Chapter 5

Archaeobotany at Harappa: Indications for Change

Steven A. Weber

The growing database of information from excavations in Northwestern South Asia shows that the Indus valley culture evolved from independent village farming settlements into a highly organized, culturally integrated civilization. Well planned and walled cities like Harappa are, in part, a result of a successful food producing economy. Food production is closely tied to the evolution of this civilization, with shifts in agriculture playing a prominent role in explanatory models.

Whereas it is generally agreed that agricultural production was variable throughout the evolution of the Indus civilization and that it can be both causal and consequential to culture change, few studies have attempted to directly interrelate agriculture and urbanism when explaining culture change. This chapter will attempt to critically examine agriculture and culture change at a single Indus site, Harappa. Its size, length of occupation, large horizontal exposures, detailed archaeological documentation, and quality of organic preservation mean it is one of the few prehistoric urban centers in South Asia where the relationship of agricultural change and culture change can be comprehensively addressed.

While it is evident that there are elements of consistency and change in the archaeobotanical record over the occupation of Harappa, the critical question is what does this mean? Since archaeological seed distributions from specific contexts within Harappa have discrete depositional patterns, it is important to determine whether these reflect human activities, or whether these patterns have been skewed by natural and cultural processes involved in the formation of the archaeobotanical record. Do these patterns reflect human behavior and culture change at Harappa only, or do they reflect more general shifts commonly associated with the civilization as a whole? This chapter will account for these factors while attempting to present an argument of how best to view the Harappa material.

Harappa

The Indus civilization was an economically centralized civilization that emerged at around 2600 B.C. along the floodplains of the ancient Indus and Saraswati rivers in Northwest South Asia. With disruptions in trading networks and the food supply, and a decline in the large urban centers, this period of integration and centralization came to an end at the beginning of the second millennium B.C.

The site of Harappa lies approximately 100 miles south of Lahore, Pakistan. Its status as one of the oldest cities in the world may be due in part to its central location between two major tributaries of the Indus River, where it served as a major center for both local and regional trade items, including agricultural products. It lay in the northernmost area of the Harappan civilization, an area based today on a winter cultivation strategy using wheat and barley. With good rainfall and fertile soils, this area can have, and still does have, abundant harvests.

At its height, Harappa was a fully developed city complex, housing a population in excess of 35,000 people. Based on city layout, styles of painted ceramics, and inscribed seals and weights, we can conclude that the inhabitants of this site shared the same culture with other Indus civilization sites (Kenoyer 1998). Harappa is not only the "type" site of this civilization but it is one of the most important; any trends identified here have significance for the culture as a whole. The most recent excavations at this site began in 1986 and continue today (Dales and Kenoyer 1991; Kenoyer and Meadow 1992, 1993; Meadow et. al. 1994, 1995, 1996). Though these excavations have exposed only a small portion of the settlement, all of the major mounded areas of the site have been trenched. A significant amount of new data has been uncovered over the past fifteen years that have provided new insights into Harappa's formation, character, evolution, and decline. With the collection and dating of carbon samples, a good chronology now exists.

Period 5	Late Harappan Phase (Cemetery H)	c. 1800- 1700 B.C.
Period 4	Transitional	c. 1900- 1800 B.C.
Period 3C	Harappan Phase	c. 2200- 1900 B.C.
Period 3B	Harappan Phase	c. 2450- 2200 B.C.
Period 3A	Harappan Phase	c. 2600- 2450 B.C.
Period 2	Transitional (Kot Diji)	c. 2800- 2600 B.C.
Period1A and1B	Early Harappan (Ravi)	c. 3300- 2600 B.C.

Harappa is not only one of the few sites that span the complete temporal range of the Indus civilization, but is also one of the few sites where large numbers of archaeobotanical samples have been collected and analyzed in a systemic manner. This has led to the collection of tens of thousands of carbonized seeds, representing dozens of species. Since only a portion of the archaeobotanical assemblage has been analyzed, the data used in this study will be presented in three broader, temporal phases. "Early Harappan" will be used for the Ravi and Kot Diji phases or Periods 1 and 2 (3300-2600 B.C), "Harappan" for Periods 3A, 3B and 3C (2600-1900 B.C.), and "Late Harappan" for Periods 4 and 5 (1900-1700 B.C). Eventually, when a larger portion of the data is analyzed, all five phases will be discussed separately.

Archaeological Seed Data

Harappa is one of only a few sites excavated in South Asia with not only an interest in extracting and interpreting archaeobotanical remains but also with an intensive and systematic strategy in place for macrobotanical analysis of material that is both chronologically and contextually well documented. Where most existing reconstructions of Indus civilization agricultural strategies draw upon data from a number of overlapping sites to produce a sequence (see: Saraswat 1992; Kajale 1991; Meadow 1996; Jarrige 1985; Fuller 2000), Harappa offers a unique opportunity to develop an agricultural sequence from a single site that incorporates all phases of this civilization, avoiding some of the inherent biases in data collected from different types of sites, excavated at different times, using different collection and analysis strategies. This in turn will help us understand the factors that bias archaeobotanical data.

The objective of paleoethnobotanical inquiry at Harappa has been to identify what plants occurred in the archaeological record, which of these plants are there as a result of human activity, and then to use this information to reconstruct the agricultural strategy for each period and subperiod of occupation. Over the last fifteen years at Harappa, over 10,000 liters of soil have been systematically collected and floated from a variety of locations and features. The strategy was to sample as wide a variety of contexts as possible and to sample these contexts multiple times. In order to maximize the value of the archaeobotanical material while minimizing the inherent biases in this kind of database, samples were collected and analyzed from each phase and within each context. The majority of samples used here are from the interior of hearths or on occupational surfaces. Samples from such contexts have a quantitative value and represent discrete depositional patterns that reflect human behavior (Fuller and Weber in press).

Like artifacts, seeds can be identified, their spatial and temporal distribution determined, and their uses inferred (Weber 1999:819; Johannessen 1988). Combining existing knowledge regarding archaeobotanical data with the context of the material to be analyzed permits the analyst to determine if, how, and when a plant was being used (Dennell 1974, 1976, Miller 1997; Hastorf and Popper 1988). With additional information about plant morphology, place of origin, geography, and growing requirements, it is possible to reconstruct what the surrounding habitat may have looked like and what plants might have been available to the site's inhabitants during each phase of occupation (Weber 1999:819). The basic assumption being applied to the Harappa data is that when a large, systematically analyzed sample that represents all occupations equally is used, then trends and regularities that are identified for each period tend to reflect patterned behavior for that period.

All samples analyzed and used in this chapter were floated using a standard flotation system. The light and heavy fractions were weighed, their volumes recorded, and they were then carefully sorted. All macrobotanical specimens were counted and, when possible, identified to species. The resulting archaeological seed record is then summarized for each of the three periods by using a system of quantification which involves the use of ratios and provides a simple means for standardizing data by comparing two values by division (see: Pearsall 1988, 1989; Miller 1988). Ubiquity is the percentage of samples from which a specific taxon or plant was recovered. Density is the number of seeds per liter of soil and percentage is the relative abundance within a given assemblage. All numbers are listed as whole numbers with fractions being rounded off. While each of these methods has advantages and disadvantages, together they help counteract the inherent biases in the data (Sullivan 1987).

The preservation of carbonized seeds and fragments has been very good at Harappa. Seeds were recovered from most of the flotation samples with fewer than 5 percent failing to contain seeds. Nearly all of the ninety samples being used in this study contained seeds (table 5.1). The average seed density for these samples was thirty-nine seeds per liter of soil. Since density often reflects the intensity of the accidents leading to seed preservation, the more intense the ac-

Period	Samples	Liters Floated	Seed Density	Taxa
Early Period (1 – 2)	32	280	36	15
Harappan Period (3A – 3C)	41	394	58	25
Late Period (4 - 5)	17	232	11	34
Total for Harappa:	90	906	39	36

Table 5.1 The archaeobotanical database used in this study

Plant Taxon	Cropping Season	Early 3300 – 2600	Harappan 2600 - 1900	Late 1900 - 1700
Cereals				
Wheat (*Triticum*)	W	X	X	X
Barley (*Hordeum*)	W	X	X	X
Rice (*Oryza*)	S	-	?	X
Millets (*Panicum*)	S	X	X	X
Pulses and vegetables				
Peas				
Pisum	W	X	X	X
Cicer	W	-	-	X
Lathyrus	W	-	X	X
Lentils (*Lens*)	W	X	X	X
Gram				
Vigna	S	-	X	X
Medicago	S	-	X	X
Oilseed and fiber				
Linseed (*Linum*)	W	-	X	X
Mustard (*Brassica*)	W	-	X	X
Fruits				
Melon (*Cucumis*)	S	-	X	X
Date (*Phoenix*)	S	X	X	X
Jujube (*Ziziphus*)	W	X	X	X
Grape (*Vitis*)	S	X	X	X

Note: W=winter/spring-harvested; S=summer/fall-harvested; X=present; - =not recovered

Table 5.2 Categories of cultivated plants recovered from Harappa based on seeds from flotation samples

tivity involving that type of plant or the more the activity involves fire, the higher the density of seeds in the sample (Sullivan 1987; Miller 1988). Associated with this relatively high seed density is the sheer diversity of the material being recovered. At least three different taxa have been identified from each seed-bearing sample, to a maximum of over twenty different species. At least thirty-five different species are represented at Harappa, of which over half are cultivated varieties (table 5.2).

Regardless of the period, the most common plants recovered at Harappa were cereals, followed by pulses and vegetables, and finally oil-seed, fiber, and fruit plants (table 5.2). This pattern may be due to the fact that plants that are crushed for juice or oil, dried for later use, or species consumed in a fresh state such as roots, greens, fruits, and nuts are less likely to be preserved than seed plants that are parched, cooked, or processed in close proximity to fires.

The cereals category, comprising winter/spring harvested cereals of wheat (*Triticum*) and barley (*Hordeum*), makes up the majority of the recovered remains (table 5.3 a-c). Grains of these cereals are found in nearly every sample and together make up over 90 percent of all seeds recovered from the Early Harappan Period. While seeds of wheat occur in nearly as many samples as barley, it is evident that barley is the dominant grain. With an average of four more barley seeds per liter soil and making up 9 percent more of a sample, barley was being burned more frequently and subsequently being preserved in the archaeological record at a higher rate than wheat.

Other winter/spring harvested crops represented in samples from these early levels of Harappa were lentils (*Lens*), pea (*Pisum*), grass pea (*Lathyrus*), and jujube (*Ziziphus*). They are present in fewer than half the samples and together account for less than 3 percent of the recovered seeds. This period also had low counts of the summer/fall harvested crops of date (*Phoenix*), grape (*Vitis*), and millets (*Panicum*), which accounted for less than 2 percent of the seeds and had a ubiquity rating of less than 10 percent. Clearly, the basis of the agricultural strategy at Harappa during the Early Harappan Period was the winter cultivation of wheat and barley. The people who settled this site brought with them cereal grains, and a proven agricultural strategy for this region of South Asia involving wild plant collecting and some cultivating of vegetables and fruits. They focused, however, on wheat and barley.

By 2600 B.C., or the beginning of the Harappan Period, a more extensive agricultural system involving a greater variety of plants was in place (table 5.2). Although wheat and barley still appear to have been the mainstays of the agricultural system, they now account for only 81 percent of the seeds with ubiquity dropping to 90 percent (table 5.3.a-c). A combination of summer millets, rice, vegetables, fruits, oilseed, and fiber-oriented crops make up an increasing proportion of the cultivated plants. While the agricultural strategy is still one based on winter/spring harvested crops, the roles of wheat and barley seem to be reversed. Wheat now accounts for 45 percent of the recovered seeds compared to barley with only 36 percent of the total. Wheat is up 3 percent from the early period while barley is down 15 percent from that same period.

More seeds were being preserved in the archaeological record during the Harappan Period than at any other time. Besides a rise in seed density to nearly 60 seeds per liter of soil, a combination of summer-oriented crops make up an increasing proportion of the assemblage. Still, the agricultural strategy is based on winter crops.

The Late Period at Harappa had the fewest soil samples and the lowest seed density with an average of only 11 seeds per liter of floated soil 9 (table 5.1). For this reason the patterns identified in the archaeobotanical record need to be explored cautiously with the view that until more samples are added the results may be skewed. Nonetheless, the patterns identified with these samples do fit data sets from other Harappan sites with Late Harappan occupations (Weber 1999). The decline in seed density is most notable among the winter crops where an 86 percent decline occurred (table 5.3 a-c). In contrast the ubiquity of winter crops remains similar to the previous period. Wheat and barley show a slight decline in sample percentage but still remain the foundation of the agricultural strategy. However, at this point barley once again becomes the dominant grain in this strategy.

Seed Patterns Indicating Change

In general, the data as presented in table 5.3 a-c, demonstrates that some trends and regularities remain constant for all periods of occupation at Harappa. In fact, if you look at the archaeological seed record as a single entity, and averages for all samples together, the same general pattern or agricultural strategy occurs in each period. This strategy focuses on sowing crops in the fall, relying on winter rains to feed them, and then harvesting them in the spring. It is one that is typical for sites in this region (Meadow 1991). While winter sown cereals are found in nearly every sample and make up the majority of the archaeobotanical remains from each sample, the agricultural strategy is more diverse and includes some summer sown cereals and a variety of pulses, vegetables, and fruits (table 5.2). A complex multicropping strategy is evident in all periods of occupation, although it appears to increase in importance over the occupation of the site. While the overall strategy may appear to be constant, we can identify a number of patterns that are important to understanding change at Harappa.

First, there is a growing importance of summer crops. As time went on, seeds from summer crops were being preserved at more locations throughout Harappa implying increased use (table 5.3 a-c; figure 5.1). Although the density of summer-cropped seeds and their overall percentage of a given sample increase little over time, both show significant increases relative to the winter crops. Clearly summer-cropped plants became increasingly important at Harappa. With more efforts at multicropping, agricultural intensification was occurring. There appears to have been a constant and gradual process of increasing use of summer cropped plants, with the biggest jump seen in the Late Harappan samples. It is in this Late period where we see the summer-cropped seed density and ubiquity at its highest and most significant levels relative to the winter-cropped plants.

While seed density declines significantly in the Late Period (table 5.1), there is an increase in the density and proportions of the type of by-products generally associated with crop processing (table 5.3 a-c; Figure 5.2). An increase in spikelet forks, glume bases, and straw nodes, the kind of debris associated with threshing, winnowing, grinding, and cleaning of grains, is good evidence for a shift in crop-processing activities occurring over the occupation of Harappa.

There is also a constant increase in the number of different species being cultivated at Harappa (table 5.3 a-c, figure 5.3). With few crops ever disappearing from the diet, each period sees a significant increase in crop diversity from the previous period. There are almost three times as many edible taxa per

Plant Category	Early Period	Mature Period	Late Period	Total or Average
Wheat	90	90	88	90
Barley	93	85	94	90
Other Cereals	6	17	35	17
Cereals (total)	93	95	94	94
Pulses	9	12	35	15
Oilseed and Fiber	9	10	11	14
Fruits	32	7	23	18
Weeds/Unknown/Other	84	88	100	89
Seed Total	93	95	100	95
Seed By-products	3	11	35	
Winter Crops	93	90	100	93
Summer Crops	9	19	47	21

Table 5.3.a Ubiquity rates at Harappa. Ubiquity is listed as the percentage of samples from which a specific taxon or plant category was recovered. All numbers are listed as whole numbers with all fractions being rounded off.

Plant Category	Early Period	Mature Period	Late Period	Total or Average
Wheat	12	26	3	-
Barley	16	22	4	-
Other Cereals	1	2	1	-
Cereals (total)	29	50	8	-
Pulses	1	1	1	-
Oilseed and Fiber	1	1	1	-
Fruits	2	1	1	-
Weeds/Unknown/Other	3	5	2	-
Seed Total	36	28	11	-
Seed By-products	1	2	5	-
Winter Crops	31	51	7	-
Summer Crops	2	3	2	-

Table 5.3.b Density rates at Harappa. Density is the number of seeds per liter of soil. All numbers are listed as whole numbers with all fractions being rounded off.

Plant Category	Early Period	Mature Period	Late Period	Total or Average
Wheat	42	45	34	40
Barley	51	36	41	43
Other Cereals	1	2	5	2
Cereals (total)	93	83	80	85
Pulses	1	2	2	2
Oilseed & Fiber	1	1	1	1
Fruits	3	1	1	1
Weeds/Unknown/Other	2	13	16	10
Winter Crops	96	83	77	85
Summer Crops	2	4	7	4

Table 5.3.c Percentage rates at Harappa. Percentage is the relative abundance of a specific taxon or category of plants within a given assemblage. All numbers are listed as whole numbers with all fractions rounded up.

total number of edible fragments recovered per flotation sample during the Late Period than during the earlier periods (Weber 1999). This increasing diversity of food plants implies that people at Harappa were broadening their use of crops without abandoning existing plants. The new crops were not used as replacements, nor was their initial use extensive. These plants, whether local varieties or species being introduced from great distances away, appeared as part of a gradual process of supplementing existing crops (see: Weber 1998, 1999).

The broadening of the agricultural strategy at Harappa was neither rapid nor sudden. Each subsequent period contains a greater variety of plants and represents an increasing effort at cropping throughout the year. Associated with this pattern is an increase in the proportion of weed seeds. While they make up no more than 2 percent of the material in the Early Period, they increase to over 10 percent in the Harappan period and nearly 15 percent in the Late period (tables 5.3 a-c; figure 5.4). Their presence in the samples is useful for reconstructing crop husbandry practices since they commonly grow in agricultural fields and are removed prior to consumption. They also could reflect use as medicine, a food supplement, or even an increase in disturbed areas throughout the area. Further, the mix of weedy species and cereal grains may also reflect an increased use of dung as a fuel (see Miller 1984, Miller and Smart 1984).

The fifth and final pattern showing change, and one of the most interesting, is seen in the changing proportions of the cereal grains (table 5.3 a-c; figure 5.5). While the summer cereals are increasingly important, the shift from one taxon to another is best seen in the wheat-barley record. At the earliest occupation, barley is the dominant grain. During the Harappan Period, wheat increases in ubiquity, density, and percentage until it becomes the most common species at Harappa (Weber 1999:822). Finally, in the Late Period, wheat declines and barley once again becomes the dominant cereal.

Influencing Factors and Explanations for Change

Both natural and cultural factors influence all archaeobotanical assemblages. With careful examination of such influencing variables as the environment, plant processing and usage, postdepositional events, and methods in excavation and analysis, the archaeological seed record at Harappa can be interpreted. All explanations for change at Harappa need to account for these four variables, and such an accounting will help identify many of the more problematic issues surrounding the growing archaeobotanical database in South Asia.

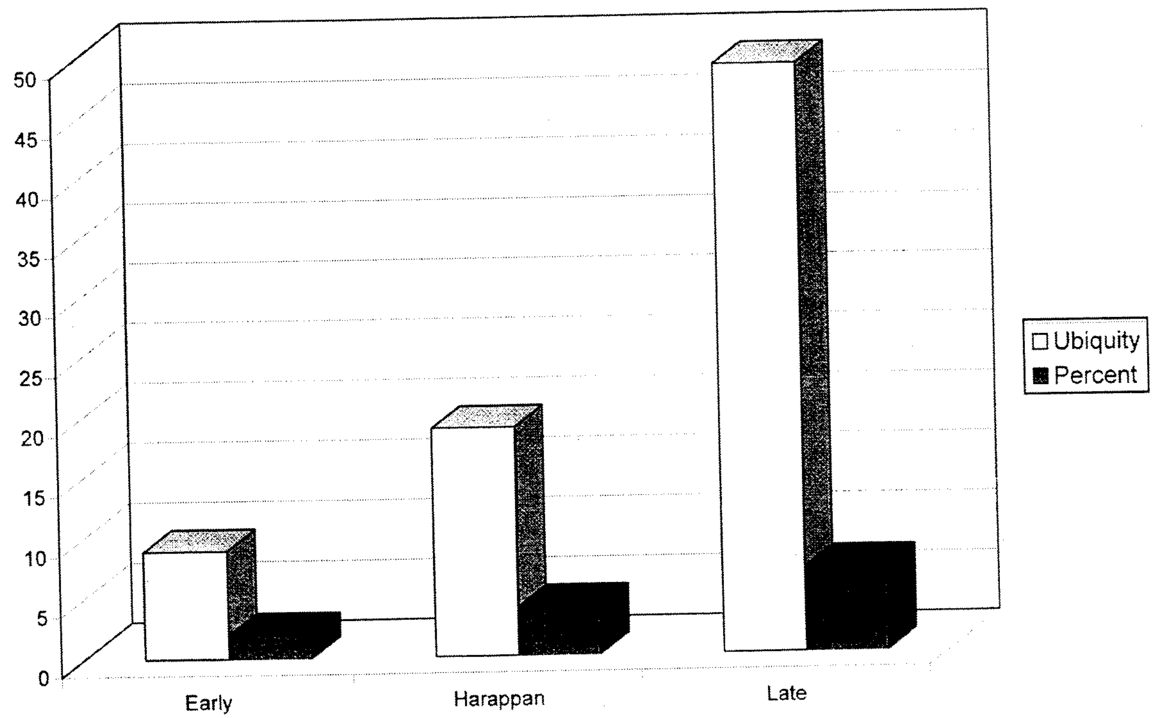

Figure 5.1 Graph of summer crops at Harappa

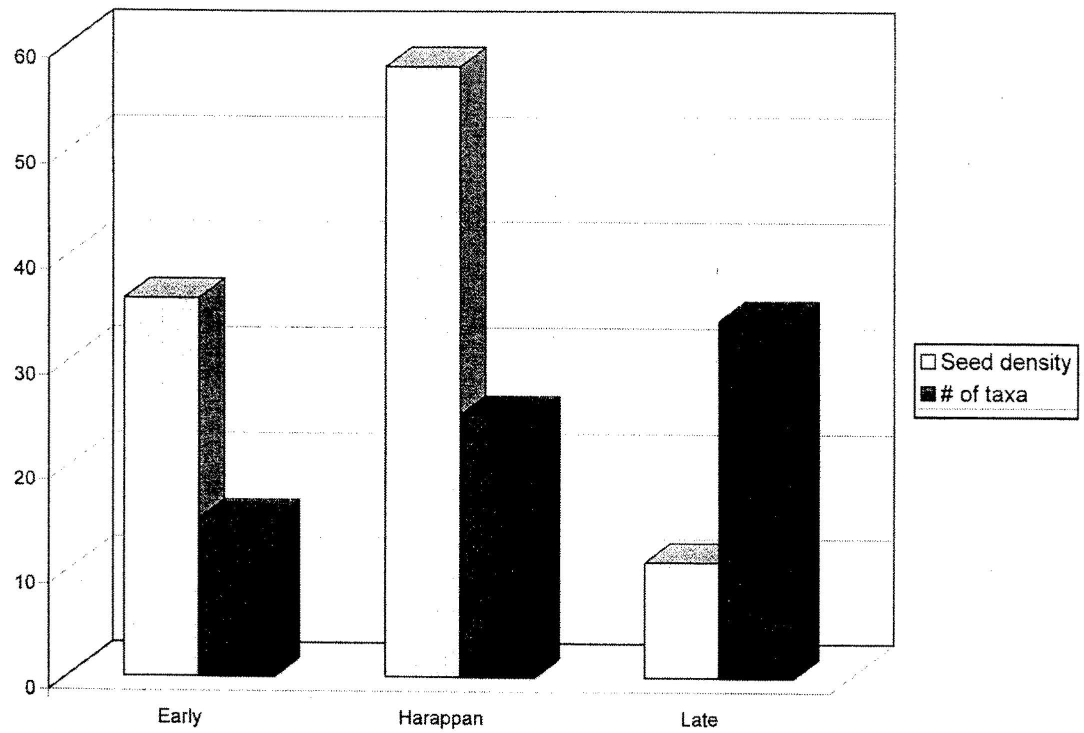

Figure 5.2 Graph of seed density at Harappa

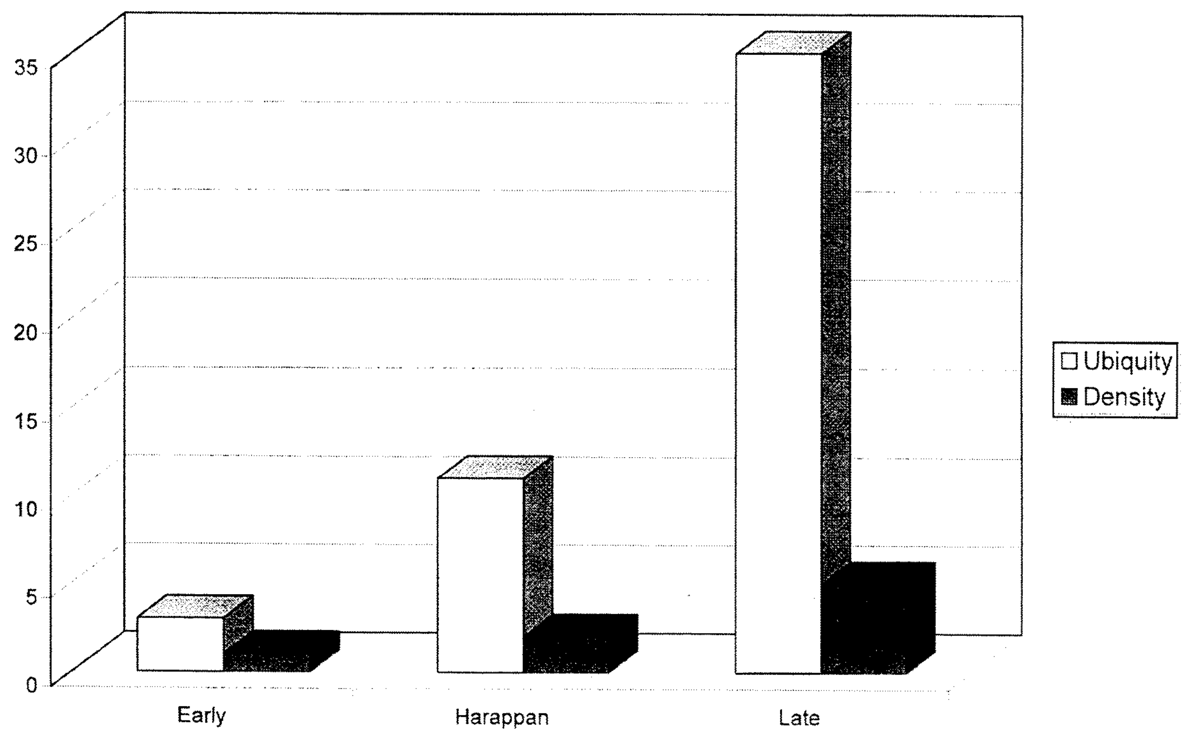

Figure 5.3 Graph of plant by-products

Environment

The natural environment is the primary determinant of what plants are present in the archaeological record. Unless seeds are being brought in from great distances, the archaeobotanical assemblage will reflect what was locally available. A common cause of agricultural change or observed shifts in the seed record, one that can affect all aspects of society, is change in the climate and environment (Weber 1999). Climate, for example, influences site location and tends to delimit the parameters of subsistence and settlement patterns. Any change in climate could have drastically altered the way people lived, driven them to another area, or dramatically affected access to productive resources. The climate and environment of South Asia during the Harappan times have attracted interest and provoked controversy for some time (see: Possehl 1997). Environmental change as a result of shifts in moisture patterns, river drainage, or temperature has played an important part in many theories about Harappan society.

While environmental conditions may have had a direct impact on Harappan settlement systems, their effects on agricultural production at Harappa are less evident. The analysis of the seed records from each phase of occupation at Harappa suggests that shifts in plant use were toward species that grow in similar environments. No significant climatic shift is necessary to explain them. Although the emphasis on certain plants changes over time, no species disappear from the archaeological record, implying that whatever was acquired or used was kept in the agricultural repertoire.

The environment does constrain which crops are grown and when they are planted. While an increase in the summer moisture pattern could account for an increased occurrence in summer crops at Harappa, it would not explain shifts in the winter crops. It is more likely that the increasing importance of the summer crops was based on efforts at creating a more dependable food supply throughout the year. Of the winter crops, barley is the more drought-resistant plant. It needs less water, has a shorter growing season, and grows in a more saline soil. If environment alone were the driving force behind the shifts in the wheat and barley record at Harappa, then one would expect to see a more dramatic decline in the wheat record. Yet wheat remains a primary crop throughout all phases. There is no doubt that any shift in the landscape around Harappa may have affected the ratio of people to the resource potential, and could have caused a shift in agricultural strategies. Yet there is no clear evidence that shifts in the archaeobotanical record, seen over all three periods, are a direct result of this. Other factors had to have played a role at Harappa if we are to understand the changes occurring at this site. In fact, changes in agricultural strategies and patterns of plant use, while subject to climatic and hydrological constraints, are too complex to be reduced to shifts in the environment

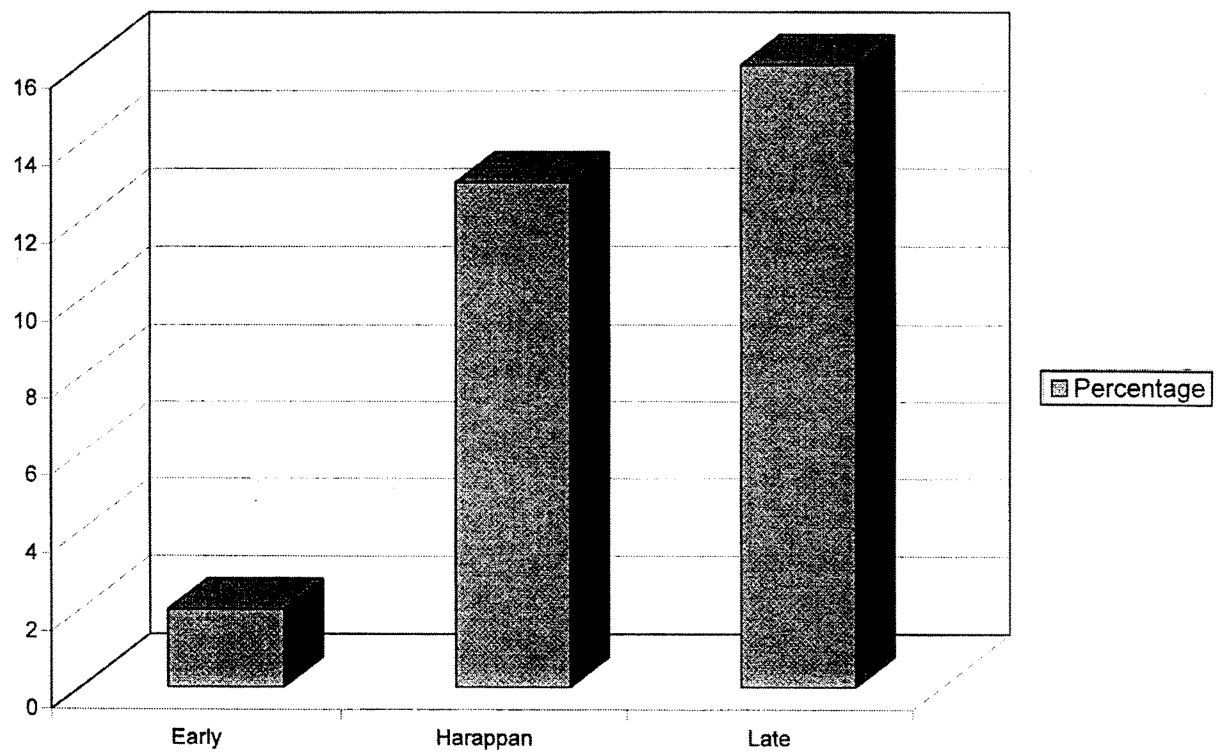

Figure 5.4 Graph of weed plants recovered at Harappa

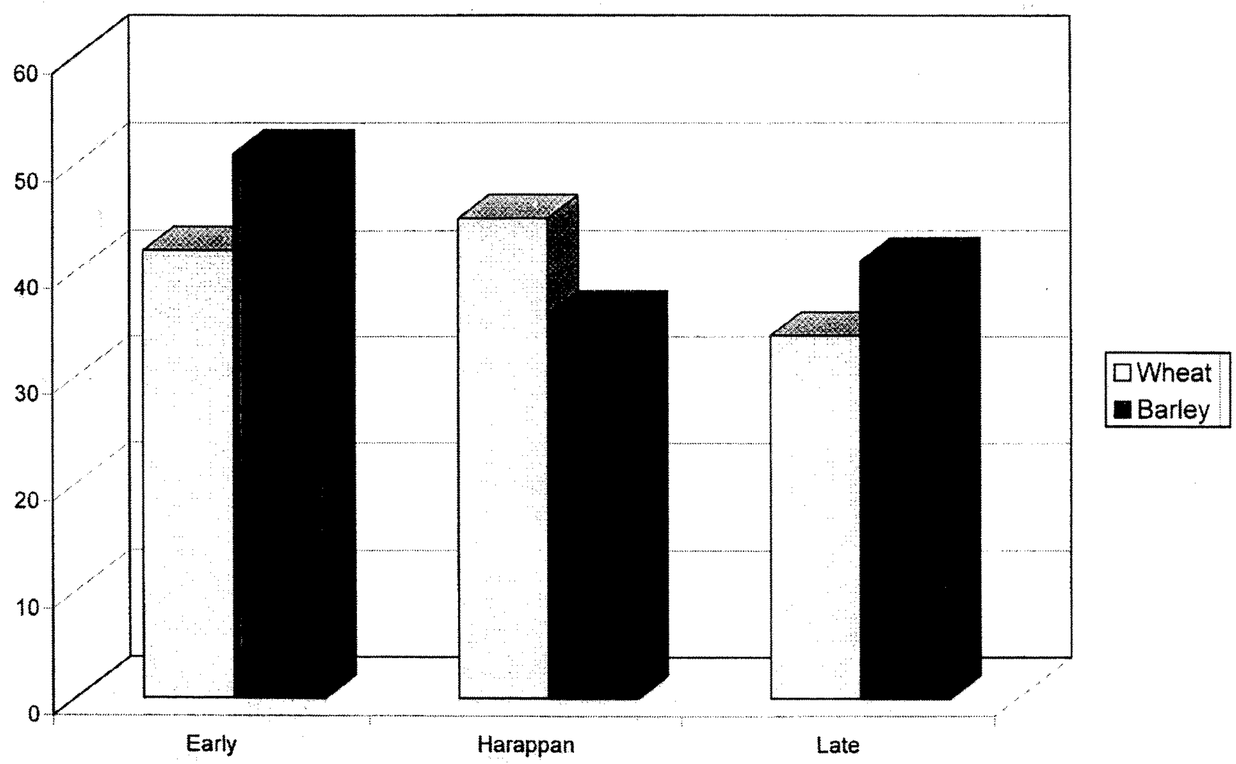

Figure 5.5 Graph of wheat and barley percentages at Harappa

Plant Processing and Usage

Once seeds have been taken from the environment, human actions begin to influence the archaeobotanical assemblage. The use of a plant will clearly affect its chances of occurring in the archaeological record since it is unlikely that seeds will preserve in this region unless they are in a carbonized state. This means that many seeds will decompose without trace in the macrofossil record, and that those that do get preserved are likely to be in hearths or redeposited as secondary refuse, often infilling structures or other features (Fuller and Weber in press). The routes through which a plant or its by-products may be charred include intentional burning as a fuel, or accidentally through parching, spillage, or cleaning (Reddy 1997). The charring process itself also affects the composition of the assemblage in that some plant components or seeds are more likely to survive the charring process than others (Hillman 1981). While high counts of wheat and barley at Harappa may be slightly influenced by this factor, it should affect all periods equally and therefore it is not a variable in shifting proportions over time. In contrast, the low proportions of chaff and other by-products of the cereal grains, which are less resilient to charring, may be directly related to issues of differential destruction. Once people select plants to exploit they need to process them. Crop processing activities not only vary between species but also may change within a given species. Where and when such activities take place impact the chance of a variety of plants or plant parts being represented in the archaeological assemblage.

While crop processing works as a filter that impacts which seeds and plant parts are preserved and which might eventually become part of the archaeological record, usage is the primary variable that is affecting the archaeobotanical assemblage at Harappa. The more a seed is used, the greater its chance of being exposed to fire, and ultimately being preserved. The high rates of wheat and barley in all assemblages suggest high rates of use.

Postdepositional Factors

While human activities may affect the deposition of botanical material, a variety of postdepositional factors differently influenced the accumulation, distribution and preservation of archaeobotanical material (Fuller and Weber in press). Living organisms and geologic processes impact archaeobotanical material, and cultural activities also play a part in the postdepositional history of a site. People are continuously digging into cultural deposits and mixing contexts or occupations. The net result of these postdepositional activities is that archaeobotanical material representing different contexts is often mixed and difficult to distinguish. Patterns seen in the archaeobotanical record at any point in time, as well as any shifts seen in the seed record over time, might be skewed as a result of these processes.

While this was an important consideration at Harappa, strategies were implemented to try to account for these events. First, the focus of analysis was on assemblages from well-defined contexts that represent primary deposits with minimal mixing. Heterogeneous samples in which processes of deposition, destruction, and mixing were difficult to separate were avoided. Second, large numbers of samples were collected from a variety of locations throughout Harappa. This lowers the impact of any single sample skewing the interpretation. The consistency of the archaeobotanical seed record from one sample to the next within each phase suggests that a small number of recurrent processes were responsible for the archaeobotanical record rather than individual, postdepositional activities.

Methodological Issues

The archaeobotanical assemblage is lastly influenced by methods of excavation, collection, and analysis. In a large urban settlement like Harappa, where only a small portion of the site has been excavated, the location or context of the excavation units greatly influence data collection and site interpretation. Although patterns seen in the archaeobotanical record could be a result of this process, by constantly adding new data, the archaeobotanical assemblage at Harappa is always being updated, tested, and verified. As a result, the sampling strategy at Harappa is periodically modified in accordance with growing knowledge.

Because biases in the recovered material may be introduced through the soil processing and recovery techniques employed, special care must be taken to minimize contamination of samples (Wagner 1982). Mixing between the prehistoric soil samples during the flotation process is a constant concern and requires that the tank be washed out on a regular basis. Recent material may also get mixed in with the exposed dirt or in the water during processing (Keepax 1977). Loss and breakage of archaeobotanical material also occurs and can skew samples. In anticipation of these difficulties, a test was employed at Harappa that consisted of placing fifty carbonized poppy seeds (*Papaver somniferum*) in the archaeological soil of some of the samples at the point of excavation (see Wagner 1982). Checking on the condition and number of poppy seeds recovered from these samples during the sorting stage of analysis gives a good indication of the recovery rate accuracy for the flotation system. Recovery rates at Harappa have generally been maintained at around 90 percent.

Conclusion

While postdepositional factors and methodological procedures can greatly impact the archaeobotanical assemblage at any site, these issues have been addressed at Harappa and are unlikely to account in any significant way for the shifts in the seed record. In contrast, the environment did constrain what types of plants were grown locally, although the types of shifts seen in the archaeobotanical record are not typically influenced by climatic change. While the habitat around Harappa may not have been constant, and the use of fuels may also have shifted as a result of this, most of the crops are consistently associated with a winter cultivation strategy.

While there appears to have been a continued effort at Harappa to diversify crops, we also see changing proportions of winter sown cereals, an increasing use of summer sown plants, the introduction of a number of new crops, significant changes in the density and ubiquity of seed crops in general, an increased occurrence of weeds and the by-products of cereals, and a declining percentage of cereal grains as a whole. These shifts seem to be interconnected, and seem to reflect changes in specific activities, and are probably a result of changing needs of the society. If these patterns are closely related to the evolving relationship between Harappa and the surrounding settlements, and to issues dealing with storage, trade, and the centralization and control of the food supply, then a shift in the status of Harappa as an agricultural producer, consumer, and importer of crops may be the kind of explanation that integrates these changes. In the end, they should be seen as an indicator of, rather than as an instigator for, culture change.

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References

Dales, G. F., and J. M. Kenoyer

1991. Summaries of Five Seasons of Research at Harappa, 1986-1990. In *Harappan Excavations 1986-1990: A Multidisciplinary Approach to Third Millennium Urbanism*, edited by R. H. Meadow, 185-262. Madison, Wisc.: Prehistory Press.

Dennel, R. W.

1974. Prehistoric Crop Processing Activities. *Journal of Archaeological Science* 1: 275-84.

—1976. The Economic Importance of Plant Resources Represented on Archaeological Sites. *Journal of Archaeological Science* 3:229-247.

Fuller, D. Q.

2000. Fifty Years of Archaeological Studies in India: Laying a Solid Foundation. In *Indian Archaeology in Retrospect, Vol. III. Archaeology and Interactive Disciplines.* edited by S. Settar and R. Korisettar, 247-363. Publications of the Indian Council for Historical Research. New Delhi: Manohar.

Fuller, D. Q. and S. A. Weber

In Press. Formation Processes and Paleoethnobotanical Interpretation in South Asia. In *Formation Processes*, edited by K. Paddayya. Pune: Deccan College.

Hastorf, C. A., and V. S. Popper (eds)

1988. *Current Paleoethnobotany.* Chicago: University of Chicago Press.

Hillman, G. C.

1981. Reconstructing Crop Husbandry Practices From Charred Remains of Plants. In *Farming Practices in British Prehistory,* edited by R. Mercer, 123-62. Edinburgh: University Press.

Jarrige, J. F.

1985. Continuity and Change in the Npoth Kachi Plain at the Beginning of the Second Millennium B.C., In *South Asian Archaeology1983*, edited by J. Schotsmans and M. Taddei, 35-68. Naples: IsMEO.

Johannessen, S.

1988. Plant Remains and Culture Change: Are Paleoethnobotanical Data Better than We Think? In *Current Paleoethbotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains,* edited by C. A. Hastorf and V. S. Popper, 145-66. Chicago: University of Chicago Press.

Kajale, M. D.

1991. Current Status of Indian Palaeoethnobotany: Introduced and Indigenous Food Plants with a Discussion of the Historical and Evolutionary Development of Indian Agriculture and Agricultural Systems in General. In *New Light on Early Farming*, edited by J. M. Renfrew. Edinburgh: Edinburgh University Press.

Keepax, C.

1977. Contamination of Archaeological Deposits by Seeds of Modern Origin with Particular Reference to the Use of Flotation Machines. *Journal of Archaeological Science.* 4: 221-29.

Kenoyer, J. M.

1998. *Ancient Cities of the Indus Valley Civilization.* American Institute of Pakistani Studies. Karachi: Oxford University Press.

Kenoyer, J. M., and R. H. Meadow
1992. Harappa Archaeological Project, 1992. Report Submitted to the Director-General of Archaeology and Museums, Government of Pakistan, Karachi.
—1993. Harappan Archaeological Research Project: 1993 Excavations. Report Submitted to the Director-General of Archaeology and Museums, Government of Pakistan, Karachi.
Meadow, R. H. (ed)
1991. *Harappa Excavations 1986-1990.* Madison, Wisc.: Prehistory Press.
Meadow, R. H.
1996. The Origins and Spread of Agriculture and Pastoralism in Northwestern South Asia, In *Agriculture and Pastoralism in Eurasia,* edited by D. R. Harris London: Institute of Archaeology, University College London.
Meadow, R. H., J. M. Kenoyer, and R. P. Wright
1994. Harappa Archaeological Research Project: Harappa Excavations 1994. Report Submitted to the Director-General of Archaeology and Museums, Government of Pakistan, Karachi.
—1995. Harappa Archaeological Research Project: Harappa Excavations 1995. Report Submitted to the Director-General of Archaeology and Museums, Government of Pakistan, Karachi.
—1996. Harappa Archaeological Research Project: Harappa Excavations 1996. Report Submitted to the Director-General of Archaeology and Museums, Government of Pakistan, Karachi.
Miller, N. F.
1984a. The Interpretation of Some Carbonised Cereal Remains. *Bulletin of Sumerian Agriculture.* 1: 45-47.
—1988. Ratios in Paleoethnobotanical Analysis. In *Current Paleoethbotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains,* edited by C. A. Hastorf and V. S. Popper, 72-85. Chicago: University of Chicago Press.
—1997. Farming and Herding along the Euphrates: Environmental Constraint and Cultural Choice. In *MASCA Research Papers in Science an Archaeology 14,* edited by R. Zettler.
Miller, N. F., and T. L. Smart
1984. Intentional Burning of Dung as Fuel: Mechanism for the Incorporation of Charred Seeds into the Archaeological Record. *Journal of Ethnobiology,* 4(1): 15-28.
Pearsall, D. M.
1988 Interpreting the Meaning of Microremain Abundance: The Impact of Source and Context. In *Current Paleoethbotany: AnalyticalMethods and Cultural Interpretations of Archaeological Plant Remains,* edited by C. A. Hastorf and V. S. Popper 97-118. Chicago: University of Chicago Press.
—1989 *Paleoethnobotany: A Handbook of Procedures.* New York: Academic Press.
Possehl, G. L.
1997 Climate and the Eclipse of the Ancient Cities of the Indus. In *The Third Millennium B.C. Climate Change and Old World Collapse,* edited by H. N. Dalfes, G. Kukla and H. Weiss, Series I: Global Environmental Change, Vol. 49. 193-242. Springer: Berlin.

Reddy, S.

1997 If the Threshing Floor Could Talk: Integration of Agriculture and Pastoralism During the Late Harappan in Gujarat, India. *Journal of Anthropological Archaeology*. 16: 162-87.

Saraswat, K. S.

1992 Archaeobotanical Remains in Ancient Cultural and Socio-economical Dynamics of the Indian Subcontinent. *Palaeobotanist*. 40: 514-45.

Sullivan, A. P.

1987 Seeds of Discontent. *Journal of Ethnobiology*. 7(2): 137-53.

Weber, S. A.

1998 Out of Africa: The Initial Impact of Millets in South Asia. *Current Anthropology*. 39(2): 267-74.

—1999 Seeds of Urbanism: Paleoethnobotany and the Indus Civilization. *Antiquity*.