of group C2 characterized by smooth outer surface to Prunus cerasus L. and those of group C3 characterized by deep ridged outer surface to Prunus persica (L.) Stokes. The identification is further confirmed by the shape and type of sclereids as shown in Table 13.

Phasewise Distribution

The distribution of various species of endocarps as recorded in different phases of the site is given in Text Fig.3.
Table 12: Morpho-anatomical characteristics of extant endocarps.

<table>
<thead>
<tr>
<th>Botanical species</th>
<th>Shape</th>
<th>Size length (mm)</th>
<th>MORPHOLOGY</th>
<th>Inner surface</th>
<th>ANATOMY (SCLEREIDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Outer surface</td>
<td></td>
<td>Type/s</td>
</tr>
<tr>
<td><em>Prunus cerasus</em></td>
<td>Ovoid to round</td>
<td>17-28</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Macrosclereids</td>
</tr>
<tr>
<td><em>P. armeniaca</em></td>
<td>Ovoid</td>
<td>18-20</td>
<td>Shallow</td>
<td>Smooth</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>sculptured</td>
<td></td>
<td>1. Majority Brachysclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Some Macrosclereids or Osteosclereids</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>Ovoid compressed</td>
<td>25-45</td>
<td>Deep</td>
<td>Smooth</td>
<td>1. Macrosclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ridged</td>
<td></td>
<td>2. Brachysclereids</td>
</tr>
<tr>
<td><em>P. amygdalus</em></td>
<td>Ovoid to oval</td>
<td>30-40</td>
<td>Smooth</td>
<td>Smooth</td>
<td>1. Macrosclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and pitted.</td>
<td></td>
<td>2. Brachysclereids</td>
</tr>
<tr>
<td><em>P. domestica</em></td>
<td>Ovoid</td>
<td>9-12</td>
<td>Smooth</td>
<td>Smooth</td>
<td>1. Macrosclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Brachysclereids</td>
</tr>
<tr>
<td><em>Juglans regia</em></td>
<td>Spherical</td>
<td>35-45</td>
<td>Reticulate</td>
<td>Raised</td>
<td>Asterosclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>markings</td>
<td>projections</td>
<td></td>
</tr>
<tr>
<td><em>Celtis australis</em></td>
<td>Globose to round</td>
<td>8-12</td>
<td>With wavy</td>
<td>Smooth</td>
<td>Brachysclereids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>markings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 13: Morpho-anatomical characteristics of archaeological endocarps

<table>
<thead>
<tr>
<th>Botanical species</th>
<th>MORPHOLOGY</th>
<th>ANATOMY (SCLERIDES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shape</td>
<td>Outer surface</td>
</tr>
<tr>
<td></td>
<td>length</td>
<td>Inner surface</td>
</tr>
<tr>
<td></td>
<td>(mm)</td>
<td>Type(s)</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td>Diameter (µm)</td>
</tr>
<tr>
<td></td>
<td>length</td>
<td>Breadth (µm)</td>
</tr>
<tr>
<td>Lot A (Zelkova serrata)</td>
<td>5-18</td>
<td>Reticulate</td>
</tr>
<tr>
<td>Lot B (Celtis australis)</td>
<td>3-8</td>
<td>Reticulate</td>
</tr>
<tr>
<td>Lot C1 (P. amemica)</td>
<td>Globe to round</td>
<td>Smooth</td>
</tr>
<tr>
<td>Lot C2 (P. persica)</td>
<td>Ovoid</td>
<td>112-165</td>
</tr>
<tr>
<td>Lot C3 (P. persica)</td>
<td>Ovoid</td>
<td>125-187</td>
</tr>
</tbody>
</table>

*Macro-sclereids:*
- Deeply ridged
- 2-5 pieces

*Brachysclereids:*
- Ridges present
- 2-17 pieces
- Smooth

*Stones:*
- With raised projections
- 2-17 pieces
- Ridges present
- 2-17 pieces
- Smooth

*Macro-sclereids:*
- 102-162
- Smooth

*Brachysclereids:*
- 125-175
- Smooth
Text Fig. 3: Phase wise distribution of endocarps.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Species</th>
<th>No. of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>Prunus armeniaca</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Celtis australis</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Juglans regia</td>
<td>2</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>Prunus armeniaca</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Prunus cerasus</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Juglans regia</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Celtis australis</td>
<td>4</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>Prunus armeniaca</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Prunus persica</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Juglans regia</td>
<td>3</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>Prunus armeniaca</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Prunus persica</td>
<td>1</td>
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<tr>
<td></td>
<td>Juglans regia</td>
<td>2</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>Prunus armeniaca</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Prunus persica</td>
<td>4</td>
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<tr>
<td></td>
<td>Celtis australis</td>
<td>1</td>
</tr>
</tbody>
</table>
VI) WOODS

A large number of charcoals were also recovered from all the phases. Various species identified from different phases are described below:

Phase I : PRE-N.B.P.

Wood I

Material

Small piece of fragile charred wood.

Microscopic Anatomy (Fig. 108, 109)

The wood is non-porous. Growth rings are distinct. The wood is entirely made up of tracheids aligned in definite radial rows. Early wood tracheids are thin walled with large lumen (upto 25 μm) compared to late wood tracheids which are thick walled with small lumen (8 to 12 μm). Tracheids are squarish to polygonal in shape. Vertical resin canals present mostly confined to the central part of the ring. Epithelial cells surrounding the resin canals are thin walled. Vertical parenchyma absent.

The pits on the radial walls are large, bordered, in single rows. Ray tracheids are neither
interspersed nor dentate. The cross field pits are large window like, one to two in each cross field.

Identification

The main anatomical features of the wood are a) non-porous wood; b) presence of vertical resin canals; c) absence of vertical parenchyma cells; d) single row of bordered pits on radial walls and e) window like cross field pitting. This set of anatomical characters leads to five genera of Gymnosperms i.e. Pinus, Picea, Larix, Cedrus and Pseudotsuga (Brown 1925, Phillips 1948, Brown et al 1949, Jane 1956, Ghouse 1969). Pseudotsuga, a native of north America, and Picea, Larix and Cedrus which have resin canals with thick walled epithelial cells and bear piceoid, cupressoid and taxodioid cross field pits respectively can be excluded. The present material is, therefore, placed under genus Pinus.

A comparison of the anatomical features of Indian species of Pinus further indicates that the unknown belongs to Pinus wallichiana Jack Syn. P. excelsa Wall. Owing to the presence of smooth walled ray tracheids and window like cross field pits (Ghouse 1969).
Wood II

Material

Small pieces of fragile charred wood.

Microscopic Anatomy (Fig. 110, 111,112,113)

The wood is non-porous. Growth rings are distinct. Tracheids are arranged in definite radial rows. Early wood tracheids are thin walled, having larger lumen (12 \( \mu \text{m} \) to 20 \( \mu \text{m} \) in diameter) compared to late wood tracheids which have thick walls and small lumen (10 \( \mu \text{m} \) to 15 \( \mu \text{m} \) in diameter). Tracheids are squarish to somewhat rectangular in shape. Vertical resin canals present but scanty, about 75 \( \mu \text{m} \) in diameter. Epithelial cells surrounding the resin canals are crushed and appear to be moderately thick walled. Vertical parenchyma is absent.

Rays in cross section appear to be uniseriate. Cross field areas are quite visible in the radial sections but they do not reveal the cross field pits. Cross field pitting, as revealed after maceration, is of piceoid type.

Identification

Important anatomical characters are a) presence
of resin canals with moderately thick walled epithelial cells and b) piceioioid cross field pits. These characters suggest that the wood belongs to *Picea* sp. (Ghouse 1969).

In India *Picea* is represented by two indigenous species namely *P. smithiana* Boiss and *P. spinulosa* (Griff.) Henry (Ghouse 1969). On comparison with the extant wood, the unknown from Semthan closely matches *Picea smithiana* Boiss.

**Wood III**

**Material**

Well preserved small pieces of charred wood.

**Microscopic Anatomy** (Fig. 114, 115)

The wood is non-porous. Growth rings are not visible. Bulk of the wood is made up of tracheids which are aligned in definite radial rows. Tracheids are squarish to polygonal in shape, moderately thick walled with fairly wide lumen (20 to 35 μm in diameter). Resin canals are lacking but traumatic canals are present, about 70 μm in tangential diameter.

Rays in cross section appear to be uniseriate.
It has not been possible to locate any pit on the tangential wall. The radial walls of the tracheids have large and scalloped bordered pits.

**Identification**

The main anatomical features are a) non-porous wood (b) absence of resin canals (c) presence of traumatic canals and (d) scalloped bordered pits. According to the classification of non-porous woods, this wood falls under the genera *Pinus*, *Picea*, *Larix* and *Cedrus*. The presence of traumatic canals and scalloped bordered pits on the radial walls of vertical tracheids lead one to discard all the genera except *Cedrus* (Brown 1925, Pearson and Brown 1932, Phillips 1948). In the Indian subcontinent genus *Cedrus* is represented by *C. deodara*. Comparative study of the microscopic anatomy of this wood and the archaeological wood showed complete agreement in all respects. The wood is, therefore, placed under *Cedrus deodara* Don.

**Wood IV**

**Material**

Small pieces of charcoal, well preserved.
Microscopic Anatomy (Fig. 116, 117)

The wood is semi-ring porous to diffuse porous. Growth rings are distinct. Vessels are ovoid to round usually solitary and occasionally in multiples of two and three, 50 to 80 µm in tangential diameter. Tyloses occasionally present.

Parenchyma apotracheal diffuse and paratracheal. Fibres thin to moderately thick walled, oval to angular, 10 to 15 µm in diameter.

Rays unstoried, 1-3 seriate, homogenous as well as heterogenous upto 14 cells and 25-100 µm in height and 5 to 15 µm in width.

Identification

The main anatomical characters are a) semi-ring to diffuse porosity b) apotracheal diffuse and paratracheal parenchyma c) occasional presence of tyloses and d) homogenous to heterogenous, 1-3 seriate rays. When compared with the extant woods growing in Kashmir, the wood shows close affinity towards *Juglans* sp. of family *Juglandaceae*. Two species of the genus are met with in Kashmir valley namely *J. regia* L. and *J. nigra* L. However, the wood did not match exactly with any one of them,
hence it is placed under Juglans sp.

Wood V

Material

Small well preserved pieces of charcoal.

Microscopic Anatomy (Fig. 118, 119).

The wood is semi-ring to ring porous. Growth rings are not distinct. Early wood vessels are comparatively larger than the late wood vessels. Vessels occur usually singly and rarely in groups of 2 to 4. Vessels are rounded in shape having tangential diameter of 60 μm to 130 μm. Tyloses occasionally present. Intervessel pits are oval to orbicular.

Parenchyma paratracheal, scanty to vasicentric. Fibres angular in cross section, moderately thick walled, 10 to 20 μm in diameter.

Rays narrow to moderately wide and widely spaced; unstoried, 1 to 6 seriate, heterocellular, 4 to 20 cells and 100 to 325 μm in height and upto 30 μm in width.
Identification

The main anatomical features are a) ring porosity b) occasional presence of tyloses c) paratracheal parenchyma and d) 1 to 6 seriate heterogenous rays. These features bring the wood very close to *Celtis* sp. of family Ulmaceae. When compared with the extant species of this genus, the unknown shows closest resemblance with *Celtis australis* L.

Wood VI

Material

Small pieces of charcoal.

Microscopic Anatomy (Fig. 120, 121)

The wood is ring porous. Vessels medium to large, in pairs or in multiples of upto four cells. The early wood vessels form more or less continuous rows in the form of radial strings. Vessels are 75 μm to 150 μm in tangential diameter. Intervessel pits moderately large, oval to orbicular.

Parenchyma sparse, metatracheal and diffuse. Fibres thin to moderately thick walled, oval to angular and 5-10 μm in diameter.

Rays unstoried, 2-5 seriate, homogenous to heterogenous.
**Identification**

The above set of anatomical characters and comparison with extant woods indicates that the wood belongs to *Quercus* sp.I of family Fagaceae.

**Wood VII**

**Material**

Some very small fragile pieces of charcoal.

**Microscopic Anatomy (Fig. 122,123)**

The wood is diffuse porous. Growth rings are not clearly defined. Vessels are rounded to oval, solitary or in pairs, moderately thick walled having tangential diameter of 30 µm to 50 µm. The largest vessels have tangential diameter upto 160 µm.

Parenchyma paratracheal, fibres abundant, oblong to angular in cross section, thick walled, 5 µm to 15 µm in diameter.

Rays unstoried, homogenous to heterogenous, 2-8 seriate, 6-22 cells and 120 to 260 µm in height and upto 30 µm in width.
Identification

The main anatomical characteristics include:
a) diffuse porosity, b) paratracheal parenchyma
and c) homogenous to heterogenous, 2-8 seriate rays.
These anatomical characters clearly indicate that
the wood belongs to some member of family
Leguminosae.

As Senn (1943) has remarked that comparative
study of wood anatomy produced "no sharp lines
separating various sub families and genera of
Leguminosae", therefore, the material could not
be assigned to any particular member. However, on
comparison the unknown shows characteristics
resembling Acacia sp. and Robinia sp. The
possibility of the wood being Robinia is remote,
as its introduction into Kashmir is historical
being introduced recently (Vishnu Mittre and
Sharma 1966). Hence the wood might belong to
Acacia sp.

Phase II : N.B.P.

Wood I

Material

Small pieces of well preserved charred
wood.
Microscopic Anatomy (Fig. 124, 125, 126)

The wood is non-porous. Growth rings are distinct due to demarcation between early wood and late wood tracheids. The early wood tracheids have thinner walls and larger lumen (20 µm to 30 µm in diameter) compared to late wood tracheids which have thicker walls and smaller lumen (10 µm to 18 µm in diameter). Tracheids are arranged in definite radial rows and are squarish to polygonal in shape.

Vertical resin canals are present and have a tendency to occur in the region transitional between early and late wood. The vertical resin canals are mostly circular, 120 µm to 170 µm in diameter. The epithelial cells surrounding the resin canals are crushed and have thin walls. Vertical parenchyma is lacking.

In cross section the rays appear to be uniseriate. Radial walls of the tracheids are pitted. Ray tracheids possess wavy walls. Cross field pits are large window like 1 to 2 µm in cross field.
Identification

The main anatomical features i.e. a) presence of resin canals with thin walled epithelial cells and b) large window like cross field pits, clearly indicate that the unknown wood belongs to *Pinus wallichiana* Jack.

Wood II

Material

Pieces of well preserved charcoal.

Microscopic Anatomy (Fig. 127, 128)

The wood is non-porous. Growth rings are distinct. Tracheids are squarish to polygonal in shape, aligned in definite radial rows. The last 4 to 5 rows of the late wood are tangentially flattened. Transition from early to late wood is gradual. The early wood tracheids have large lumen (20 μm to 30 μm) and the late wood tracheids have a diameter of 10 μm to 25 μm. Vertical parenchyma is lacking. Resin and traumatic canals are lacking.

The rays are uniseriate, 5 to 10 cells and 60 μm to 90 μm in height. Spiral thickenings are
seen on the radial walls of the tracheids. Cross field pitting of taxodioid type.

**Identification**

The main anatomical features of the wood are: a) non-porosity; b) absence of resin canals and c) presence of uniseriate rays. These characters lead to Tsuga, Cupressus, Cedrus and Abies. Absence of resin as well as traumatic canals, vertical parenchyma and scalloped tori eliminates Tsuga, Cupressus and Cedrus. Thus we are left with Abies sp. This is further confirmed by the presence of taxodioid cross field pitting. When the structure of the wood is matched with that of extant Abies pindrow it shows full agreement in all the respects. In view of this the wood is placed under Abies pindrow Royle.

**Wood III**

**Material**

Well preserved small pieces of charcoal.

**Microscopic Anatomy (Fig. 129, 130, 131)**

The wood is non-porous. Growth rings are distinct. Tracheids are arranged in radial rows.
Early wood tracheids are polygonal in shape with tangential diameter of 30 μm to 55 μm and the late wood tracheids are comparatively thick walled and tangentially flattened towards the outer margin of the growth ring with a tangential diameter of 15 μm to 30 μm. Transition from early to late wood slightly abrupt. Vertical parenchyma is absent. Resin canals absent.

In cross section the rays appear to be uniseriate. The radial walls of the tracheids possess large, scalloped bordered pits. The walls of the ray tracheids are wavy. Cross field pitting is of taxodioid type.

Identification

The above set of anatomical characters clearly indicate that the wood belongs to Cedrus deodara Don.

Wood IV

Material

Small pieces of fragile charcoal.

Microscopic Anatomy (Fig. 132, 133, 134)

The wood is ring-porous. Vessels very large in the spring wood, 90 μm to 180 μm in tangential
diameter and summer wood vessels are smaller 40 µm to 60 µm in diameter. Vessels solitary, visible to the naked eye, thin walled and rounded in shape. Intervessel pitting orbicular to elliptical, 3–6 µm in diameter vessel segments annular.

Parenchyma paratracheal as well as metatracheal diffuse. Paratracheal parenchyma sparse, restricted to few cells, not forming a sheath. Fibres thick walled, angular to rounded, 10 to 15 µm in diameter.

Rays are of two types: uniseriate rays and broad aggregate rays of oak type. Broad rays 8 to 10 seriate and 75 µm to 100 µm in width. Rays unstoried, homogenous.

**Identification**

The main anatomical features are a) ring porous wood; b) large vessels and c) two types of rays uniseriate and aggregate rays of oak type. These characters undoubtedly reveal that the wood belong to *Quercus* sp. II of family Fagaceae.

**Wood V Material**

Well preserved pieces of charcoal.
Microscopic Anatomy (Fig. 135, 136)

The wood is ring porous. Early wood vessels are arranged in more or less continuous, wavy, concentric bands. Vessels numerous, occurring either solitary or usually in multiples of 2 to 5, ovoid to round, 40 µm to 120 µm in diameter. Inter-vessel pitting, ovoid, 2 to 10 µm in diameter.

Parenchyma paratracheal, scantly as well as vasicentric. Fibres numerous, thin to moderately thick walled, oval in cross section, 8 µm to 13 µm in diameter.

Rays wide, unstoried, 3-8 seriate, essentially homogenous, upto 600 µm and 50 cells in height and 60 µm and 10 cells in width.

Identification

The important anatomical features are a) ring porous structure b) vessels in continuous wavy bands and c) multiseriate, essentially homogenous rays.

The well known ring porous woods of north India are Celtis sp. Fraxinus sp. Morus sp. Prunus sp. Tectona grandis, Quercus sp. and Ulmus sp. (Chowdhury 1964). The arrangement of vessels in
wavy concentric bands is characteristic of *Ulmus* sp. (Brown et al 1949, Panshin et al 1964). When the unknown wood is compared with the extant wood of *Ulmus wallichiana*, it shows complete agreement in all the respects. The wood is, therefore, placed under *Ulmus wallichiana* Planch.

**Wood VI**

**Material**

Well preserved small pieces of charred wood.

**Microscopic Anatomy** (Fig.137,138)

The wood is semi-ring to diffuse porous. Growth rings not clear. Vessels medium, usually in multiples of 2 to 4 and occasionally solitary, oval to spherical, moderately thick walled, 23 μm to 100 μm in diameter. Intervessel pits small, oval.

Parenchyma sparse, restricted to a few cells. Fibres oval to rounded, thin to moderately thick walled, 3 μm to 5 μm in diameter.

Rays very fine, unstoried, uniseriate, essentially homogenous 2 to 6 cells and upto 150 μm in height and 10 to 15 μm in width.
Identification

The main anatomical features are a) semi-ring to diffuse porous structure b) sparse parenchyma and c) essentially homogenous uniseriate rays. This set of characters leads to two genera viz. Salix and Populus of family Salicaceae. In Salix the rays are essentially heterogenous (Jane 1956), therefore, the present material is placed under Populus sp.

Wood VII

Material

One large and some small pieces of fragile charcoal.

Microscopic Anatomy (Fig. 139, 140)

The wood is diffuse porous. Growth rings not distinct. Vessels solitary or in pairs, oval, thin to moderately thick walled, 25 μm to 60 μm in tangential diameter. Intervessel pits small, orbicular to broad oval.

Parenchyma matatracheal diffuse and paratracheal. Paratracheal parenchyma not forming a sheath. Fibres thin to moderately thick walled,
10 to 25 μm in diameter.

Rays unstoried, of two types - uniseriate and multi (2-6) seriate, upto 22 cells and 250 μm in height and 75 μm in width.

Identification

The important anatomical features are:

a) diffuse porous nature, b) two types of rays, uni as well as multiseriate and c) nature of parenchyma. These characters bring the material very close to *Betula* sp. of family Betulaceae. The woods of different species of *Betula* cannot be separated with certainty on the basis of gross or minute wood anatomy (Brown et al 1949). However, two species *B. utilis* and *B. alnoides* are found in Kashmir. Comparative study revealed that the present material shows close resemblance with *B. Utilis* Don.

Wood VIII

Material

Small pieces of fragile as well as well preserved charcoal.
Microscopic Anatomy (Fig. 141, 142)

The wood is ring porous. Vessels large, usually solitary and occasionally in pairs. Spring wood vessels larger than the summer wood vessels, rounded to oval, 30 µm to 75 µm in diameter.

Parenchyma paratracheal forming a sheath. Fibres numerous, thin to fairly thick walled, angular to rounded in shape, 12 µm to 17 µm in diameter.

Rays normally spaced, unstoried 1 to 4 -seriate homogenous, upto 20 cells and 265 µm in height and 50 to 60 µm in width.

Identification

Main anatomical features are: a) ring porous structure, b) paratracheal parenchyma forming a sheath and c) multiseriate homogenous rays. When compared with the extant ring porous woods, the present material shows closest resemblance with Fraxinus excelsior L. of family Oleaceae.

Wood IX

Material

Several small pieces of charcoal.
**Microscopic Anatomy (Fig. 143, 144)**

The wood is ring-porous. Vessels few, rounded to polygonal in shape, solitary or in groups of 2 to 4 having tangential diameter of 12 to 40 μm.

Parenchyma not distinct. Fibre content very high; fibre elements in cross section squarish, polygonal to rounded, thick walled, 6-10 μm in diameter.

Rays unstoried, 1 to 4 seriate, up to 400 μm in height, essentially homogenous.

**Identification**

The important anatomical features are a) ring porosity and less vessels b) scarcity of parenchyma and c) very high fibre content. Attempt has been made to compare the structure of the unknown wood with the extant ring porous woods. This revealed that the wood matches *Prunus* sp. of family Rosaceae the most.

**Wood X**

**Material**

Some pieces of well preserved charcoal.
Microscopic Anatomy (Fig. 145,146)

Wood is semi-ring to diffuse porous. Vessels large, oval to round, thin walled, solitary or in groups of two and three, with diameter of 45 µm to 125 µm. Tyloses occasionally present.

Parenchyma sparse, diffuse. Fibres thin to moderately thick walled, oval to oblong, 15 to 20 µm in diameter.

Rays normally spaced, unstoried, 2-5 seriate, heterogenous, up to 250 µm in height.

Identification

The main features are a) semi-ring to diffuse porous wood, b) occasional presence of tyloses c) sparse parenchyma and e) multiseriate heterogenous rays. These characters and comparison with extant woods brings the material very close to Ficus sp. of family Moraceae.

Phase III: INDO GREEK

Wood I

Material

Pieces of fragile charcoal.
Microscopic Anatomy (Fig. 147, 148)

The wood is non-porous. Bulk of the wood is made up of tracheids arranged in definite radial rows. Tracheids in cross section are squarish to polygonal having a diameter of 12 µm to 35 µm (average 22 µm). Vertical parenchyma cells are absent. Vertical resin canals present having diameter of 70 µm to 150 µm. Epithelial surrounding the resin canals are crushed and their walls are probably thick.

In tangential section are seen two types of rays: the uniseriate rays 2 to 10 cells and 60 µm to 260 µm in height; and the fusiform rays, which possess horizontal resin canals, up to 5 cells and 45 µm in width and 15 cells in height. The horizontal resin canals have a diameter of 60 µm to 90 µm. Tracheids have bordered pits on the tangential walls. Spiral thickenings on the radial walls of longitudinal tracheids are present. The cross field pits are of piceied type.

Identification

The main anatomical features are a) non-porous wood b) presence of vertical and horizontal resin
canals c) thick walled epithelial cells surrounding the resin d) piceioid type of cross field pitting. With the above set of anatomical features, the material shows affinity towards Pinus and Picea amongst the conifers. Presence of thick walled epithelial cells surrounding the resin canals and piceioid type of cross field pitting exclude Pinus. Hence the material belong to Picea sp. A comparison of the anatomy of the unknown with extant Picea smithiana shows conformity in all respects. Therefore, the material is identified as Picea smithiana Boiss.

Wood II

Material

Some large well preserved pieces of charred wood, apparently from a young twig.

Microscopic Anatomy (Fig. 149, 150)

The wood is diffuse-porous. Growth rings conspicuous. Vessels round to oval, usually solitary and occasionally in multiples of two with tangential diameter of 20 μm to 40 μm.

Parenchyma not distinct, apparently terminal in
position. Fibres thin to moderately thick walled, angular, 8 \( \mu \text{m} \) to 10 \( \mu \text{m} \) in diameter.

Rays fine, closely spaced, unstoried, uniseriate, occasionally bicelled in the middle, heterogenous as well as homogenous, upto 200 \( \mu \text{m} \) in height.

**Identification**

The main features are a) diffuse porous wood and b) uniseriate rays. Shape and position of vessels and parenchyma and uniseriate rays bring the material very close to *Salix* and *Populus* of family Salicaceae. In *Populus* rays are essentially homogenous. Therefore, the material belongs to *Salix* (Gane 1956)

**Wood III**

**Material**

Small pieces of well preserved charcoal.

**Microscopic Anatomy** (Fig. 151, 152)

The wood is diffuse porous. Growth rings not distinct. Vessels uniformly distributed, oval, in
pairs or in multiples of three to four, 30 \( \mu m \) to 40 \( \mu m \) in tangential diameter. Intervessel pits orbicular to angular.

Parenchyma sparse, scattered diffuse. Fibres oval to angular, thin to moderately thick walled, 4 \( \mu m \) to 10 \( \mu m \) in diameter.

Rays very fine, normally spaced, unstoried, homogenous, uniseriate, upto 8 cells and 200 \( \mu m \) in height.

Identification

Attempt has been made to compare the anatomy of the unknown with the extant woods growing in the valley. On comparison, it has been found that the unknown matches best with *Aesculus indica* Golebr, the only species of the genus found in the valley, of family Hippocastanaceae.

Wood IV

Material

Small pieces of well preserved charcoal.

Microscopic Anatomy (Fig. 153, 154)

The wood is diffuse porous. Growth rings not distinct. Vessels oval, rounded to angular,
usually solitary and occasionally in pairs, 20 \( \mu \text{m} \) to 40 \( \mu \text{m} \) in tangential diameter.

Parenchyma sparse, not well defined. Fibres thin to moderately thick walled, 8 \( \mu \text{m} \) to 16 \( \mu \text{m} \) in diameter.

Rays closely spaced, unstoried, uniseriate, occasionally bicelled in the middle, heterogenous.

**Identification**

Based on the above anatomical features the unknown matches *Salix*, *Populus*, *Aesculus* and *Viburnum* among the Angiosperms. When compared with the woods of various species of these genera, the present material shows very close likeness with *Viburnum* sp. of family Caprifoliaceae.

**Wood V**

**Material**

Pieces of fragile charcoal.

**Microscopic Anatomy** (Fig. 155, 156)

The wood is semi-ring to ring porous. Vessels large, either solitary or in groups of up to three, ovoid to round in shape, 40 \( \mu \text{m} \) to 80 \( \mu \text{m} \) in
tangential diameter, moderate to thick walled. The vessels are occluded with tyloses like depositions.

Parenchyma paratracheal, not forming a sheath. Fibres oval to angular, thick walled, 5 \( \mu m \) to 15 \( \mu m \) in diameter.

Rays normally spaced, homogenous to heterogenous unstoried, 2-6 seriate with a height of 200 \( \mu m \) to 350 \( \mu m \) and width of upto 50 \( \mu m \).

**Identification**

The above set of anatomical characters brings the material close to *Celtis*, *Ulmus*, *Fraxinus* and *Robinia*. Comparison of the structure with extant woods shows that the material belongs to *Ulmus* sp. of family Ulmaceae.

**Phase IV : KUSHAN**

**Wood I**

**Material**

Pieces of well preserved charcoal.

**Microscopic Anatomy (Fig. 157, 158, 159, 160)**

The wood is non-porous, growth rings are
indistinct. Bulk of the wood is made up of tracheids, aligned in definite rows. Tracheids are oval, rounded to polygonal in shape, 15 \( \mu \text{m} \) to 28 \( \mu \text{m} \) in diameter. Resin canals are absent.

Parenchyma cells are discernible in cross section. They are diffused in between the tracheids. Tracheids possess bordered pits on their tangential and radial walls. Ray tracheids are wanting.

Rays are uniseriate, 3 to 5 cells and 25 to 65 \( \mu \text{m} \) in height, 5 to 8 \( \mu \text{m} \) in width. Cross field pits are cupressoid.

**Identification**

The important anatomical features are a) absence of resin canals, b) presence of diffuse vertical parenchyma c) cupressoid cross field pits and d) absence of ray tracheids. Absence of resin canals leads to genera *Abies*, *Cupressus*, *Juniperus* and *Tsuga* (Brown 1925, Phillips 1948, Brown et al 1949, Panshin et al 1964, Ghouse 1969). Because of absence of ray tracheids *Tsuga* can be discarded. Taking into consideration the distribution of vertical parenchyma *Abies* and *Juniperus* can be excluded. In view of this the
material is placed under *Cupressus* sp. of family Cupressaceae.

**Wood II**

**Material**

Some pieces of well preserved charcoal.

**Microscopic Anatomy** (Fig. 161, 162)

The wood is semi-ring to diffuse porous. Growth rings distinct. Vessels are oval to rounded in shape, solitary or in multiples of two or three, 30 μm to 90 μm in diameter.

Parenchyma apotracheal diffuse. Fibres thin to medium thick walled, oval to angular, 10 μm to 20 μm in diameter.

Rays unstoried, closely spaced, 2-4 seriate heterogenous, 4 to 9 cells and 120 μm to 300 μm in height; upto 40 μm in width.

**Identification**

The anatomical features as above, indicate that the material belongs to *Juglans* sp. of family Juglandaceae. However, these characters could not be helpful in assigning a definite species.
Wood III

Material

Pieces of well preserved charcoal.

Microscopic Anatomy (Fig. 163, 164)

The wood is diffuse porous. Growth rings not distinct. Vessels oval to subglobular, usually in multiples of 2 to 5 or more, occasionally solitary, 23 μm to 35 μm in diameter. Intervessel pits oval to orbicular.

Parenchyma sparse in the form of diffuse cells. Fibers thin to medium thick walled, angular to squarish, 10 μm to 15 μm in diameter.

Rays unstoried, uniseriate occasionally bicelled, essentially homogenous, sometimes heterogenous, 6 to 15 cells and 100 μm to 300 μm in height; 10 μm to 15 μm in width.

Identification

The above set of anatomical characters undoubtedly leads to genus Populus of family Salicaceae.

Wood IV

Material

Some pieces of well preserved charcoal.
The wood is diffuse porous. Growth rings not conspicuous. Vessels small, numerous, moderately thick walled, rounded usually solitary or in pairs, 20 µm to 35 µm in tangential diameter, the largest one up to 60 µm in diameter.

Parenchyma metatracheal diffuse in the form of single celled bands. Fibres thick walled with small lumen, 8 to 12 µm in diameter.

Rays normally spaced, fine multi (2-4) - seriate, unstoried, heterocellular, 100 to 260 µm in height and up to 30 µm in width.

Identification

The main anatomical features are a) numerous rounded vessels, b) metatracheal parenchyma and c) multiseriate, heterocellular rays. When compared with the extant woods, the material shows closest resemblance with Parrotiopsis Jacquemontiana Done of family Hamamelidaceae.

Wood V

Material

Small pieces of charcoal.
The wood is diffuse porous. Growth rings not conspicuous. Vessels medium sized, numerous, moderately thick walled, solitary or in pairs, 20-35 μm in tangential diameter and oval to rounded in shape. Tyloses present. Intervessel pits oval to round, small, numerous.

Parenchyma apotracheal diffuse, scanty. Fibres thick walled, oval to orbicular with small lumen, 6 μm to 10 μm in diameter.

Rays unstoried, multi (2-3)-seriate heterogeneous, upto 8 cells and 125 μm in height, upto 40 μm in width.

Identification

The above set of anatomical features bring the unknown very close to Parrotiopsis and Crataegus. On comparison with the extant woods of these species it has been found that the unknown shows maximum resemblance with, and is, therefore, placed under, Crataegus oxyacantha L. of family Rosaceae.

Wood VI

Material

Small pieces of charcoal, fragile as well as well preserved.
Microscopic Anatomy (Fig. 169,170)

The wood is semi-ring to ring porous. Growth rings are distinct. Early wood vessels are comparatively larger than the late wood ones. Vessels in general rounded solitary, 70 µm to 150 µm (average 120 µm) in diameter. Occasionally tylosis is present. Intervessel pits small, oval to orbicular.

Parenchyma paratracheal, scanty to vesicentric. Fibres angular, thick walled, 8 µm to 12 µm in diameter.

Rays narrow to moderately wide, normally spaced, unstoried, 1-4 seriate and heterocellular, 110 µm to 320 µm and 4 to 15 cells in height and upto 38 µm in width.

Identification

On comparison with the extant semi-ring and ring porous wood§, the wood under investigation shows maximum resemblance with Celtis sp. Amongst the various species of Celtis, it very closely matches Celtis australis L.

Wood VII

Material

Small pieces of well preserved charcoal.
The wood is diffuse porous. Growth rings are not conspicuous. Vessels small, numerous, nearly uniform in size and quite evenly distributed, spherical to oval in shape, thin walled, occur singly or in multiples of two to several, 20 μm to 45 μm in diameter. Vessel members storied with other members as well as unstoried. Intervessel pits orbicular to angular.

Parenchyma apotracheal, scattered diffuse and scanty. Fibres angular, thick walled with small lumen, 5-15 μm in diameter.

Rays normally spaced, unstoried, homogenous, uniseriate with occasional biseration in some rays, upto 18 cells and 345 μm in height and 17 μm in width.

Identification

The wood under investigation shows resemblance with Populus sp., Salix sp., and Aesculus indica as is evident from the anatomical features. When compared with the extant woods of these species it shows maximum resemblance with Aesculus indica Colebr. of family Hippocastanaceae.
Wood VII

Material

Small piece of fragile charcoal.

Microscopic Anatomy (Fig. 173, 174)

The wood is semi-diffuse to diffuse porous. Growth rings are not distinct. Vessels numerous, solitary or in multiples of up to five, oval to spherical, 40 µm to 60 µm in tangential diameter. Intervessel pits small, oval to orbicular.

Parenchyma apotracheal diffuse, scanty. Fibres thin to moderately thick walled, 8 µm to 15 µm in diameter.

Rays normally spaced, unstoried, essentially homogenous, 2-4 seriate, up to 240 µm in height and 25 µm in width.

Identification

Main anatomical features are a) semi diffuse to diffuse porosity, b) small and numerous vessels, c) apotracheal diffuse parenchyma and d) 2-4 seriate unstoried homogenous rays. These characters when compared bring the wood close towards family Rosaceae. On comparison with various species within the family it shows maximum resemblance with Pyrus sp. of P. pashia Buch et Ham.
Wood IX

Material

Some small pieces of charcoal.

Microscopic Anatomy (Fig. 175, 176)

The wood is diffuse porous. Growth rings are indistinct. Vessels large, oval to round; almost uniform in size and evenly distributed, solitary or in multiples of two or three, 30 μm to 70 μm in diameter and thin to moderately thick walled.

Parenchyma paratracheal diffuse, not forming a sheath. Fibres thin to moderately thick walled, 10 to 20 μm in diameter.

Rays unstoried, 1-5 seriate, essentially homogenous upto 250 μm in height and 45 μm in width.

Identification

When compared with the extant woods the charcoals under investigation resemble Betula sp. of B. utilis Don. of family Betulaceae.

Wood X

Material

Small pieces of charcoal.
Microscopic anatomy (Fig. 177, 178)

The wood is ring porous. Vessels medium sized forming continuous bands and each vessel is 30 μm to 55 μm in tangential diameter. Intervessel pits oval to rounded.

Parenchyma paratracheal forming a sheath. Fibres thin to medium thick walled, oval to angular, 12-17 μm in diameter.

Rays unstoried, 1-4 seriate and homogenous, 140 μm to 200 μm in height.

Identification

When compared with the extant woods it becomes evident the material under investigation belongs to Fraxinus excelsior L.

Wood XI

Material

Pieces

Well preserved piece of charcoal.

Microscopic Anatomy (Fig. 179)

The wood is semi-ring to ring porous. Growth rings are distinct. Vessels medium sized, those at the beginning of the ring somewhat large, closely placed and aligned in more or less a continuous row,
elsewhere in the ring quite uniform in size, evenly distributed, solitary or in multiples of upto 4; 35 μm to 80 μm in tangential diameter. Intervessel pits oval to orbicular.

Parenchyma very scanty. Fibres angular, thin to thick walled, 8 μm to 15 μm in diameter.

Rays in cross section appear to be multi-seriate, longitudinal sections do not reveal any detailed features.

Identification

When compared with the extant woods, it becomes evident that the wood belong to Prunus sp.

Phase V : HINDU RULE

Wood I

Material

Small piece of well preserved charcoal.

Microscopic Anatomy (Fig. 180, 181)

The wood is non-porous. Growth rings indistinct. Bulk of the wood is made of tracheids aligned in definite radial rows. Tracheids are oval to squarish in shape, 17-25 μm in diameter.
Resin canals absent. Parenchyma cells scattered in between the tracheids.

Rays uniseriate, 2 to 7 cells and 10 μm to 80 μm in height and 8 to 15 μm in width. Ray tracheids absent. Cross field pitting of cupressoid type.

Identification

The main anatomical features are (a) non-porous wood (b) squarish to oval shape of tracheids (c) absence of resin canals (d) presence of scattered parenchyma cells and (e) cupressoid cross field pits. These characters clearly indicate that the wood belongs to *Cupressus* sp.

Wood II

Material

Some well preserved pieces of charcoal.

Microscopic Anatomy (Fig. 182, 183)

The wood is diffuse porous. Growth rings not conspicuous. Vessels numerous, thin to moderately thick walled, solitary or in pairs, oval to rounded, 20 μm to 50 μm in diameter.

Parenchyma apotracheal diffuse and scanty. Fibres thick walled, angular, 6 μm to 10 μm in diameter.
Rays normally spaced, 2-4 seriate, heterogenous, unstoried, upto 15 cells and 210 μm in height, 30 μm in width.

Identification

The above set of anatomical features brings the wood very close to *Crataegus* sp. and *Parrotiopsis* sp. Because of comparatively larger vessels and wider rays the material shows more affinity towards *Crataegus* sp. and shows complete agreement in all respects with *C. oxyacantha* L.

Wood III

Material

Some well preserved pieces of charcoal.

Microscopic Anatomy (Fig. 184, 185)

The wood is semi-ring to diffuse porous. Growth rings not conspicuous. Vessels numerous, usually solitary, occasionally in pairs or multiples of three, oval to rounded, 30 μm to 60 μm in tangential diameter. Intervessel pits small, oval to angular.

Parenchyma sparse, paratracheal as well as apotracheal diffuse. Fibres thin to moderately
thick walled, oval to angular, 5 µm to 12 µm in diameter.

Rays closely spaced, heterogenous as well as homogenous. Rays of two types: narrow rays 1-3 seriate, 60 µm to 220 µm in height, 6 µm to 30 µm in width and broad rays 3 to 7 seriate, 250 µm to 620 µm in height and 10 µm to 70 µm in width.

Identification

The important anatomical features of the wood are a) small, numerous, oval to rounded vessels; b) spare parenchyma and c) two types of rays. With these features it becomes evident, on comparison, that the wood belongs to *Acer* sp. and probably *A. caesuim* (Wall) Brandis of family Aceraceae.

Wood IV

Material

Well preserved pieces of charcoal.

Microscopic Anatomy (Fig. 186, 187, 188)

The wood is semi-diffuse to diffuse porous. Growth rings distinct. Vessels frequently crowded or clustered and occasionally solitary, oval to
round, 30 µm to 80 µm in diameter. Intervessel pits small, alternate and crowded. Tyloses occasionally present.

Parenchyma paratracheal and metatracheal diffuse. Paratracheal parenchyma scanty, not forming a sheath. Fibres numerous, thin to moderately thick walled, angular to oval, 8 µm to 15 µm in diameter.

Rays unstoried, normally spaced, multi (3-9)-seriate, essentially homogenous, 200 µm to 450 µm in height and upto 103 µm in width.

Identification

The main anatomical features are a) crowded vessels b) vessels occasionally occluded with tyloses, c) paratracheal and metatracheal diffuse parenchyma d) small crowded intervessel pits and e) large homogenous rays. When compared with the extant woods these features clearly indicate that this wood belongs to *Platanus orientalis* L. of family Platanaceae.

Wood V

Material

Some pieces of well preserved charcoal.
Microscopic Anatomy (Fig. 189, 190, 191)

The wood is ring porous. Growth rings distinct. Vessels in the spring wood larger than those in the summer wood, oval to rounded, solitary, in pairs or groups of up to five, thin walled, larger ones with a diameter of 50 µm to 90 µm and the smaller ones 20 µm to 40 µm; some occluded with tyloses. Intervessel pits small, oval to orbicular.

Parenchyma paratracheal and metatracheal diffuse; paratracheal parenchyma surrounds the vessels and forms continuous bands i.e. paratracheal confluent parenchyma. Fibres thin to moderately thick walled, angular, oval or round, 10 µm to 15 µm in diameter.

Rays fairly wide, normally spaced multi (1-6)-seriate, homogenous to heterogenous.

Identification

The main anatomical features are a) ring porous nature b) clustered vessels c) paratracheal confluent parenchyma. These characters clearly indicate that the present wood belongs to Morus sp. and probably Morus alba L. of family Moraceae.
Wood VI

Material

Several pieces of well preserved charred wood.

Microscopic Anatomy (Fig. 192, 193)

The wood is diffuse porous. Growth rings not conspicuous. Vessels small, numerous, thin to moderately thick walled, almost of uniform size and evenly distributed; usually solitary and occasionally in groups of two or three, 20 μm to 30 μm in tangential diameter. Intervessel pits small, numerous, oval to round.

Parenchyma metatracheal diffuse in the form of single celled bands. Fibres thick walled, 8 μm to 15 μm in diameter.

Rays fine, normally spaced uniseriate to biseriate occasionally 3-seri rate, 90 μm to 260 μm in height and 8 to 30 μm in width, homogenous to heterogenous

Identification

The above set of anatomical features brings the material close to Parrotiopsis sp. and Crataegus sp. Because of comparatively smaller vessels and narrow
rays the material matches best *Parrotiosis jacquemontiana* Dcne. of family Hamamelidaceae.

**Wood VII**

**Material**

Small pieces of charcoal.

**Microscopic Anatomy** (Fig. 194, 195).

The wood is semi-ring to diffuse porous. Growth rings are not distinct vessels round to ovoid, numerous, almost evenly distributed, 20 \( \mu m \) to 50 \( \mu m \) in diameter.

Parenchyma scanty, metatracheal diffuse. Fibres numerous, angular, thick walled and 5 \( \mu m \) to 12 \( \mu m \) in diameter.

Rays multi-seriate (2-4 seriate), unstoried, homogenous to heterogenous.

**Identification**

Semi-ring porosity, scanty metatracheal parenchyma and multiseriate homogenous to heterogenous rays are some of the important anatomical characters which bring the unknown very close to genus *Prunus* of family Rosaceae. On comparison with the extant species of *Prunus*, the wood could not be placed convincingly under any definite species. Hence it is identified as *Prunus* sp.
III. **STATISTICAL ANALYSIS**

(i) **Chi-square Analysis**

Chi-square analysis of seed and charcoal data was performed to determine whether the seed and wood taxa were randomly distributed among the five time periods of the site. The analysis matrix for cereals is presented in table 14, for pulses in table 15, for endocarps in table 16, for weed seeds in table 17 and for charcoals in table 18.

(ii) **Intensity of occupation**

This function has been obtained from charred wood counts through time. Following results were obtained which are shown in Fig. 196.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Wood count</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre-N.B.P.</td>
<td>294</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>498</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>330</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>716</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>381</td>
</tr>
</tbody>
</table>

(iii) **Species Diversity (H)**

For this analysis all the wood taxa and time periods were used. Following results were obtained which are shown in Fig. 197.
Table 14: Chi square analysis of cereals and time periods.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
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<td>4</td>
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<td>0</td>
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<td>29.8</td>
<td>0.001</td>
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<tr>
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<td>16.57</td>
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<td>0.51</td>
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<td></td>
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<tr>
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<td>3</td>
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<tr>
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<tr>
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<tr>
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<td>0.66</td>
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</tr>
<tr>
<td>Col.Total</td>
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<td>161</td>
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<td>5</td>
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<tr>
<td>Col. Chi</td>
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<td>27.1</td>
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<td>0.01</td>
<td>0.001</td>
<td>0.001</td>
<td>0.70</td>
<td>0.50</td>
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</tbody>
</table>

Overall Chi square = 82.6 with 30 degrees of freedom, significant at less than 0.001 level.

Taxa abbreviations: **Oryza sativa** (O.s), **Triticum aestivum** (T.a.), **Triticum sphaerococcum** (T.s), **Hordeum vulgare** (H.v.), **Avena fatua** (A.f.) and **Avena sativa** (A.s).
<table>
<thead>
<tr>
<th>Period</th>
<th>P.a.</th>
<th>P.m.</th>
<th>P.ac.</th>
<th>L.C.</th>
<th>P.s.</th>
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<th>Row Chi</th>
<th>Sign level</th>
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<td>0.50</td>
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<td>0.50</td>
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<td>0.58</td>
<td>4.0</td>
<td>0.50</td>
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<tr>
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<td>1.00</td>
<td>0.33</td>
<td>0.50</td>
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</tr>
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<td>V</td>
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<td>0</td>
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<td>3</td>
<td>5</td>
<td>3.55</td>
</tr>
<tr>
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</table>

Overall Chi square = 15.1, with 25 degrees of freedom, significant at 0.90 level.

Taxa abbreviations: Phaseolus aureus (P.a.), Phaseolus mungo (P.m.),
Phaseolus acutifolius (P.ac.), Lens culinaris (L.C.) and
Pisum sativum (P.s.)
Table 16: Chi square analysis of endocarps and time periods

<table>
<thead>
<tr>
<th>Period</th>
<th>P.a.</th>
<th>P.P.</th>
<th>P.c.</th>
<th>J.r.</th>
<th>C.a.</th>
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<td>3</td>
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<tr>
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<td>0.01</td>
</tr>
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<td>II Ob.</td>
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</tr>
<tr>
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<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
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<td>7.9</td>
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<tr>
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<tr>
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<td>0.50</td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>7</td>
<td>10.5</td>
<td>0.05</td>
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<td>2.53</td>
<td>1.45</td>
<td>0.72</td>
<td>7</td>
<td>10.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Col. Tot.</td>
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<td>12</td>
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<tr>
<td>Col. Chi</td>
<td>5.3</td>
<td>11.3</td>
<td>13.8</td>
<td>2.8</td>
<td>13.8</td>
<td>47.0</td>
<td>47.0</td>
<td></td>
</tr>
<tr>
<td>Sign. Lev.</td>
<td>0.30</td>
<td>0.05</td>
<td>0.02</td>
<td>0.8</td>
<td>0.02</td>
<td>0.30</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Overall Chi square = 47.0, with 25 degrees of freedom significant at less than 0.01 level.

Taxa abbreviations: Prunus amenaica (P.a), Prunus persia (P.p), Prunus cerasus (P.c), Juglans regia (J.r) and Celtis australis (C.a).
Table 17: Chi square test of weed seeds and time periods.

<table>
<thead>
<tr>
<th>Period</th>
<th>Vicia</th>
<th>Lithospermum</th>
<th>Galium</th>
<th>Others</th>
<th>Row Total</th>
<th>Row Chi</th>
<th>Sign.lev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Ob.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ex.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Ob.</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>8.6</td>
<td>0.05</td>
</tr>
<tr>
<td>Ex.</td>
<td>0.79</td>
<td>1.67</td>
<td>2.66</td>
<td>0.88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Ob.</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>6.4</td>
<td>0.20</td>
</tr>
<tr>
<td>Ex.</td>
<td>3.93</td>
<td>1.39</td>
<td>2.21</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Ob.</td>
<td>5</td>
<td>6</td>
<td>23</td>
<td>6</td>
<td>40</td>
<td>4.0</td>
<td>0.50</td>
</tr>
<tr>
<td>Ex.</td>
<td>5.25</td>
<td>11.14</td>
<td>17.71</td>
<td>5.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. Ob.</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>2.1</td>
<td>0.70</td>
</tr>
<tr>
<td>Ex.</td>
<td>1.31</td>
<td>2.79</td>
<td>4.43</td>
<td>1.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Col. Totl</td>
<td>8</td>
<td>17</td>
<td>27</td>
<td>9</td>
<td>61</td>
<td>24.1</td>
<td></td>
</tr>
<tr>
<td>Col. Chi</td>
<td>5.4</td>
<td>8.0</td>
<td>6.5</td>
<td>1.2</td>
<td>21.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sign. Lev.</td>
<td>0.20</td>
<td>0.05</td>
<td>0.20</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Chi square = 24.1, With 16 degrees of freedom significant at 0.20 level.
Table 18: Chi square analysis of wood taxa and time periods.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinus</td>
<td>31</td>
<td>18</td>
<td>0</td>
<td>22</td>
<td>0</td>
<td>28</td>
<td>29</td>
<td>38</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Picea</td>
<td>10.33</td>
<td>7.16</td>
<td>4.11</td>
<td>7.42</td>
<td>3.84</td>
<td>35.77</td>
<td>9.41</td>
<td>11.26</td>
<td>3.71</td>
<td>7.42</td>
</tr>
<tr>
<td>Abies</td>
<td>47</td>
<td>0</td>
<td>31</td>
<td>34</td>
<td>0</td>
<td>87</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>Cedrus</td>
<td>17.50</td>
<td>12.12</td>
<td>6.96</td>
<td>12.57</td>
<td>6.51</td>
<td>60.60</td>
<td>15.93</td>
<td>19.07</td>
<td>6.28</td>
<td>12.57</td>
</tr>
<tr>
<td>Cupressus</td>
<td>0</td>
<td>36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>37</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Gymn.</td>
<td>11.60</td>
<td>8.03</td>
<td>4.61</td>
<td>8.33</td>
<td>4.31</td>
<td>40.15</td>
<td>10.56</td>
<td>12.64</td>
<td>4.17</td>
<td>8.33</td>
</tr>
<tr>
<td>Celtis</td>
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<td>0</td>
<td>16</td>
<td>64</td>
<td>42</td>
<td>47</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Juglans</td>
<td>25.17</td>
<td>17.42</td>
<td>10.00</td>
<td>18.07</td>
<td>9.36</td>
<td>87.12</td>
<td>22.91</td>
<td>27.43</td>
<td>9.04</td>
<td>18.07</td>
</tr>
<tr>
<td>Quercus</td>
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<td>0</td>
<td>0</td>
<td>13</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>Fraxinus</td>
<td>13.40</td>
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<td>5.32</td>
<td>9.61</td>
<td>4.98</td>
<td>46.36</td>
<td>12.19</td>
<td>14.60</td>
<td>4.80</td>
<td>9.61</td>
</tr>
</tbody>
</table>

Col. Tot. 78 | 54 | 31 | 56 | 29 | 270 | 71 | 85 | 28 | 56

Col. Chi. 141.3 | 152.6 | 107.1 | 101.2 | 32.3 | 20.8 | 95.4 | 123.8 | 59.6 | 46.5

Sign Lev. < 0.0001 < 0.0001 < 0.0001 < 0.0001 0.001 0.001 < 0.0001 < 0.0001 < 0.0001 < 0.0001

contd....
<table>
<thead>
<tr>
<th></th>
<th>Ulmus</th>
<th>Betula</th>
<th>Populus</th>
<th>Prunus</th>
<th>Aesculus</th>
<th>Salix</th>
<th>Viburnum</th>
<th>Parrotiopsis</th>
<th>Crataegus</th>
<th>Pyrus</th>
<th>Acer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8.35</td>
<td>5.96</td>
<td>10.47</td>
<td>10.07</td>
<td>7.29</td>
<td>4.50</td>
<td>2.65</td>
<td>5.56</td>
<td>4.77</td>
<td>2.25</td>
<td>2.78</td>
<td></td>
</tr>
<tr>
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<td>19</td>
<td>23</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>14.14</td>
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<td>17.73</td>
<td>17.06</td>
<td>12.34</td>
<td>7.63</td>
<td>4.49</td>
<td>9.43</td>
<td>8.08</td>
<td>3.82</td>
<td>4.71</td>
<td></td>
</tr>
<tr>
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<td>0</td>
<td>32</td>
<td>34</td>
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<td>0</td>
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<td>0</td>
</tr>
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<td>11.30</td>
<td>8.18</td>
<td>5.96</td>
<td>2.98</td>
<td>6.25</td>
<td>5.35</td>
<td>2.53</td>
<td>3.12</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>24</td>
<td>60</td>
<td>29</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>24</td>
<td>17</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20.32</td>
<td>14.52</td>
<td>25.49</td>
<td>24.52</td>
<td>17.75</td>
<td>10.97</td>
<td>6.45</td>
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<td>11.62</td>
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<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>12</td>
<td>0</td>
<td>21</td>
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<td>10.82</td>
<td>7.72</td>
<td>13.56</td>
<td>13.05</td>
<td>9.44</td>
<td>5.84</td>
<td>3.43</td>
<td>7.21</td>
<td>6.18</td>
<td>2.91</td>
<td>3.61</td>
<td></td>
</tr>
<tr>
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<td>45</td>
<td>79</td>
<td>76</td>
<td>55</td>
<td>34</td>
<td>20</td>
<td>42</td>
<td>36</td>
<td>17</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>130.9</td>
<td>38.3</td>
<td>82.6</td>
<td>48.4</td>
<td>99.9</td>
<td>194.4</td>
<td>114.2</td>
<td>43.0</td>
<td>36.9</td>
<td>35.6</td>
<td>101.2</td>
<td></td>
</tr>
</tbody>
</table>

\(<0.0001 \,<0.001 \,<0.001 \,<0.001 \,<0.0001 \,<0.0001 \,<0.001 \,<0.0001 \,<0.001 \,<0.001 \,<0.0001 \\
\text{contd...} \)

128
<table>
<thead>
<tr>
<th>22 Platanus</th>
<th>23 Morus</th>
<th>24 Ficus</th>
<th>25 Other Ang.</th>
<th>26 Row Total</th>
<th>27 Row Chi</th>
<th>28 Significant level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>113</td>
<td>294</td>
<td>313.0</td>
<td>0.0001</td>
</tr>
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<td>1.59</td>
<td>2.38</td>
<td>1.46</td>
<td>123.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>11</td>
<td>162</td>
<td>498</td>
<td>378.2</td>
<td>0.0001</td>
</tr>
<tr>
<td>2.69</td>
<td>4.04</td>
<td>2.47</td>
<td>209.16</td>
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<tr>
<td>0</td>
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<td>0</td>
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<td>330</td>
<td>629.7</td>
<td>0.0001</td>
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<tr>
<td>1.79</td>
<td>2.68</td>
<td>1.64</td>
<td>138.60</td>
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<td></td>
<td></td>
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<td>0</td>
<td>5.81</td>
<td>3.55</td>
<td>300.73</td>
<td>716</td>
<td>299.2</td>
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</tr>
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<td>3.87</td>
<td>0</td>
<td>0</td>
<td>310</td>
<td></td>
<td></td>
<td></td>
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<td>18</td>
<td>0</td>
<td>213</td>
<td>381</td>
<td>398.0</td>
<td>0.0001</td>
</tr>
<tr>
<td>2.06</td>
<td>3.09</td>
<td>1.88</td>
<td>160.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>18</td>
<td>11</td>
<td>932</td>
<td>2219</td>
<td>2018.1</td>
<td></td>
</tr>
<tr>
<td>57.9</td>
<td>86.8</td>
<td>37.9</td>
<td>29.5</td>
<td>2018.1</td>
<td></td>
<td></td>
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<tr>
<td>0.001</td>
<td>0.0001</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Overall chi square = 2018.1, with 96 degrees of freedom, significant at less than 0.0001 level.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Species Diversity (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>0.79</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>0.92</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>0.71</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>0.87</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Iv. **Species Richness (r):**

All the wood taxa and time periods were used for this analysis. Following results were obtained which are presented in Fig. 198.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Species Richness (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>1.23</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>1.77</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>1.03</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>1.82</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>1.35</td>
</tr>
</tbody>
</table>

v. **Species Evenness (e):**

Using wood taxa and time periods, following results were obtained which are shown in Fig. 199.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Species Evenness (e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre N.B.P.</td>
<td>0.38</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>0.37</td>
</tr>
<tr>
<td>III. Indo Greek</td>
<td>0.36</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>0.34</td>
</tr>
<tr>
<td>V. Hindu Rule</td>
<td>0.30</td>
</tr>
</tbody>
</table>
vi. **Standard Scores (z)**

Following results were obtained using data from various species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Standard scores (z) in various phases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Rice</td>
<td>0</td>
</tr>
<tr>
<td>Wheats</td>
<td>-0.54</td>
</tr>
<tr>
<td>Barley</td>
<td>-1.31</td>
</tr>
<tr>
<td>Oats</td>
<td>-1.89</td>
</tr>
<tr>
<td>Pulses</td>
<td>-1.63</td>
</tr>
<tr>
<td>Prunus spp.</td>
<td>-0.76</td>
</tr>
<tr>
<td>Walnut</td>
<td>-0.62</td>
</tr>
</tbody>
</table>

The values of wheats, oats, pulses and Prunus were obtained using data of all the species collectively. Standard scores of cereals, pulses and fruit crops are shown in Fig. 200, 201 and 202 respectively.

vii. **Coefficient of similarity (S)**

Following values were obtained using cereal data.

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.75</td>
<td>0.67</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>II</td>
<td>0.89</td>
<td>0.80</td>
<td>0.75</td>
<td></td>
</tr>
</tbody>
</table>
For Pulses following values of 'S' were obtained:

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td></td>
<td>0.90</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

For fruit crops (*Prunus* spp. and *Juglans*) following values of 'S' were obtained:

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.33</td>
<td>0.50</td>
<td>0.33</td>
<td>0.80</td>
</tr>
<tr>
<td>II</td>
<td>0.60</td>
<td>0.75</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.33</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

For wood taxa following values of 'S' were obtained:

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
<td>0.50</td>
</tr>
<tr>
<td>II</td>
<td>0.50</td>
<td>0.66</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>1.00</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
### Phase II III IV V

<table>
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<th></th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.50</td>
<td>0.40</td>
<td>0.38</td>
<td>0.24</td>
</tr>
<tr>
<td>II</td>
<td>0.32</td>
<td>0.48</td>
<td>0.35</td>
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<tr>
<td>III</td>
<td>0.30</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>0.55</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### VIII. Co-efficient of similarity (T)

Using cereal data following values of 'T' were obtained:

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.44</td>
<td>0.50</td>
<td>0.56</td>
<td>0.67</td>
</tr>
<tr>
<td>II</td>
<td>0.79</td>
<td>0.77</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.59</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For pulses following values were obtained:

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.22</td>
<td>0.33</td>
<td>0.125</td>
<td>0.29</td>
</tr>
<tr>
<td>II</td>
<td>0.36</td>
<td>0.38</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.20</td>
<td>0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>0.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For fruit crops following values were obtained:

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.11</td>
<td>0.31</td>
<td>0.40</td>
<td>0.25</td>
</tr>
<tr>
<td>II</td>
<td>0.29</td>
<td>0.11</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>0.55</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

For wood taxa following values were obtained:

<table>
<thead>
<tr>
<th>Phase</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.53</td>
<td>0.51</td>
<td>0.41</td>
<td>0.42</td>
</tr>
<tr>
<td>II</td>
<td>0.48</td>
<td>0.52</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.37</td>
<td>0.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION
I) ARTIFICIAL CARBONIZATION

The plant remains recovered from various phases of the site were preserved in carbonized form. The seeds, grains, fruits and wood etc have been reduced to carbon while retaining, more or less, their characteristic shape. In order to get awareness about the changes in shape, size and proportions caused by carbonization, artificial carbonization of extant grains and seeds of various species was carried out.

The results (Figs. 6-21) indicate that in all the five species of *Triticum* the length of the grains decreases with carbonization whereas the breadth increases. In *Triticum monococcum*
the length decreases by 7.33% and the breadth increases by 18.18%. In *T. dicoccum* decrease in length is 6.84% and increase in breadth 21.42%. Similarly *T. turgidum* shows 16.1% decrease in length and 26.4% increase in breadth. *T. sphaerococcum* shows 12.08% decrease in length and 7.3% increase in breadth while *T. aestivum* shows 18.92% decrease in length and 38.8% increase in breadth.

All the species of *Hordeum* show similar behaviour. The length decreases by 10.63% in *H. spontaneum* and breadth increases by 9.58%. In *H. distichum* length decreases by 11.7% and breadth increases by 14.2%. *H. hexaploidum* shows 28.9% decrease in length and 12.6% increase in breadth. In *H. vulgare* (hulled form) the decrease in length is 7.6% and the increase in breadth is 5.59%.

*Avena fatua* shows 13.8% decrease in length and 21.62% increase in breadth whereas in *A. sativa* decrease in length is 7.07% and the increase in breadth is 23.03%.

Decrease in length is 11.56% and 11.34% in *Oryza sativa* cultivar China 1039 and *O. sativa* cultivar Noon Beoul respectively whereas the
increase in breadth is 9.6% and 9.4% respectively.

The pulses carbonized show decrease in both length and breadth. 10.28% decrease in length and 5.55% decrease in breadth is observed in Phaseolus aureus. In Lens esculenta the decrease in length is 15.83% and the decrease in breadth 10.93%.

In all the species of Triticum, Avena and Hordeum the morphological features are well preserved on carbonization. In the awned strain of rice, Oryza sativa cultivar Noor Beoml the awn was lost in almost all the grains. The husk got detached in about 80% grains of cultivar China 1039 and in about 35% of cultivar Noon Beoml. Wherever retained morphological features are characteristically well preserved. In Phaseolus spp. the hilum is lost in 70-80% of the seeds but its position remains clear. Partially or wholly the seed coat is lost in almost all the seeds of Phaseolus spp. and Lens esculenta.

The foregoing account reveals the whereas the size varies with carbonization, the morphological features remain well preserved.
Further it has been pointed out by Hopf (1955, 1957) that the prehistoric cereal grains are smaller in size than their exact present day counterparts even when these are also carbonized. The present investigations have confirmed these observations. Table 19 summarizes the measurements of modern fresh, modern carbonized and archaeological carbonized seeds/grains.

At this stage it would be pertinent to look into the causes of carbonised nature of archaeological material. It has been suggested that 'spontaneous combustion' (Biffen 1934), referred to as a slow process of ageing (Dimbleby 1967), can occur, as when a rick of green hay ferments internally to such an extent that it builds up a high enough temperature to cause it to ignite. Indeed, it has been suggested that it was through such combustion in his pile of bedding - perhaps grass or bracken, that man first discovered fire (Dimbleby 1967). However, it appears that, in nature, fire is essential for the conversion of plant material into elemental carbon.
Table 19: Dimensions of modern fresh, modern carbonized and archaeological carbonized grains/seeds.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Botanical species</th>
<th>Nature</th>
<th>Length (mm)</th>
<th>Breadth (mm)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Triticum monococcum</em></td>
<td>Modern fresh</td>
<td>7.5</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>6.95</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized.</td>
<td>5.18</td>
<td>2.25</td>
<td>Hopf (1955)</td>
</tr>
<tr>
<td>2.</td>
<td><em>T. dicocuccum</em></td>
<td>Modern fresh</td>
<td>7.3</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>6.8</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized.</td>
<td>5.71</td>
<td>3.06</td>
<td>Hopf (1955)</td>
</tr>
<tr>
<td>3.</td>
<td><em>T. speltaeococcus</em></td>
<td>Modern fresh</td>
<td>4.8</td>
<td>2.98</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>4.22</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized.</td>
<td>3.7</td>
<td>2.7</td>
<td>Present study</td>
</tr>
<tr>
<td>4.</td>
<td><em>T. aestivum</em></td>
<td>Modern fresh</td>
<td>6.34</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>5.14</td>
<td>4.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized.</td>
<td>4.37</td>
<td>2.51</td>
<td>Present study</td>
</tr>
<tr>
<td></td>
<td>Species</td>
<td>Condition</td>
<td>Modern Fresh</td>
<td>Modern Carbonized</td>
<td>Archaeological Carbonized</td>
</tr>
<tr>
<td>---</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------</td>
<td>-------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>5.</td>
<td><em>Hordeum vulgare</em> (hulled form)</td>
<td>Modern fresh</td>
<td>7.8</td>
<td>3.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>7.2</td>
<td>3.88</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Archaeological carbonized</td>
<td>5.12</td>
<td>2.56</td>
<td>Present study</td>
</tr>
<tr>
<td>6.</td>
<td><em>H. vulgare</em> (naked form)</td>
<td>Modern fresh</td>
<td>7.3</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>6.5</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized</td>
<td>5.2</td>
<td>2.58</td>
<td>Hopf (1955)</td>
</tr>
<tr>
<td>7.</td>
<td><em>Oryza sativa</em></td>
<td>Modern fresh</td>
<td>7.7</td>
<td>2.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>6.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized</td>
<td>5.4</td>
<td>2.75</td>
<td>Present study</td>
</tr>
<tr>
<td>8.</td>
<td><em>Avena fatua</em></td>
<td>Modern fresh</td>
<td>8.1</td>
<td>1.5</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>6.96</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized</td>
<td>3.4</td>
<td>1.1</td>
<td>Present study</td>
</tr>
<tr>
<td>9.</td>
<td><em>A. sativa</em></td>
<td>Modern fresh</td>
<td>9.9</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modern carbonized</td>
<td>9.2</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeological carbonized</td>
<td>4.5</td>
<td>1.7</td>
<td>Present study</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>10. <strong>Phaseolus aureus</strong></td>
<td>Modern fresh</td>
<td>4.3</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modern carbonized</td>
<td>3.8</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Archaeological carbonized</td>
<td>3.6</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Present study</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. <strong>Lens esculenta</strong></td>
<td>Modern fresh</td>
<td>4.8</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modern carbonized</td>
<td>4.04</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Archaeological carbonized</td>
<td>3.95</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Present study</strong></td>
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<td></td>
</tr>
</tbody>
</table>
II) THE BOTANICAL EVIDENCE

A) Archaeobotanical and Phytogeographical Significance

The plant assemblage identified from various phases of the site is presented in Table 20. First of all we shall consider each of the plant remains separately and see what archaeological, botanical and phytogeographical significance does it convey.

CEREALS

(i) Rice

The genus *Oryza* consists of 20 wild species (both diploid and tetraploid forms) and two cultigens namely *O. sativa* L. and *O. glaberrima* Steud (Chang 1986 a). Among the wild relatives the perennial *O. rufipogon* Griff. Syn. *O. perennis* Moench is generally considered to be the ancestor of *O. sativa* (Chang 1976 a,b,c, 1983, 1985 a,b, 1986 a,b ; Second 1982). On the other hand *O. glaberrima* whose economic importance is restricted to west and central Africa is closely related to the African species, *O. breviligulata* A.Chev et Roehr Syn. *O. barthii* A.Chev. but their genetic affinity has been differentially interpreted. According to Porteres (1950),
Table 20: Phase-wise plant Economy at Semthan

<table>
<thead>
<tr>
<th>Phase</th>
<th>Gereals</th>
<th>Millets</th>
<th>Pulses</th>
<th>Endocarps</th>
<th>Weed seeds</th>
<th>Woods</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre.N.B.P.</td>
<td>Oryza sativa;</td>
<td></td>
<td>Phaseolus</td>
<td>Juglans</td>
<td></td>
<td>Pinus wallichiana;</td>
</tr>
<tr>
<td></td>
<td>Triticum aestivum;</td>
<td></td>
<td>aureus;</td>
<td>regia;</td>
<td></td>
<td>Cedrus deodara;</td>
</tr>
<tr>
<td></td>
<td>P. sphaerococcum;</td>
<td></td>
<td>Lens</td>
<td>Prunus</td>
<td></td>
<td>Picea smithiana;</td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare.</td>
<td></td>
<td>culinaris.</td>
<td>armeniaca.</td>
<td></td>
<td>Juglans sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Celtis australis;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quercus sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leguminosae.</td>
</tr>
<tr>
<td>II. N.B.P.</td>
<td>Oryza sativa;</td>
<td></td>
<td>Phaseolus</td>
<td>Prunus</td>
<td>Lithospermum</td>
<td>Pinus wallichiana;</td>
</tr>
<tr>
<td></td>
<td>Triticum aestivum;</td>
<td></td>
<td>mungo;</td>
<td>cerasus;</td>
<td>arvense;</td>
<td>Abies pindrow;</td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare;</td>
<td></td>
<td>P. aureus;</td>
<td>P. armeniaca;</td>
<td>Vicia/</td>
<td>Cedrus deodara;</td>
</tr>
<tr>
<td></td>
<td>Avena fatua.</td>
<td></td>
<td>P. aconitifolius;</td>
<td>Juglans</td>
<td>Lathyrus sp.</td>
<td>Quercus sp II.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pisum sativum;</td>
<td>regia;</td>
<td></td>
<td>Ulmus wallichiana;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lens culinaris.</td>
<td>Celtis</td>
<td>australis.</td>
<td>Fraxinus excelsior;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Betula utilis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prunus sp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ficus sp.</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>Phase</th>
<th>Cereals</th>
<th>Millets</th>
<th>Pulses</th>
<th>Endocarps</th>
<th>Weed seeds</th>
<th>Woods</th>
</tr>
</thead>
<tbody>
<tr>
<td>III. Indo Greek</td>
<td>Oryza sativa;</td>
<td>Panicum sp.</td>
<td>Phaseolus × mungo;</td>
<td>Prunus × persica;</td>
<td>Lithospermum × arvense;</td>
<td>Picea smithiana;</td>
</tr>
<tr>
<td></td>
<td>Triticum aestivum;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Salix sp;</td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aesculus indica;</td>
</tr>
<tr>
<td></td>
<td>Avena fatua;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Viburnum sp;</td>
</tr>
<tr>
<td></td>
<td>A. sativa.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ulmus sp.</td>
</tr>
<tr>
<td>IV. Kushan</td>
<td>Oryza sativa;</td>
<td>Setaria sp.</td>
<td>Phaseolus × aureus,</td>
<td>Prunus × armeniaca;</td>
<td>Galium aparine,</td>
<td>Cupressus sp;</td>
</tr>
<tr>
<td></td>
<td>Triticum aestivum;</td>
<td></td>
<td></td>
<td></td>
<td>G. tricorne,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T. sphaerocephalum;</td>
<td></td>
<td></td>
<td></td>
<td>G. asperuloides,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare;</td>
<td></td>
<td></td>
<td></td>
<td>Populus sp;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avena sativa.</td>
<td></td>
<td></td>
<td></td>
<td>Parrotiopsis oxyacantha;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. × munson,</td>
<td></td>
<td>Celtis australis;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. × persica;</td>
<td></td>
<td>Aesculus indica;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Juglans × regia.</td>
<td></td>
<td>Pyrus pashia;</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Betula utilis;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fraxinus excelsior.</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>V. Hindu Rule.</td>
<td>Oryza sativa;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cupressus sp.</td>
</tr>
<tr>
<td></td>
<td>Triticum aestivum;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Acer sp.</td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Platanus orientalis;</td>
</tr>
<tr>
<td></td>
<td>Avena sativa.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Morus alba;</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Parrotiopsis jacquemontiana;</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Crataegus oxyacantha;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prunus sp.</td>
</tr>
</tbody>
</table>
Morishima et al (1963), Oka (1974), Chang (1976 b) Q. glaberrima was domesticated from Q. breviligulata. Others contend that Q. glaberrima was introduced into Africa from Asia and Q. breviligulata was a hybrid derivative either between Q. glaberrima and Q. longistaminata. A. Chev et Roehr (Richaria 1960) or between Q. glaberrima and a more recent introduction of Q. sativa in Africa (Nayar 1973). Some of the phylogenetic relationships proposed are presented in text fig. 4. According to Oka (1974) Q. sativa may have been domesticated independently in various areas. Its differentiation is under selective forces in the course of domestication. Chang (1976 b, 1986 a) believes that the present day distribution of wild rice is an outcome of the continental drift. The Gondwanaland origin of rice and its interspecific differentiation before the supercontinent fractured and drifted apart are indicated by the pantropical distribution of the wild species of the genus in a non-disjunct manner across Africa, Asia, Oceania and Latin America. Nayar (1973) proposed that Q. glaberrima was introduced in Africa from Asia, Q. breviligulata escaped from cultivated fields following the introgression of genes of Q. sativa in Q. glaberrima. Recently Second (1982) proposed three primary domesticaions. The differentiation
Text Fig. 4: Phylogenetic relationships in Rice.

a) Oka (1974); Moishima et al (1963)

\[ \begin{align*}
&O. \text{rufipogon} \rightarrow O. \text{sativa} \\
&O. \text{brevilligulata} \rightarrow O. \text{glaberrima} \\
&O. \text{brevilligulata} \times O. \text{glaberrima} \rightarrow \text{weedy } O. \text{brevilligulata}
\end{align*} \]

b) Chang (1976 b)

\[ \begin{align*}
&\text{Gondwanaland ancestor} \\
&O. \text{rufipogon} \rightarrow O. \text{sativa} \rightarrow \text{Japonica} \\
&O. \text{brevilligulata} \rightarrow O. \text{glaberrima}
\end{align*} \]

c) Nayar (1973)

\[ \begin{align*}
&O. \text{rufipogon} \rightarrow \text{Old } O. \text{sativa} \rightarrow \text{Modern } O. \text{sativa} \\
&O. \text{glaberrima} \times O. \text{sativa} \rightarrow O. \text{brevilligulata}
\end{align*} \]

d) Second (1982)

\[ \begin{align*}
&\text{Common ancestor} \\
&C. \text{rufipogon} \rightarrow \text{in China } \text{sub sp. } O. \text{sativa} \\
&\text{in south and south- east India.} \\
&O. \text{brevilligulata} \rightarrow O. \text{glaberrima} \\
&O. \text{glaberrima} \times O. \text{sativa} \rightarrow \text{Weedy } O. \text{brevilligulata.}
\end{align*} \]
of cultivated rice resulted in part from the geographical differentiation of races of *O. rufipogon*. Some of the weedy forms of *O. brevilligulata* evolved through introgression of genes of *O. sativa* into *O. glaberrima*.

The chronology of rice cultivation in different parts of Asia as revealed by archaeobotanical finds is summarized in Table 21 (Chang 1986 a, Lone et al 1986 b). The wild variety of rice is reported from Protoneolithic levels at Chopani Mando (9th–8th millenium B.C.) in the Belan valley of Vindhy ranges (Sharma and Misra 1980). The oldest record of cultivated rice is from Mahagra and Koldihawa in the same region. The dates tend to support the view that the Asian cultigen of rice evolved over a broad belt that extended from southern foot hills of the Himalaya, across upper Burma, northern Thailand, Laos, to north Vietnam and southwest and south China (Chang 1976 b, 1986 a, Glover 1977). The chronology available till date reveals that the Vindhyan region might have the credit for originating the domestication of *O. sativa*.

Regarding *O. glaberrima*, it has its primary centre of diversity in the swampy area of the Upper
Table 21: Chronology of oldest rice remains from Asia

<table>
<thead>
<tr>
<th>Site</th>
<th>Type of plant remains</th>
<th>Estimated age</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chirand, Bihar India.</td>
<td>Charred grains</td>
<td>2500-1800 B.C.</td>
<td>Vishnu Mittre (1972)</td>
</tr>
<tr>
<td>Rangpur, Saurashtra, India</td>
<td>Impressions</td>
<td>2,000-1500 B.C.</td>
<td>Vishnu Mittre and Savithri (1982)</td>
</tr>
<tr>
<td>Lothal, Gujrat, India.</td>
<td>Impressions</td>
<td>2300-1700 B.C.</td>
<td>Vishnu Mittre (1961)</td>
</tr>
<tr>
<td>Ahar, Rajasthan India.</td>
<td>Impressions</td>
<td>1885-1070 B.C.</td>
<td>Vishnu Mittre (1969)</td>
</tr>
<tr>
<td>Semthan, Kashmir, India.</td>
<td>Charred grains</td>
<td>c.1500 B.C.</td>
<td>Present Study</td>
</tr>
<tr>
<td>Ban Chiang, Thailand</td>
<td>Husk remains in potsherds.</td>
<td>3500 B.C.</td>
<td>Yen (1982)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chang and Loresto (1984)</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>Location</th>
<th>Findings</th>
<th>Date</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulu Leang, S. Sulawesi, Indonesia</td>
<td>Carbonized grains and glume fragments.</td>
<td>c. 4000 B.C.</td>
<td>Glover (1977)</td>
</tr>
<tr>
<td>Heng Chium, Taiwan.</td>
<td>Glume imprints on potsherds.</td>
<td>1985 B.C.</td>
<td>Li 1983.</td>
</tr>
</tbody>
</table>
Niger River and its two secondary centres are to the south-west near the Guinean coast. The primary centre was formed c. 1500 B.C. while the secondary centres around 1000 B.C. (Porters 1956, Chang 1975).

So far as Kashmir valley is concerned, the excavations at Burzahom (2325 B.C.) and Gofkral (2100 B.C.) have not revealed rice in the early neolithic levels (Sharma 1982, Buth et al 1986 a). Thus the rice finding at Semthan (c. 1500 B.C.) is very interesting. Rice, which is the main crop of the valley today, appears at Gofkral towards the end of the Neolithic II datable to c. 1000 B.C. (Sharma 1982). It becomes evident that the rice culture was introduced into the valley somewhere around 1500-1000 B.C. At that time rice culture was well established in the Indo-Gangetic plains and apparently rice was introduced from there along with the migration of people. The people of Neolithic Kashmir were in definite contacts with those of the Indo Gangetic plains at that time (Buth and Kaw 1985, Buth et al 1986 a).

(ii) Wheat

Sakamura reported as early as 1918 that wheats form a polyploid series with 14, 28 and 42 chromosomes.
Later Kihara (1924) recognized three types of genomes, each composed of seven chromosomes and labelled them A, B and D. The diploid wheats have only A genome, tetraploids A and B and the hexaploids A, B and D. Further studies revealed the possible sources of A, B and D genomes and models for the evolution of diploid, tetraploid and hexaploid wheats were provided (Kihara 1944, McFadden and Sears 1946, Paterson 1965, Riley 1965, Feldman 1976).

While the diploid wheats have only A genome, the sources of the B and D genomes appear to be in the closely related genus *Aegilops*. The B genome is believed to have been donated by an ancestor of the present day *Aegilops speltoides* whose genomes SS appear to be closely similar to the BB genomes of tetraploid wheat (Paterson 1965). Similarly *Aegilops squarrosa* is suggested as the donor of D genome (Kihara 1944, McFadden and Sears 1946). The possible evolution of cultivated diploid, tetraploid and hexaploid wheats is provided in text Figs. 5 and 6.

Distribution of wild relatives of wheat as well as distribution, ecological behaviour and genetic interaction of the weed races and archaeological findings
Triticum boeoticum

(\textit{A})

gene mutation, natural cross of mutant forms, automatic and deliberate selection by farming.

\[\text{Triticum monococcum (A)}\]

\[\text{Triticum araraticum (AG)}\]

(\textit{race of dicocoides, genetic differences developed due to isolation mutation}).

\[\text{Triticum timopheevi (AG)}\]

\[\text{Triticum turgidum (AB)}\]

\[\text{Crossing with T. compactum Triticum aestivum.} \]

\[\text{mutation ind. mutation of 'Q' gene to 'q' promoting soft glumes and tough rachis.} \]

\[\text{Triticum durum (AB)}\]

\[\text{gene mutation} \]

\[\text{Triticum polonicum (AB)}\]

\[\text{T. carthillicum (AB)}\]

Aegilops speltoides

(\textit{B})

Crossed, followed by Chromosome doubling.

\[\text{Triticum dicoccoides (AB)}\]

\[\text{gene mutation, natural hybridization, automatic and deliberate selection by farming.} \]

\[\text{Triticum dicoccum (AB)}\]

\[\text{Triticum durum (AB)}\]

\[\text{mutations + crossing of mutant forms} \]

Text Fig. 5: The possible evolution of cultivated diploid and tetraploid wheats (Based on Paterson 1965, with genomes added after Bell in Hutchinson 1965).
Text Fig. 6: Possible evolution of Hexaploid wheats
(After Paterson, 1965 with genomes added after Bell in Hutchinson, 1965).
indicate that the Near East comprising the early farming villages excavated in the area of hilly flanks from the Deh Luran Plain in Iran through southeast Turkey to southern Jordan is the centre of origin and domestication of this crop as early as 7000 B.C. (Harlan and Zohary 1966, Harlan 1971). The diploid wild einkorn *Triticum boeoticum* has been found at Ali Kosh - Bus Mordeh Phase c. 7500-6750 B.C. (Helbaek 1966 b); at Jarmo c. 6750 B.C. (Helbaek 1959 b); at Aceramic Hacilar c. 7000 B.C. (Helbaek 1965 b) and at Tell Mureybit c. 8050-7542 B.C. (Van Zeist and Casperi 1968).

Cultivated einkorn *T. monococcum* is recorded at Ali Kosh Bus Mordeh Phase 7500 - 6750 B.C. (Helbaek 1966 b); Tell es Sawwan 5800-5600 B.C. (Helbaek 1965 a); Jarmo c. 6750 B.C. (Helbaek 1959 b), Catal Huyuk 5850 - 5600 B.C. Helbaek (1964 a); late Neolithic Hacilar (Helbaek 1966 b); Ghediki 6000-5000 B.C. (Renfrew 1965); Argissa 6000-5000 B.C. (Hopf 1962); Azmaska c. 5000 B.C. and Karanova c. 5000 B.C. (Hopf cf. Renfrew 1969). Consequently Helbaek (1966 b) postulated that "West Central Anatolia was the primary centre of conscious development and selection took place about 6000 B.C."
The tetraploid wheat *T. dicoccoides* (wild emmer) has been identified from Jarmo c. 6750 B.C. only (Helbaek 1960 b, 1966 b) whereas cultivated *T. dicoccum* is found in all the earliest sites of Near East, Antolia and Southern Europe (Helbaek 1960 a; Renfrew 1973). The other tetraploid wheats are rather scanty in the archaeological contexts as at Fayum, Egypt. 5th millennium B.C. *T. durum* is reported (Tackholm, Tackholm and Drar 1941). Similarly at Beycesultan *T. durum* and *T. turgidum* and in Spain *T. turgidum* is suspected (Hopf 1970). Buth (1970) reported *Triticum* sp. (cf. *T. dicoccum*) from Nubia Egypt 2500 B.C.

The present evidence reveals that hexaploid wheats *T. aestivum* and *T. compactum* are of equal antiquity (about 5000 B.C. : Renfrew 1973) in the Near East *T. aestivum* is found at Tape Sabz; 5500-5000 B.C. (Helbaek 1966 b); Tell es Sawwan c. 5800-5600 B.C. (Helbaek 1965 a), Catal Huyuk 5850-5600 B.C. (Helbaek 1964 a, 1966 b) and late Neolithic Hacilar 5800-5000 B.C. (Helbaek 1966 b). *T. compactum* has been recorded in the pre-pottery neolithic B levels at Tell Ramad (Van Zeist and Botteima 1966).

On spelt wheat *T. spelta* Helbaek (1966 b) holds
the view that it "never occurred in prehistoric west Asia and even in Europe which seems to be its area of origin (as a cultivar at least), it is rather a new comradé. The remaining hexaploid wheat, T. sphaerococcum is found from the sites in northwest India dating to third millennium B.C. It is recorded at Harappa 2250 B.C. (Burt 1941), Mohenjodaro 2250 B.C. (Stapf 1931, Shaw 1943), Chanhu-daro (Shaw 1943), Burzahom 2300 B.C. (Buth and Kaw, 1985). In view of these finds and its absence from the sites in Near East and Europe T. sphaerococcum is supposed to have originated in the northwestern area of the Indian subcontinent (Rao 1974). Aegilops tauschi growing wild in Kashmir might be one of its ancestors. Singh (1946) opined that due to its high resistance to drought T. sphaerococcum was particularly selected by our ancestors and according to Ellerton (1939) it appears to be a derivative of T. aestivum.

Chronology of the oldest wheat remains from Indian is summarized in Table 22. It becomes evident that India has received only hexaploid naked wheats, T. aestivum, T. compactum and T. sphaerococcum. Chowdhury, Saraswat and Buth (1977) have pointed out that "all these species have been named only recently based on conventional method of classification. In the early
Table 22: Chronology of some oldest wheats from India.

<table>
<thead>
<tr>
<th>Site</th>
<th>Botanical species</th>
<th>Estimated age</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mohenjodaro</td>
<td>T. sphaerococcum; T. compactum</td>
<td>2250-1750 B.C.</td>
<td>Stapf 1931</td>
</tr>
<tr>
<td>Harappa</td>
<td>T. sphaerococcum</td>
<td>2250-1750 B.C.</td>
<td>Burt 1941</td>
</tr>
<tr>
<td>Chandhodaro</td>
<td>T. sphaerococcum, T. compactum</td>
<td>2250-1750 B.C.</td>
<td>Shaw 1943</td>
</tr>
<tr>
<td>Banawali, Haryana</td>
<td>T. aestivum</td>
<td>c. 2300 B.C.</td>
<td>Lone et al. 1986a</td>
</tr>
<tr>
<td>Kalibangan, Rajasthan.</td>
<td>Triticum sp.</td>
<td>c. 2300-1750 B.C.</td>
<td>Vishnu Mittre and Savithri, 1975</td>
</tr>
<tr>
<td>Gofkral, Kashmir</td>
<td>Triticum sp.</td>
<td>2100 B.C.</td>
<td>Sharma 1982</td>
</tr>
<tr>
<td>Chirand Bihar</td>
<td>T. sphaerococcum</td>
<td>1800 B.C.</td>
<td>Vishnu Mittre, 1972</td>
</tr>
<tr>
<td>Navdatoli,</td>
<td>T. compactum, T. vulgare</td>
<td>1660-1440 B.C.</td>
<td>Vishnu Mittre, 1961</td>
</tr>
<tr>
<td>Semthan, Kashmir</td>
<td>T. aestivum, T. sphaerococcum</td>
<td>1500 B.C.</td>
<td>Present study</td>
</tr>
</tbody>
</table>
stage of their evolution when man used these cereals he was not in a position to separate them by the look of the plants or by other criteria — — — when these early hexaploid wheats were introduced in north India, they were still at a stage of rapid internal changes and at the same time making an effort to adjust themselves in the new environments. As a result of all these, we find in the early hexaploid wheats grown in India, a great variation in their morphological features".

Recent excavations at Mehrgarh in Pakistan revealed cultivation of T. monococcum, T. dicoccum, and T. durum (or T. aestivum) in the Neolithic period I: 6000-5000 B.C. (Jarriage and Meadow 1980). This is the first and very interesting record of diploid and tetraploid wheats from Indian region. Thus Mehrgarh offers proof of the earliest centre of cereal cultivation in the Indo Pak region. A rethinking of the belief that India received only hexaploid wheats is needed. May be Indopak region was an independent or secondary centre of origin and domestication of wheats (Khan 1986, Lone et al 1986b, Naseem 1986).
In Kashmir valley the hexaploid wheats *T. sphaerococcum* and *T. aestivum* are reported from Burzahom 2325 B.C. (Buth and Kaw 1985) and Gofkral c. 2100 B.C. (Sharma 1982). Thus the valley appears to have received wheats as early as the Harappans and other contemporary cultures of India and have been continuously in use from the time of their domestication over here.

(iii) Barley

Barley is a self pollinating deploid with \(2n = 14\) (Takahashi 1955; Nilan 1971). The wild two row form *Hordeum spontaneum* is believed to be the ancestor of all the cultivated barleys (Harlan 1976). Under domestication six rowed races appeared as shown in text fig. 7.

So far as archaeobotanical finds are concerned several grains of barley were reported from a late Palaeolithic site, dating between 17,000 and 18,000 B.P. at Wadi Kubbaniya near Aswan in Egypt (Wendorf et al 1979, Stemler and Falk 1980, 1984) which of course was a tentalizing discovery. However, recent studies indicated that these grains were not associated with the late Palaeolithic occupations. The age determination of the actual cereal grains using linear accelerator
Text Fig. 7: Evolution of cultivated barley Hordeum vulgare, after Harlan (1976).
radiocarbon counter revealed an age of 4850 to 820 B.P. indicating that these were contaminants into the late Paleolithic levels (Wendorf and Schild 1984).

The undoubted palaeobotanical finds tend to support the belief that *H. spontaneum* is the ancestor as this is the only form of wild barley yet found in the early farming villages (Harlan 1968, Renfrew 1969, 1973). It has been reported from Ali Kosh Bus Mordeh phase 7500-6750 B.C. (Helbaek 1966 b); Tepe Guran 6200-5500 B.C. (Meldgaard et al 1963); Jarmo 6750 B.C. (Helbaek 1959 a); Tell Mureybit 8050-7542 B.C. (Van Zeist and Casperi 1968) and Beidha c. 7000 B.C. (Helbaek 1966 b). The Beidha finds are of particular interest since many thousand impressions of *H. spontaneum* were found with grains larger than in the purely wild forms and so were described as "cultivated wild barley". Some signs of domestication are also seen in the Jarmo finds (Helbaek 1960 a).

Fully domesticated *Hordeum distichum* occurs at many sites at a slightly later date as in Ali Kosh; 6750-5600 B.C. (Helbaek 1966 b), Tape Sabz: 5500-500 B.C. (Hole and Flannery 1967), Tape Guran 6200-5500 B.C.
(Meldgaard et al 1963), Tell es Sawwan 5800-5600 B.C. (Helbaek 1965 a, b); Matarrah 5500 B.C. (Helbaek 1966 a) and late neolithic Hacilar 5800-5000 B.C. (Helbaek 1961).

Cultivated form of *H. vulgare* has been identified at Ali Kosh 6750-6000 B.C. (Helbaek 1966 b), Tape Sabz 5500-5000 B.C. (Helbaek 1966 b). Aceramic Hacilar c. 7000 B.C. (Helbaek 1966 b) Beidha 7000 B.C. (Helbaek 1966 b); Catal Huyuk 5850-5600 B.C. (Helbaek 1964 a, b; 1966 b); Tell es-Sawwan 5800-5600 B.C. (Helbaek 1965 a); Mersin 5750 B.C. (Helbaek 1959 b); late neolithic Hacilar 5800-5000 B.C. (Helbaek 1961); Can Hasan c. 5250 B.C. (Renfrew 1968) and Argissa Magnhula 6000-5000 B.C. (Hopf 1962).

From the earliest contexts of Indian subcontinent, Jarriage and Meadow (1980) reported cultivation of two row hulled *H. distichum* and naked barley *H. vulgare var. nudum* from Mehrgarh period I 6000-5000 B.C. Yet another excavation at Mahagara in the Ganga basin has yielded the evidence of barley cultivation dating 6th - 7th millenium B.C. (Sen Gupta 1985). Some other oldest records include *H. vulgare var. nudum* at Mohenjodaro 2250-1750. (Luthra 1936); *H. vulgare var hexastichum* at Harappa 2250 B.C. (Vats

The foregoing account and the modern distribution of wild barley (Harlan and Zohary 1966) establish that barley was domesticated in Near East. In the Indian region its cultivation dates back to 6th-7th millenium B.C. The barley culture in India can be followed with certainty across northern India and then southwards (Sankalia et al 1953; Raikes and Dyson 1961; Bakshi and Rana 1974; Vishnu Mittre 1974). Barley culture of Kashmir is as old as that of wheat and appears to have been introduced from its place of origin through Indian plains at a very advanced stage. Only hulled barley adapted to the Indian conditions and naked barley was confined to some isolated areas like the Ladakh region.

(iv) **Oats**

*Avena* species occur at three ploidy levels, diploids (2n = 14), tetraploids (2n = 28) and hexaploids (2n = 42). A summary of present knowledge
on species relationships is provided in text fig. 8 which is based on Holden (1966, 1976), Rajhathy and Sadasivaish (1969), Ladizinsky (1971), Ladizinsky and Zohary (1971), Zohary (1971), Rajhathy and Thomas (1974). Accordingly either *A. magna* or *A. murphyi* must be regarded as a tetraploid ancestor of *A. sterilis*. Cytogenetic studies indicated *A. strigosa* as a genome donor to hexaploids. The occurrence of at least one other diploid species presently unknown can be predicted as a common ancestor to *A. magna*, *A. murphyi* and *A. sterilis*.

Previously it was thought that *A. fatua* is the progenitor of *A. sativa* and *A. sterilis* that of *A. byzantina* but Coffman (1946) showed that all the cultivated oats are derived from *A. sterilis*.

Finds of wild oat *A. sterilis* grains have been reported from the early Neolithic villages in the Near East at Ali Kosh 6750–5600 B.C. (Hole and Flannery 1967); Beidha 7000 B.C. (Helbaek 1966 b) and in Amouq A.C. 5750 B.C. (Helbaek 1960 c). Only at Beidha the species has been identified as *A. ludoviciana* syn. *A. sterilis* ssp. *ludoviciana*. 

Text Fig. 8: showing relationships in *Avena*

after Holden (1976).
A. *fatua*, A. *strigosa* and A. *sativa* have been reported from prehistoric contexts in Europe. The earliest oat grain from Europe comes from aceramic Neolithic levels at Achilleoin, Thessaly, Greece 6000-5000 B.C. but its species could not be identified (Renfrew, 1966). A. *fatua* has been found in the Bronze lake side villages at Alpenquai on lake Zurich and Morigen (Bertsch and Bertsch 1949) and Lengyel in Hungary (Tempir 1964). In Britain the common wild oats are found at Maiden castle, little Salisbury, Worlebury, Meare lake village, Glastonbury (Helbaek 1952b) and Aldwick Barley (Renfrew 1965). A. *strigosa* has also been reported in the Alpine region in the Bronze Age at Montellier in Savoy (Heer 1866) and in early Iron age Britain at Maiden Castle and Fifield Bavant (Jessen and Helbaek 1944). Matthias and Schultze-Motel (1967) referred the impressions from Schrapian and Galbe to A. *sativa* on account of their large size.

Surprisingly there is no record of oats from Indian archaeological excavations. Jarriage and Meadow (1980) recovered a few grains of *Avena* sp. from Mehrgarh period III which is so far the earliest record from Indian subcontinent. The present oat grains
from Semthan have been referred to wild *A. fatua* as well as cultivated *A. sativa* based on the size of the grains alone. *Avena fatua* grows wild in the valley. Therefore, it appears that oats were probably locally adopted by and ancient inhabitants as a fodder crop.

**MILLETS**

(i) *Panicum* sp.

The genetics of *Panicum* is not well understood. The common millet belongs to *Panicum miliaceum* and is not known in the wild state. On the basis of close morphological similarity, its progenitor is thought to be wild Abyssinian species *Panicum callosum* Hochst (Helbaek 1952 c). *P. spontaneum* Lyssovex Zukovskig which occurs as a weed in the crop in central Asia is probably a derivative rather than its progenitor (Purseglose 1974).

*Panicum miliaceum* originated in northern China and has been cultivated since earliest neolithic times (Bishop 1933; Li 1970; Zhimin 1986). The earliest archaeological finds so far some from Neolithic of China, central and eastern Europe. It
has been reported in the Aggtelek cave in Hungary (Bertsch and Bertsch 1949), Eisenburg settlement in Danubian I culture in Thuringia (Natho and Rothmaler 1957), at several Tripolye sites in Roumania (Gimbutas 1956), in the neolithic Swiss lake side villages (Bertsch and Bertsch 1949), neolithic contexts in Poland (Schultze-Motel 1968); bronze age sites in Italy (Helbaek 1956), Holland (Helbaek 1961) and Denmark (Helbaek 1952 c). It has been found in neolithic Yang Shao contexts in China (Watson 1969). In Near East the earliest record is from Jemdet Nasr in Mesopotamia dating c. 3000 B.C. (Helbaek 1959 b) followed by seventh century B.C. deposits at Nirmud (Helbaek 1966 d).

So far there is no record of Panicum from prehistoric contexts in India. Recovery of only few seeds from Samthan, though not a positive evidence of its cultivation yet indicates that because of its earlier harvesting and drought endurance properties might have been adopted by the ancient inhabitants and was probably introduced from China - its centre of origin. The historical data confirm that some areas in the valley have been used for its cultivation during famine and drought conditions (Lawrence 1967).
ii) *Setaria* sp.

The cultivated species *Setaria italica* L. is not known in the wild state and is believed to have been derived from *S. viridis* (L.) Beauv, a common weed in the Old World (Purseglove 1974). *Setaria italica* is of very early appearance in northern China and it is quite possible that its cultivation began in China (Li 1970, Zhimin 1986). It has been recorded from more than twenty sites in the yellow River Valley, China (Zhimin 1986).

*Setaria italica* has been identified from Montellier and Buchs lake side settlements Lee (1866); from several sites in Switzerland and Hallstall in Austria (Neuweiler 1905). From the New World *Setaria* dated to 6000 to 5500 B.P. is known from Ocampo, Caves Mexico and Tehuacan valley (Reed 1976).

*S. viridis* has been recorded from neolithic deposits in the Agglelek cave in Hungary, at Schussenthal in the bronze age settlement at Alpenquai on Lake Zurich (Bertsch and Bertsch 1949) and in the stomach of Granballe man (Helbaek 1958).

In India Vishnu Mittre and Savithri (1978) reported for the first time *Setaria* in the ancient plant economy from Surkotda, Gujrat belonging to
S. *italica*, *S. viridis* or *S. verticillata* dating back to 1600 B.C. Wagner (1983) reported one carbonized and 100 uncarbonized *Setaria* grains from Oriya Timbo a late Harappan site in Gujrat. However, there is no earlier record of *Setaria* sp. from prehistoric contexts of Kashmir. *Setaria viridis* and *S. glauca* are the two species of the genus which grow wild in Kashmir. Therefore *Setaria* sp. might have been locally adopted by the inhabitants.

**PULSES**

(i) **Lentil**

Lentils are diploid with $2n = 14$ (Hector 1936). The cultivated species *Lens esculenta* syn. *L. culinaris* was thought to have been derived from the wild *L. nigricans* which is native to southeast Europe and western Asia (Berstch and Berstch 1949), but comparative morphology and observations on natural hybridization have revealed that *Lens orientalis* (Boiss) Hand. is the ancestor of the cultigen which is distributed mainly in Turkey, Syria, Israel, northern Iraq and western and northern Iran (Zohary 1972, 1976).
Lentils were definitely associated with the start of agriculture in the Near East (Zohary 1972, 1973, 1976, Zohary and Hopf 1973, Renfrew 1973) which confirms the belief that the centre of origin of lentil is in Near East (Vavilov 1949/50). Carbonized lentil seeds have been reported from Jericho c. 7000 B.C. (Hopf 1969); Jarmo c. 6750 B.C. (Helbaek 1960 a); Tape Sabz 5500-5000 B.C. (Hole and Flannery 1967); Ali Kosh 7500-5600 B.C. (Helbaek 1966 e), Hacilar 5800-5600 B.C. (Helbaek 1966 e). Significantly some of the fifth millenium B.C. remains were larger than the wild form and attain 4.2 mm diameter which is an obvious development under domestication (Zohary 1976). In Europe lentils occur at Argissa c. 6000-5000 B.C. (Hopf 1962), Ghediki c. 6000-5000 B.C. (Renfrew 1966); Tell Aşmak c. 5000 B.C. (Renfrew 1969) and some other sites in Switzerland, the Mediterranean basin and central Europe (Renfrew 1973, Zohary 1976).

100 A.D. (Vishnu Mittre et al. 1972). Thus lentils are of early cultivation in West Asia and southern Europe and from these areas spread northwards in Europe, eastwards to India and southward to Ethiopia (Purseglove 1977). From Kashmir lentils are recorded at Burzahom (Buth and Kaw 1985, Khan 1986), Gofkral (Sharma 1982) and now from Semthan. The available evidence clearly indicates that the crop has been introduced from West Asia and has been utilized from the very dawn of agriculture over here along with wheat and barley.

(ii) Pea

Neither the wild progenitor nor the early history of the pea crop is known (Davies 1976). All the peas are diploid with $2n = 14$. Zukovskij (1950) suggests that the wild ancestor may be *Pisum elatius* and *P. arvense* (*P. sativum* var. *arvense*) may be an intermediate form. Benze'ev and Zohary (1973) and Davis (1970) maintain that the genus consists of only *P. fulvum* and *P. sativum* (*P. elatius*, *P. humile* and *P. sativum* being the members of a single species.)
Vavilov (1949/50) proposed central Asiatic and Near Eastern centre of origin for *Pisum sativum*. The earliest archaeological finds are those from Jericho c. 7000 B.C. (Hopf 1969); Jarmo c. 6750 B.C. (Helbaek 1960 a); Can Hasan c. 5250 B.C. (Renfrew, 1968) all belonging to *P. sativum var. arvense* (Renfrew 1973). At acaromic Hacilar c. 7000 B.C. and at Catal Huyuk 5850-5600 B.C. *P. elatius* was predominant (Helbaek 1964). In Europe peas occur at Ghediki c. 6000-5000 B.C. and Sesklo 6000-5000 B.C. and some other sites (Renfrew 1966, 1973).

The archaeological records of *P. arvense* from India are from Harappa 2250 B.C. (Vats 1940), Chirand c. 1800 B.C. (Vishnu Mittre, 1971, 1972), Navdatoli-Maheshwar 1550-1440 B.C. (Vishnu Mittre 1962) and Diamabad 2200-1000 B.C. (Kajale 1977). From Kashmir valley *Pisum arvense* is reported from Gofkral c. 2100 B.C. (Sharma 1982) and *Pisum sativum* from Burzahom (Khan 1986). It appear that the crop was introduced into the valley from Central Asia or West Asia somewhere during third millenium B.C.

(iii) **Phaseolus** spp.

Three species of *Phaseolus* namely *P. aureus,*
*P. mungo* and *P. aconitifolius* were recovered from Semthan. *Phaseolus aureus* is of ancient cultivation in India but the plant is not found in the wild state. It is probably derived from *P. radiatus* L. which occurs wild throughout India and Burma (Purseglove 1977). Vavilov (1949/50) has proposed Indian and Central Asiatic centre of origin for the crop. The archaeological records are from Navdatoli-Maheshwar 1550-1440 B.C. (Vishnu Mittre 1962, 1974) Diamabad (Kajale 1977) and Apegaon (Kajale 1979).

Similarly *P. mungo* is of ancient cultivation and has probably originated in India but is not known in the wild state. It probably originated from *P. trinervius* Heyne or *P. sublobatus* Roxb. which occur wild in India (Vavilov 1949/50; Purseglove 1977). Hitherto the earliest record is from Banawali c. 2300 B.C. (Lone et al. 1986 a) followed by Navdatoli-Maheshwar 1550-1440 B.C. (Vishnu Mittre 1962, 1968, 1974), Diamabad (Kajale, 1977), Atranjikhera (Chowdhury et al 1977); Apegaon (Kajale 1979), Nevase and Inamgaon (Kajale 1977). There is no earlier record from Kashmir.

So far as *P. aconitifolius* is concerned it
originated in Indian centre of Vavilov (1949/50). It is a native of India, Pakistan and Burma where it grows wild (Purseglove 1977). A perusal of literature does not reveal any record of its presence in the archaeological contexts of India or elsewhere.

The evidence presented above clearly indicates that various species of Phaseolus have been introduced into the valley from the Indian centre of origin of Vavilov (1949/50), at various stages of human development.

**WEED SEEDS**

The weed seeds are of great significance to agriculture and have played an important role in plant domestication. The evolution of weeds of often parallels that of crops. Both weeds and crops often begin with a common progenitor and many cultivated plants have one or more companion weed races (Langenheim and Thimann 1982).

Any disturbance of natural vegetational cover provides growth opportunities for plants not normally dominant. In agricultural clearings selective weeding
further favours particular small or low growing plants. This phenomenon has been much studied and complexes of weeds in fields of different crops in most of the parts of the world are well known. Their occurrence in excavated pollen spectra, particularly in macroscopic collections, sometimes indicates not only cultivation but even the kind of crops being grown (Alexander 1969). Weed seeds have been associated with the prehistoric deposits all over the world. Renfrew (1973) has provided an exhaustive catalogue, of the wild plants recovered from archaeological excavations of Near East and Europe. Weed seeds have also been identified from some archaeological excavations in India (Table 23). The seeds recovered from Semthan belong to Lithospermum arvense, Galium tricorne, G. asperuloides, G. aparine, Medicago sp. Melilotus albus and Vicia/Lathyrus sp. The association of these weed seeds with cereals and other food plants is either deliberate indicating primitive stage of farming when both wild as well as cultivated plants were harvested or else the weed seeds were merely contaminants with the harvested crops. The third possibility is that these weeds were growing in or around the vicinity of the site and somehow found way into the floor. All these genera are amongst the common weeds of cultivated lands of
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<tr>
<th>Site</th>
<th>Weeds</th>
<th>Reference</th>
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<tr>
<td>Burzahom</td>
<td>Medicago denticulata</td>
<td>Vishnu Mittre (1968 a, Khan 1986)</td>
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<td></td>
<td>M. falcata</td>
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<td></td>
<td>Lotus corniculatus</td>
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<td>Lithospermum arvense</td>
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<td></td>
<td>Ipomoea sp.</td>
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<td></td>
<td>Euphorbia sp.</td>
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<td></td>
<td>Galium sp.</td>
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<td>Gufkral</td>
<td>Medicago sp.</td>
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<td></td>
<td>Trifolium sp.</td>
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<td>Lithospermum arvense</td>
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<tr>
<td>Navdatoli</td>
<td>Vicia sativa</td>
<td>Vishnu Mittre (1962, 1968 a)</td>
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<td></td>
<td>V. tetrasperma</td>
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<td>Lathyrus sphaericus</td>
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<td>Kaundinyapur</td>
<td>Lathyrus sphaericus</td>
<td>Vishnu Mittre (1966, 1968 a)</td>
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the valley today.

ENDOCARPS

(i) Walnut

Several species are cultivated or exploited from the wild for their edible seeds ('nuts') which are enclosed within a hard drupaceous endocarp. Walnuts are native to Central Asia, Iran, Caucasus, Anatolia, Balkan and southern Europe (Hudson 1962, Smith 1976). *Juglans regia* has 2n = 32 (Smith 1976). It has occasionally been encountered in the archaeological deposits as at Meckur, Bulgaria (Arnaudov 1936, 1948/1949, Gaul 1948); at Sadowetz northwest Bulgaria Dark Age deposits (Arnaudov 1937/1938). Neuweiler (1905) reported walnut from Iron Age settlements at Fontinellato and Bertsch and Bertsch (1949) from Wangen, Untersee, Bleiche and Haltnau.

Perusal of literature reveals that there is no record of *Juglans regia* from Indian archaeological excavations. However, the Plio-Pleistocene and Post-glacial deposits of Kashmir have yielded carbonized woods, leaf impressions and pollen grains of
Juglans sp. (Vishnu Mittre 1965, 1984; see also part II of the thesis). Thus its recovery at Semthan is significant. The foregoing evidence suggests that it might have been brought from its centre of origin in Central Asia alongwith human migrations. However, the occurrence of Juglans since Plio-Pleistocene times suggests that it might have been domesticated locally in Kashmir.

(ii) Apricot, Beach and Cherry

It seems probable that the first diploid Prunus species arose in Central Asia (Vavilov 1949/50, Watkins 1976).

Watkins (1976) believed that P. armeniaca, the apricot, has primary centre of origin in western China and the secondary centre of origin in western Asia. However, there is no archaeological record from India or elsewhere except Kashmir where it has been reported from Gofkral c. 26000 B.C. contexts (Sharma 1982). In the light of these facts it appears that this fruit has been introduced into the valley from Central Asia or western China.

Prunus persica, the peach, is also believed to have originated in western China on botanical grounds (Vavilov 1949/50, Li 1970, Watkins 1976).
However there is no archaeological record. Its recovery from the Kashmir archaeological excavations and its continued cultivation now-a-days makes to believe that it has been introduced from China.

As far as *Prunus cerasus*, Cherry, is concerned its place of domestication is not known, but is believed to have evolved from *P. fruticosa* in western and Central Asia (Watkins 1976). So far it has not been found in the archaeological deposits. Interestingly *Prunus* spp. are represented in the Pleistocene deposits of the valley (Vishnu Mittre 1984, see Part II of the thesis). Further *Prunus cerasus* does grow wild in the valley at present. Therefore, it might have been collected locally by the ancient man.

**WOODS**

The charcoals identified from various phases belong to both conifer as well as broad leaved elements. Some of them belong to the ornamental trees of today with interesting background history.

Among the conifers, the recovery of *Cupressus* sp. is the most interesting one. There is no
indigenous species of the genus in Kashmir. *Cupressus* spp. grow on the high mountains on the outer ranges of the Himalaya from Chamba to Nepal at 6,000 to 9,000 ft (Brandis 1971, Gamble 1972). From the pollen analysis of some Lower Karewa deposits pollen belonging to *Cupressus* have been reported (Gupta et al. 1985, Sharma et al. 1985, Sharma and Gupta 1985). This leads to think that either the Semthan charcoals belong to the Pleistocene remnants of *Cupressus* in the valley or they belong to the trees introduced during period IV at Semthan from outside. In the light of the present day distribution, it appears that *Cupressus* was introduced into the valley from the area of its distribution, probably in Punjab Himalayas, through the contact of the inhabitants. The identification of *Cupressus* pollen in the Pleistocene deposits needs to be re-examined. If they are really of *Cupressus*, then these might have come from much longer distances from the Punjab Himalayas. So far no megafossils of *Cupressus* have been recovered from the Pleistocene deposits of the valley.

Among the other Gymnosperms recovered, *Pinus wallichiana* is presently distributed over
Kuram valley at 8,000 to 11,000 ft; Safed Koh, Kafiristan, Himalaya and also in some more arid valleys such as Lahaul, Kunawar, eastward as far as Nepal; also in Bhutan and Afghanistan. *Abies pindrow* grow in the Kuram valley from 8,000 to 11,000 ft; Chitral, outer Himalaya from 8,000 to 10,000 ft. *Picea smithiana* grows in the Kuram valley from 8,000 to 12,000 ft; Kafiristan, Chitral, Gilgit, Himalaya common from Kashmir to Garhwal from 7,000 to 11,000 ft, in the inner valleys of Sikkim and Bhutan from 8,000 to 15,000 ft. *Cedrus deodara* is distributed in Afghanistan, Kuram valley from 7,500 to 10,000 ft; Chitral; northwestern Himalaya at 4,000 to 10,000 ft. ascending at places upto 12,000 ft; in the basin of the principal tributaries of the Indus, Tous, Jumna and Bhagerate rivers, cultivated in Kumaon and Nepal (Troup 1921, Pearson and Brown 1932, Raizada and Sahni 1960, Brandis 1971, Gamble 1972). *Pinus wallichiana* is widely distributed in the valley today. *Abies pindrow* too, is fairly distributed. *Picea* in the Kashmir valley forests is extremely poor. *Cedrus deodara* though almost absent on the Pir Panjal side, is found in other parts of the valley both in dry and moist regions. It is of limited occurrence
unlike Pinus and Abies. Palaeobotany and palynology of the Lower Karewa and post glacial deposits (see Part II) reveal that all of these have been growing in Kashmir since Plio-Pleistocene times. Therefore the inhabitants must have been collecting these woods from the local forests.

Amongst the broad leaved elements recovery of Quercus sp. Platanus orientalis, Morus alba, Betula sp., Juglans sp., Ficus sp. and the leguminous wood probably belonging to Acacia sp. are quite significant.

Oaks (Quercus spp.) present the most vexing problem amongst the floral elements of Kashmir. They are almost absent in the present day flora of the valley (Royle 1839, Drew 1875, Parker 1924, Lambert 1933, de Terra and Paterson 1939, Puri 1948, Rao 1960). However, the megafossil evidence has revealed their presence during Pliocene and Pleistocene times in the valley (de Terra and Paterson 1939, Puri 1948, Vishnu Mittre 1965, see also Part II). The palynological observations have confirmed these observations (Vishnu Mittre et al 1962, Gupta et al 1985, Sharma et al 1985, Sharma and Gupta 1985). Of major interest is the evidence of oaks in the pollen

Thus the identification of *Quercus* sp. in the archaeological woods is quite significant. Though the exact species could not be identified yet the woods do not belong to the exotic European oak *Quercus robur* L. that has been planted in the valley in recent years (Vishnu Mittre 1963). Hence the charcoals belong to some indigenous species. Some stray patches of *Q. dilatata* and *Q. semicarpifolia* do occur in the present day valley forests (Vishnu Mittre 1963, personal observation).

The dominance of oaks in the valley during Pliocene-Pleistocene and their near absence today has largely been explained by the uplift of mountain barrier: the Pir Panjal which flanks the valley in south and southwest. This has acted as an effective barrier and prevented the monsoon from entering the valley resulting in extremely low precipitation (Puri 1957, Puri et al. 1983). However, the presence of oaks in the post-glacial deposits and now in the archaeological deposits does not support this thesis.
as there is no evidence to suggest that the mountain barrier subsided substantially during the post-glacial period, thus allowing the monsoons to enter the valley and create ideal climatic conditions for the immigration of oaks. Further, the climatic requirements of some species of oaks distributed in western Himalaya show a very great range and reduction in precipitation could not have been detrimental up to the extent of their extinction. Some other reasons must also be involved.

The present day distribution of the various species of oaks is as follows (Troup 1921, Pearson and Brown 1931, Brandis 1971):

*Q. semicarpifolia* grows in Kuram valley from 9,000 to 11,000 ft; Himalaya 8000 to 10,000 ft, in eastern Manipur, on the Burma frontier. *Q. incana* grows in northwestern Himalaya, eastward as far as Nepal at 4000 to 8000 ft. *Q. glauca* grows in the valley of outer Himalaya ascending up to 6000 ft. *Q. dilatata* in the Kuram valley at 7000 to 8500 ft. and in northwestern Himalaya at 5000 to 9000 ft.

In view of these facts it appears that some patches of indigenous oaks must have been growing
near the site or at a reachable place in the forests wherefrom the inhabitants collected the wood. This further provides a clue that in addition to climatic changes biotic factor might also have been involved in the reduction of oaks from the valley.

Coming to the plane tree, *Platanus orientalis*, it is believed to be indigenous to eastern Mediterranean region (Anonymous 1969; Brandis 1971). It is cultivated in Afghanistan and northwestern Himalaya particularly in Kashmir, eastward to Sutlej, Pehawar and at the foot of northwestern Himalaya (Brandis 1971).

The tree is very closely associated with the cultural matrix of the valley and its introduction is usually ascribed to the Moghul emperors Jehangir (1605-1627 A.D.) and Shah Jahan (1627-1658 A.D.) who brought it from Central Asia (Lawrence 1967). Retrieval of its charcoals at Semthan reveals that this tree has been in existence centuries before the advent of Moghuls. This evidence could further be authenticated by some literary records. Screening through the literature some instances in this regard have been found e.g. Lal Ded (1320-1390 A.D.), the famous mystic poetess of Kashmir in an epigram compares
"virtuous and loving wife to the cool and refreshing shade on a hot summer day of a 'Buin' (Buin in Kashmiri is *Platanus orientalis*). Lal Ded lived two centuries before the advent of Moghuls in Kashmir and the tree from which she had drawn her imagery could have been a full grown one, may be some hundred years old (Fodedar, A.N. Personal communication). Further the "Akbarnama" has a reference that "the emperor took 34 persons inside the hollow trunk of an aged chinar". Similarly Jehangir in his memoirs mentions a huge chinar in the hollow of which he and seven of his companions could be comfortably accommodated. Thus the plane tree has been growing in Kashmir since much earlier times. From its natural home in Mediterranean, it could have spread eastward through natural agencies such as wind, water, animals and birds etc. However, it has not been reported to have spread except perhaps in its original home by natural means. How and when the tree reached Kashmir still remains obscure. Perhaps the cultural contacts of the prehistoric people might have been responsible. The present evidence dates back its introduction to 500 to 1000 A.D.
**Morus alba** is another interesting find. The tree is of very ancient cultivation in China and is not indigenous to India. It is commonly cultivated in Baluchistan, Afghanistan, northern part of trans Indus territory, Punjab plains, Kashmir, northwest Himalaya, Europe and Central Asia, and in China (Brandis 1971). Retrieval of its charcoals at Semthan is the earliest report of the genus over here. The tree has been apparently introduced into Kashmir from China mainly for silkworm rearing.

The genesis of sericulture in Kashmir is as yet an unsolved historical issue. As a matter of fact many theories have been put forth. Some assert that sericulture has an indigenous origin in Kashmir (Ganju 1945), whereas other believe that it is a 15th-16th century introduction to Kashmir (Mirza Haider 1973). The first notion is based on the reverence paid to the mulberry trees by the Hindus at their two religious ceremonies namely the Bhairwa Pooja and the Yajneopavita ceremony since very ancient times in comparison to other trees. This has led Ganju (1945) to conclude that silkworm rearing based on mulberry culture was carried out by the people of Kashmir since very ancient times. The second theory is based on the fact that mulberry
trees were growing in Kashmir in abundance during 16th century. To quote Mirza Haider "Among the wonders of Kashmir are the quantities of mulberry trees (cultivated) for their leaves (from which) silk is obtained".

In the light of the present discovery of *Morus alba* in the contexts dating 500-1000 A.D. it becomes clear that sericulture is neither indigenous nor a 15th or 16th century introduction. This being an established fact that sericulture first originated in China (Encyclopedia Britannica Vol 20 p 519, Radzinski 1979), the mulberry must have been transported into Kashmir from there. It is very difficult at this stage to give an exact date of its diffusion. However the present evidence has led us to 500-1000 A.D. The famous silk route could have been followed for the purpose (Fig. 203). During this period Kashmir had developed very close contacts with central Asia and China (Ahmad 1986, Kachroo 1986, Shali 1986).

*Betula* is another interesting discovery. The present day distribution of *B. utilis* in the Indian region is in the Kuram valley from 10,000 to 11,000 ft and in the Himalayas from 10,000 to
Birch today occurs only at high altitude in the Kashmir valley. The retrieval of its charcoals at Sem than suggest that the tree might have been growing at lower elevations in the past. The names of archaeological sites such as Burzahom ('Burz' means birch in Kashmiri) also suggest the occurrence of birch woods in the valley proper in the recent historical past. Its recent extermination from the valley proper must obviously be due to human influence. Its destruction may be attributed to the removal of its leaves to feed sheep and goats and removal of its bark to provide the famous "Bhojpatra" for writing manuscripts.

Juglans today is mostly planted in the valley proper. It also occurs as a less frequent constituent of the forest at high altitude. Perhaps the tree was very widespread in the historical past. Once again human hands might have led to its reduction. The possibility of human interference leading to the reduction of oaks, birches, walnut etc from the valley can be justified by the fact that merely by removal of leaves for sheep a whole-sale destruction of birch forest at Kainmal about 1000 m, above Gulmarg has taken place in recent human memory (Vishnu Mitrre and Sharma 1966).
Species of *Ficus* are distributed in Punjab, outer Himalaya, eastward to Nepal, upto 5500 ft, on hills of Marwa and Abu (Agarwal 1970, Brandis 1971). The tree is not a component of the present day vegetation of the valley. However, *Ficus cunia* has been reported from Pleistocene deposits of the valley (Vishnu Mittre 1984). The possibility of some trees growing near the site is very remote and it is quite possible that *Ficus* introduced from outside probably for some religious purposes.

The leguminous wood shows affinity towards *Acacia* sp. The tree grows in West Bengal, is indigenous to Sindh, also occurs in Rajputana, Gujarat, north of Andhra Pradesh, often cultivated in drier parts and fallow lands throughout India (Agarwal 1970). Presently the tree is absent from the valley. Two possibilities are there: either some trees were growing in the vicinity of the site during the period of occupation or the wood was transported from outside. The second possibility seems to be more probable.

The other woods belong to *Aesculus indica*, *Parrotiopsis Jacquemontiana*, *Acer* sp, *Salix* sp., *Populus* sp, *Crataegus oxyacantha*, *Pyrus pashia*. 
Fraxinus excelsior, Ulmus wallichiana, Viburnum sp. and Celtis australis. The present day distribution of these tree species in India is as follows:

**Aesculus indica** grows in northwest Himalaya 4000 to 9000 ft., trans Indus, in Kafiristan at 7000 to 8000 ft; Indus to Nepal chiefly in moist and shaddy valleys. **Parrotiopsis jacquemontiana** grows in the Kuram valley, Kashmir and Chamba from 3800 to 8500 ft. The species of **Acer** commonly found in Kashmir are **A. oblongum**, **A. pentapornicum**, **A. villosum**, **A. caesuim**, **A. caudatum** and **A. pictum**. **A. pentapornicum** grows from 2300-2700 ft; **A. caesuim** from 4000-10,000 ft; **A. villosum** at 7000-9000 ft; **A. caudatum** at 8,000-11,000 ft; **A. pictum** from 4000-9000 ft and **A. oblongum** ascends upto 6000 ft. **Salix** is distributed in the Kuram valley at 10,000 to 12,000 ft; very common in the Himalayas from 7000 to 8000 ft. In Kashmir it grows from 6000 to 8000 ft. The common species of **Populus** in India are **Populus euphratica**, **P. nigra**, **P. alba** and **P. ciliata**. **P. euphratica** is common in the forest belt of Sindh along Indus. **P. nigra** is frequently planted in northwest Himalaya particularly in Kashmir and also in Ladakh as high as 12,500 ft. **P. ciliata** is distributed in northwestern Himalaya from 4600 to
Crataegus oxycantha is distributed in Baluchistan, Kuram valley, northwest Himalaya, from Indus to Ravi at 5,000 to 9000 ft; Afghanistan, western Asia, Siberia and Europe. Pyrus pashia grows in Afghanistan, trans Indus, Himalaya, Hazara to Bhutan at 2500 to 8000 ft; Khasi hills, Manipur, upper Burma, Kashmir to Kumaon. Fraxinus excelsior is distributed over northwestern Himalayas, basin of the Jhelum, Chenab and Ravi rivers from 4000 to 9000 ft, in Europe and mountains of western Asia. Ulmus wallichiana is distributed over northwestern Himalaya from Indus to Nepal at 3500 to 10,000 ft. Viburnum is a very common deciduous shrub in the forests of Kashmir along the slopes from 5,200 to 7000 ft. and Celtis australis is very common along the graveyards in the valley (Troup 1921, Brandis 1971, Singh and Kachroo 1976).

All these plant species are indigenous to the valley as evidenced by the palaeobotany and palynology of the Pliocene-Pleistocene deposits of the valley and therefore must have been locally available to the inhabitants (See Part II).
The foregoing account makes it clear that there are only a few plants that have been available to the ancient inhabitants of Kashmir locally. Those that were available to them mostly catered to their needs for wood. Ethnobotanically speaking, the way plants are used by peoples of different regions indicates both their development and the nature of culture and also the origin and history of cultivated plants they use (Li 1970). Man utilizes plants first for food next for clothing and later uses being for industrial purposes etc. We have already seen that none of the food plants utilized by ancient man in Kashmir evolved locally except perhaps *Triticum sphaerococcum*. Almost all were brought from their respective places of origin. The plants have been brought from Indian plains, China, West Asia, Central Asia, Mediterranean region etc. In order to know about the diffusion of various plants it seems imperative to look for the ancient routes which, if at all they were available, were followed by ancient people to get the various plants into the valley. A look back into the
subject reveals that such routes were available since Palaeolithic times (Dikshit 1982, Ahmad 1986, Kachroo 1986).

Sahni (1936) stated that "round about Middle Pleistocene time when the main valley of Kashmir was still occupied by the great "Karewa Lake", interglacial man of about the same stage of cultural development - as Neanderthal or Mousterian man in Europe and as Peking man in the Far East flurished a) in the plains of northern Punjab b) on the shores of Karewa lake in the heart of Kashmir and c) just across the Great Himalayan range indicating contact between early human cultures on the two sides of the main Himalaya and the Pir Panjal range". The discovery of Palaeolithic stone flake industries in three widely separated parts of northern India i.e. southwest of Rawalpindi (Chitta, Pakistan), few Kilometers east of Srinagar (Pampur, Kashmir) and at Kargil (Ladakh) reveal with respect to human activities. Kargil lies beyond the main Himalayan range on the ancient trade route over Zoji-la connecting India with Central Asia, Tibet and China. In this connection de Terra's remark is significant that traces of prehistoric human industry have been
discovered even north of central Himalayan range on the borders of Little Tibet! (cf. Kachroo 1986).
In fact Sahni (1936) asserted that the Himalaya and the Pir Panjal range could not act "as a barrier to the migration of Palaeolithic or even Neolithic man". Thus long before man conquered the ocean, intercourse between ancient culture of India and China was possible by the direct route across the Himalaya even in Palaeolithic and Neolithic times.

The circumstantial evidence that presents itself is that during Neolithic times from a "nucleus" in central Asia there could have been a two fold migration. One to southwest and thence to Kashmir and one to northeast to China - Manchuria-Siberia. Dikshit (1982) has also stated that "the entry to Kashmir was through Gilgit and Sarhad and then along the foot hills of Kun Lun ranges. But did neolithic man trode these routes into Kashmir. There is no 100% proof yet faith that he did come thence. There are historical facts and cultural links (Kachroo 1986).

The roads carved by man since pre-historic times played an important role in the dissemination
of one's people and culture to the other. The most important ancient 'highway' was the silkroute (Fig. 203) which connected China with Europe, West Asia and India. Other roads that connected India with Central Asia passed through its north and northeastern regions. Central Asia was also connected with Tibet and with Kashmir valley through the northeastern regions and these were connected with silk-route (Ahmad 1986).

As for the main roads linking Kashmir with Central Asia, there are three main roads: one in the northwest passing through Baramulla to Muzaffarabad. Roads also led from the valley to Mansura near Hyderabad (Pakistan) and it is interesting to note that Kashmiri merchants sailed down the Indus from the Jhelum as far as delta of Indus. The other roads that passed from the valley to Central Asia was via Gilgit and Chitral; and the important road that connected the valley with Tibet and Sinkiang passed through Leh and Karakorum mountains (Ahmad 1986).

Thus any of the routes could have been followed by the ancient inhabitants in bringing the plants like Prunus persica, P. armeniaca,
P. amygdalus, Panicum sp. Setaria sp. and Morus alba etc from China and Central Asia. So far the crops of Near Eastern origin like wheat, barley, peas and lentil are concerned, these could have been brought either through Harappa or Indo-Gangetic plains as there are resemblances and indications of contact between the Harappan and Burzahom neolithic cultures in respect to pre-Harappan pot and semi precious stones found at Burzahom (Buth and Kaw 1985) on one hand and Pre-N.B.R. phase at Semthan and late Harappan Bara type of pottery at Banawali in Haryana (Bisht 1986). Sharma (1982) has also suggested Harappan contact in the late phase of Neolithic at Gofkral. Further an idea has been put forth that neolithic of Central Asia may be of west Asian origin (Diskshit, 1982, Kachroo 1986) and therefore these crops might have been passed to Kashmir via central Asia. However, it appears most likely that the Indian route was followed. Similarly rice was also carried from Indo Gangetic plains (Buth et al 1986 a) as might have been Phaseolus spp; and Ficus sp. Platanus orientalis being of Mediterranean origin might have been brought via Central Asia.
C) Probable Uses of the Plants Recovered

In the absence of any artefacts and from the nature of plant remains one can at best speculate on the probable uses to which various plant species might have been put by the inhabitants in the light of their present day uses as follows:

**Oryza sativa:**

- Used as food after cooking in water; buns and bread made from flour; paddy and broken rice as poultry feed; husk as fuel and binding material; culms as cattle feed; grass for roof thatching.

**Triticum aestivum** and **T. sphaerococcum**:

- Used as human food in the form of bread and porridge; as animal feed; fresh culms as fodder; residues left after threshing and grinding as cattle feed.

**Hordeum vulgare**:

- For making bread and porridge; as fodder and cattle feed; probably for making some crude liquor.

**Avena fatua** and **A. sativa**:

- For feeding livestock especially winter feeding of stalled animals.
Panicum sp:
As meal, bread or porridge; cattle feed.

Setaria sp:
As meal, bread or porridge; cattle feed.

Phaseolus aureus:
As dhal and vegetable; haulms as fodder;
hulls and split beans as livestock food;
hay as green manure.

P. mungo:
Green pods as vegetable; as dhal; hulls and straw as cattle feed; as green manure.

P. aconitifolius:
As human and/or animal food; as forage;
hay for livestock; green manure.

Pisum sativum:
As vegetable; human and stock feeding;
green manure.

Lens culinaris
Used as dhal; husks, bran and dried haulms as fodder for livestock.

Juglans regia:
Kernels eaten fresh or dried; oil extracted from kernels; stones as fuel; wood used for making household items, furniture; as firewood.
Prunus persica:
As edible fruit; firewood and fuel; cash crop.

P. cerasus:
Edible fruit; fuel.

P. armeniaca:
Edible fruit; oil; fuel; firewood.

Weed Seeds: For feeding livestock.

Celtis australis:
Firewood; to a lesser extent for agricultural and household items; leaves as fodder; as a sacred tree.

Pinus wallichiana:
Building constructions and houseposts, for agricultural and household items; firewood.

Picea smithiana:
As building material; for household items; firewood.

Cedrus deodara:
Building construction; boat making; agricultural implements; household items; firewood.
Abies pindrow:

Construction purposes; agricultural implements; firewood.

Cupressus sp:

As ornamental; firewood.

Aesculus indica:

As firewood; household items.

Betula utilis:

Bark for roof thatching; thin papery layers as writing material; firewood.

Ulmus wallichiana:

Construction purposes; firewood, leaves as fodder.

Quercus spp.:

Building material, furniture, agricultural implements; firewood; charcoal; leaves as fodder.

Fraxinus excelsior:

Agricultural implements, furniture, firewood, fodder.

Ficus sp.:

For some religious ritual.
**Populus spp:**

Construction purposes, agricultural and household implements; firewood, fodder.

**Salix sp:**

Agricultural and household items; furniture making, firewood; fodder; twigs chewed for cleaning teeth.

**Viburnum sp:**

As firewood; for fencing purposes.

**Parrotiopsis jacquemontiana:**

Agricultural implements; firewood; fencing purposes.

**Crataegus oxyacantha:**

Agricultural implements; firewood.

**Pyrus sp:**

Edible fruit; fodder, fuel.

**Acer sp:**

Furniture making, building material; firewood.

**Morus alba:**

Silkworm rearing; for making agricultural implements; furniture; fodder; firewood.
Platanus orientalis:
Ornamental; furniture making; firewood.

D) State of Economy

In this aspect we shall consider each of these items of plants under different age groups collectively so as to point out in which particular aspect progress is evident and where there are signs of retrogression.

(a) Agriculture

Period I: Pre-N.B.P.

The plant assemblage recovered from this phase is quite interesting. Just above the natural soil rice (Oryza sativa); barley (Hordeum vulgare) and wheat (Triticum aestivum and T. sphaerococcum) are recovered. Associated with these cereals were the pulses lentil (Lens culinaris) and green gram (Phaseolus aureus) and endocarps of Juglans regia, Prunus armeniaca and Celtis australis. Some of these plant remains were found embedded in the mud-clods. The question of their getting into the mud-clods remains unaccounted for.

Coming to cereals they constitute about 85%
of the total seeds recovered from this phase (Fig. 204, 205). Of these rice constitutes 55.8%, wheat 30.8% and barley 14.4% (Fig. 206). Rice is a summer crop and needs plenty of water for optimal growth. Wheat and barley are well known winter crops and require moderate irrigation. This indicates that the inhabitants raised two crops a year; rice in the summer and wheat and/or barley in the winter which indicates that the agriculture was very advanced and the people that had settled at Semthan carried with them a good knowledge of agriculture and were well acquainted with the "double cropping" system. From the literary records it is known through Vedic literature that "two harvests a year were gathered (Bose et al 1971) and the Vedic period according to some scholars begins about 1500 B.C. (Kosambi 1965, Thapar 1966, Sankalia 1971). Further, the practice of growing two crops a year was in vogue much earlier than Vedic period as revealed by retrieval of rice and barley together at Atranjikhera Phase I: 2000-1500 B.C. (Chowdhury et al 1977). However, we are still unaware of the cropping pattern and rotation practices of Harappans although a meagre evidence of mixed cropping is revealed by Kalibangan furrowed field (Vishnu Mittle and Savithri 1982).
As regards pulses, they constitute just 4 to 5% of the total seed economy of the phase and are represented by *Lens culinaris* and *Phaseolus aureus*. *Lens culinaris* is a cold weather unirrigated crop and as a pulse ranks inferior to green gram (Kachroo and Arif 1970) whereas *Phaseolus aureus* is a crop that can be grown in spring or summer and needs a well distributed moderate rainfall. It can be grown on unirrigated lands and is a much valued pulse (Anonymous 1969, Kachroo and Arif 1970). The recovery of a summer crop and a winter crop amongst the pulses as well further confirms that two crops a year were harvested.

The endocarps recovered constitute 9.3% of the seed economy and are represented by *Prunus armeniaca*, *Juglans regia* and *Celtis australis*. Recovery of *Juglans regia* and *Prunus armeniaca* hints towards the probability of horticultural crops being grown or collected by the inhabitants which further marks their advancement in agriculture. The recovery of endocarps of *Celtis australis* is a bit intriguing. However a point may be mentioned here that amongst the wood remains recovered from this phase there were pieces belonging to *Celtis*
wood. It is quite possible that a few dry fruits attached to the tree, that were felled, somehow found their way into the mud clods.

The whole evidence leads to the conclusion that the settlers at Semthan had a good knowledge of agriculture and were utilizing cereals, pulses and some fruits as well.

**Period II: N.B.P.**

The plant assemblage in this phase consists of cereals, pulses, endocarps and weed seeds (Fig. 204). Of these cereals constitute 74.8% of the total economy and are represented by the three cereals recovered from Pre-N.B.P. phase i.e. *Oryza sativa*, *Triticum aestivum* and *Hordeum vulgare* with the addition of few caryopses of *Avena* sp. (cf. *A. fatua*). None of the grains referable to *Triticum sphaerococcum* could be recovered. Amongst the cereals rice constituted 17.5%, wheat 25%; barley 56.25% and oats 1.17% (Fig. 206).

Pulses constitute 4.38% of the economy (Fig. 204, 205) and show a lot of variety being represented by *Phaseolus mungo* (26.6% of the pulses),
Phaseolus aureus (33.3%); P. aconitifolius (6.6%), Lens culinaris (6.6%) and Pisum sativum (6.6%). All these belong to the family of legumes which are well known for their ability to fix atmospheric nitrogen and thereby improve the fertility of soil on which they grow. It may be pointed out that Vedic literature has emphasized the "rotation of crops" in order to maintain "soil fertility and crop productivity" (Bose et al. 1971). The ancient Kashmiris, too, were aware of this fact. New additions to the Pre-N.B.P. pulses are Phaseolus mungo, P. aconitifolius and Pisum sativum. Phaseolus mungo is a highly prized pulse and is grown in the valley as a summer (Kharif) crop. Phaseolus aconitifolius is the most drought resistant of the Kharif pulses (Anonymous 1969 b). Pisum sativum requires a cool growing season and flourishes best with a fairly abundant rainfall (Martin and Leonard 1967) and a relatively humid climate (Purseglove 1977). Such a large variety of pulses indicates that the inhabitants were well aware about the utility of pulses.

The endocarps recovered constitute 17.25% of the total economy (Fig. 204, 205) of which Prunus cerasus accounts for 61.2%, P. armeniaca 15.2%.
Juglans regia 16.9% and Celtis australis 6.7%.

Prunus cerasus is the new addition to Pre-N.B.P. endocarps. It is a wild edible fruit tree which might have been collected by the inhabitants from the nearby forests.

Weed seeds constitute 3.5% of the plant economy (Fig. 204,205) and are represented by Lithospermum arvense and Vicia/Lathyrus sp. Both are the common weeds of the local field crops particularly the rainfed crops.

From these facts one is led to presume that there is certainly a great advancement in the agricultural economy over period I.

Period III : Indo Greek Phase

The agricultural economy of this phase is constituted by cereals, a millet, pulses, endocarps and weed seeds (Fig.204). The cereals constitute 80% of the economy and the interesting feature is the addition of oat grains that could be referred to Avena fatua as well as Avena sativa. Rice (Oryza sativa) constitutes 23.5%, wheat (Triticum aestivum) 4.4%, barley (Hordeum vulgare) 67.6% and oats (Avena fatua, Avena sativa) 4.4% of the cereal
economy (Fig. 206), Avena is essentially a winter crop and can also be grown as a summer crop. Perhaps the utility of this crop as a fodder had become known to the early farmers who had begun its cultivation.

Recovery of a few grains of Panicum sp. is quite interesting and significant too. Panicum is among those "unconventional cereals" which are known as "poor man's food" to which man is resorted in the times of scarcity or famine (Vishnu Mittre 1985). It is also cultivated and grown exclusively on unirrigated poor soils (Anonymous 1969 b). Was there any kind of famine or scarcity during this period? Literary records in this regard are lacking.

Pulses constitute 4.7% of the economy (Fig. 204, 205) and are represented by seeds of Phaseolus mungo and Phaseolus aureus. Among the endocarps which constitute 9.4% of the economy, Prunus persica is the new addition. Others recovered are Prunus armeniaca and Juglans regia. Weed seeds constitute 5.6% of the economy and are represented by Lithospermum arvense, Vicia/Lathyrus sp. and some unidentified leguminous seed.
The overall evidence reveals that during period III i.e. towards the beginning of Christian era, quite a large number of plant species had been cultivated thereby indicating a continuous upward trend in the rural economic and agricultural development.

**Period IV: Kushan Period**

Cereals constitute 72.3% of the total seed economy of this phase. Of these rice constitutes 28%, wheat 39.3%, barley 27.8% and oats 4.5% (Fig. 206). Wheat is represented by two species, *Triticum aestivum* and *T. sphaerococcum*.

Interesting feature of this phase is the recovery of few seeds of *Setaria* sp. It is an important millet and could have been adopted as an "unconventional cereal".

Pulses constitute 4.3% of the economy (Fig. 204, 205) and are represented by *Pisum sativum*, *Lens culinaris*, *Phaseolus aureus*, *P. mungo* and *P. aconitifolius* as in N.B.P. Phase. Endocarps which constitute 1.8% of the economy are represented by *Prunus armeniaca*, *P. persica* and *Juglans regia*.

Another interesting feature of this phase has
been the recovery of a large number of weed seeds which constitute 21.5% of the total seed economy (Fig. 204, 205) and are represented by Galium aparine, G. asperuloides, G. tricorne, Lithospermum arvense, Vicia/Lathyrus sp., Medicago sp. and some unidentified seeds. The presence of various types of weed seeds indicates a progressive trend in the rural village farming activity. It is also deducible that some of the weeds were deliberately collected for feeding cattle which in turn indicates an advanced animal husbandry.

From the above evidence, it becomes clear that rural and agricultural economy was aspiring climax during this period. A lot of cereals, pulses and fruit trees were being cultivated. The ancient literature, accounts of travellers and archaeological discoveries describe that the period between 5th and 9th centuries is the period of maximum prosperity in the valley (Ray 1957). The Kushan period dates upto the threshold of this prosperous period in the valley.

**Period IV: Hindu Rule Phase**

The agricultural economy is represented by cereals, pulses, endocarps and weed seeds (Fig. 204, 205)
Cereals constitute 71.17% of which rice (Oryza sativa) constitutes 32.3%, wheat (Triticum aestivum) 23.9% barley (Hordeum vulgare) 38% and Oat (Avena sativa) 5.63% (Fig. 206). Pulses constitute 2.02% and are equally represented by lentil and pea. Endocarps constitute 12.12% and are represented by Prunus armeniaca, P. persica and Celtis australis. Weed seeds constitute 14.14% being represented by Galium tricorne, Lithospermum arvense, Vicia / Lathyrus sp. Melilotus albus and some unidentified seed.

These evidences lead to the conclusion that rural economy during this period was more or less a continuation of what was established in Kushan period (between 2000-1500 B.P.). There is no new addition to the plant economy.

(b) Forestry

Period I: Pre-N.B.P.

At the outset it seems pertinent to point out that small pieces of charred wood that were recovered came from the same source as cereals, pulses, endocarps and weed seeds. It is not quite clear how these got into the floor of the house; however, these wood remains are significant. In this
context Braid-wood and Howe (1960) have aptly said "we were very conscious of the fact that plants and animals do not domesticate themselves, nor does an environment domesticate them. The domesticator is man".

The wood remains recovered from this phase belong to *Pinus wallichiana*, *Picea smithiana*, *Cedrus deodara*, *Juglans* sp. *Celtis australis* *Quercus* sp. and some legume wood probably belonging to *Acacia* sp. The use of these few woods amongst the large number available to them is very significant. Considering the economic stage of their existence, it is remarkable to note that these well valued timbers were known to them in preference to many others that formed the then virgin forests around them.

**Period II : N.B.P. Phase**

The wood remains recovered from this phase belong to *Pinus wallichiana*, *Abies pindrow*, *Cedrus deodara*, *Quercus* sp. *Ulmus wallichiana*, *Fraxinus excelsior*, *Prunus* sp. *Betula utilis* and *Ficus* sp. Addition of so many more timbers is a clear indication of the advancement, with respect to utilization of forest wealth over period I.
Period III : Indo Greek Phase

Wood remains recovered from this phase belong to *Picea smithiana*, *Malix* sp. *Aesculus indica*, *Viburnum* sp. and *Ulmus* sp. *Aesculus*, *Salix* and *Viburnum* are the new ones that were tried and utilized by the inhabitants. It is quite evident that people were trying more and more woods in order to know their utility and economic potential which is an indication of economic advancement.

Period IV : Kushan Phase

The timbers recovered from this phase belong to *Cupressus* sp. *Juglans* sp. *Populus* sp. *Parrotiopsis jacquemontiana*, *Crataegus oxyacantha*, *Celtis australis*, *Aesculus indica*, *Pyrus pashia*, *Betula utilis* and *Fraxinus excelsior*. The new woods utilized during this period are *Cupressus* sp. *Parrotiopsis jacquemontiana*, *Crataegus oxyacantha*, *Pyrus pashia* and *Prunus* sp. Thus, if the agricultural economy of this phase depicts the climax of advancement, the forestry economy is also quite illuminating.

Period V : Hindu Rule Phase

Wood remains belonging to *Cupressus* sp., *Acer caesium*, *Platanus orientalis*, *Morus alba*. 
Parrotiopsis *lacquemontiana*, *Crataegus oxyacantha* and *Prunus* sp. have been recovered from this phase. Thus introduction of *Platanus* and *Morus* is depicted. *Acer caesium* has also been utilized for the first time.

The overall evidence on ancient forestry is indicative of the fact that relationship between the woody trees and man in Kashmir is of great antiquity and with the passage of time wood has been put to innumerable and varied uses by the prehistoric man. The same woods are not always repeated in all the periods. Along the passage of time the inhabitants gradually gained experience of the quality of different woods and consequently new woods were tried and utilized while others were omitted. If in our advanced stage of technology we make use of different characteristics such as strength, workability, durability, density etc. in our selection of woods for a vast range of primary and secondary products, the prehistoric man, too, had awared himself of the best wood for burning, for warmth, those durable for building purposes, and those for making tools etc.

From the domestication point of view it may be emphasized that man discovered fire long before he
started cultivating the food plants. For fire, the wood was a pre-requisite. Thus the kinship between wood and the early man is very antique. However the evidence for the use of wood is available in the late Palaeolithic age in England and Germany where entire spears made of wood have been found (Hawkes and Wooley 1963). Scanning through the information available in India, one finds that fire as a tool was known to the early man almost at the commencement of the Holocene period (8000 B.C.) at Sarai Nahar Rai where the charred bones of animals provide a testimony to the deliberate use of fire for cooking purposes (Sankalia 1974). Coupled with this is the evidence of several hearths suggesting incipient community life. Pollen studies, too, provide evidence of fire as early as that but it remains to be determined whether it was a natural or man made fire (Vishnu Mittre 1974 b).

Initially the man might have used any kind of wood whatsoever available to him at hand. Along the passage of time he got experienced and began to use selective ones and discard others. This resulted in the transportation of various woods from the far off places which further resulted in the contact of people living in distant localities and provided links
for exchange of ideas. In the course of time, evidently, man preferred those woody plants which besides providing wood of good quality also provided some other purposes like edible fruits, leaf vegetables fodder etc. Here once again the selection played an important role. If some of such trees were not available locally, man must have brought them from far off places and in the course of time tried to grow them in his own locality, a process which still continues. This hypothesis is duly substantiated by the evidence presented above; but, indeed, more work is needed on the early prehistoric sites to delineate the process at regional as well as global levels.

c) Relation with other cultures

Having discussed the forest and agricultural economy at Semthan it would be interesting to find out whether the contemporary sites in India had attained equal advancement or there were some differences among them. Although a large number of sites have been reported by field archaeologists, yet so far there is little information on plant economy. The results of investigations on Hastinapur, Atranjikhera, Noh and Semthan during 1500-400 B.C. is given in Table 24.
Table 24: Results of archaeological excavations at Hastinapur, Noh, Atranjikhera and Semthan.

<table>
<thead>
<tr>
<th>Site</th>
<th>Settlement</th>
<th>Way of life</th>
<th>Cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hastinapur Phase II P.G.W.c.1100-800 B.C.</td>
<td>Signs of mud houses with thatched roof.</td>
<td>Farming and hunting</td>
<td>Oryza sp.</td>
</tr>
<tr>
<td>Noh P.G.W. Phase 1000-400 B.C.</td>
<td>--</td>
<td>Farming and hunting</td>
<td>Oryza sp.</td>
</tr>
</tbody>
</table>
As is clear from the table, it is not easy to determine the degree of dependence on plants from the four sites; however, the variety of plants used at Semthan indicate that the ancient inhabitants of Kashmir enjoyed a higher economic status than other contemporary settlements in India.

E) Behaviour of Individual Plant Groups

The behaviour of cereals, pulses, endocarps and weed seeds from Period I to Period V is shown in (Fig. 204, 205). It is seen that the cereals continue to dominate over other plant groups and represent 70 to 80% of the total economy of each period. Pulses maintain a low frequency of 2 to 5% in all the phases. The endocarps show maximum frequency of 17.25% in period II and a very low frequency of 1.79% in Period IV. The weed seeds are absent from Period I but show an increasing frequency thereafter attaining maximum frequency of 21.58% in Period IV.

Among the cereals rice shows a frequency of 55.8% in Period I, then declines to 17.5% in Period II and thereafter shows a continuous increase. It has already been suggested that rice was introduced during
1500-1000 B.C., at the time of Period I at Semthan. Its very high frequency at this time is quite surprising as wheat and barley were established crops at that time which show frequencies of 30.8% and 14.4% respectively. After Period II rice shows a steady increasing frequency. Further it is seen that wheat declines to its minimum frequency of 4.4% in period III and then increase upto 39% in Period IV. On the other hand barley, after having lower values in period II goes high up substantially reaching a value of about 67% in Period III and thereafter shows a decline. Oats, being introduced during period II, maintain a low frequency throughout but show a continuous slight increase (Fig.206).

It seems reasonable to conclude that the settlers at Semthan started with the cultivation of wheat, barley and rice; initially barley and wheat being preferred over rice. Barley was much preferred even upto a much later time as it constitutes about two-thirds of the total economy of Phase III. However, rice continues to replace wheat and barley towards the later periods.
F) Vegetation and Climate

Apart from their archaeological and botanical interest the identification of plant remains is of considerable significance in view of the light they throw on past vegetation and climate that prevailed in the region during the period of occupation. The present investigations indicate that the coniferous elements in the vegetation included *Pinus wallichiana*, *Picea smithiana*, *Abies pindrow* and *Cedrus deodara*. Broad leaved trees included *Quercus* spp., *Ulmus wallichiana*, *Fraxinus excelsior*, *Celtis australis*, *Betula utilis*, *Populus* sp., *Aesculus indica*, *Juglans* sp., *Acer caesium*, *Pyrus pashia*, *Prunus* sp. and shrubs, like *Salix wallichiana*, *Parrotiopsis Jacquemontiana* and *Viburnum* sp. The introduced elements included *Cupressus* sp., *Platanus orientalis*, *Morus alba* and *Ficus* sp. All these give an indication of arboreal vegetation. Some evidence of ground vegetation has come through the identification of weed seeds like *Lithospermum arvense*, *Galium tricorne*, *G.asperuloides*, *G. aparine*, *Melilotus albus*, *Medicago* sp., *Lathyrus / Vicia* sp. etc. The agroecosystems consisted of rice in the irrigated fields and wheat, barley, oats and pulses in the
drylands. Some horticultural trees like *Juglans* and *Prunus* were also probably cultivated. It would be interesting to find out how this compares with the present vegetation of the valley.

Except *Quercus*, *Ficus* and *Cupressus* all the species grow as the components of the present day vegetation. Even exotic species of these trees like *Quercus robur*, *Ficus palmata*, *Cupressus sempervirens* etc. are grown and regenerate in the valley. Does this mean that these trees were growing in the valley three to four thousand years ago? Of course *Quercus* is the most important of all. Its charcoals are not found after period II i.e. 2200 B.P. the tree might have been growing in very low frequencies in the forests and as a result of biotic factor and some still unknown reasons, the tree was reduced to omission.

Further, it can be speculated that *Pinus*, *Cedrus*, *Abies*, *Acer*, *Crataegus*, *Parrotiopsis*, *Viburnum* etc. were restricted only to the forests whereas *Salix*, *Populus*, *Juglans*, *Ulmus*, *Celtis*, *Prunus*, *Pyrus*, *Fraxinus* etc. could also have been propagated by the inhabitants in their own locality.

The frequency and number of charcoals can
hardly give an idea about the relative frequency of different trees. From a comparative study of the past flora, as revealed by the plant remains, and the present vegetation, it seems reasonable to conclude that forest cover of the region on the whole has remained more or less of the same type. The floristic complex indicated by the charcoal determinations is generally characteristics of a temperate forest (Champion and Seth 1968). Taking all these factors into consideration, it would not be far wrong in assuming that the climate and rainfall of the valley have not changed to any appreciable extent during last three thousand five hundred years or so.

G) Origin and history of agriculture

The archaeobotanical investigations coupled with palynological investigations could also be employed in depicting the origin and history of agriculture. Man's struggle for comfortable existence and evolution from food gathering to food producing is reflected in his behaviour to grapple with his environment at every level. When man began to practise agriculture, he had to clear land for farming and as such had to disturb the natural
vegetation. The events of the earliest vegetation by man could be depicted through pollen analysis of lake and swamp deposits. Such studies in Kashmir at Haigam lake and Anchar lake trace the beginnings of agriculture in the valley to 4000 years B.P. and at about the same time undoubted evidence of agriculture is available from archaeological excavations (Vishnu Mittre and Sharma 1966, Dodia et al 1985). Taking into consideration the evidence from India, the earliest evidence goes back to c.7000-8000 B.P. as depicted by the pollen analysis of Salt lakes of Rajasthan (Singh 1971), the evidence of rice cultivation at Koldihawa and barley cultivation at Mahagara (Sharma and Mandal 1980, Sen Gupta 1985). As such Kashmir falls some 3,000 to 4,000 years behind. But is it really true? Indeed some more excavations and pollen analyses are needed before arriving at a sound conclusion.

The first report on the plant remains from Kashmir archaeological excavations came when Vishnu Mittre (1966) identified seeds of weed plants like *Lithospermum arvense*, *Medicago* sp. *Lotus corniculata*, *Ipomoea* sp. etc. from Neolithic levels at Burzahom and commented that inhabitants were essentially food gatherers. Recent studies on the site have revealed
the cultivation of wheat, barley, lentil, and pea, from the Neolithic phase of this site which clearly indicates that people were cultivating these cultigens (Buth and Kaw 1985). This is further confirmed by the retrieval of wheat and barley at Gofkral (Sharma 1982) and wheat, barley, and rice at Samthan at a slightly later stage as evidenced by the present study.

The evidence from these three sites in the valley which cover a time span of 4325 to 1000 B.P. gives a clear picture of origin and progressive development of agriculture. The earliest cultivation in Kashmir, as the present evidence suggests, started with the cultivation of wheat, barley, lentil, and pea which interestingly were the first crops to have been domesticated in the Near East which forms the cradle of civilization and where the agriculture first developed (Renfrew, 1973). Subsequently rice and species of Phaseolus were introduced. The agriculture was further substantiated by the adoption of horticultural fruits like Juglans regia, Prunus armeniaca and P. persica etc.

Taking the cropping pattern and progressive development of agriculture in consideration a significant
evolutionary trend is indicated as follows:

(a) **Single cropping**

During third millennium B.C. only the Rabby or winter crops were cultivated. This is indicated by the grains of exclusively of winter crops such as wheat, barley, lentil and pea at Burzahom Period I and Gofkral Period I (Sharma 1982, Khan 1986).

(b) **Double cropping**

During second millenium B.C. two crops a year were cultivated. Winter crops as stated above and the kharif or summer crops like rice and Phaseolus spp. as evidenced during the close of Neolithic Period II at Gofkral and Period I at Semthan.

(c) **Mixed cropping**

Towards the close of second millenium B.C. and during the first millenium B.C. the double cropping was substantiated by the cultivation of horticultural fruits like *Prunus* sp. *Juglans* sp. as also some trees for fodder and fuel like *Salix, Populus, Celtis, Ulmus, Fraxinus* etc. This was later substantiated by the introduction of more useful trees like *Morus alba*, which marks
the beginning of sericulture Industry, and Platanus orientalis etc.

So based on this evidence the history of agriculture in the valley can be depicted as presented in Text Fig. 9.

III. STATISTICAL ANALYSES

In order to evaluate the ecological implications and the stability of subsistence strategies from the archaeobotanical data some statistical analyses were carried out. For these analyses the data obtained from equal number of flotation samples of equal volume from each phase were used.

(A) Chi-square analysis

Chi-square analysis of cereals revealed a chi-square value of 82.6 (d.f. =30) which indicates a high significant difference \( p < 0.01 \). Thus the cereal taxa do not appear to be randomly distributed among time periods. Period I and III account for most of the lack of randomness between periods. Amongst the individual cereals Avena fatua and A. stiva show the highest randomness in distribution.
### Text Fig. 9

**Progressive Development of Kashmir Agriculture.**

<table>
<thead>
<tr>
<th>Era</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 B.P.</td>
<td>Threshold of Modern Agriculture</td>
</tr>
<tr>
<td>3500-2500 B.P.</td>
<td>Cultivation of Rabi as well as Kharif crops (Rice and Phaseolus spp. introduced)</td>
</tr>
<tr>
<td>5,000-4000 B.P.</td>
<td>Cultivation of Rabi crops (Wheat, barley lentil, pea).</td>
</tr>
<tr>
<td>Upto 6000 B.P.</td>
<td>Plant gathering</td>
</tr>
</tbody>
</table>

- Mixed cropping
- Double cropping
- Single cropping
For pulses a chi-square value of 15.1 (d.f = 25) indicates a significant difference of 0.90 revealing that these taxa are randomly distributed in time periods. However, this very high randomness can be due to very small counts in the time periods and unevenness of data.

The endocarps and weed seeds show a chi-square value of 47.0 (d.f = 25) and 21.03 (d.f = 16) indicating significant differences of 0.01 and 0.20 respectively. These values indicate that weed seeds are more randomly distributed as compared to endocarps among the time periods. Most of the lack of randomness is accounted by Lithospermum among the weeds and Prunus cerasus, P. persica, and Celtis australis among the endocarps. Juglans among the endocarps and 'others' among the weeds appear to be most randomly distributed.

As chi-square value of 2018.1 (d.f. = 96) for the wood charcoal data indicates a very high significant difference (p ≪ 0.001). Therefore, wood taxa do not appear to be randomly distributed among the time periods. Chi-square analysis was also performed to determine if non-random distributions existed within wood type categories or within time periods. The analysis showed that period III
accounted for most of the lack of randomness between periods followed by periods V, II, I and IV respectively. Among the taxa most of the lack of randomness is accounted by Pinus, Picea, Abies, Cedrus, Juglans, Ulmus, Salix, Viburnum, Acer, Celtis, Aesculus, Morus and Populus. This conclusion has been drawn by comparing the observed (Ob.) and expected (Ex) values for the matrix points in the row or column where high chi-square values occurred. For example much of the deviation from chance giving a high chi-square value for period III row (629.7) occurs at Picea, Ulmus, Salix and Viburnum points; for period V row at Morus and Acer points; for period II at Pinus, Abies and Cedrus points and so on (compare observed and expected values for these taxa).

The data matrix for charcoals was also used to know the behaviour of Gymnosperm and Angiosperm woods collectively over time. The results show that during Phase I and II Gymnosperms account for 31.6% and 39.9% respectively. In the subsequent phases their percentage declines to 22.1% in Phase III, 11.2% in Phase IV and 17.5% in Phase V respectively with corresponding increases in the Angiosperm woods. This can be attributed to the availability of
Gymnosperms in the near vicinity during the earlier phases. As a result of large scale exploitation, these were restricted to the higher mountains leading to utilization and adoption of more and more broad leaved elements.

The overall evidence suggests that selection played a very important role in the adoption and domestication of various plant species which have not been randomly chosen.

(B) Intensity of occupation

The total amount of charcoal resulting from deliberate burning can serve as a measure of the intensity of use of an occupation area (Asch and Asch 1975, Johaunessen 1981 a,b). An occupation containing a much higher amount of charcoal under conditions of similar preservation and sampling is interpreted as having more intensive cooking or other hearth activity. Present studies at Samthan reveal that Period IV (Kushan Phase) shows the highest intensity of occupation (wood count = 716) followed by period II (N.B.P Phase; wood count = 498). The other three periods show somewhat constancy in the intensity measure. It can be concluded that the
intensity measure shows an increasing trend from Period I to IV with some decrease in activity in Period III. In the last phase the intensity measure declines, but remains slightly high as compared to Phase I and II (Fig. 196).

(C) **Species Diversity, Species Richness and Species Evenness.**

Species diversity is a measure that takes into account both the total number of species or taxa present in a population and the abundance of each species (Pielou 1969). High diversity results when a large number of species are evenly distributed i.e. when it would be difficult to predict what a randomly selected item would be. Low diversity results when the number of species present is low, or when abundance of each species is variable. Yallen (1977) and Pearsall (1983) have used Shannon Weaver information index as a diversity measure and the same index was used in this study. It is seen, that species diversity index attains fairly high value (0.67 in Period V to 0.92 in Period II). The highest diversity is found in Period II and IV and lowest in Period V (Fig. 197).
General diversity is affected by both the number of species present and the evenness with which they are distributed (Potter and Kesselle 1980). To separate these effects Margalefs' (1957) measure of species richness and Shannon and Weavers' (1949) index of species evenness were used. Once again Period IV (1.82) and Period II (1.77) showed highest value of species richness index, the least being in Period III (1.03). As far as species evenness is concerned all the phases show some constancy in this index with the values ranging from 0.30 in Period V to 0.38 in Period I.

The above account indicates that the vegetation comprised of stable populations having large number of species present with a very high abundance. However, the species do not appear to have been evenly distributed.

(D) Standard Scores

The standard scores provide an idea of the mean count of each species through time and can be examined as data points, rather than raw counts. This reduces the impact of absolute quantities and evens out insignificant differences (Blalock 1972).
Similarities in the direction of changes observed by different absolute counts can be very easily seen (Pearsall 1983).

The standard scores of cereal taxa indicate that Period IV accounts for high positive deviation from the mean for rice, wheat and oats whereas Period II accounts for high positive deviation for barley. In Periods I, III and V most of the taxa occur below the mean (Fig. 200). The standard scores of pulses occur below mean in Period I, III and V and above mean in II and IV; the highest deviation being in Phase II (Fig. 201).

The endocarps of Prunus show negative deviation from the mean in standard scores in all the phases except Period II where it shows a high positive deviation. Similarly standard scores for walnut show very high positive deviation in Period II and remain around the mean in other phases (Fig. 202).

Thus barley being utilized more compared to rice and wheats up to Period II gives way to rice in Period IV. At this stage oats also show the highest existence. The data for pulses and fruit crops are not quite significant.
(E) Co-efficients of Similarity 'S' & 'T'

The values of coefficients of similarity provide an insight into the relationship between any pairs of phases regarding man-plant interactions and other ecological and subsistence factors. These values reveal how much any two phases share common in between. The values of 'S' and 'T' vary from 1 when all the species and their number are common to zero when none of the species are common in pair of sites/phases under consideration.

For cereals values of 'S' vary from 0.67 (between I & III) through 0.75 (between I & II, I&V and II and V), 0.80 (between I & IV, II & IV and IV&V), 0.89 (between II & III and III & V) to 0.90 (between III & IV). For pulses 'S' varies from 0.33 (between I & II, I & IV and III & IV) to 0.80 (between I & V). For fruit crops the 'S' varies from 0.40 (between II & V) to 0.80 (between I & II, I & III, I & IV, III & V and IV & V). For wood taxa its values range from 0.25 (between III and V), 0.30 (between III & IV), 0.32 (between II and III) to 0.55 (between IV & V). Other values are shown on page ——.
However, this index (s), does not reflect the actual situation as the number of individuals of the species are not taken into consideration. To compare the phases on the basis of quantitative index values of 'T' become significant.

For cereals the values of 'T' range from 0.44 (between Phases I & II) through 0.50 (between I & III), 0.56 (between I & IV and II & V), 0.59 (between III & IV), 0.64 (between III & V), 0.66 (between IV & V), 0.67 (between I & V), 0.77 (between II and IV) and 0.79 (between II & III). For pulses the values range from 0.125 (between I & IV) to 0.50 (between II & V). For fruit crops the values range from 0.11 (between I & II and II & IV) to 0.57 (between III & V). For wood taxa the values vary from 0.37 (between III & IV) to 0.60 (between IV & V). Corresponding values between any pair of phases gives an idea of similarity with respect to a particular group of plants.

The above mentioned account reveals that statistical analysis of hard archaeobotanical data can yield interesting inferences on human interactions with the environment and the extent to which various taxa of plants were utilized at different stages. The quantitative approaches have shown that Periods
II and IV were the periods with intensive occupation, species diversity, richness, evenness and subsistence strategy. All these measures indicate Period IV followed by Period II to have been the most prosperous phases. These results correlate very well with the data discussed earlier.

However, in this ethnobotanical analysis there are some sources of error that might have affected the conclusions drawn. These include smaller counts of charred macroremains of some taxa from some time periods which affect the pattern of distribution in the analysis. Another potential source of error is differential preservation of wood taxa based on their relative hardness.
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* Original not seen.
PLATES
Figure 1: Map of Kashmir valley showing location of sites of present study.

Figure 2: Panoramic view of the mound at Semthan.
Figure 3: Average monthly rainfall.*

Figure 4: Mean maximum and mean minimum temperature.*

Figure 5: Schematic representation of section through the mound showing various cultural phases.

*Rainfall and temperature correspond to the data from Bijbehara, 2km from the site.
Figures 6-9: Histograms showing changes in dimensions due to laboratory carbonization of:

Figure 6: *Triticum monococcum*
Figure 7: *T. dicoccum*
Figure 8: *T. turgidum*
Figure 9: *T. sphaerococcum*

UL - Uncarbonized length
UB - Uncarbonized breadth
CL - Carbonized length
CB - Carbonized breadth.
Figures 10-13: Histograms showing changes in dimensions due to laboratory carbonization.

Figure 10: *Triticum aestivum*

Figure 11: *Hordeum spontaneum*

Figure 12: *H. distichum*

Figure 13: *H. hexaploidum*
Figures 14–17: Histograms showing changes in dimensions due to artificial carbonization in:

Figure 14: *Hordeum vulgare*

Figure 15: *Oryza sativa* cultivar China 1039.

Figure 16: *O. sativa* cultivar Noon Beoul

Figure 17p *Avena fatua*
FIG. 14

HORDEUM VULGARE HULLED

DISTANCE IN mm

NO OF GRAINS

FIG. 15

ORYZA SATIVA CHINA 1039

DISTANCE IN mm

NO OF GRAINS

FIG. 16

ORYZA SATIVA NOON BEIJUL

DISTANCE IN mm

NO OF GRAINS

FIG. 17

Avena Sativa
Figures 18–21: Histograms showing changes in dimensions due to laboratory carbonization of

Figure 18: *Avena sativa*

Figure 19: *Phaseolus aureus*

Figure 20: *P. mungo*

Figure 21: *Lens culinaris*
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Figure 23, 24: Archaeological rice caryopses.

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Figure 26: SEM of surface of archaeological rice caryopsis showing sinuous walled cell x 200.

Figure 27: SEM of husk of archaeological rice showing characteristic chess board pattern x 100.

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Figure 32: Archaeological caryopses in ventral view.

Figure 33: Cross section of extant (A) compared with that of archaeological caryopsis (B).
Figure 34: SEM of pericarp of archaeological caryopsis x 500.

Figure 25: SEM of pericarp of extant *Triticum aestivum* caryopsis for comparison with Fig.34.x500.

Figure 36: Caryopses of extant *T.sphaerococcum* (left) compared with archaeological caryopses of lot B₂ (right).
Figures 37 - 40: *Triticum sphaerococcum*

Figure 37: Archaeological caryopses in dorsal view.

Figure 38: Archaeological caryopses in ventral view.

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Figure 40: SEM of pericarp of extant caryopsis for comparison with Fig. 39. x 200.
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**Figure 42:** Archaeological caryopses.

**Figure 43:** Archaeological caryopses in dorsal view.

**Figure 44:** Archaeological caryopses in ventral view.

**Figure 45:** Cross section of extant (A) and archaeological caryopses (B).
Hordeum vulgare

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**Figure 53:** Archaeological caryopses in ventral view.

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Oats - *Avena* spp.

Figure 55: SEM of pericarp of archaeological caryopsis. x 500.

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Figure 57: Peeling of archaeological caryopsis. x 500.

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Figure 61: SEM of pericarp of archaeological *Panicum* sp. x 1000.

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Figure 67: Seeds of extant *P. aureus* (left) compared with archaeological seeds (right).
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Figure 70: Seeds of extant P. aconitifolius (left) compared with archaeological seeds (right).

Figure 71: Palisade cells from archaeological seeds of P. aconitifolius x 400.

Figure 72: Archaeological seeds (left) compared with extant seeds of Pisum sativum (right).
Figure 73: Archaeological seeds of *Pisum sativum*.

Figure 74: Palisade cells from archaeological seeds of *P. sativum* x 400.

Figure 75: Archaeological seeds (left) compared with extant *Lens culinaris* seeds (right).

Figure 76: Archaeological seeds of *Lens culinaris*.

Figure 77: Palisade cells from archaeological seeds of *Lens culinaris* x 400.
Figure 78: Seed and seed coat anatomy of Indian pulses.
<table>
<thead>
<tr>
<th>S NO</th>
<th>NAME OF SPECIES</th>
<th>SEEDS</th>
<th>HILUM</th>
<th>PALISADE CELLS</th>
<th>CUTICLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cajanus Cajan (L) Millsp.</td>
<td>62x46 smooth</td>
<td>3x2</td>
<td>Partially covered with whitish hard tissue raised above the level of seed surface.</td>
<td>89.13 smooth, thin</td>
</tr>
<tr>
<td>2</td>
<td>Cicer Arietinum L.</td>
<td>72x55 primarily blistered</td>
<td>23x6</td>
<td>In a sunken pouch below the level of seed surface.</td>
<td>37.27 slightly rough</td>
</tr>
<tr>
<td>3</td>
<td>Cyamopsis Tetragonolobus L. Var.</td>
<td>43x4 lightly bluntered</td>
<td>1x5</td>
<td>Below the level of seed surface, partially covered with whitish tissue.</td>
<td>94.15 smooth</td>
</tr>
<tr>
<td>4</td>
<td>Dolichos biflorus L.</td>
<td>63x45 smooth</td>
<td>1x5</td>
<td>Completely covered with whitish hard tissue.</td>
<td>6410 smooth</td>
</tr>
<tr>
<td>5</td>
<td>Dolichos lablab L.</td>
<td>83x79 smooth</td>
<td>2x1</td>
<td>Above the level of seed surface, prominent raphe running many mm.</td>
<td>13418 smooth</td>
</tr>
<tr>
<td>6</td>
<td>Lathyrus sativus L.</td>
<td>48x45 smooth</td>
<td>2x1</td>
<td>In level with seed surface, whitish tissue absent.</td>
<td>9616 dentate</td>
</tr>
<tr>
<td>7</td>
<td>Lens culinaris Medic.</td>
<td>48x46 smooth</td>
<td>15x5</td>
<td>Almost in level with seed surface, whitish hard tissue absent.</td>
<td>4713 dentate</td>
</tr>
<tr>
<td>8</td>
<td>Phaseolus acutifoliolus Jacq.</td>
<td>47x27 smooth</td>
<td>2x1</td>
<td>Completely covered with whitish hard tissue.</td>
<td>5619 smooth</td>
</tr>
<tr>
<td>9</td>
<td>Pisum sativum L.</td>
<td>63x50 smooth</td>
<td>5x3</td>
<td>Surface whitish tissue absent.</td>
<td>6517 with papillae</td>
</tr>
<tr>
<td>10</td>
<td>Vicia Faba L.</td>
<td>84x7 smooth</td>
<td>46x2</td>
<td>Almost in level with seed surface, whitish tissue absent.</td>
<td>17112 slightly rough</td>
</tr>
<tr>
<td>11</td>
<td>Vigna catjang Walp.</td>
<td>88x54 smooth</td>
<td>46x2</td>
<td>Completely covered with whitish hard tissue raised above the level of seed surface.</td>
<td>7610 rough</td>
</tr>
<tr>
<td>12</td>
<td>Vigna sinensis (L) savi ex Hassak.</td>
<td>143x75 smooth</td>
<td>3x2</td>
<td>Completely covered with whitish hard tissue.</td>
<td>6418 rough</td>
</tr>
</tbody>
</table>

**FIG. 78**

Figure 79: Nutlets of archaeological Lithospermum arvense.

Figure 80: Archaeological seeds (right) compared with extant nutlets of Lithospermum arvense (left).

Figure 81: SEM of surface of archaeological seed of Lithospermum arvense x 200.

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Figure 84: SEM of archaeological seed of G. asperuloides with scarce papillae on the surface x 50.
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FIG. 180

FIG. 181

FIG. 182

FIG. 183
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Modified from: Ma, Yong, The Unesco Cousier. June 1984, p.23.
FIG. 202

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Behavior of major agricultural plant groups over time

FIG. 205
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PERCENT OF TOTAL CEREALS

BEHAVIOR OF INDIVIDUAL CEREALS IN DIFFERENT PERIODS

FIG. 206