Archaeol Anthropol Sci (2010) 2:35–43
DOI 10.1007/s12520-010-0025-0

ORIGINAL PAPER

Does size matter: the role and significance of cereal grains in the Indus civilization

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Received: 23 October 2009 / Accepted: 26 January 2010 / Published online: 12 March 2010

Abstract Cereal grains play a pivotal role in the rise and character of the Indus civilization. Archaeologists have traditionally focused their attention on the large-grained crops of wheat and barley while often minimizing the importance of the smaller-grained millets. Both environmental and cultural variables influence crop selection in the past as well as today. This paper explores the role and significance of cereal grain size during the evolution of the Indus civilization.

Keywords Seed size · South Asia · Harappan civilization · Archaeobotany · Agriculture

Introduction

At around 2600 B.C., a highly organized, economically centralized, and culturally integrated civilization had emerged in the northwestern part of South Asia (see Kenoyer 1998; Possehl 2003). Large, well-planned cities with substantial populations and public architecture evolved from independent village farming communities (Possehl 2003; Glover and Ray 1994). In part, urbanization was the result of a successful food producing economy and the establishment of trade networks that facilitated the flow of the subsistence resources to the major cities and regional centers (Fig. 1). By the beginning of the second millennium B.C., with disruptions in the food supply and trading networks, the cultural homogeneity that characterized the Harappan civilization came to an end (Kenoyer 1998). The result was a return to regional systems that were no longer integrated by a single ideological or socioeconomic system. This change is closely associated with shifts seen in the agricultural record implying that food crops not only played a pivotal role in the rise and character of the Indus Civilization but that they may also be one of the significant keys to understanding the evolution of Harappan culture.

Agriculture was extensively and intensively practiced throughout the Indus civilization. While many different plants were cultivated, cereals appear to be the major crop grown at most settlements. They are the main crops recovered from Harappan sites and are still the primary plants cropped in the region today. This paper explores the role and significance of cereal grain selection during the evolution of the Indus civilization. Where traditional approaches to Indus agricultural practices focus on regional variations in crop use, the focus here will be on seed size and its influence on crop selection. Why did all large, urban settlements of the Indus civilization tend to cultivate large-grained cereals while many small settlements were primarily dependent on the small-grained millets? The proposal here is that seed size does matter and that grain size correlates with the size of the settlements.

The importance of grain size is not new to archaeology. It has been used as an important variable in discussions about the origins of agriculture and the beginnings of sedentary life (see Blumler 1992, 1998; Diamond 1997). These discussions have typically focused on the importance of large-grain cereals and have paid little or no attention to small-grained crops, the argument being that large-seeded grasses had advantages that might have persuaded hunter-gatherers living in seasonally dry environments to become farmers and adapt to a more sedentary lifestyle (Blumler 1992, 1993, 1998; Diamond 1997). Large-seeded, annual grasses are seen as better adapted to surviving long seasons of drought and were therefore more readily available for

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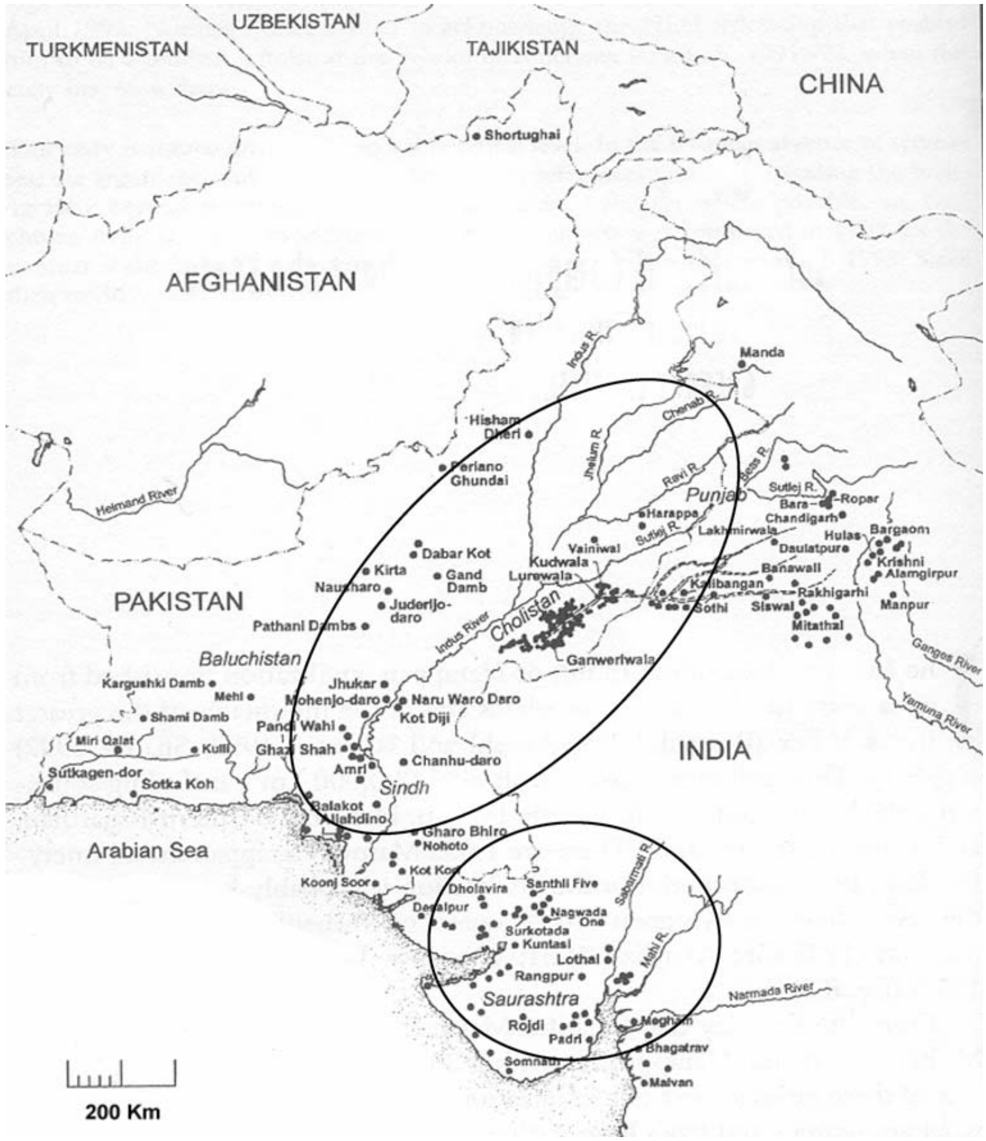

Fig. 1 Map showing the distribution of Indus civilization sites. The upper region is dominated by winter cropping, while the lower region is primarily a summer cropping area. This map is modified from Possehl and Raval (1989) and Weber (1999)

collection, storage, and consumption by some hunting and gathering populations (Blumler 1998). As can be seen in the Near East, people took advantage of large-grained barley and wheat early due to their abundance. These large-grained cereals were relatively easy to cultivate, resulting in very productive economic outcomes. Both Blumler (1992) and Diamond (1997) go on to argue that it is no coincidence that regions where the largest seeded grasses grew in the wild are where we see the first settled farmers. When given a choice of grasses, people generally chose to cultivate the larger grained taxa.

Whether correct or not, these studies only focus on the importance of large-grained seeds and their impact on the beginnings of agriculture. There is little discussion regarding the impact grain size might have had on settled communities or on the development of large urban centers. In contrast, what is of interest here is how grain size affects the ability or inability of agricultural settlements to grow in size and complexity. To better understand this relationship, we need to examine both environmental and cultural variables that influenced crop selection. Specifically, large- and small-grained crops need to be explored in terms of their ecology, nutrition, management, and use within a given culture. What we propose is that grain size should be seen as a link between the environment and culture. While the ecology influences what plants can be grown in a given environment, it is the characteristics of the crops themselves that impact culture. As a result of the wide range of cereals being grown in South Asia, the Indus civilization is an ideal place to explore the influence and significance of grain size.

Indus civilization cropping strategies

The Indus or Harappan civilization, involving nearly a thousand sites dispersed throughout northwestern India and

Pakistan, ranged from village farming communities and small towns to large cities with tens of thousands of people. Extensive models have been developed to explain the agricultural diversity and productivity of the civilization (see Meadow 1996; Weber 1999, 2003; Fuller and Madella 2001). The common thread in these approaches is their focus on levels of precipitation by distinguishing regional moisture patterns and their impact on crop selection. As a result, two agricultural strategies are often discussed (Fig. 1). One strategy, the *rabi*, involves crops sown in the autumn, harvested in the spring, and fed with winter rains. This strategy was most common at Harappan sites found in Baluchistan, Bannu Basin, Sindh, Punjab, Swat, and Kashmir. Many of the winter crops, including wheat, barley, oats, peas, and lentils were introduced into South Asia from Southwest Asia. The second strategy, the *kharif*, centers on crops sown in the summer and harvested in the fall, making use of summer monsoon rains, and includes the cultivation of millets, rice, cotton, dates, and gram. Many of the summer crops were indigenous to the region or were introduced from somewhere else in South Asia. The agricultural strategy in Gujarat, Kutch, Rajasthan, and Maharashtra focused primarily on the *kharif* season. While both the *rabi* and *kharif* strategies were often practiced in the same area, the emphasis was generally on one season based on location. This pattern of dividing regions by agricultural strategies based primarily on cropping continues through the historic record into modern times.

The Indus civilization is often divided into three distinct Periods or Phases, each of which corresponds to a different cropping strategy depending upon what plants were available (Table 1). Most settlements from the Early Harappan Period (3300 B.C. to 2600 B.C.) are located in regions where the winter crops and rabi strategy are practiced (see Fig. 1). These areas contain some of the oldest evidence for an agricultural way of life, most often with a focus on the Southwest Asian crops. The few Early Harappan communities that have been excavated—those located in an environment better suited for summer agriculture—tend to focus on the summer plants. Little multicropping was practiced during this Period, with most communities cropping either winter or summer cereals, not both. The Harappan Period (2600 B.C. to 1900 B.C.), with the large urban sites, was also dominated by the winter crops, as most of the large sites were located along the Indus River. Although more communities practiced both summer and winter cultivation, the emphasis remained on the season best suited to the local environment. During the Late Harappan Period (1900 B.C. to 1700 B.C.), summer cropping became more prominent throughout the civilization. This was in part due to a shift to many small settlements located in regions where the summer monsoons were prominent. This sequence, like most models for Harappan agriculture, emphasizes regional variation, moisture patterns, seasonality, and temporal shifts in plant use strategies (Table 1). While these variables are important, they fail to consider a variety of characteristics about the plants being cropped. One of the most distinctive characteristics of the cereal crops is their grain size. Aside from the fact that differences in size would have been very easy to gauge, there are subtle advantages and disadvantages to cropping large- or small-grained crops that may in turn have directly influenced the selection process. Cropping was not only a result of the environment in which plants were grown. Cropping was closely linked to the needs of those individuals or communities planting those crops. The study of grain size will help us better understand the relationship between crops, climate, and people.

Grain size as a variable

Our study focuses on cereals, as they are the most commonly recovered seeds from Indus civilization sites. For example, at the site of Harappa, nearly 80% of the 250,000 carbonized seeds were cereals (Weber 2003). Our goal was to place all Harappan cereal grains into either the large or small seed categories. Our categories were based on both seed dimensions and their weight. To set up our study, we first selected nine of the most common cereals cropped in northwest South Asia today or in the historical past (*Triticum aestivum*, *Hordeum vulgare*, *Oryza sativa*, *Sorghum bicolor*, *Pennisetum glaucum*, *Paspalum scrobiculatum*, *Sateria italica*, *Sateria viridis*, and *Panicum sumatrense*). Then, using seeds collected from herbariums in India and Pakistan, we measured their length and breadth. The seeds were all whole, unburned, cleaned, and modern. Today, they are part of Dr. Weber's comparative collection at Washington State University Vancouver. Twenty seeds of each species were measured under a microscope. The maximum, minimum, mean, and standard deviation for the lengths and widths are presented in Table 2. As can be easily seen in Table 2 and Fig. 2, while a size range does exist, it is relatively narrow and does not interfere with distinguishing between large- and small-seeded cereals. *Triticum*, *Hordeum*, *Oryza*, and *Sorghum* all have a length above 4 mm and should be considered large-grained cereals. *Pennisetum*, *Paspalum*, *Sateria*, and *Panicum* better fit the small-seeded category, as they never have a length above 3 mm. While a variety of subspecies exist that could mildly alter some of the results, it would not change which species should be considered as large grained and which are small grained.

To support our grain size categories that were based on measurements, we counted the number of seeds it would take to equal 10 g of the crop (Fig. 3). Weight provided a

Table 1 Primary crops of the Harappans and their cropping season

	Cropping season	Early Harappan	Harappan	Late Harappan
Cereals				
Wheat	Rabi	2	2	2
Barley	Rabi	2	2	2
Oat	Rabi	?	1	1
Rice	Kharif	0	?	1
Millets	Kharif	1	2	2
Pulses and vegetables				
Peas	Rabi	0	1	1
Lentil	Rabi	1	1	1
Cow pea	Rabi	0	1	2
Gram	Kharif	0	2	2
Oil seed and fiber				
Linseed	Rabi	0	1	2
Cotton	Perennial	?	1	1
Mustard	Rabi	0	1	1
Fruits				
Date	Kharif	1	1	1
Jujube	Rabi	2	2	2
Grape	Kharif	1	1	1

0 no finds, *1* low ubiquity and low density, *2* high ubiquity and high density

much clearer measure, in that all small cereal grains added up to more than 2,000 seeds per 10 g. All large-grained cereals have fewer than 2,000 seeds per 10 g. Used together, these approaches demonstrate that there are dramatic differences between the largest and smallest cereal grains. The small millets are many times smaller and lighter than the large-grained crops. The large-grained millets, like *Sorghum* and *Pennisetum*, were not introduced into Harappan sites and did not become a significant food crop until the Late Harappan Period. Applying these results to the archaeological record, specifically during the Mature Period, is simplified by the fact that almost all the large-grained cereals being used by the Harappans were either *Triticum* or *Hordeum*, while the small-seeded cereals were *Sateria* and *Panicum*. Based on our methodology, wheat and barley were clearly differentiated from the small millets (Table 2 and Figs. 2 and 3).

The gap between large-grained and small-grained crops is quite pronounced and easy to distinguish in the archaeobotanical record. Nearly all cereal grains recovered from Harappan sites clearly fit into either end of the grain size spectrum. While seed size clearly manifests a visible difference between the cereal grains, other characteristics of these crops are harder to distinguish and may not have been relevant to the Harappans. For example, based on similar volumes or weights, nutritionally, these grains are quite similar (Seetharam et al. 1989; Hulse et al. 1980). On average, there is no significant difference in protein, fat, energy (kcal), or thiamin between large- and small-grained cereals (Seetharam et al. 1990). Small grains do have

Table 2 Nine common South Asian crops and their maximum, minimum, and mean length and width

Grain	Maximum		Minimum		Mean		SD	
	L	W	L	W	L	W	L	W
Hordeum vulgare	8.2	3.9	6.0	3.0	6.9	3.3	0.64	0.29
Triticum aestivum	8.0	3.5	6.5	3.8	7.3	3.2	0.48	0.28
Oryza sativa	7.0	2.6	5.0	1.8	6.1	2.2	0.65	0.28
Sorghum bicolor	5.0	2.5	4.0	1.7	4.3	2.0	0.35	0.19
Pennisetum glaucum	3.0	2.5	2.0	1.9	2.3	2.0	0.27	0.14
Paspalum scrobiculatum	3.0	2.1	2.2	1.8	2.6	1.9	0.26	0.06
Sateria italica	2.0	1.6	1.5	1.0	1.6	1.3	0.11	0.22
Sateria viridis	2.0	1.0	1.9	0.9	1.9	0.9	0.02	0.40
Panicum sumatrense	1.5	1.0	1.0	0.6	1.0	0.8	0.13	0.11

The standard deviation for the 20 measured seeds is also presented

L length, *W* width

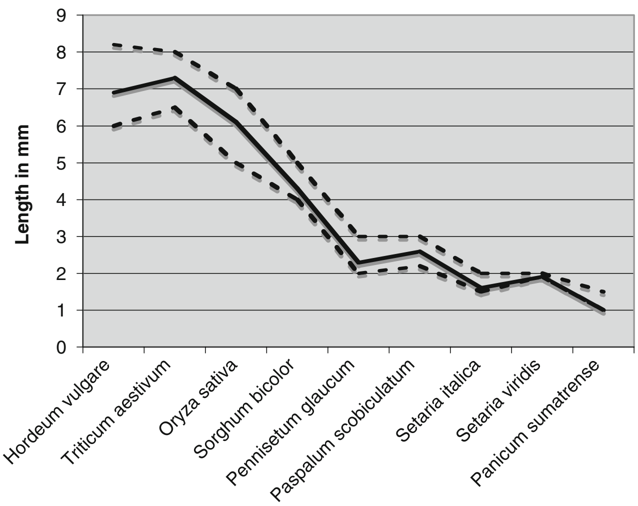

Fig. 2 The maximum, minimum, and mean lengths of nine common South Asian cereals

slightly more fiber and slightly less niacin than the larger-grained cereals.

Where nutritionally they differ minimally, their root systems are dramatically different. Many of the small millets have root length averages of less than 50 cm (Nakamoto et al. 1992), half of what is commonly seen among the larger-grained cereals. As a result, the small-grained cereals are more susceptible to water stress because any soil moisture close to the surface is, for the most part, depleted by evaporation (Bernard and Toft 2007). Small-rooted crops often have high levels of seedling mortality. In contrast, larger grains have deeper and more extensive root systems. This allows for greater access to moisture at deeper levels and thus enables them to tolerate stresses encountered during seedling establishment. The mature root system of larger-seeded crops, like wheat and barley (under favorable conditions), have a working level of 104–121 cm and a maximum depth of 152–213 cm (Weaver 1926). Because of their larger root system, when grown in similar conditions, larger-seeded crops seem to have a higher germination percentage than smaller-seeded crops (Benard and Toft 2007; Black 1956; Winn 1985; Hendrix and Trapp 1992). As a result of the root systems, the larger-grained cereals appear to have greater output and produce more seeds (Stearns 1992; Sletvold 2002).

The small-grained millets are often referred to as “famine crops” due to their quick germination and growth rates (Weber and Fuller 2007). While they generally do well in a variety of soils and climates, they are usually grown in the summer and watered by the monsoons. Generally, they require less rainfall than many of the larger-seeded cereals and are fairly tolerant of drought due to the fact that they mature fairly quickly. Because of the more intensive cropping stages associated with wheat and barley, the small millets generally take less energy to plant and manage, yet the net cost involved in gathering and processing the smaller-grained crops is higher relative to the amount of food collected (Bewley et al. 2006; Weiss et al. 2004). Seeds from small grains must be freed from the hulls by de-husking, a very labor-intensive process. While some of the larger grains do need threshing, the bread wheat and barley of the Harappans were free-threshing and did not require dehusking. Some small-grained crops like *P. sumatrense* have very tiny seeds making this process even more labor-intensive, producing little food for the intense energy input. Additionally, small grain grasses are much more difficult to collect than larger-seeded varieties (Weiss et al. 2004). Low-growing plants with an average height of 61 cm require much more bending and scooping than large grain grasses with an average height of 125 cm.

In contrast to the small millets, the larger-grained crops of wheat and barley have a longer growing season and require substantially more management time to get reasonable yield. They are generally planted in early winter, fed by the winter rains, and are harvestable 4 months after sowing. While barley grows in a greater variety of soils and is more drought resistant than wheat, neither crop is as versatile as the small cereals (Weber 1999). Neither wheat nor barley grows well in humid or dry environments. While the yield of crops is influenced by soil, sowing time, and moisture supply, tillage and irrigation can increase yield by more than 130% (Government of India 1976).

The invention of tillage technology had important ramifications for these grain categories. Early on, people realized that turning the soil in preparation for planting increased productivity, helping to destroy the weeds by mixing them with nutrients found in the soil. With the adoption of plowing, even deeper penetration into the soil

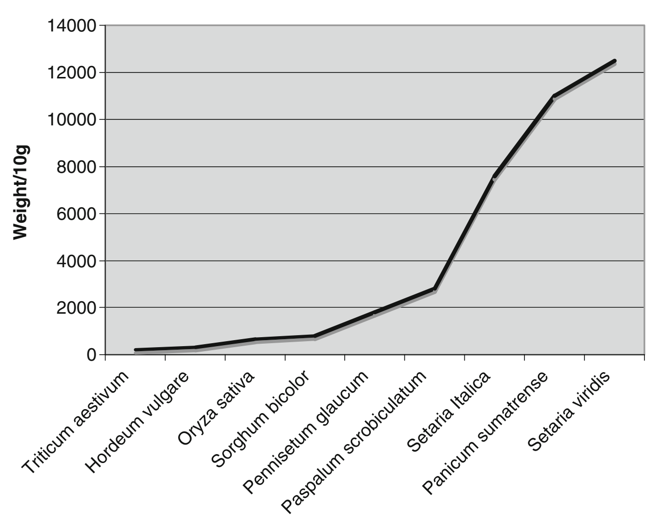

Fig. 3 Distinguishing grain size based on weight. Numbers of seed needed to account for 10 g

can be obtained. While loosening and aerating the soil, plowing also encourages the growth of deeper roots (Government of India 1976). Most important for the amount of energy input, it significantly increases nutritional output or yield. With tillage, farmers could produce more food per unit of land and feed more people. A system of tillage selects for larger grain size, as it requires to be planted at deeper levels (Fuller 2007). Tillage has less impact on smaller-grained crops as their root systems are shallower. With the help of tillage technology, crops planted in deeper burrows increase yield dramatically (compared to smaller grains), thus producing significantly more food for less energy and could support much larger populations. Extensive tillage and irrigation systems will increase the yield of the millets but not to the same extent as seen with wheat and barley. The implication is that settlements with large populations would select for large-seeded crops, as they would produce a more favorable yield. With the use of draught animals, as was probably occurring during the Indus civilization, tillage would become even more efficient and resulting in a significantly higher yield.

Large cities of the Indus civilization needed intensive agricultural practices to feed the tens of thousands of urban residents, yet there is little direct evidence for either tillage or irrigation practices. Although a potential field with furrows has been identified at the Harappan site of Kalibangan (Possehl 2003), this is unusual and not without controversy. Though limited, terracotta models of plows have been recovered from Harappan sites (Dhavalikar 1995). From Banavali, fragments of what has been described as a plow has been recovered (Dhavalikar 1995). There are also symbols of many of the seals that closely resemble an ard or plow. Together, with the early historic and ethnographic records, it seems likely that at least in some areas, the Harappans were practicing tillage.

What grain size means for Indus civilization

No agreement exists as to which method is best in determining settlement size. Neither data nor calculations have been standardized to compare all Indus civilization sites. While population estimates have been proposed for only some of the more well-known settlements like Harappa and Mohenjo-daro (Possehl 2003; Kenoyer 1998), the surface area of most archaeological sites has been measured and published (see Possehl 1999). Using site area as expressed in hectares does have drawbacks. Such variables as the type of settlement, how disturbed it was, and whether it represents a single or multiple occupations can help skew the results. To avoid many of these biases, our approach was to separate settlements into only two very broad categories, large and small. Since most large settlements are larger than 30 ha and most small sites are less than 10 ha, few if any sites are in a range that would be debatable. Most Harappan sites fall in the range of small and are less than 10 ha. To avoid issues of settlement-size changes over time, we focused our analysis on the Harappan Period (2600–1900 B.C.). When multiple sizes appeared in the literature either due to different approaches or from different phases of occupation, we took an average. Of the over 880 mature Harappan sites that have its size recorded (Possehl 1999), less than 10% have any record of archaeobotanical remains (see Weber 1999, 2003; Fuller and Madella 2001; Kajale 1991).

We selected 34 sites found within the Harappan sphere of influence that dated to between 2600 B.C. and 1900 B.C. All these sites had identifiable archaeobotanical material (pollen, phytoliths, seeds, and starches) and had a known size. The sites are listed in Table 3 with their hectares and whether the archaeobotanical analysis was extensive or limited at the site. This is an important variable since flotation was not practiced at all sites and could therefore be biased toward the larger-grained crops. Without floating, small seeds are often missed. Only 12 of the sites involved extensive archaeobotanical research, involving systematic soil collection and analysis. Flotation was carried out at most of these. Sites with occasional or isolated finds of carbonized seeds, or where only limited soil was analyzed, are referred to as limited. Also noted in this figure is whether large- and small-grained cereals were recovered from the site. Although many sites contained both large- and small-grained cereals (Table 3), the settlements always focused only on crop size. When the seed size of the primary cereal crops at these settlements are examined and compared, a correlation of large-grained crops and large settlements appears. Small communities show a mix, some being dependent on large cereals, while others are primarily dependent on small-grained cereals. The different approaches in determining settlement size and the potential biases in the archaeobotanical record do not appear to distort the relationship between settlement size and grain size.

Whether we selected only sites with clearly defined and measured areas in which large carbonized seed collections were obtained through flotation, or incorporated as many sites as possible—including those with fuzzy dimensions and with minimal plant material—the pattern seems to hold up. Large sites like Harappa and Mohenjo-daro rely primarily on large-grained cereals, while small sites like Rojdi are largely dependent on small-grained millets.

Whenever detailed archaeobotanical analysis was conducted, involving extensive flotation, both small-grained and large-grained cereals were recovered (see Weber 1999). Quantification of those remains always suggests a strong emphasis on one cropping season over another. For

Table 3 Sites located within the sphere of Harappan influence that date to between 2600 B.C. and 1900 B.C. and contain identifiable archaeobotanical material

Site name	Hectares	Archaeobotanical analysis	Cereals identified	
			Large grains	Small grains
Allahdino	1.40	Limited	+	−
Babar Kot	2.70	Limited	−	+
Balakot	2.40	Extensive	+	−
Banawali	16.0	Limited	+	−
Burthana	<5	Limited	+	−
Burzahom 1	<5	Limited	+	−
Chanhu Daro	4.70	Limited	+	−
Daulatpur	4.6	Limited	+	−
Dholavira	60.0	Extensive	+	+
Farmana	18.0	Extensive	+	+
Ganeriwala	80–81.5	Limited	+	−
Ghalegay II	<5	Limited	+	−
Harappa	100–150	Extensive	+	+
Kalibangan	11.5	Extensive	+	−
Kanmer	<5	Limited	+	+
Kot Diji	2.20	Extensive	+	+
Kunal 1C	2.90	Limited	+	−
Kuntasi	3.30	Limited	+	+
Laduwala	<5.0	Limited	+	−
Lothal	4.8	Extensive	+	+
Mehrgarh VII–VIII	75.0	Extensive	+	−
Miri Qalat IV	3.70	Limited	+	−
Mohenjo Daro	100	Limited	+	−
Nausharo	1.80	Extensive	+	+
Rakhigarhi	40.00	Limited	+	+
Rangpur	<10	Limited	+	+
Rohira	9.0	Limited	+	+
Rojdi A/B	7.50	Extensive	+	+
Rupar	8.0	Limited	+	+
Sanghol	9.0	Limited	+	−
Shikarpur	5.30	Extensive	+	+
Sohr Damb	1.0	Limited	+	+
Surkotada	1.9	Limited	+	+
Tigrana	5.0	Limited	+	+

Included is the site size, the extent of archaeobotanical analysis that was carried out, and the presences of either large- or small-grained cereals. All sites larger than 30 ha had an emphasis on large-grained cereals regardless of the presence of small-grained cereals

example, people at Harappa used small-grained millets, but wheat and barley were their primary crops (Weber 2003). Similarly, most settlements took advantage of both the summer monsoons and winter rains, and used both *rabi* and *kharif* crops in their agricultural strategy. The emphasis generally remained on the crop best suited to their particular environment. Mohenjo-daro, located in southern Sind where there is little summer rain, depended mainly on the winter crops of wheat and barley. The ecology drives what crops can be grown and when they need to be cropped, but it is the characteristics of the plant species that impact culture.

Grain size can impact urbanism and population growth. Sowing grains into tilled soil with an underlying water table would select for large-seeded crops, which are better able to survive and germinate successfully from deeper levels. In turn, these crops can feed substantially more people. The implication here is that only after large grains are available will we see a growth in urbanism or large populated settlements. Regions better suited for small-grained cereals will remain less urban and have smaller settlements. Large grains are a necessary, but not the only, factor for large settlements.

Settlements like Harappa and Mohenjo-daro, located in ecosystems suitable for large cereals grains such as wheat and barley could easily feed large populations. With the help of tillage technology and domesticated mammals, these settlements could readily grow in size and importance.

Large grains with tillage produced high yields that could feed many more people and provide the same amount of nutrition with much less energy and labor. In contrast, settlements like Rojdi and Lothal, located in a region of Gujarat and well suited for the smaller-grained, summer crops, benefit little from the addition of tillage technology. As a result, the settlements remain smaller in size. Large settlements do not become common in this area until large-grained, summer crops are introduced into the region. The *kharif* crops of rice and *Sorghum*, which thrive in the summer monsoon-growing season, take hold in this area around the beginning of the second millennium B.C.

At about 1900 B.C., cultural integration begins to break down. This marks the beginning of the Late Harappan Period and is associated with the rise in regional cultures and major shifts in the settlement system (Possehl 1999). Large settlements became smaller, and many new areas were populated. These changes resulted in the rise of many more settlements which overall were significantly smaller in size. The decentralization of the Late Period is identifiable in the subsistence system as it is in the socioeconomic and political systems. Centrally organized grain processing in the Harappan Period appears to break down in the Late Period (Weber 1999, 2001; Fuller 2001a, b). At that time, there is a shift toward more self-reliant communities that process crops at the household level. Crop diversity increased with new species being incorporated into the agricultural strategy. Interestingly, the trend toward smaller, self-reliant communities is associated with an increased dependence on small-grained crops. As settlements grew smaller and the need to feed large numbers of people declined, areas could be inhabited that were well suited for small-grained cereals. The result is an influx of population into these more marginal environments.

Conclusion

The basic argument put forward in this paper is that seed size is an important variable in understanding plant-use strategies in prehistory. Just as plant ecology is important and needs to be studied, the characteristic of crops cultivated also need to be examined. Grain size is associated with the structure and function of root systems and, ultimately, crop management systems. This in turn relates to and has an effect on crop productivity and settlement size.

Within the Indus civilization, large, cereal grains are a necessary, although not sufficient, condition for large settlements. All large sites of the Harappan Period are associated with large-grained cereals. Small Harappan communities may focus on either large- or small-grained cereals depending on their ecology. During the Late Harappan Period, grain size becomes less important as communities become smaller and more independent. As a result, small-seeded crops increase in use. Grain size is only an important variable when settlements become large and need to be able to increase productivity. Small settlements with relatively small populations would not be driven to increase production capacity by shifting to more labor-intensive crops.

More in depth studies are still needed to better understand the significance of seed size during the Indus civilization. Other crops beyond cereals need to be examined, and more extensive archaeobotanical material needs to be collected and analyzed. Finally, whether issues of grain size have significance beyond this civilization also needs to be addressed.

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