TRACING THE IMPACT OF 4.2 KA AND 3.2 KA BP CLIMATIC EVENTS ON THE AGRICULTURE OF TELL ATCHANA AND TOPRAKHISAR SITES IN THE HATAY REGION THROUGH MULTIDISCIPLINARY EXAMINATION OF ARCHAEOBOTANICAL ASSEMBLAGES

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ABSTRACT

TRACING THE IMPACT OF 4.2 KA AND 3.2 KA BP CLIMATIC EVENTS ON THE AGRICULTURE OF TELL ATCHANA AND TOPRAKHISAR SITES IN THE HATAY REGION THROUGH MULTIDISCIPLINARY EXAMINATION OF ARCHAEOBOTANICAL ASSEMBLAGES

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This thesis investigates the impacts of 4.2 ka and 3.2 ka BP climatic changes on the agricultural practices in Toprakhisar Höyük and Tell Atchana, located in the Hatay region of southern Turkey. The fundamental inquiry in this thesis is if or to what extent the aforementioned climatic changes affected the agricultural practices of the communities. To answer this question, a descriptive analysis of cereals and wild seeds of archaeobotanical assemblages of these two sites has been assessed. Besides, morphometric measurements and stable carbon isotope analysis on wheat and barley grains have been carried out to examine if there was water stress due to climate change. The findings demonstrate that Toprakhisar Höyük and Tell Atchana switched their preferred grains to drought-tolerant varieties in the time periods that coincide with climate changes. Grain size reduction and water stress were only visible in the hulled wheat grains. Overall, the data generated for this thesis demonstrates that, although agricultural systems did not drastically change or completely collapse, the societies of Atchana and Toprakhisar appeared to have adapted to the increasingly arid conditions by changing the types of cereals they cultivated. By combining different methodologies, results were obtained that enabled the widening of climate change studies and provided a better understanding of climatic impacts, especially on the local scale. This study also shows that archaeobotanical studies could be very appropriate not only for understanding the culinary activities and consumption habits of past societies but also for determining environmental conditions when integrated into these types of environmental studies.

Keywords: The 4.2 ka BP Event, The 3.2 ka BP Event, Archaeobotany, Tell Atchana, Toprakhisar Höyük

ÖZ

4.2 KA VE 3.2 KA İKLİM OLAYLARININ HATAY'DAKİ AÇÇANA VE TOPRAKHİSAR HÖYÜKLERİNİN TARIMSAL AKTİVİTELERİ ÜZERİNDEKİ ETKİSİNİN ARKEOBOTANİK ÖRNEKLER ÜZERİNDEN MULTİDİSİPLİNER YÖNTEMLERLE İNCELENMESİ

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Bu çalışma, Türkiye'nin güneyinde Hatay bölgesinde yer alan Toprakhisar Höyük ve Tell Atchana'daki 4.2 ka ve 3.2 ka BP iklim değişikliklerinin tarımsal uygulamalar üzerindeki etkilerini araştırmaktadır. Çalışmanın temel araştırma konusu, bahsi geçen iklim değişikliklerinin toplulukların tarımsal uygulamalarını etkileyip etkilemediği veya ne ölçüde etkilediğidir. Bu soruyu cevaplamak için, höyüklerden alınan arkeobotanik örneklerdeki tahıl ve yabani bitki tohumlarının tanımlayıcı analizi yapılmıştır. Ayrıca, iklim değişikliğinden kaynaklanan bir kuraklık stresi olup olmadığını incelemek için, buğday ve arpa taneleri üzerinde morfometrik ölçümler ve kararlı karbon izotop analizleri yapılmıştır. Bulgular, Toprakhisar Höyük ve Tell Atchana sakinlerinin iklim değişikliğine denk gelen zaman dilimlerinde, daha çok kuraklığa dayanıklı tahılları tercih ettiklerini göstermektedir. Tohum boyutunda küçülme ve kuraklığa bağlı stres ise sadece kabuklu buğday tohumlarında görülmüştür. Genel anlamda, bu tez için oluşturulan veriler, tarımsal sistemler büyük ölçüde değişmemiş veya tamamen çökmemiş olsa da Atchana ve Toprakhisar toplumlarının yetiştirdikleri tahıl türlerini değiştirerek, giderek artan kurak koşullara uyum sağladıklarını göstermektedir. Bu çalışma sonucunda, farklı metodolojilerin birleştirilmesiyle, iklim değişikliği çalışmalarının yaygınlaşmasına olanak sağlayan ve iklim değişikliklerinin özellikle yerel ölçekteki etkilerinin daha iyi anlaşılmasına yardımcı olan sonuçlar elde edilmiştir. Bu çalışma aynı zamanda, arkeobotanik araştırmaların sadece geçmiş toplumların mutfak faaliyetlerini ve tüketim alışkanlıklarını anlamak için değil, bu tür iklim çalışmalarına entegre edildiğinde, geçmişteki çevresel koşulların belirlenmesi için de çok kullanışlı olabileceğini göstermektedir.

Anahtar Kelimeler: 4.2 ka İklim Değişikliği, 3.2 ka İklim Değişikliği, Arkeobotanik, Tell Atchana, Toprakhisar Höyük

To my father

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CHAPTER 1

INTRODUCTION

1.1. OVERVIEW OF THE RESEARCH

The period of the last 11500 years is named Holocene in the geological time scale. It is the most recent interglacial period in Earth's history. Even if interglacial periods provide a suitable climate for organisms to flourish, rapid climate changes may occur because of changes in solar radiation, ocean water circulation, and several other factors (Clarke et al., 2016; Staubwasser & Weiss, 2006) and can interrupt the biological, cultural, economic, ideological progress of the human societies. It has been suggested that the Holocene period witnessed six such rapid climate changes (RCC) between 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000, and 600–150 cal yrs BP on a global scale (Mayewski et al., 2004).

Since the above-mentioned changes in climate are represented by decreased annual temperatures and rainfall, they have a direct and quick effect on the plants, correspondingly on agricultural practices and yields. One can expect to see traces of the change in archaeobotanical remains found in the archaeological sites. Consequently, archaeobotany has a great potential to contribute to palaeoclimatological studies and interpretation of the impacts of climate on agricultural systems. Revealing these effects can also give hints about the social and economic responses to climate change in past societies, and the evolution of these responses can be traced back through time.

This thesis specifically focuses on the rapid climatic events that took place at 2200 and 1200 BC, also known as 4.2 ka and 3.2 ka events, in geological sciences literature. The study sites are Tell-Atchana and Toprakhisar Höyük, located in the Amuq Plain region of Hatay province of modern Turkey. The potential changes in agricultural practices, agricultural products, and consumption patterns caused by climatic changes in these mounds will be investigated with the help of macrobotanical remains comprising nearly 1000 years of the period between 2200 BC and 1200 BC.

1.2. RESEARCH OBJECTIVES

One of the significant problems in climate studies is the inconsistency of the data on a regional scale. Mayewski et al. (2004) suggest that even if the 6 RCCs on a global scale are supported with a large amount of proxy data, the effects of RCCs on a regional scale are still a debated topic. Thus, producing regional data for the climate changes is essential to fill the gaps in paleoclimatic studies and better understand the regional discrepancy of RCCs. The archaeobotanical evidence studied in this thesis is likely to add to arguments on the occurrence of associated climatic changes in the Amuq Plain in the broadest sense. However, the primary goal of this thesis is not to verify the occurrence of the 4.2 ka BP and 3.2 ka BP RCCs in the region but rather to contribute to understanding responses developed by past peoples in such changes. The impacts of such climatic changes on human subsistence economies can vary and be of different intensity. Consequently, societies can develop several responses (further detailed in section 2.1.). It has been suggested that societies can a) collapse/decline, b) migrate to long distances, c) adapt to the new conditions, or d) remain the same when they experience these kinds of abrupt climate changes (Clarke et al., 2016).

Investigating the effects of climatic changes by using archaeobotanical data is not a new attempt. Climate change and its effects on agricultural decision-making in the ancient Near East were examined using crop product ubiquity data and stable carbon isotope data in previous studies (Riehl, 2008, 2009; Riehl et al., 2008). The use of wheat and barley seed measurements to track variations in crop size owing to water shortage induced by climate change is one of the principal methodologies of this thesis.

Still, carbon isotope analysis is carried out, as well, to compare the results of morphological and chemical measurements. Another methodology includes the study of the wild plant species in the assemblages to observe the changes in environmental exploitation due to changing climate.

The main research objectives of this thesis are as follows:

1) Were agricultural systems in Tell Atchana and Toprakhisar Höyük changed by the 3.2 ka and 4.2 ka BP climatic changes?
2) What was the degree of change if there was any?
3) Is there any evidence of water shortage as a result of climate change in the crops of Tell Atchana and Toprakhisar Höyük?
4) Did water scarcity observe in the crop yields affect the preferences of occupants? In other words, did the people change their exploitation strategies?

To speculate about the climatic effects on agriculture, mainly four aspects of archaeobotanical finds are in focus:

a) The ratio of complete barley seeds to complete wheat seeds. As barley is drought-tolerant species, farmers might prefer barley as a staple crop in times of water shortage. Consequently, a higher ratio of barley over wheat is expected to be seen in the assemblages in the archaeological levels that coincides with the RCCs.

b) The changes in the sizes of wheat. Water stress and cool temperatures have a negative influence on the growth rate of plants. Wheat cultivated under the conditions brought by climate change should be smaller than those produced in more optimal conditions. Thus, a morphometric analysis is carried out to see the changes throughout time.

c) The changes in the stable carbon isotope composition. The low moisture and arid conditions are represented with low $\Delta^{13}C$ values in the results. On the contrary, the high $\Delta^{13}C$ values indicate the availability of the moisture regardless of its source (for instance, the source of the humidity can be both the water of rain and irrigational water) (Riehl, 2008). Thus, the $\Delta^{13}C$ analysis should give low values in the seed samples from climate change periods.

d) The changes in the type and rate of wild plants that people exploited. Food shortages can oblige people to find alternative food sources. These alternative food sources were the naturally grown plants in the environment of past societies. It is expected to observe a higher ratio of wild plants in the assemblages belonging to periods of 4.2 ka and 3.2 ka events. Additionally, as the flora changed because of the drier climate, a higher number of drought-tolerant species should be present in the samples.

CHAPTER 2

LITERATURE REVIEW

2.1. REACTIONS OF SOCIETIES TO CLIMATIC CHANGES: THEORIES

As the core of this thesis, it is better to start the literature review with opinions about the variety of responses that societies give to environmental changes, especially to climatic oscillations. It has been argued that societies might react to climatic crises in four ways. In the worst scenario, climate change drives societies to collapse by undermining the functioning social, political, and economic systems. The other three scenarios are way better than the collapse. The societies that face the challenges of changes in the climate might stay resilient by adopting their systems to the new conditions. They also might move elsewhere and settle down in new places where they do not have to deal with the hardship brought by the new climate. Lastly, the best scenario in any environmental change is getting no impact. Sometimes, societies might not be affected by the changes in their environment at all and stay the same in every aspect (Flohr et al., 2016). Undoubtedly, these four effects are simple suggestions for human responses to environmental challenges. Human behavior is usually more complicated and heterogeneous than the above-referred categories. So, in the following sections, these categories are explained in detail, and the theoretical discussions about the topic are mentioned.

2.1.1. Resilience

The interesting characteristics of the triggers explained by Butzer (2012) are not always the cause of the collapse. Human populations might also become resilient to the challenges that they faced. Walker et al. (2006) describe resilience as " … *the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity*."

Societies might cope with challenges and can reconstitute their social, political, and economic systems. Alternatively, they might not even need to reconstitute them by absorbing them with the changing coping mechanisms. These coping techniques for environmental changes include changing social organization, adopting new technologies, or leaving particular ecological niches. The collapse may occur if the shock of the change is too strong to withstand (Ocakoğlu et al., 2019). Even though a society can change some of its constitutions to resist change and be considered resilient, resilience is still defined by the capacity to absorb change without switching to a different constitution (Walker et al., 2006).

2.1.2. Migration

Migration is listed as one of the responses that are given by people in the face of abrupt climate changes. Migration can be seen as an adaptive response and usually does not take place as a separate event. In most examples, migration is one side of the coin, while collapse is the other. People migrate to new places to reach new sources and adapt to new conditions. On the other side, the settlements/cities that people abandoned are considered evidence of collapse.

In most cases, the collapse happened because of the migration flow and depopulation of the settlements (further discussed in section 2.3.). As a result, it may be preferable not to consider the collapse and migration as different processes. Instead, they are a succession of events that occur cyclically at different periods.

2.1.3. Collapse

Collapse is a concept with numerous definitions and understanding the various aspects of collapse or different ideas about it requires these definitions. So, if one asks this fundamental question: “What is collapse?” there is more than one answer. In some circumstances, the terrible pictures that come to mind when the word "collapse" is mentioned may be accurate. Nevertheless, the background processes that drive societies to collapse need more discussion. According to Tainter (1988), the collapse is a political process. According to him, a society that achieves a level of sociopolitical complexity and maintains it for one or two generations faces the risk of collapse if that complexity swiftly declines. In other words, collapse is the sudden process that results in becoming less complex because of sociopolitical changes.

On the other hand, Diamond (2005) characterizes the collapse as a population decline. He distinguishes the milder sorts of declines from the collapse, which he considers to be a high-impact event. According to his definition of collapse, sociopolitical or economic developments that do not affect the population of a particular area are not deemed collapses. At the completion of the process, the number of people living in the impacted region should drop.

Collapse is a multidimensional process, as observed from the two definitions of collapse described above and is unlikely to be explained by just one of these causes. The crucial thing for the scope of this thesis is how archaeologists describe the collapse. In the archaeological literature, descriptions of collapse underline this multi-causality. Political disintegration of states, partial or complete abandonment of urban centers, decentralization of power, degradation of trade networks, and the deterioration of civilizational notions are all part of the process (Schwartz, 2006). Butzer (2012) also identifies the collapse as a “multicausal and rarely abrupt” event. In his extensive conceptual model, he describes institutional failure as a factor that leads to collapses. Poor leadership, dysfunctional administration, and ideological instabilities are examples of this type of failure. He describes the triggers that precondition causes after identifying these instances as preconditions. Climate change, foreign invasion, economic network disruption, food and raw material shortages, and productivity decrease are among the triggers he lists. Essentially, the trigger is an economic downturn brought on by a deterioration in political institutions.

While the causes of the collapse are essential, the units damaged by the collapse are equally important since they yield archaeological data. In each scenario, the affected unit or units may be different. Individual communities, political units, cultural units, systems, and people/populations are the five types of units (Middleton, 2017). As a first unit, individual communities relate to unsustainable small settlements rather than self-sufficient complex societies. Political units are, basically, empires or kingdoms in which people live together across a large area under the control of a hegemonic family or individual. Cultural units mean groups of people that share the same material or ideological culture in a geographically close area. Systems are networks of societies or locations constantly in contact to exchange goods, materials, ideas, and people. Populations, the final unit, are the people affected by the collapse. While the first two units -individual communities and political units - appear to be interchangeable, the population is more closely linked to demography and demographic decline.

After giving the archaeological definition of collapse, explaining its reason, and the suffering units by collapse, the topic can be narrowed down by focusing on climate change as a cause of the collapse. Today, environmental change is associated with collapse by many. One of the leading causes of environmental change/degradation is climatic perturbations. This thesis mainly focuses on two of them, which are now called 4.2 ka and 3.2 ka BP events.

2.2. CLIMATE CHANGE-RELATED ARCHAEOBOTANICAL RESEARCH

2.2.1. Theoretical Background

Environmental circumstances, economic interests, political aims, and cultural preferences are all elements that impact agricultural decision-making in communities (Riehl, 2009). However, because they are complicated and dynamic variables, one may occasionally surpass the other. Riehl (2009) suggests that during stable environmental conditions, economic and political aims may have had a more significant effect on the agricultural decisions of past societies. When the environment was unstable, on the other hand, the stress caused by it may have had a greater influence on agricultural decision-making than the other factors.

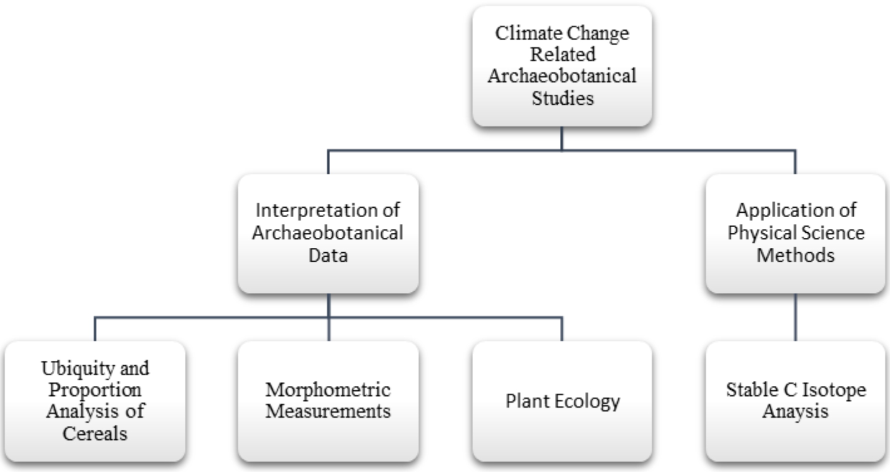

Figure 1. Figure shows the different parameters used in climate change related archaeobotany studies.

Archaeology has long been interested in the environmental dynamics around archaeological sites. Climate change studies are just one facet of this environmental dynamics research. Developing methodologies in archaeobotany contributes to this effort significantly since it investigates the largest environmental group impacted by climate change: plants. The archaeobotanical research on climate change focuses on several aspects of the data that are produced (Figure 1), namely, ubiquity/proportion analysis of cereals, plant ecology, morphometric measurements of plants, and stable C isotope analysis.

2.2.2. Ubiquity and Proportion Analysis of Cereals

The percentage and ubiquity of grains is the second factor that can be explored in climate change-related archaeobotanical investigations. The percentage of a particular plant group in the overall archaeobotanical assemblage is referred to as proportion. As a result, it indicates plant dominance and relative frequency. However, the proportion does not provide information on the existence and frequency of specific plant taxa in different contexts. Defining the contextual properties (being present in different types of contexts) of a plant taxon is possible with the ubiquity calculation. The occurrence frequency of a plant group across all samples recovered from the location is called ubiquity. According to percentage calculations, for instance, free-threshing wheat grains may appear dominant in samples from a site. However, ubiquity calculations may indicate that this dominance is not accurate for all samples obtained from the site. For example, because one of the samples was collected from a free-threshing wheat storage pit, the percentage is high. As a result, free-threshing wheat grains have a high proportion in the samples, but it is not ubiquitous as it is not a frequent cereal among the other samples (Riehl, 2009). The percentage and ubiquity calculations of grains are the first step in examining archaeobotanical data in order to comprehend the influence of climate on society's agricultural decision-making. Some species are drought resistant, whereas others are drought susceptible, as stated in the introduction. Most archaeobotanical research on climate change focuses on the quantity and ubiquity of drought resistant and drought-sensitive plants to better understand the impact of climate on agricultural choices. Riehl (2009) represents the list of drought and salinity tolerance and the economic importance of different crops (Figure *2*); here, only cereals are included as this thesis solely deals with cereals rather than other main crops. The table indicates that two-row barley (*Hordeum distichum*) has the highest drought tolerance among the cereals. Two-row barley is followed by six-row barley (*Hordeum vulgare*) in drought tolerance and is also highly tolerant to the absence of water.

Crop species	Measured parameters	Drought tolerance	Salinity tolerance	Economic value
Two-row barley (*Hordeum vulgare* convar. *distichon* (L.) Alef.)	Decrease in nitrate reductase under drought-stress (Choi and Min, 1982)	High (more than six-row barley)	High	High (higher yields than *H. vulgare convar. vulgare L.*, higher starch content)
Six-row barley (*Hordeum vulgare* convar. *vulgare* L.)	Decrease in nitrate reductase under drought-stress (Choi and Min, 1982)	High (less than six-row barley)	High	High (higher protein content than *H. vulgare convar. distichon L.*)
Free-threshing wheat, tetraploid (*Triticum turgidum* L. spp. *durum* (Desf.) Husnot)	Relative water content, membrane stability index, H_2O_2 and malondialdehyde contents, activity of superoxide dismutase, catalase and peroxidase (Sairam et al., 2001)	Good (high water-holding capacity) (Percival, 1974)	No data	Not as labor-intensive as emmer wheat
Free-threshing wheat, hexaploid (*Triticum aestivum* L.)	Relative water content, membrane stability index, H_2O_2 and malondialdehyde contents, activity of superoxide dismutase, catalase and peroxidase (Sairam et al., 2001)	Moderate (low water-holding capacity) (Oleinikova, 1976); better response to increased rainfall than *T. turgidum* ssp. in areas with >400 mm annual precipitation, but *T. aestivum* is little flooding-tolerant (Davies and Hillman, 1988; Amar, 1998)	No data	
Emmer wheat (*Triticum turgidum* subsp. *dicoccon* (Schrank) Thell.)	Losses of water at wilting, return of turgor and protoplasm permeability (Oleinikova, 1976)	Good (high water-holding capacity) (Sairam et al., 2001); high resistance to poor soils and fungal diseases if stored within the glumes	Probably high (Hunshal et al., 1990)	Hulled wheat, labor-intensive in processing for consumption
Einkorn wheat (*Triticum monococcum subsp. monococcum* L.)	Hydraulic conductivity of the root system in relation to chromosome ploidy (Zhao et al., 2005); photosynthetic rate per unit leaf area Kishitani and Tsunoda, 1981)	Low (drought-susceptible) (Oleinikova, 1976)	No data	Hulled wheat, labor-intensive in processing for consumption, low yield

Figure 2. Table represents the drought tolerance, salinity tolerance, and economic value of different cereals. Retrieved from (Riehl, 2009, p.98).

2.2.3. Morphometric Measurements

Morphometrics is a quantitative study that focuses on the form of the materials, including their size and shape. The information obtained from the morphometric analysis may be utilized to determine the changes and variations in the material being researched (Portillo et al., 2020). Morphometric analysis is now employed in archaeobotany to investigate a variety of plant remnants, including seeds, wood charcoal, phytoliths, pollens, and starch grains. However, the morphometric analysis in this study is limited to seeds. Morphometrics may well be applied to seeds in a variety of situations. Domesticated crops may be distinguished from their wild origins, and the change in size over time can be traced. In addition, morphometrics is used in taxonomic research to distinguish between plant species that are closely related (e.g., different wheat species) (Portillo et al., 2020).

Charring is the major constraint in the morphometric study, preserving the seeds and enabling them to reach the present day. It produces distortions in the seeds and alters their size and shape to some extent. As a result, archaeobotany has long been interested in the effects of charring on seeds, and several experimental and archaeobotanical studies were carried out (Boardman & Jones, 1990; Bonhomme et al., 2017; Braadbaart, 2008; Braadbaart & Van Bergen, 2005; Guarino & Sciarrillo, 2003; Gustafsson, 2000). In the carbonization experiments carried out with einkorn (*Triticum monococcum*), emmer (*T. dicoccum*), spelt (*T. spelta*), bread wheat (*T. aestivum*), and six-row barley (*Hordeum vulgare*) under different temperatures and different oxygenic conditions, it has shown that the most resistant type of cereal to charring and distortion was einkorn. On the other hand, bread wheat and barley are very prone to charring, even at lower temperatures (Boardman & Jones, 1990). The tendency of bread wheat, and barley to carbonize at lower temperatures is also observed in various other experiments (Guarino & Sciarrillo, 2003; Gustafsson, 2000). Expectedly, the hulled wheat species (einkorn, emmer, and spelt) are better preserved in the fire than free-threshing wheat (bread wheat). The latter starts to be destroyed in low temperatures (Boardman & Jones, 1990). The main effect of heat on wheat grains is the increased width and decreasing length (Braadbaart, 2008). The experiments carried out by Braadbaart and van Bergen (2005) showed that emmer wheat, durum wheat, and macaroni wheat are separable from each other with the measurements. However, with the treatment with heat higher than 290°C, the shape of emmer becomes more similar to that of durum and macaroni wheat. The temperatures higher than 290°C makes mentioned wheat varieties inseparable by using measurements. Like wheat species, barley (both six-row and two-row barley) shortens, widens, and becomes more rounded after carbonization (Ros et al., 2014).

As stated in the introduction, morphometric measurements of well-preserved wheat grains are one of the methodologies used in this thesis to explore the impact of climatic change. However, because the dimensions of these grains are likely to have altered during the charring, it would be irrational to simply use only the height or width measurement to infer the change in size. Thus, it is assumed that computing volume and surface area and analyzing the changes in those morphological features would provide the optimum analytical result for balancing length shortening and width increase during combustion.

In addition to the studies that investigate the effects of charring, various studies have been conducted to predict the morphological features of contemporary wheat species, such as surface area and volume (Markowski et al., 2013; Sharma et al., 2021). To overcome the restriction specified in the preceding paragraph, the formulae developed in these studies are used in this thesis. As far as is known, no study estimates the surface area and volume of cereals based on archaeobotanical materials. Thus, the adoption of research on contemporary variety is required.

In a case study on modern wheat (Markowski et al., 2013), wheat was considered a three-dimensional ellipsoid (triaxial ellipsoid, Figure *3*). The overlapping image of the wheat and triaxial ellipsoid is also given in Figure *4* to ease the envisioning.

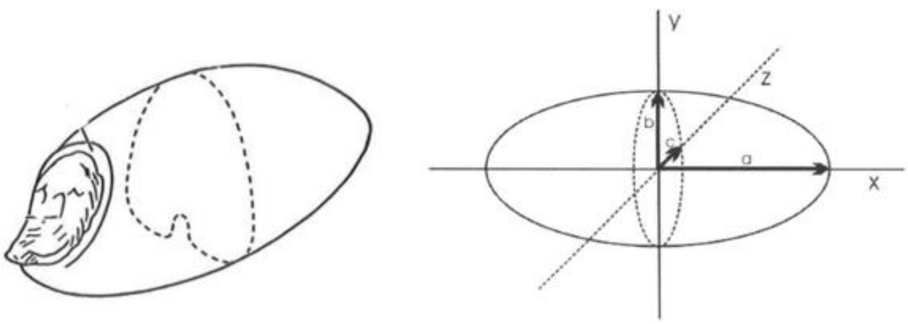

Figure 3. Wheat grain from the dorsal view (on the left) and triaxial ellipsoid shape (on the right)

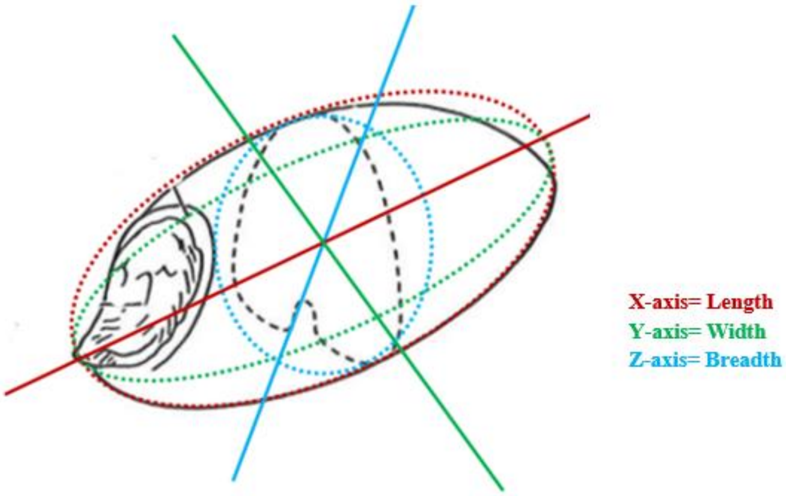

Figure 4. The overlapping image of wheat grain and triaxial ellipsoid. The length (red dashes) of the wheat grain is represented by the line extending on the x-axis, the width (green dashes) by the line extending on the y-axis, and the breadth (blue dashes) by the line extending on the z-axis.

For the calculation of the volume and surface area of the wheat grains, Markowski et al. (2013) are followed, and the formulas for the given morphological traits are as follows.

$$\mathbf{V = \frac{\pi}{6} LWB} \quad \mathbf{(1)}$$

$$\mathbf{A = \frac{\pi}{2} LL_m \left(\frac{L_m}{L} + \frac{1}{U} \arcsin U \right)} \quad \mathbf{(2)}$$

Where,

$$\mathbf{L_m = \frac{W + B}{2}} \quad \mathbf{(3)}$$

$$\mathbf{U} = \frac{\sqrt{(\mathbf{L}^2 - \mathbf{L}_m^2)}}{\mathbf{L}} \qquad \textbf{(4)}$$

2.2.4. Wild Plants and Their Ecology

One of the assumptions of the thesis concerns wild plant species. Past societies tended to exploit naturally grown plant sources throughout human history. However, after the domestication of wheat and barley, the exploitation of the wild plants decreased due to the availability of the more easily accessible and high-calorie cultivars. When the harvest of readily available crops fails because of external factors, people might be inclined to gather more wild plants to sustain themselves.

The comparison between the crop plant taxa and wild plant taxa is essential as it is assumed that human populations tend to exploit their surroundings more intensively in times of food scarcity. It is already argued that in the earliest phases of Neolithic, people should be needed to continue to collect wild plants to meet the food demand that was not met by the cultivable plants (Van Zeist, 1992). Similar to this situation, if crop failures increased during the drought, people might be turned toward the wild plants as an additional food source. It is challenging to detect such a tendency towards wild plants as many other factors might be involved in the presence of the wild species in the archaeobotanical assemblages. One of these factors is the probability of the wild plants being widely consumed by the people in the sites without any additional environmental compulsion. But even in that case, some of the phases might have relied more on wild seeds than the others. The other factor that might affect the presence of wild taxa is the usage of dung as a fuel. Dung usage as a fire fuel is a widespread activity that is observed in ancient sites, and it significantly increases the presence of wild species that brought to the sites with dung and was burnt. On the other hand, the influence of this factor might be eliminated with the evaluation of the contextual data with care. If especially, hearth contexts produce a vast number of wild plant remains, then the probability of dung usage during the firing of the hearths rather than human consumption of wild plants should be considered. If all these additional factors are eliminated, the changing consumption habits might be considered again, and the possible environmental reasons behind these changes might be further discussed.

Wild plant exploitation is only one way to interpret the wild plant data. However, wild plant taxa also can give clues about the environmental conditions of the time. The plants that grow under moist, arid, warm, or cold conditions differ. Thus, the presence of different kinds of species in the botanical assemblages can point to different environmental conditions. Thus, it is also beneficial to consider the wild plant content of the samples according to their habitats.

2.2.5. Stable Carbon Isotope Analysis

First and one of the most common aspects that are investigated is the carbon isotope composition of the plants. Water availability is one of the indicators of climate change. Thanks to the available scientific technology adopted by archaeobotany, researchers can deduce the amount of water that was absorbed by plants in the past using carbon isotope analyses. Since its first application in the 1980s, stable carbon isotopes have become important in environmental archaeology studies, not just because of their scientific strength in determining the ancient diet but also their potential in reconstructing the ancient environmental conditions and agricultural practices. Nitrogen (N), Oxygen (O), and Strontium (Sr) are among the other elements that are used to carry out stable isotope analysis, especially in the determination of the details of ancient agriculture (Riehl, 2020).

Nevertheless, this section of the thesis is designed to give the details of solely carbon stable isotope analysis as it is the only analysis carried out on wheat and barley seeds in this study. In this section, first, the theoretical background and biological mechanism of ^{13}C and ^{12}C accumulation in plants are mentioned. Then, the expected $\Delta^{13}C$ value interval for wheat and barley is mentioned to specify what should be expected from the results of this study.

Plants diverge into three categories in their photosynthetic pathways: C3 (use conventional pathway), C4 (use dicarboxylic acid pathway), and CAM (have crassulacean acid metabolism) plants. The difference results from the differential products of the CO_2- five carbon molecule reaction. In C3 plants, when atmospheric CO_2 and five-carbon molecule reacts, two three-carbon atoms are produced. So, these groups of plants are named C3 plants. The mediator enzyme in this reaction is ribulose-biphosphate carboxylase (RuBP-carboxylase). On the other hand, in C4 plants, an enzyme called PEP carboxylase is in the play, and atmospheric CO_2 is initially fixed with this enzyme. The end-product of this first fixation, thus, is a four-carbon molecule. The photosynthetic pathway of CAM plants is similar to that of C4 plants. The fixation of atmospheric CO_2 is done by PEP carboxylase, but this fixation happens at night in CAM plants, unlike in C4 plants (Simpson, 2019). C3 plants include all tree species, winter cereals, and legumes. Maize, sorghum, millets, and some tropical grasses are the representatives of C4 plants (Fiorentino et al., 2015). CAM plants are often succulents adapted to xeric environments (Simpson, 2019).

As part of C3 plants, wheat and barley discriminate the CO_2 that has a ^{13}C isotope ($^{13}CO_2$) and prefer CO_2 that has ^{12}C isotopes ($^{12}CO_2$) during the photosynthesis because of their RuBP-carboxylase enzyme. The lower reactivity of the ^{13}C isotope causes the preference of light isotopes over the heavier ones. But lack of humidity causes plants to close their stomata, decreases the CO_2 intake, and also causes an increase in the $\delta^{13}C$ composition of the plant. The $\delta^{13}C$ value of a plant increases with the decreasing water availability. Thus, the plants grown in times of water stress have higher $\delta^{13}C$ content (Fiorentino et al., 2015). The range of $\delta^{13}C$ value for modern barley was determined as -28‰ and -25‰ (Hartman & Danin, 2010; Riehl et al., 2014). Research carried out by Ferrio et al. (2007) showed that the charring does not affect on carbon stable isotope content of the cereals. Thus, the same range for modern barley may as well be expected in the results retrieved from ancient barley grains.

The term "carbon isotope discrimination" refers to the preference for lighter isotopes over heavier isotopes, and it is determined using the formula below (Farquhar et al., 1982). The $\delta^{13}C$ readings can be calibrated using this equation for accounting for changes in atmospheric CO_2 content throughout time (Riehl et al., 2014).

$$\Delta^{13}\mathrm{C} = \frac{\delta^{13}\mathrm{C}_{\mathrm{air}} - \delta^{13}\mathrm{C}_{\mathrm{plant}}}{(1 + \delta^{13}\mathrm{C}_{\mathrm{plant}}/1{,}000)} \quad \textbf{(5)}$$

$\Delta^{13}C$=Carbon Isotope Discrimination
$\delta^{13}C_{air}$= ^{13}C Composition on Air
$\delta^{13}C_{plant}$= ^{13}C Composition of Plant

The $\Delta^{13}C$ values decrease with the decreasing water availability. Thus, the grains cultivated in drier environments/conditions have lower values of $\Delta^{13}C$. As a result, the climatic changes that are the topic of this thesis are predicted to lower the $\Delta^{13}C$ values of the grains that are chronologically correlated to these changes. For the barley seeds gathered from Fertile Crescent mounds (including Atchana), the $\Delta^{13}C$ value ranges between 15‰ and 18‰ (Riehl et al., 2014). Below 16‰ represents high aridity stress. The values between 16‰ and 17‰ are considered moderate drought stress, whereas the values below 17‰ point to the water availability (Riehl, 2020; Riehl et al., 2014). The range of $\Delta^{13}C$ value for modern durum wheat (*Triticum durum*) cultivated in northwest Syria is calculated as 12.9‰ and 17.6‰ (Ferrio et al., 2001). The moderate water stress range was regarded between 15‰ and 16‰ for wheat as they were more susceptible to water shortages and are exposed to drier conditions in the summer because of their longer growth cycle (for references, see Karakaya, 2019). Because wheat is more sensitive to water shortage than barley, Ferrio et al. (2005) reported that $\delta^{13}C$ values of wheat grains are lower in drier environments than barley.

Divergent $\Delta^{13}C$ values might indicate irrigation activities for the same type of grain from the same sample. In other words, if the findings of the same species in a sample have a significant standard deviation, irrigation of that crop should be considered (Ferrio et al., 2005; Wallace et al., 2013). The amount of water (both precipitation and irrigation, if there was any) received by the plants (i.e., water input, WI) is also calculable by using the $\Delta^{13}C$ results (Araus et al., 1997; Ferrio et al., 2005). The following formulas are used when calculating received water amounts for wheat and barley (Ferrio et al., 2007).

$$\mathrm{WI_{wheat}}\,(\mathrm{mm}) = 0{,}175 \text{ x } \mathrm{e}^{(0{,}376\mathrm{x}\,\Delta^{13}\,\mathrm{C})} \tag{6}$$

$$\mathrm{WI_{barley}}(\mathrm{mm}) = 0{,}225 \text{ x } \mathrm{e}^{(0{,}364\mathrm{x}\,\Delta^{13}\,\mathrm{C})} \tag{7}$$

2.2.6. Case Studies

The agricultural decision-making in the ancient Near East during the Chalcolithic, Bronze Age, and Iron Age and the effects of climate changes on agricultural preferences were investigated in several studies (Riehl, 2008, 2009, 2010b, 2010a; Riehl et al., 2008, 2009, 2012, 2014; von Baeyer et al., 2021). These studies mainly achieved this aim by tracking the change in archaeobotanical data and using isotope analysis on cereal seeds. In addition to transformation in agricultural preferences, some studies focus on the reconstruction of the climate and the crop conditions, including water availability, by using the stable carbon isotope (Araus et al., 1997; Araus & Buxo, 1993; Ferrio et al., 2005; Ferrio et al., 2007; Fiorentino et al., 2008; Fiorentino et al., 2012; Flohr et al., 2011; Vignola et al., 2017; Voltas et al., 2008). In the following paragraphs, some of the cited studies are discussed to provide insight into how past research was conducted and what the conclusions were.

In this section, several case studies from the Near East are reviewed in order to elucidate the relation of the concept of climate change and its relationship with archaeobotanical studies. Hereby, these case studies constitute a background for the research questions of this thesis by investigating such as: How is archaeobotanical data analyzed? What type of questions are answered? How are the results interpreted? The answers to these questions provide a background for the interpretation of the results of this thesis. They also represent the results of the research, particularly carried out in the Near East.

In her early studies in the Near East, Riehl (2008) used archaeobotanical assemblages to explore the shift in crop distribution patterns in the transition from EBA to MBA (the time overlaps with the 4.2 ka event) and determine if these changes are associated with other paleoclimate proxy records. She also intended to incorporate stable carbon isotope analysis into her research to explore the likely explanations of the relationship between climate change and crop utilization patterns. The study relied on an archaeobotanical database built by Riehl and her collaborator Kümmel. Crop residues for stable carbon isotope analysis were collected from seven Bronze Age sites in the Near East (mostly barley, n=70). Drought-tolerant barley (*Hordeum vulgare*) was the predominant grain crop during the EBA and MBA Near East settlements in terms of both percentage and frequency, according to cereal distribution patterns. The archaeobotanical data showed that different wheat species were chosen at various times. However, because distinct varieties of free-threshing wheat (*Triticum aestivum*-bread wheat vs. *Triticum durum*-macaroni wheat) are difficult to distinguish, they are all considered drought-prone. The prevalence of free-threshing wheat was high in Bronze Age Near Eastern archaeobotanical data. However, its proportion was low compared to barley, especially in the Euphrates. The Euphrates region societies appear to have prioritized barley production above other crops. The percentage of free-threshing wheat in the MBA is significantly smaller, notably in Syria. According to Riehl, the lower proportions of naked wheat during the Bronze Age might be due to the greater water demand of these species. During EBA, quantities of hulled wheat (*Triticum monococcum* and *T. dicoccum*) were likewise low in northern Syria. The emmer wheat (*Triticum dicoccum*), on the other hand, was ubiquitous in the same region since it was presumably one of the crop products that was consumed regularly but not in large quantities. Einkorn wheat totally disappeared from the assemblages belonging to the MBA period. Because einkorn wheat requires more water than emmer wheat, humans likely abandoned its cultivation during periods of aridity. Overall, the archaeobotanical data suggested a change in crop usage patterns during the transition from EBA to MBA. When the carbon isotope values of the barley grains were compared to the modeled precipitation of the various sites, it was discovered that the two variables had a strong correlation. Carbon isotope levels also declined from EBA to MBA, with grains from the MBA period having notably low values. The shift in isotopic components of the grains aligns with the aridity data recovered from other paleoclimate proxy records, indicating that the results represent a change in the environment rather than a change in irrigational activity, according to Riehl.

Riehl (2009) extended her research on crop usage in Near East and classified crop plants into two groups in her study, which she conducted using archaeobotanical data from multiple Near Eastern archaeological mounds. The first group of plants was drought-resistant plants, including barley (*Hordeum vulgare*), emmer wheat (*Triticum dicoccum*), tetraploid free-threshing wheat (*Triticum durum*), and bitter vetch (*Vicia ervilia*). Tetraploid free-threshing wheat is relatively drought tolerant when compared to hexaploid free-threshing wheat. The second group involved the drought susceptible plants such as hexaploid free-threshing wheat (*Triticum aestivum*), einkorn wheat (*Triticum monococcum*), olive (*Olea europaea*), lentil (*Lens culinaris*), garden pea (*Pisum sativum*), fiber flax (*Linum usitatissimum*) and grape (*Vitis vinifera*). The study aimed to investigate the agricultural decision-making during not just the 4.2 ka event but also the 3.2 ka event in the Near East by tracking the changes in the usage of these crops. Riehl represented the ubiquity and proportion of crops by creating maps on GIS. Since the change was under investigation, the archaeobotanical data of EBA, MBA, LBA, and Iron Age sites in the Near East were included in those maps. When the data was separated by area, it showed that the amount of free-threshing wheat in Khabur declined during MBA, while the proportion of barley and emmer increased.

Throughout EBA and MBA, barley had the highest proportion and ubiquity in practically all Near Eastern sites. Emmer wheat was abundant in EBA areas, but it vanished from Syria at the start of MBA. Tetraploid and hexaploid free-threshing wheat have extremely similar morphology, making species differentiation difficult. As a result, the research did not assign free-threshing wheat to a species level. During the EBA period, free-threshing wheat was found in low quantities in the Euphrates, although it was rather abundant in some places in the Khabur region. The ubiquity of free-threshing wheat was high in EBA and decreased during MBA, particularly in the Euphrates. In the southern Levant, however, the ubiquity of the same species increased throughout Bronze Age. Einkorn wheat was found in many EBA sites. However, it disappeared from the archaeobotanical assemblages from MBA onwards except for the Euphrates, where it represented high ubiquities in many sites. The study suggests that crop utilization patterns are connected to climate change, especially during the transition from EBA to MBA. Most of the Near Eastern sites managed to adapt to change, particularly during the 4.2 ka event, by shifting the agricultural plants that they sowed and by adjusting the amount of them. On the other hand, economic interests and cultural preferences influenced agricultural decisions on specific crop species. One example of this sort of economic or cultural inclination is the concentration on barley production in the Middle Euphrates area throughout the Bronze Age. Riehl claims that drought-susceptible species are the first to be abandoned during times of climate change. Drought-tolerant crops, on the other hand, are more likely to be influenced by cultural choices than by environmental restrictions.

Additional evidence for a shift in agricultural growing conditions in the Bronze Age Near East was offered by Riehl et al. (2008). They analyzed carbon isotopes in 9 different types of crops from seven Bronze Age sites in northern Mesopotamia and the Levant, including Tell Atchana. There were 163 grains in total that were examined. The period that the seeds belonged was between 3000-1200 BC. The goal of the study was to discover if the theory of increasing water stress during the Bronze Age was correct. Plants used for carbon isotope analysis included barley, free-threshing wheat, emmer wheat, einkorn wheat, lentil, grape, fig, and fiber flax. The isotope analysis results were compared to literature-based ancient precipitation models and other paleoclimate proxy records from Lake Van and Soreq Cave. Climate models and paleoclimate proxies suggested wetter conditions throughout the EBA, although aridity began to rise around 2200 BC (4.2 ka event). There was a link between the $\Delta^{13}C$ levels of the charred seeds and the modeled precipitation. The $\Delta^{13}C$ findings also revealed that aridity increased throughout the MBA (2000-1600 BC) compared to the later EBA (2700-2000 BC) period, especially in northern Syrian sites, where $\Delta^{13}C$ values were lower in MBA samples.

In her work at Tell-Atchana, Riehl (2010a) investigated the association between the economic decision-making of Atchana society and climate during the LBA (ca. 1600-1200 BC). Archaeobotanical data from both crops and wild seeds, as well as carbon isotope composition values, were employed to attain this goal. The free-threshing wheat (*Triticum aestivum/durum*) had the largest percentage and ubiquity among the crops. One of the rare cereal rachises discovered in the sites was macaroni wheat (*Triticum aestivum*) rachis. These findings suggested that the Atchana environment was wet enough to support the cultivation of a drought-resistant free-threshing wheat variety. Barley (*Hordeum vulgare*) was also abundant in the samples, although not as much as free-threshing wheat (The results of this study are presented in more detail in section 2.5.1.17.). Several species of wetland wild seeds were also present in the samples, again suggesting moisture availability in the environment during that time. Isotope analysis was carried out on 52 plant remains. The results of the carbon isotope analysis showed that wheat had higher water stress than barley as mean and median of $\Delta^{13}C$ values were lower for wheat grains. Wheat grains, on the other hand, have higher individual $\Delta^{13}C$ levels than barley grains. She speculated that there might be three causes for this outcome. First, some of the wheat fields may be watered. Second, wheat might be cultivated on purpose on naturally moist soils. Third, wheat from locations with wetter conditions might well be imported. Overall, the evidence gathered for Atchana does not indicate that agricultural production was under stress. According to Riehl, the impacts of increased aridity, reported in several Near Eastern sites, were not apparent at Tell-Atchana.

Tell Mozan was the subject of research similar to the one indicated in the preceding paragraph (Riehl, 2010b), but this time it focused on the transition from EBA to MBA. One of the main topics in Riehl's work at this site was if there was a cause-and-effect relationship between changes in crop production and the 4.2 ka climatic change. Drought-tolerant barley was the primary crop during the EBA and MBA at Tell Mozan (possibly all of the barley was two-row barley, *Hordeum distichum*). There was also abundant free-threshing wheat on the site. Rachis remnants revealed that the majority of these free-threshing wheat were drought-tolerant tetraploid free-threshing wheat variety (*Triticum durum*). Emmer (*Triticum dicoccum*), a drought-tolerant wheat type, was also found in the samples, although in varying quantities from EBA to MBA (for details, see section 2.5.2.4.). At the end of the MBA, free-threshing wheat was clearly chosen over emmer wheat; however, emmer wheat proportions increased again in the MBA samples indicating it regained relevance during that period. Riehl suggested that the crop choice should be influenced by the suitability of the environment in Tell Mozan. While barley was cultivated throughout the occupation, free-threshing wheat was favored as one of the main crops when the conditions were advantageous. People, on the other hand, cultivated emmer wheat, a more resilient crop, when the conditions were the opposite.

Riehl et al. (2014) carried out stable carbon isotope analysis on 1037 barley grains from 33 archaeological sites and 13 modern settlements on Fertile Crescent. The grains used in this study belonged to a time period that comprised Aceramic Neolithic (ca. 10000 BC) to the late Iron Age (ca. 500 BC). With the amount of carbon isotope data produced in the study, Riehl and her colleagues could track the changes in water availability throughout the Holocene period. The study was carried out to learn how earlier societies managed to farm in the face of climate change and geographically varying environmental circumstances. The range of $\delta^{13}C$ values was considerable in the samples from the Euphrates, where irrigation was evident, according to the research findings. The wide range of values was linked to the selective irrigation of agricultural lands. The results of the study also showed that the $\Delta^{13}C$ values of the barleys ranged from 15‰ to 18‰. The grains with $\Delta^{13}C$ values below 16‰ were evaluated as grown under high water stress, whereas the values between 16‰ and 17‰ were regarded as an indicator of moderate water stress. The fluctuations in the $\Delta^{13}C$ values were consistent with the times corresponding to 5.2 ka, 4.2 ka, and 3.2 ka climatic changes. The study divided the archaeological sites into four groups based on their climatic zones: coastal sites (high precipitation), Euphrates sites (drier land but access to water source), Khabur sites (north of it close to the Taurus mountains, and the south had access to irrigation), and the fourth group of sites was those not located near the coasts or near water sources. The results, as expected, revealed regional variances. Throughout the Holocene, barley values from coastal sites seldom suggested extreme water stress, even during the 4.2 ka and 3.2 ka climate fluctuations, suggesting drought was not a significant issue in those areas. On the other hand, several samples from the Euphrates and Khabur sites had values as low as 13‰. In the samples coming from those locations, the results were rarely higher than 17‰. During the stated climatic changes, all of the sites in the Euphrates and Khabur areas showed signs of severe or moderate water stress (Riehl et al., 2014). The findings highlight the need to analyze data on a regional level, as farmers in each region did not equally experience the environmental stress brought by climate changes.

Ferrio et al. (2005) modeled the water inputs of the different crops by using the $\Delta^{13}C$ values. Applying the method to the different crops enabled the identification of different agricultural treatments on different crops. In other words, the differences in water management practices were investigated. This way, the climatic and anthropogenic effects on the crops tried to be explored. The geographical regions under investigation in this study were northeast and southeast Spain and northwest Syria. According to the research results, all these regions witnessed a significant decrease in water availability from the Neolithic onwards. In the study, to differentiate the anthropogenic interference on crop irrigation and environmental availability of the water, the $\Delta^{13}C$ values of the crops were compared with the $\Delta^{13}C$ values retrieved from wild plants and trees. The barley and wheat grains from northeast Spain and deciduous oak and juniper wood charcoal from southeast France were compared to achieve this aim. As the values coming from the crops and trees were correlated, it was argued that the water was available in the environment without human interference in the region. The selective irrigation practices were also traced in the study by comparing the values of $\Delta^{13}C$ in different crops. For this, two different groups of plants were compared. In the first group, wheat and barley were compared. In the second, wheat and barley were compared with faba bean (*Vicia faba* L. *minor*) and lentil (*Lens culinaris*). $\Delta^{13}C$ values of barley and wheat were correlated and had similar trends suggesting that they were grown in similar conditions. Contrary to the wheat and barley correlation, faba bean and lentil values were significantly higher than those of the cereal grains. The study suggested that the difference between the $\Delta^{13}C$ values of the cereals and legumes might be related to their differences in growth cycle (cereals produce ears once, but legumes produce pods several times throughout their life cycle) and the possibility of irrigation of the legumes.

Fiorentino et al. (2008) incorporated the ^{14}C dating in stable carbon isotope analysis in their research that they carried out in Ebla, Syria. The simultaneous analysis of ^{14}C dating and stable carbon isotope analysis helped to understand the exact dates of the fluctuations in the $\delta^{13}C$ values of plants. It enabled to identify the correlations of these fluctuations with the major climatic changes. $\delta^{13}C$ values reached a peak between ca. 2200-1750 BC. The study suggested that this peak might be related to environmental factors, namely water availability. The results also showed that the abrupt aridity event at the end of the 3rd millennium BC chronologically correlated with the political and economic collapse at Ebla.

The case studies mentioned above showed the different aspects of data evaluation and interpretation. There can be seen several interpretation types that are followed in climate change related archaeobotanical studies. First, the change in the contents of archaeobotanical samples is tracked throughout the periods, not just for the periods that comprise the climate change but also before and after it, to better understand the changing trends in crop consumption. The drought-tolerant species are associated with the effects of climate change most of the time. Nevertheless, other contributors also play a role in agricultural decision-making besides climate, such as economy and culture. The role of these contributors is not always easy to detect; however, sometimes, their effects might become predictable during the data interpretation. For instance, if a particular crop species (e.g., barley) continued to be used throughout different periods, its usage is interpreted for economic and social reasons rather than environmental forcing. Additionally, if an archaeological site has different crop consumption from its contemporary sites in its surrounding, then it also can be a sign of cultural or economic preference. Incorporating two different methods is also helpful to take a step closer to more accurate data interpretation. The combination of the analysis of archaeobotanical data and isotope analysis is one type of this incorporation. Suppose the change in consumed plant types in archaeobotanical samples throughout periods is correlated with the decreasing $\Delta^{13}C$ values in the analyzed grains and the possibility of plants being affected by climate change increases. The second type of data evaluation is detecting the changes in the $\Delta^{13}C$ values, as hinted in the previous sentence. Since these values are directly related to water availability, the fluctuations in them are associated with drought, in fact, climate change. The inclusion of the ^{14}C dating of the seeds is another method that makes the interpretations of $\Delta^{13}C$ values more robust if fluctuations in the $\Delta^{13}C$ values are related to climate change; ^{14}C dating shows the accurate date of the fluctuations rather than simply giving the relative chronology of the material studied. The last aspect of data interpretation is the absence/presence of irrigation. It is known that Tell Atchana or Toprakhisar does not have archaeological traces of an irrigation system. However, the farmers of these sites might still benefit from their surrounding streams and rivers and irrigate their fields in a way that is not archaeologically visible today. Thus, the possibility of irrigation is worth discussing here. Possible irrigation is mainly investigated by comparing $\Delta^{13}C$ values of different crop types, for example, comparing $\Delta^{13}C$ results of cereals and lentils or comparing the results between different cereals. Since this thesis only focuses on wheat and barley, their results can be compared to see differential treatments during cultivation.

Overall, this section explains the theoretical background of the different methodologies applied to archaeobotanical data and the previous case studies that combine archaeobotany and climate change. It is expected that the research questions, methodologies, data analysis, and data interpretation mentioned in this part both give an idea about the state of the research and help the interpretation of the result of this thesis.

2.3. THE MBA AND LBA CLIMATE CHANGES AND RELATED COLLAPSES

The biological, chemical, and physical properties recorded in Earth's geology are considered proxy data sources for understanding the past climate. By analyzing these records, the ancient climate can be reconstructed. Tree rings, pollen, ice cores, and marine sediments are some examples of potential proxy data sources. There are a variety of additional proxy data sources used to reconstruct past climates and climatic oscillations.

The changes in solar insolation appeared as the leading cause of global-scale rapid climate changes (RCC) in the Holocene (Mayewski et al., 2004). Solar insolation varies depending on Earth's orbital fluctuations and solar variability. Several studies have suggested that Holocene climate shifts occur in 2800-2000 and 1500-year cycles (Bond et al., 2001; Bray, 1972; Denton & Karlén, 1973; Stager et al., 1997). As a result, this information became well-known in the literature.

2.3.1. 4.2 ka BP RCC

The 4.2k BP RCC was an event that occurred between 4500- and 3500 years BP. The most significant effects of it started to be seen from 4200 years BP and continued for nearly 300 years in the geological record (Staubwasser & Weiss, 2006). As a result, it might have reached its apex during that time. Because it left traces on the proxy record in diverse regions of the planet, the event has global aspects. The data obtained from North and South America, Europe, Africa, and Asia pointed to the existence of cooler and drier climate in this period of Holocene (Ran & Chen, 2019). The study by Riehl et al. (2008) also indicated a distinctive decline in moisture availability in Upper Mesopotamia around 4000 years of BP. The proxy records of Nile Valley suggest a more saline sea surface caused by dryness in the climate, decreased water discharge of the Nile River, and extended desertification in the corresponding period. The Indus Valley also seems to have witnessed similar conditions. One of the two most damaging climatic catastrophes in the valley's occupancy history was recognized as this one. The Indian summer monsoon lost efficiency due to a drop in the rate of Indus River discharge, according to positive isotope studies (Ran & Chen, 2019). The precipitation brought on by Mediterranean westerlies fell by about 30% to 50% (Weiss, 2016).

While proxy evidence from several parts of the world show that the 4.2 ka BP event resulted in colder temperatures and drought in general, the social consequences in different regions were not the same. Thus, besides mentioning the geological evidence and the ecological impacts of the event, it is also essential to focus on its archaeological imprints. This climatic oscillation has been linked to a number of state or urban center breakdowns and severe degradations in history. The following paragraphs will discuss worldwide examples of collapses corresponding to the 4.2 ka RCC reported in various studies.

2.3.1.1. Mohenjo Daro and Harappan Civilization

Mohenjo Daro was one of the big urban sites of the Harappan civilization located in the Indus Valley of present-day Pakistan. The primary source of rainfall fluctuations in South Asia, including the area where the Harappan civilization grew and resided, is attributed to solar variability in the Holocene (Staubwasser et al., 2003). According to Staubwasser and Weiss (2006), Mohenjo Daro and another big city, Harappa, lost their urban characteristics due to gradual abandonment and became rural locations with about 4.2 ka RCC. The occurrence coincided with an increase in the population size of the sites in Northern India, which could suggest that the Mohenjo Daro and Harappa people were in pursuit of new habitats. Staubwasser et al. (2003) speculate that because these two catastrophes occurred in the same period, the decrease in yearly rainfall may have resulted in a decrease in water discharge of the Indus River, on which Indus agriculture is heavily reliant. As a result, many people relocated to Northern India to sustain themselves.

2.3.1.2. Akkadian Empire, Syria, and Mesopotamia

Tell-Leilan, one of the largest cities of the Khabur Plain (modern Syria) in the 3rd millennium BCE, provides the majority of knowledge on the Akkadian Empire's demise. Until the 26th century BC, this mound had a small community that subsisted on rain-fed agricultural fields. Following that period, a city-state flourished in the Khabur Plain, and the settlements in the plain, including Tell-Leilan, enlarged. Sargon of Akkad and his dynasty united southern Mesopotamia between 4300 and 4200 yrs BP. The Akkadian occupations, however, were abruptly abandoned in 4175 ± 150 BP. The rapid shift in depositional conditions of a well-preserved stratum in Tell-Leilan Trench B indicates an environmental change coinciding with hiatus in the occupation of the mound. According to soil micromorphology analysis, this quick shift indicates that the plain was deserted, most likely as a result of increased aridity, wind turbulence, and dust veil. As a result, Weiss et al. (1993) consider the change in depositional circumstances to be the evidence for a drop in agricultural output and link the Tell Leilan's abandonment to climatic change. In another study that comprises Tell-Leilan, Cullen et al. (2000) used the sediment record from the Gulf of Oman to indicate a rise in eolian dolomite and calcite deposition, and radiocarbon analysis suggests that this rise happened around 4025 ± 150 BP. The increase in these particles indicates a roughly 400-year aridity period in Mesopotamia that lasted until 3625 BP. The study claims that abrupt climate change was a major factor in the Akkadian Empire's eventual downfall, as the date of the aridity event was produced in regional paleoclimate data (4025 ± 150 BP). The date of the collapse that was brought forward by Weiss et al. (4175 ± 150 BP) notably correlates with the joint errors.

deMenocal (2001) also associates the related RCC with the collapse of the Akkadian Empire by referencing different studies that use various proxy data from the surrounding regions of Khabur Plain. Akkadian people abandoned the agricultural fields in northern Mesopotamia and migrated to southern Mesopotamia -from rain-fed to irrigational fields- because of the instantaneous shift towards drier climatic conditions. According to this study, the reoccupation of north Mesopotamia did not become possible until the 3900 years BP, coinciding with the termination of the harshest period of the event. Weiss (2012) indicates that the abandonment of Khabur Plain had two stages. The radiocarbon analysis dates the first stage at around ca. 2254-2220 BC. In that period, the occupational area of Tell Leilan decreased by 99%, Mohammed Diyab decreased by 72%, Tell Mozan decreased by 84%, and Tell Brak decreased by more than 50%. The Tell-Hamoukar and Tell-Barri were already abandoned at this early stage. This first stage witnessed the major abandonments by Akkadians, including administrative buildings/palaces and lower towns in all mentioned sites. The second abandonment stage dates back to ca. 2233-2196 BC. The sites of Khabur Plain were completely abandoned except few, which were nevertheless reduced in size, such as Tell-Mozan and one isolated stratum from Barri. Furthermore, Weiss (2016) claims that the "global megadrought" produced by 4.2 ka RCC resulted in a habitat tracking behavior in the populations of other settlements of western Syria and northern Mesopotamia. The new habitat tracking need is caused by the insufficiency of the products coming from rain-fed agriculture. The abandoned settlements which depend on rain-fed agriculture and the new "habitat monitoring refugia" are depicted on a map in his essay (Figure 5). In this map, it can be seen that the newly populated settlements were mostly located in riparian, paludal, and karst springs zones. In other words, according to Weiss, the people of mentioned regions abandoned their homes in search of river-fed and spring-fed locations where they could cope with the challenges brought by drought.

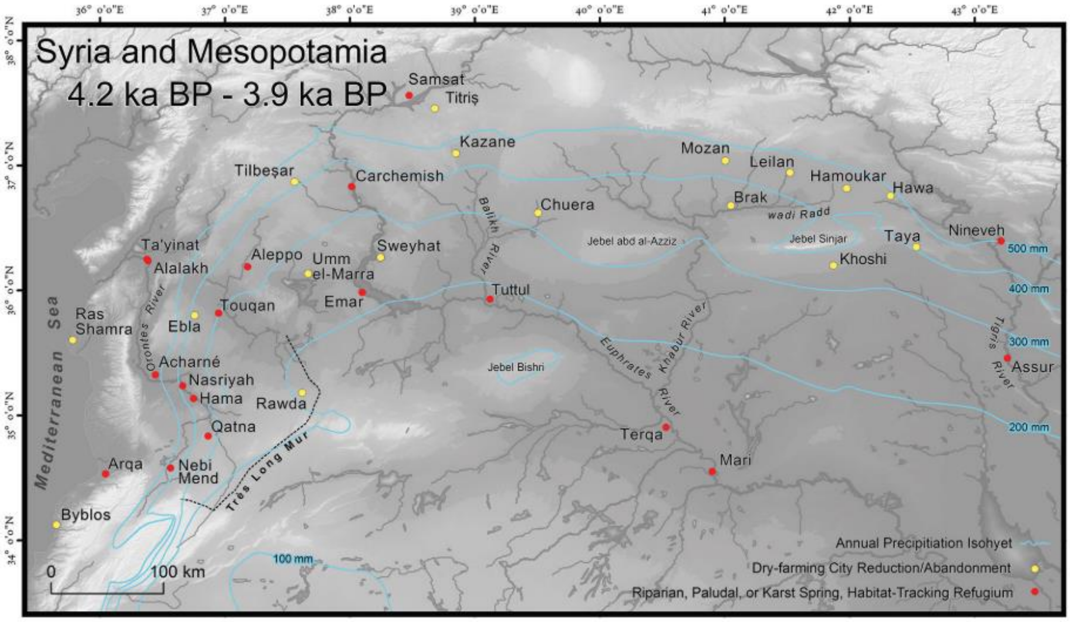

Figure 5. Map shows the changes in settlements of Syria and Mesopotamia between 4.2 ka BP and 3.9 ka BP. The yellow dots indicate the dry-farming city reduction abandonment whereas the red dots indicate the habitat tracking refugium. Retrieved from (Weiss, 2016, p.63)

Simultaneous carbon stable isotope analysis and ^{14}C dating by using Accelerator Mass Spectrometry techniques showed an aridity at the end of the 3rd millennium BC on plant remains gathered from Ebla (Fiorentino et al., 2008). The study suggests that the close correlation between the abrupt aridity indicated on the plant remains and political/structural collapse at the same time might refer to the environmental impact on collapse as in the case of Tell-Leilan.

Tell Umm el-Marra was the biggest Bronze Age site in Jabbul Plain of Syria between Aleppo and the Euphrates Valley, and ecofactual and artifactual evidence suggests that during the transition period between EBA and MBA, the site saw a series of changes in its socio-culture, economy, and material culture (Schwartz & Miller, 2007). In addition, the site went through an occupational hiatus and was fully abandoned at the same time period, as demonstrated by the lack of "transitional" pottery assemblage. At the end of the EBA, acropolis of the site, that had been utilized as a burial ground for the elites, was no longer used for this purpose, a situation that could be interpreted as confirmation of the decline of elite dominance. The changes in economy are evident in the faunal data that reveals increased number of game animals/wild species in the MBA assemblages. The increase in the number of these species of animals might indicate the need for intensified exploitation of the environment to reduce the stress of food scarcity. Even though the study carried out by Schwarz and Miller does not point out the climate as a contributing factor to decline in Umm el-Marra, it might not be a good approach to dismiss the role of changing climate, considering the synchroneity between climatic events and changing patterns in Umm el-Marra.

2.3.1.3. Anatolia

The Anatolia does not seem affected by the 4.2 ka event as the surrounding regions did even though the proxy records taken from the Anatolian lakes including Lake Van (Lemcke & Sturm, 1997; Wick et al., 2003) which located in Eastern Anatolia, Nar Gölü (Dean et al., 2015) which located in central Anatolia, and Eski Acıgöl (Roberts et al., 2008) which located in Southwestern Anatolia point to an decrease in lake levels, decrease in humidity and vegetational change towards drought-tolerant plant species. Even, central Anatolian states flourished with the establishment of Assyrian trade colonies. Still, it is important to mention what was the situation in the rest of Anatolia to better understand if developments were only seen in Central Anatolia or if it is the case for Anatolia in general.

The combination of archaeological, archaeobotanical and stable isotope analysis carried out in Troy by Blum et al. (2015) points to the changing agricultural conditions between 4500 and 4000 yrs BP because of the decreasing moisture and nitrogen availability. However, around 4200 yrs BP, the new social and economic elements that carry the Anatolian central plateau characteristic were introduced to Troy indicating the developing interactions between two regions. Additionally, the settlements in the western coast of the Anatolia witnessed a decline in cultural and economic interactions with the surrounding regions, Troy did not experience such declines even after the so-called collapse caused by the 4.2 ka RCC. So, even though the archaeobotanical and isotopic data suggest an environmental change that might have had an effect on agricultural production, the archaeological evidence points to conditions that allowed Troy to maintain its cultural, economic, and social interactions.

Massa re-evaluated the situation in Western Anatolia during the same time period, as well as in Central Anatolia (2014). In his study, he emphasizes the "fire conflagrations" found in the excavated western and central Anatolian sites with occupational strata dating from 2250 to 1950 BC. The number of sedentary villages in western Anatolia and the central plain also declined. According to him, the continual battle caused by the will for political dominancy between the Anatolian city states might be the reason of the fires and fall in settlement numbers. However, he points out that there is no evidence of widespread human mortality in any episodes of fire damage. As a result, the abandoning of towns cannot be primarily attributed to enemy fire devastation. He goes on to say that the drop in the number of sedentary communities might be due to an increase in nomadic or semi-nomadic populations escaping the damaging impacts of climatic fluctuations, as seen in Northern Mesopotamia.

Bal (2019) analyzes archaeobotanical and zooarchaeological data and compares them to regional settlement patterns in her thesis to examine the causal link between the 4.2ka event and later changes in economics, politics, and social life in Western Anatolia. Küllüoba, Troy, Kanlıgeçit, Maydos-Kilisetepe, and Karataş-Semayük are among the archaeobotanical research she mentions. Plant remains from Troy (as described above) and Küllüoba, in particular, reveal a rise in barley, glumed wheat, and drought-tolerant pulses beginning in ca. 2400/2300 BC and continuing until ca. 1950 BC. Troy, Maydos-Kilisetepe, Kanlıgeçit, and Karataş-Semayük provided the animal remains studied in the thesis. Increases in the percentages of goat and wild animals in the zooarchaeological assemblages are thought to be the result of a drought around the above-mentioned timeframe. In the final stage of her research, she discusses the erratic settlement patterns in Western Anatolia and mentions that archaeological evidence indicates that village destruction peaked in the 21st century BC, and that the number of settlements decreased. She links the destruction of settlements and the decline in the number of settlements to competition and conflict amongst societies as a result of limited water supplies and land due to drought. Overall, the thesis suggests that the 4.2ka event is associated with shifting exploitation patterns of animals and plants, as well as a decline in the number of archaeological sites, and that there may be a direct link between the climatic change and the data cited.

The 4.2 ka BP event seems to have had a significant influence in the collapse of civilizations around the globe, notably in West Asia, Mesopotamia, the Mediterranean, the Levant, and Anatolia. The Anatolian and Syrian instances of collapse are particularly relevant, and they are explained with more emphasis than other regions because the focus region of this study is physically at the crossroads of these two regions. Thus, the so-called collapses in Anatolia and Syria might aid in deciphering the social systems that emerged around 4200 BP in Toprakhisar Höyük.

2.3.2. 3.2 ka BP RCC

The 3.2 ka BP RCC coincided with the transition period from Late Bronze Age to the Early Iron Age in the Near East. The end of LBA, is not only characterized with the presence of a climate change but also witnessed the invasion of Mediterranean, Levant, Mesopotamia, and Egypt by the so called "Sea People". The identity of these people and where they came from, and their motivation are still not clear, but it is certain that there was an intense movement of populations in the related areas. The Sea People attacks to settlements on these areas identified as the last step of bigger climate-induced crisis (Kaniewski et al., 2015).Therefore, the potential environmental causes of this transition and also of this intense human movement have been an interest of archaeologists for a long while.

After beginning around 1200 BC, the climate event lasted for nearly 300 years. Kaniewski et al. (2013) suggested a major anomaly in the annual precipitation according to several proxy data, including pollen records, paleo-shorelines, and lake sediments, $d^{18}O$ speleothem scores. The data came from regions that comprise of Syria (Tell Breda, Tell Tweini, Ras El-Ain Qameshli), Nile Delta (Qarun Lake, Brullus Lagoon), Israel (Ashdod Coast, Soreq Cave), Dead Sea (Ain Gedi Shore), Eastern Mediterranean, and Cyprus (Larnaca Salt Lake). The pollen record of another study (Kaniewski et al., 2008) suggests more arid conditions in the Jableh Plain of northwest Syria. In the time between 1100-800 BC, the region had a flora of warm-steppe plants. However, since about 900 BC, when aridification was at its peak, pollen data indicated a biome dominated by hot desert plants. The eastern Mediterranean climate at that time was dominated by colder temperatures (Finné et al., 2011). The climatic change that happened before 3200 years ago was marked by cooler and drier consequences, similar to the 4.2ka BP RCC. As in the case of 4.2 ka BP RCC, this event also associated with several collapses across the world and some of them are mentioned in the following sections.

2.3.2.1. Greece

At the end of the Late Bronze Age, not only Greece but Anatolia, Mesopotamia and even Egypt witnessed a succession of abandonments and destructions, resulting in the deterioration of communities in an expanse of land almost 6 million km^2 (Knapp & Manning, 2016). One of the most complex societies of the Greek world in LBA, Mycenaeans, were also among the societies that were affected by the destructions. Especially, a series of palace destructions among the Mycenaean world during the Late 13^{th} century BC was recorded archaeologically.

One of the palaces mentioned above was the Palace of Nestor in Pylos. The stalagmite analysis carried out by Finné et al. (2017) to reveal the chronological synchronicity between climatic fluctuation and the destruction of the Mycenaean Palace of Nestor shows that, while the palace's destruction around 3150-3130 yrs BP coincides with a wetter climate, the subsequent drier period after 3150 yrs BP may have harmed Mycenaean rainfed agriculture, preventing the rebuilding of the Nestor Palace and its services. As a consequence, the study concludes that the causes for the demise of the palace and subsequent reduction in palace economics are not due to climatic changes; nonetheless, the climate's role should not be overlooked entirely. Drake (2012) also claims that the demise of palace systems was linked to the decline in annual freshwater flux in Greece and the subsequent "Greek Dark Ages." Since the surface temperatures of the Mediterranean Sea dropped before 1190 BC, evaporation rates dropped as well, resulting in a decrease in freshwater flux. According to him, because the amount of water vapor in the atmosphere decreased, Westerly winds were unable to deliver enough moisture, and resultantly precipitation decreased. The drop in precipitation is also visible in land-based proxy records, which reveal that Greece was becoming increasingly drier. He continues to argue that Palatial Centers were heavily reliant on agro-products to feed their people, and that a long-term decline in precipitation might have caused social conflicts. As a result, the breakdown of systems, abandonment, and migrations in the Eastern Mediterranean might have been the result of climatic change that happened 3200 years ago.

In their recent work, Dibble et al. (2021) take a new approach to the subject, examining the differences in faunal records of villages in Southern Greece between Late Bronze Age and Early Iron Age. The result of this study shows that LBA Greece had more homogenous distribution of animals in faunal remains. They associate this result with the central palace control over the animal husbandry practices. But, in EIA, the faunal remains show less homogeneity and the proportion of the goat bones increased in the zooarchaeological assemblages. The study interprets this increase as an adaptation to the drier conditions started in the beginnings of the EIA. The decline of palatial systems that coincides to same period also support their idea. As the palatial control was diminished over the animal husbandry, the common people of the Greece were able to adapt themselves to new drier conditions by raising more goats which are better suited animals to mentioned conditions.

Correlation between the climatic change and Mycenaean downfall are not only evident in modern archaeological data, but written evidence also points to that correlation. One of the ancient Greeks talking about the climate and drought at Mycenae was Aristotle.

In his *Meterologica*, he compares two Greek cities, Argos, and Mycenae. He claims that during the Trojan War (even though his dating of Trojan war might be incorrect), Mycenae was a moist and fertile area, but Argos was arid and swampy, with only a few inhabitants surviving. Later, however, the circumstances shifted, and Mycenae became swampy and uncultivable, whilst Argos became agriculturally fruitful. He also discusses the evidences of migrations and resettlements that happened during Mycenae's downfall (Bryson et al., 1974; Neumann, 1985).

2.3.2.2. Mesopotamia and Northern Levant

The written evidence coming from Babylon and Assyria mention drought, continuous crop failures, severe famine that leads to cannibalism, nomad unrest and invasions, and disorder between 1150-930 BC (Kaniewski et al., 2015; Neumann & Parpola, 1987).

The written records coming from Emar which was one of the flourishing cities of northeastern Syria inlands mentions the food shortages and famine and increased grain prices around 1190 BC, says “The year of hardship when three qa of grain cost one silver shekel” (Kaniewski et al., 2015; Singer, 2000).

Tell-Tweini (Gibala) was another flourishing city as a part of Ugarit Kingdom in LBA Syria. The sedimentology analysis carried out by Kaniewski et al. (2010) suggested drier climatic conditions in the coastal Syria beginning in the late 13^{th} /early 12^{th} centuries BC that lasted until the 9^{th} century BC. The date of the first conflagration seen in archaeological layers of the Tell-Tweini was assigned as around 3160 cal yrs BP in the same study with the radiocarbon aging carried out on an olive stone and on two oak fragments. At a time period between 1194-1175 BC, the capital city of the kingdom, Ugarit, was also destructed according to the information deduced from Egyptian letters. Consequently, the study suggests that the simultaneity of drought and the chain of destructions might point to a causality. The climate change induced drought might be a cause of cultural collapse in Ugarit Kingdom and in Syria which becomes archaeologically visible in conflagration layers.

2.3.2.3. Anatolia

The Hittites provide some of the few documented records regarding the climate around 1200 BC. A letter of Hittite king Arnuwanda III mentions a severe famine in Anatolia experienced by his father and citing the drought as only cause of the food scarcity (Kaniewski et al., 2015). According to other written texts found in Egyptian and Hittite archives, Bryce (2005) argues that Hittites should be heavily dependent on the grain imported from Egypt and Syro-Palestinian lands, especially in the last century before their collapse. Even, there was a certain route for grain transport. The grain departed from Egypt or Canaan lands were first transported to Ugarit and then shipped to the port in Ura which is a place located in Cilician coasts. In a letter that the Hittite court sent to Ugaritic kings demands a ship and crew for urgent transportation of nearly 450 tonnes of grain from Mukish to Ura around ∼1215–1194/1175 BC. The letter underlines the importance of the cargo by describing it as a life or death situation. (Bryce, 2005; Kaniewski et al., 2015). Even, the well-known expansion policy of Hittite Kingdom towards Syria might be connected with the will for controlling the grain produced in Syria. According to Halayqa (2011), the famine probably occurred during the last years of Suppiluliuma I dynasty and it led Hitttites to expand their territory to Northern Syria including Mukish and Ugarit to control their grain and transfer it to Anatolia.

Avşar et al. (2019) used an ITRAX micro-XRF scanner to scan the sediment cores from the area of the Tell Atchana and Tell Tayinat. According to the findings, there was an abnormality in the Ca/Ti levels between roughly 1200-900 BC. This anomaly highlighted how dry conditions prevailed throughout that time, and Avşar et al. (2019) contend that this aridification may have contributed to the demise of the Hittites.

As can be seen from the examples above there are several parameters that can be used when interpreting an event as a collapse including architectural destructions, faunal/floral records, written texts, and the changes in regional settlement patterns. However, all projected theories for the climatic causes that drive societies to collapse usually revolve around a cycle that starts with drought and water shortage in rainfed lands, resulted agricultural insufficiency, destruction, and abandonments, then societal movements to find new habitats, and finally civilization collapse. The decline in precipitation, drought, and cold weather in the adjacent regions of Tell-Atchana and Toprakhisar Höyük coincided with both 4.2 ka and 3.2 ka RCCs. Despite the fact that there are several examples of climate change as a cause of societal collapse, monocausal theories are now "out of date," and dynamic human reactions to problems are better acknowledged than ever before. As a result, this study is critical in understanding the various societal reactions, which range from collapse to resilience or both.

Even though in this part of the Chapter 2, only studies that were using the climate change for explaining the social, economic, political and settlement changes were included, it should not be forgotten that climate change might just one of the factors that drive the societies to collapse. In other words, climate change might play a part in the huge changes as exampled above, but it does not have to be the sole reason behind the changes rather it might be a contributing factor which was in progress correlatively with the other destructive changes. Thus, the difference between the causational and correlate effect of climate change will always be in the minds when evaluating the results of this thesis.

Regional investigations are important for climate change research in archaeology, as Renfrew (1990) rightwisely pointed out, because these types of regional studies yield more precise results. He goes on to say that cultures did not experience global climates, but rather local microclimates. As a result, in accordance with Renfrew’s suggestion, this thesis provides that sort of regional data for the climate-society interaction in Hatay and its adjacent regions. In the next section the occupational history of Toprakhisar Höyük and Tell Atchana are mentioned to narrow down the geographical area and to focus on the region of interest.

2.4. THE OCCUPATIONAL HISTORY OF TOPRAKHISAR HÖYÜK AND TELL ATCHANA

2.4.1. The Occupational History of Amuq Valley

The archaeological sites under study cannot be thought of without their geographical settings and boundaries. Thus, in this study, it is worth mentioning Amuq plain to emphasize its historical importance as a context that several cultures lived and interacted. The environmental geography of the plain has the following features: It extends in an area of nearly 900 km^2 surrounded by the Amanus Mountains in its west, by uplands in its east and south, and by hills in its southwest. The water is carried to the plain by 3 different sources, namely Orontes, Afrin, and Kara Su rivers (Casana & Wilkinson, 2005).

A field survey on Amuq Plain was first held by Robert J. Braidwood and a team from the University of Chicago in the 1930s. He listed 178 visible mound sites in the region. The description of the sites and the period of the sherds found in sites were also included in his study (Braidwood, 1937). The sites found in this study indicated that the occupation history of Amuq plain ranged from Neolithic to Islamic periods. The density of habitation was increasing between the Chalcolithic and Middle Bronze Age, whereas with the Late Bronze Age, a reduction in settlement numbers was documented in this pioneering survey. It was also indicated that the number of settlements increased again in the Iron Age and reached similar numbers as it was in MBA (Yener et al., 2000).

A second project on Amuq plain and surrounding accessible highlands (The Amuq Valley Regional Project, AVRP) was carried out by a team from the University of Chicago under the direction of K. Aslıhan Yener in 1995-1998. This project aimed to investigate and document the interaction between local communities and the environment by archaeological and environmental surveys. In the survey, 180 archaeological sites were visited. 126 out of 180 were recorded by Braidwood, and the rest were newly found sites (Figure *6*) (Yener et al., 2000). In the 2010 season, another survey was carried out, and the number of identified ancient sites increased to 383 (Dodd et al., 2012).

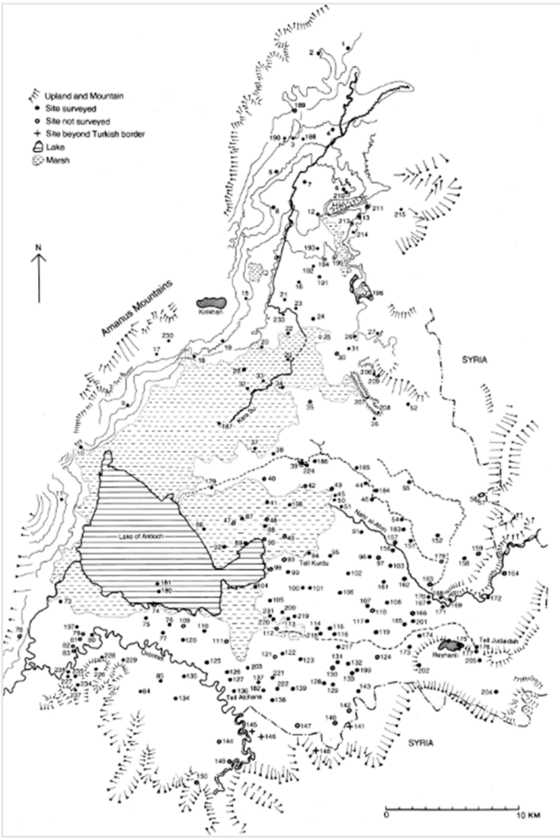

Figure 6. Archaeological sites in Amuq plain. Adopted from (Yener et al., 2000, p.172)

In the latter survey mentioned above, the team succeed to create a relative chronology for Amuq plain sites according to pottery evidence. The Table *1* constitutes this chronology, their corresponding period (Akar & Kara, 2018b; Yener et al., 2000).

Table 1. Table shows the Amuq chronology and the corresponding periods (Created by the author by adopting the information from (Akar & Kara, 2018b; Yener et al., 2000).)

Amuq Phase	Period
Amuq A-C	Before 5500 BC
Amuq D	5500-5000 BC
Amuq E	5000/4900-4400/4300 BC
Amuq F	cal. 4510-3980 BC
Amuq G	3250-2750 BC
Amuq H/I	2700-2500 BC
Amuq L	Middle Bronze Age
Amuq M	Late Bronze Age (ca. 1400-1200 BC)
Amuq N-O	Iron Age
Amuq R	Roman Period
Amuq U-V	Medieval/Islamic Period

This region should have been important throughout history as it may be considered a bridge between four different cultural zones, namely Anatolian, eastern Mediterranean, Levantine-Palestine, and northern Syro-Mesopotamian (Yener et al., 2000). Being a conjoint point for several cultures might have influenced the development of different types of responses in catastrophic situations such as famine caused by drought. Different types of flexible adaptations could have been applied by different cultures against the same event, and these adaptations can be traced in the archaeological record. Another important characteristic of the Amuq plain is the availability of several water resources (Orontes, Afrin, and Kara Su rivers). These sources might be the cause of the popularity and continuous occupation of the plain. Especially, the Orontes River might have mediated the responses to climate change as being the biggest river. Thus, special kinds of local adaptations might have been formed by the inhabitants of the plain.

The kinds of responses to 4.2 ka and 3.2 ka BP climatic events, thus, are investigated in the two sites from such an important geographical region, respectively Toprakhisar Höyük and Tell-Atchana. Toprakhisar is located in a mountainous area in the southwestern part of the Amuq plain whereas Tell-Atchana is located in the Amuq plain. Figure *7* shows their locations.

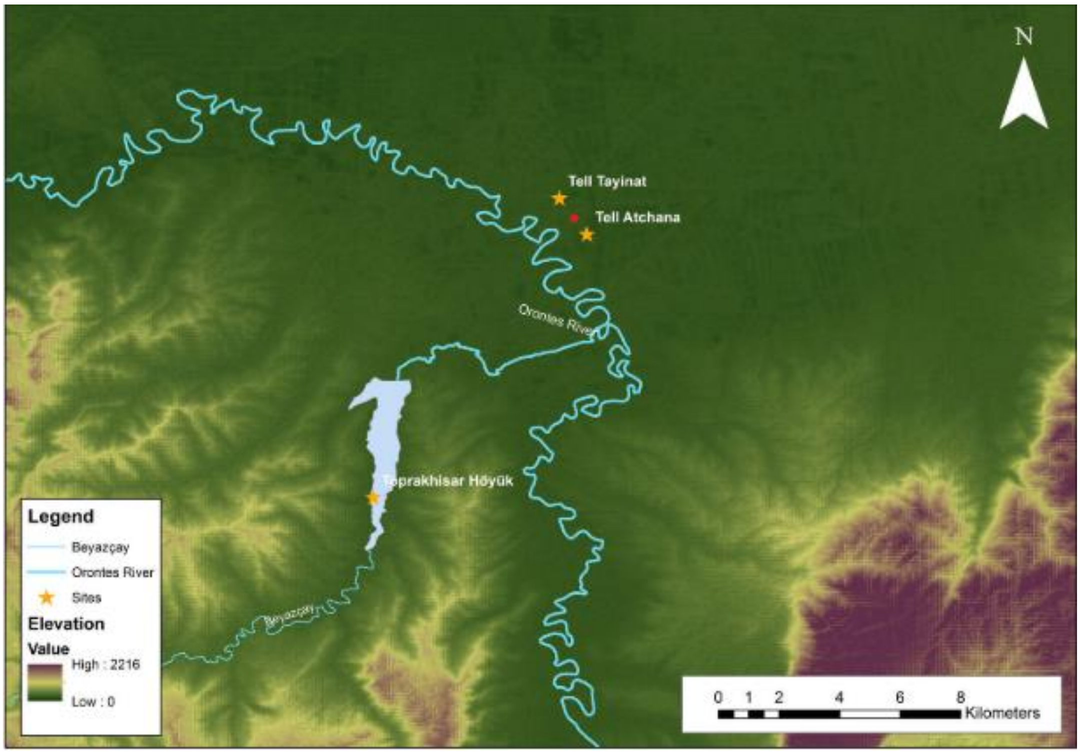

Figure 7. Geographical locations of Tell-Atchana and Toprakhisar Höyük. (Courtesy: Murat Akar)

2.4.2. The History of Toprakhisar Höyük

Toprakhisar Höyük is located in the Altınözü district of Hatay, and it extends in 2-ha area (Figure *8*). The exact extension of the site is not known because of the disturbance caused by the Yarseli dam that surrounds it and modern Toprakhisar village settlement.

The surveys carried on the site pointed a settlement history beginning from the Chalcolithic period until the Iron Age (Akar & Kara, 2018a). More precisely, the earliest pottery sherds that were encountered in the intense survey belong to Amuq D period (5500-5000 BC) (Akar & Kara, 2018b). The most abundant pottery sherds recovered in this survey, however, belong to Amuq E phase (5000/4900-4400/4300 BC). The Chaff Faced Wares that were dated to Late Chalcolithic period (Amuq F- the beginnings of 4th century BC) were also among the pottery found in the site. The occupation probably continued in the Amuq G phase, as well. Amuq H-I phase pottery indicates that there might be an archaeological stratum dated to 2700-2500 BC. Amuq J wares shows that the occupation continued without interruption in the Early Bronze Age. However, even though, pottery that can be dated to Middle Bronze Age occupation was not found in the survey, its existence was revealed later on in rescue excavations started by Hatay Archaeology Museum (Akar & Kara, 2018a). On the top of the site, few amounts of Amuq N and Amuq O ceramics were encountered which indicate the continuing occupation of the Toprakhisar in Iron I and Iron II periods.

Toprakhisar Höyük was identified as one of the rural periphery settlements under the control of the urban site Alalakh in the 2nd millennium BC which is nearly 15 km further from Toprakhisar (Akar & Kara, 2018a, 2018b). Two tablets coming from the Alalakh's Level VII Palace revealed that Yarim Lim (I) took over Alalakh and 17 other places in its surroundings with the treaty that he made with his brother. Toprakhisar was probably one of these 17 places that was acceded to control of Yarim-Lim. Akar & Kara (2018b) suggested that Toprakhisar can be one of the places specialized in olive oil production mentioned in Alalakh texts. The MBA administrative building (Building 2) found in the excavations in the site provides the archaeological evidence for professionalized production of olive under the administration of capital city. Large areas used for storage and cooking also might be the indicative of olive processing activities. The Building 2 has the sign of fire destruction and its usage ended with this fire.

Figure 8. Aerial view of Toprakhisar Höyük, 2015. Photo: Murat Akar

2.4.3. The History of Tell Atchana

Atchana was one of the major Middle Bronze Age sites in the Amuq plain (Figure *9*), and its occupation continued in LBA (Yener et al., 2000). These are the only periods that Tell Atchana was inhabited. There was a shifting occupation between Tell Atchana and its neighboring mound Tell Tayinat. In the Early Bronze Age, Tell Tayinat was settled. The MBA and LBA community moved to Tell Atchana. At the end of the LBA, the site was abandoned completely, and occupation shifted to Tell Tayinat again. It is argued that the changing riverbed of Orontes caused this oscillatory occupation between the two sites (Casana & Wilkinson, 2005; Manning et al., 2020).

Atchana was the most important site in the Amuq plain during the MBA with its 22-ha area and became the capital city of Mukish Kingdom. The site was called Alalakh in the 2nd millennium BC and served as a vassal state for Yamhad Kingdom which was located in today's Aleppo in Syria (Yener et al., 2000). Level VII Palace constructed by King Niqmepa around ca. 1650-1600 BC gives the archaeological evidence of the administrative character of Alalakh in MBA. As being a junction point between Anatolia, Levant, Mesopotamia, and Mediterranean Sea, the city could be able to benefit of trade routes and continued to flourish in that period. It should have dynamic relations not only with the region in close proximity but also with distant regions evidenced by the exotic materials found in excavations (Yener, 2013).

Figure 9. Aerial view of Tell Atchana. Photo: Murat Akar, Tell Atchana, Alalakh Excavations.

The end of the MBA in Alalakh was marked by the destruction of Level VII Palace by fire. In the subsequent period, LBA I, the Alalakh hold its administrative power for a short period and Level IV Palace was constructed around 1450 BC by King Idrimi. Also, during this time period, the vassalage of Alalakh passed to Kingdom of Mitanni (Yener, 2013). Alalakh became one of the targets for Hittites in their Syrian expansion policy in LBA. The Hittites first attacked Alalakh in the 17th century under the command of Hattusili I and gained a pallid success over Alalakh troops (Bryce, 2005). The city recovered quickly after this attack and got back its strength thanks to help coming from Mitannian king Paratarna in the first half of the 15th century BC. However, in the 14th century, another military campaign of Hittites targeted the city again. In this assault, the Hittites took over Alalakh, and their dominion began (Stirn, 2013; Yener & Akar, 2013). The domination of the Hittites over the Amuq Plain lasted nearly 130 years from the last third of 14th century BC to the end of the 13th century BC, and Alalakh kept its administrative character throughout this domination (De Martino & Devecchi, 2020). However, the Hittite domination over Alalakh is only visible in archaeological records with massive fortresses made by mudbricks but it is not evident in written texts (Yener, 2013). In the last years of the Hittites, the Mukish Kingdom (Cohen, 2017) and probably Alalakh, as a consequence, played a role in the shipment of the grain to Hittite mainland in central Anatolia. Interestingly, according to the texts coming from Ugarit archives, the welfare of Amuq plain was not good at the same time period. In the last quarter of 13th century BC and the beginning of 12th century BC, Alalakh and Mukish needed outsider help in means of labor force to revive its agriculture (De Martino & Devecchi, 2020).

Even though the earlier studies do not give the evidence of Iron Age occupation in Atchana, the latest trench opened in Area 1, 42.10, bear the traces of continuation of occupation in Atchana until the end of the 9th century BC. The pottery evidence from this trench also revealed that the temple area in Atchana was still in use as the Iron Age began, but overall occupational area of the site presumably diminished (Montesanto & Pucci, 2019). De Martino and Devecchi (2020) also suggests that the in the final stages of the LBA, the size of Atchana was reduced strongly and became ruralized. According to them, the reason behind the ruralization might be 3.2 ka BP climate event.

Toprakhisar witnessed a continuation of the occupation throughout history without abandonment record at least to the available knowledge. However, Toprakhisar community should witness the 4.2ka BP event. While further excavations in the site will give better sense of archaeological traces of the possible effects or lack of effects of the change during this time period, the archaeobotanical study carried out in this thesis will give the preliminary results of the agricultural activities in the Toprakhisar during MBA. Thus, the result of this thesis highlights the social responses given by the Toprakhisar society and the responses that might not be seen yet in the archaeological record in hand. On the contrary to Toprakhisar, demography and settlement size decreased in Atchana at the end of the 10^{th} century. Considering the climate event that lasted nearly 300 years in 1200 BC, the ruralisation of Atchana might be related with this change as suggested by De Martino and Devecchi (2020). Even if the climate might not be the sole cause behind the ruralisation of the ancient Alalakh, it might play a role as a contributing factor. Additionally, the reduction of agricultural activities at Alalakh mentioned in texts would also only be visible in the archaeobotanical samples. To bring additional light on the change in agricultural activities, and to compare and relate the societal changes taken place simultaneously with the agricultural changes, this thesis focuses on 4.2 ka BP event at Toprakhisar Höyük and 3.2 ka BP event at Tell-Atchana. The archaeobotanical data coming from both sites covers nearly 1000 years, and with this data, besides individual sites, the agriculture of Amuq region and climate change will also be investigated.

Before presenting the results of this thesis, it is also beneficial to include the published archaeobotanical data of relevant sites in Anatolia and Syria in this thesis to grasp a general sense of agriculture in related periods. Anatolia and Syria are chosen because Atchana and Toprakhisar can be regarded as representing a transitional area between those two regions. The next section will cover the archaeobotanical reports coming from MBA/ LBA Anatolian/Syrian sites.

2.5. ARCHAEOBOTANY OF MIDDLE AND LATE BRONZE AGES IN ANATOLIAN AND SYRIAN SITES

The importance of free-threshing wheat increased during Bronze Age and these species overshadowed the importance of barley and hulled wheat species (Zohary & Hopf, 2000). Given this information, it is reasonable to predict that the vast majority of the archaeological sites mentioned in the next sections will have a larger proportion of naked wheat than hulled wheat and barley in their archaeobotanical assemblages. The opposite trend in the data would suggest that there might be cultural, environmental, or socio-economic reasons to continue growing in large quantities barley and hulled wheat rather than free-threshing wheat. Thus, this section is generated to bring a perspective to MBA and LBA archaeobotanical record in Anatolia and Syria, to see the changes in agriculture in these periods if there was any, and to try to understand the possible reasons behind these changes.

Especially, the grains and chaff of *Hordeum vulgare* (barley), *Triticum monococcum/ dicoccum* (hulled wheat), *Triticum aestivum/durum* (naked/free-threshing wheat), and *Triticum* sp. (unidentified wheat) are in focus during the course of this section as this thesis investigates the ratio of barley over wheat and seeks to trace any changes in crop preference due to drought stress. In addition to main cereal products, the character of weedy taxa plants is also considered as a possible sign of environmental change caused by climate change such as the replacement of dry-land species with wetland species.

2.5.1. Archaeobotanical Record of MBA and LBA Anatolia

2.5.1.1. Kültepe – Kanesh

Kültepe is an ancient city that is located in the central Anatolia. It is known as ancient Kanesh. The site has nearly 500m diameter, and it had a continuous occupation from the beginning of the Bronze Age until the Roman Period. The site has two rivers in its close proximity, one of them is Kızılırmak River and the other one is smaller Sarımsaklı River. The geological surveys showed that the riverbed of the latter one was directly towards to the below of the mound in antiquity. The occupants of the site might be well benefitted from this source in the past (Larsen, 2015).

In the archaeobotanical research carried out in Kültepe by Fairbairn (2014), the archaeobotanical samples coming from lower and upper towns were analyzed. The lower town samples belonged to only the MBA (ca. 1920–1836 BC), period, whereas upper town samples came from both EBA III (the end of the 3rd millennium BC) and MBA periods. The study was carried out to understand the differences between the consumption patterns, in general, between upper and lower cities during EBA and MBA. However, it is included here as it also might present insight into the agricultural decision making of Kültepe society during 4.2 ka RCC since its data coming both from the end of the EBA and beginning from MBA. Therefore, the data presented in the study would be re-evaluated to see potential changes from late EBA to early MBA and also would give an understanding about the agricultural changes during and after the 4.2 ka RCC. 4 samples from EBA upper town, 5 samples from MBA upper town, and 7 samples coming from MBA lower town were analyzed in the article. Large fruits and nuts, cereal grains, cereal chaff and straw, other types of cultivars including legumes and flax, and weed seeds were among the findings of study.

Within the scope of this thesis, it is better to focus on findings of cereal grains and chaffs, in the first place. In the EBA III upper town, hulled wheat species (*T. monococcum* and *T. dicoccum*) had the highest number among the cereal plant grains. These were followed by barley (*H. vulgare*). The number of grains that were identified as free-threshing wheat (*T. aestivum/durum*) was smaller than both hulled wheat and barley. In the samples coming from MBA upper town, the total number of cereals were much lower than EBA upper town. The hulled wheat and barley were represented with few grains. Free-threshing wheat had the higher number comparing to others. Some of wheat grains were not able to identify in species level and presented as Triticum sp. In the MBA lower town samples, hulled wheat species had the highest number, whereas free-threshing wheat had the lowest number among cereal species. The number of barley grains was smaller than the hulled wheat, but it was two times higher than the number of free-threshing wheat. EBA III upper town samples produced great amount of hulled wheat glume bases/spikelet forks. The second most abundant chaff type was bread wheat (*T. aestivum*) rachis internodes, but their number was relatively much smaller than the previous one. The least abundant chaff was barley rachis internode, and their number was nearly the one third of the bread wheat rachis internode. In MBA upper town samples, only a few chaffs were barley rachis internode. The most abundant chaff was hulled wheat glume bases/spikelet forks, and it was followed by bread wheat rachis internodes. MBA lower town had more variety in its chaff remains. The rarest chaff was barley rachis internode. Free-threshing wheat (*T. aestivum* or *T. durum*) rachis internodes numbers was slightly higher than the rachis internodes. They were followed by hulled wheat glume bases/spikelet forks. The most abundant type of chaffs were bread wheat rachis internodes, and their number is nearly four times much than the hulled wheat glume bases/spikelet forks.

The ratio of glume wheat to free-threshing wheat in means of grain and chaff were also calculated in the article. According to the results of this ratio calculation, there is an increase in relative abundance of the free-threshing wheat grain and chaff in the transition from EBA III to MBA in the assemblages coming from the upper town. The study suggests that even though the sample size is small, this trend of increasing free-threshing wheat might point to a period change in agricultural consumption patterns and preference in favor of naked wheat. Another difference observed between the assemblages is the increasing variety of plants parts belonging to different plant species in MBA lower city. For instance, naked wheat rachis internode is only available in these samples. According to the report, this disparity may represent differential access of MBA lower town merchant households to agricultural products, given that they were merchant families that purchased things accessible in the market rather than producing what they eat in a standardized agricultural practice.

The wild seeds found in the site, on the other hand, probably are weeds that came as a contaminant of the crops. In this particular case, the diversity of the weeds indicated the diversity of the agricultural lands in means of wetness (Fairbairn, 2014). The contaminant weeds come from wide ranges of agricultural lands including drylands and wetlands. *Adonis* sp. (Pheasant's eye), *Heliotropium* sp. (Heliotrope), *Cephalaria* sp., *Taeniatherum* caput-medusae (Medusa head grass) and several grasses found in the Kültepe archaeobotanical samples were indicators for dryland agriculture. However, Cyperaceae family plants (sedges), *Rumex* sp. (dock), and *Polygonum* sp. (knotweed) were among the wetland species. These plants even may point to the presence of irrigated fields. it is already known from the texts in Kültepe archives (Fairbairn, 2014) that the irrigated lands had high value. Fairbairn further argued that presence of these species in both EBA III and MBA settlements suggests that the irrigation technology might be available in both phases.

As can be seen from the archaeobotanical data presented above, the Kültepe society did not experience significant changes in its agriculture, with the exception of minor variations in crops in MBA lower town which was most likely due to the availability of market products rather than climate (Fairbairn, 2014). Furthermore, the existence of wetland species and the usage of irrigational technology imply that there were abundant water supplies accessible, obviating the possibility of severe climate change affecting irrigation. Considering the fact that Kültepe started to host merchant families of Assyria at the end of 3rd millennium BC and continued to flourish in the following three centuries, even if there was a climate change, the effect of it should not be so severe as the city continued its development.

2.5.1.3. Büklükale

Büklükale is 30 ha mound that is located in Kırıkkale province of central Turkey. The site has Kızılırmak River in its close proximity. It inhabited during MBA and LBA periods. The archaeobotanical study carried out on samples coming from one shaft-like room elucidated the ceremonial plant consumption at MBA Büklükale (Fairbairn et al., 2019). The samples belong to occupational levels that date ca. 1800-1650 BC. This research carried out in Büklükale is important as it gives a brief glimpse about the agricultural variability in central Anatolia just after the so-called 4.2 ka BP event. In the 171 L (4 samples) of soils examined, hulled wheat (*T. monococcum* & *dicoccum*), free-threshing wheat (*T. aestivum/durum*), barley, several types of legumes, variety of fruit seeds and nutshells, wild grasses, wild legumes, and other weedy taxa were present.

The number of grains were low in the samples. Still, the most abundant seeds were belonging to free-threshing wheat. That was followed by the barley grains and their number was half of the free-threshing wheat. The hulled wheat was represented in the lowest abundance with only few grains. Some of the grains were identified as Triticum sp., and their number was equal to number of barleys. Among the chaffs, the most abundant parts were belonging to free-threshing wheat again. There were free-threshing wheat rachis segments. A slightly lower amount of emmer/einkorn wheat spikelet fork and glume base was also occurred in the samples. The least amount of chaff was belonging to barley rachis segments. Despite the scarcity of the grains and chaffs in the samples, the relative abundance of grain and chaff of wheat species is higher in the samples, indicating that there was no preference towards barley. But it should not be forgotten that the samples only represent the one room, and the preferences of one household or findings of the one room cannot be generalized to the whole society.

Several types of wild plants were present in the assemblages including these that grow in the agricultural fields (i.e., *Chenopodium* sp. (goosefoot), wild legumes, and species from Brassicaceae (cabbage) and Asteraceae (daisy) families). Wetland species such as *Carex* sp. (sedges), *Potamogeton* sp. (pondweed) were also found in the assemblages. The presence of wetland species also indicates the availability of water in the surrounding region.

2.5.1.4. Kaman-Kalehöyük

Kaman-Kalehöyük is a settlement located in Kırşehir province of modern Turkey. The archaeological evidence suggests that the site was occupied during Early Bronze Age, Assyrian Colony Period, Old Hittite Period, and Hittite Empire Period. It is important to note that the site has two small streams flowing nearly 30 meters near to its eastern and western slopes. The streams joins to a spring which is 150 m away from northeastern side of the mound (Omura, 2011). The archaeobotanical work carried out during the 2003, 2005, 2006 and 2007 excavation seasons produced insight about the agricultural activities in different periods.

In 2003 season, the samples coming from EBA, Assyrian Colony Period, Old Hittite Period and Iron Age were analyzed. By this way, the agricultural changes or from EBA to MBA (the change that might be caused by 4.2 ka event) and the change from LBA to IA (the change that might be caused by 3.2 ka event) are examined. One sample from the EBA period was examined in 2003 season. The volume of the sample was 10 L. Unfortunately, the exact dating of the sample was not included in the report, but it was coming from a destruction layer of a house so as can be related to the plant economy and agricultural choices of the period. It produced mainly free-threshing wheat (*Triticum aestivum/durum*), barley (*Hordeum vulgare*), grape (*Vitis vinifera*) and several types of wild seeds. However, any type of cereal chaff was not found. The naked wheat grains were more abundantly found in the sample comparing to barley grains. The wild seed assemblages were dominated by dryland plants and agricultural weeds such as *Buglossoides* sp., but wetland species was also existed (i.e. *Eleocharis* sp. (spikesedges), and *Scirpus lacustris/tabernaemontani* (soft-stem bulrush)) (Fairbairn, 2004). The presence of wetland species is not surprising as the steams flowing around the mound would create the ideal conditions for the growth of wetland species. The number of samples identified in this season and belonging to Assyrian Colony Period (MBA) was three (Fairbairn, 2004). The samples were hand-picked from the layers of burnt buildings. Hulled wheat (*T. monococcum* and *T. dicoccum*), free-threshing wheat (*T. aestivum/durum*), barley, charred awns and lemma/palea of cereals, and bitter vetch (*Vicia ervilia*) were present in the samples. The most abundant type of grain was belonging to einkorn wheat. Hulled wheat species (*T. monococcum/dicoccum*), in general, were more abundant than the naked wheat and barley. Naked wheat was the second abundant type of grains, and barley was the type least abundantly found. The charred awns and lemma/palea were not identified to species level but the lemma/palea were more abundant than the awns in the samples. Wild plants were also presents but both their number and variety were less comparing to the EBA sample. Only three types of wild seeds (*Cephalaria* sp., *Galium tricornutum* type (rough corn bedstraw), and Umbelliferae (parsley) family) were found in the samples but they were so scarce to speculate about.

In the 2003 excavation season of the Kaman-Kalehöyük, 5 samples belonging to Hittite Old Kingdom (LBA) period were assessed. The total soil volume floated was 43 L and they were coming from partially burnt buildings. The assemblages were dominated by the free-threshing wheat and barley grains; small amounts of flax, bitter vetch, and grape were also present. Siliceous awns of indeterminate cereals were found but their abundance was low. Free-threshing wheat grains were more abundant than the barley grains. Some of the seeds were not identified to species level and were left as *Triticum* sp. Several weed species were found in the samples as well, including both wetland and dryland species (Fairbairn, 2004). In the same season, 5 other samples from Iron Age totaling 30 L of soil were processed and identified. 4 of these samples were coming from hearth contexts. Barley, free-threshing wheat (both grain and chaff), einkorn wheat, flax, grape, several weed species were the findings of the study carried out. As in the case for previous period, the most abundant seeds were belonging to barley and free-threshing wheat with slightly higher abundance of the former one. Einkorn wheat was only presented with one seed. Among the chaffs, the free-threshing wheat (*T. aestivum* or *durum*) glume tips and bread wheat (*T. aestivum*) rachis segments were found. Weed species included wetland (*Carex* sp., *Isolepis* sp.), dryland species (*Thymelea* sp., *Ziziphora* sp., *Potentilla* sp.) and agricultural/weedy species (*Portulaca oleracea*, *Chenopodium* sp., *Verbena* sp., *Polygonum* sp. (knotweed), *Alopecurus* sp. and unidentified grasses (Fairbairn, 2004).

In the 2005 excavation season report (Fairbairn, 2006), 4 samples from Old Hittite Period and 8 samples from Iron Age were assessed. The total soil volume for the former period was 44.5 L and for the latter period was 163.5 L. The samples mainly came from hearth contexts for both periods. In Old Hittite Period samples, barley, free-threshing wheat, einkorn wheat, hulled wheat spikelet forks, bitter vetch, grape, and several types of weeds were among the findings. Similar to the finds of the previous year's analysis results of the period, the most abundant cereal grains were belonging to free-threshing wheat. Barley was the second most abundant type of cereal grain, and the least abundant species was einkorn wheat. The spikelet forks of the hulled wheat identified to species level when it is possible. Thus, spikelet forks were presented under two different categories: *T. monococcum* and *T. monococcum/dicoccum.* Both types were not found abundantly but, still, they were present in the assemblages. The wild seeds assemblages mostly contained *Arnebia/Lithospermum* (groomwell) species and Cruciferae (cabbage) family plants. The Iron Age assemblages of the Kaman-Kalehöyük mainly consisted of barley, free-threshing wheat, hulled wheat spikelet fork, bitter vetch, flax, grape, fig, pomegranate, and several types of weeds. Similar to the previous period, the most abundant cereal grains that were found in the samples belonged to barley and free-threshing wheat, however, their relative abundance is not clear. Small number of seeds from a sample was identified to *Triticum* genus level. The spikelet forks were rarely found in only one sample, and they belonged to *T. monococcum/dicoccum*. The weedy taxa found in Iron Age samples were more variable than the Old Hittite Period. Mostly found weed species were *Arnebia/Lithospermum* (groomwell), Cruciferae (cabbage) family plants as in the previous case, small types Gramineae (grass), and *Vaccaria pyramidata* (cowherb).

The change in numbers of hulled wheat spikelet fork from the Old Hittite Period to Iron Age is interesting considering the information that most of the samples coming from the hearths. The contexts of the samples are important here because different parts of the same architectural structure might be used for different purposes. For instance, one part of the room might belong to food preparation activities (e.g., grinding of the wheat) whereas the other part might be used for cooking. Thus, the content of the samples varies. The samples from the food preparation area might have higher amount of chaff comparing to cooking area. Since most of the soil samples in Kaman-Kalehöyük were taken from the house in this season for both periods, the decrease in hulled wheat spikelet fork might be an indicator of change in agricultural preference rather than contextual discrepancy. When it comes to the weeds, the mostly found species are same. One of these mostly found weeds are *Arnebia/Lithospermum*. The similarity of the weed assemblages in both periods might indicate that the environment of the Kaman-Kalehöyük did not change very much in the transition from the LBA to Iron Age, thus, the weed ecology remained same.

2.5.1.11. Boğazköy - Hattusha

Hattusa, the capital city of the Hittites, today located in Çorum province of Turkey, central Anatolia. Understanding the agricultural decision making and preferences over the agricultural products in Hattusha is important for the scope of this thesis as Tell Atchana came under the Hittite dominion in LBA. Since the Hittite Empire was highly dependent on the grain coming from the surrounding regions, making an interpretation over their agriculture is a difficult task to do. However, clues about the agricultural preferences and possible forces (e.g., climate change, environmental degradation) over the agriculture can still be drawn from the archaeobotanical assemblages coming from Hattusha and Atchana by comparing them. The Hattusha is situated on a high plateau, with Büyükkaya Deresi to the east and Yazır Deresi to the west. Hattusha has the benefit of being positioned on alternating limestone outcrops and clay imbedded inside soil, in addition to being flanked by two streams. This sort of geology ensures the flow of underground water and the feed of multiple water wells across the city. Hattusha, unlike the lower plateau to its north, had adequate supply of water all year; nevertheless, the areas beyond its north had uneven surface flow and deep alluvial material, blocking access to the subterranean water table (Schachner, 2017).

As an importer city, Hattusha had large storage complexes (storage chambers) to store huge numbers of grains. 36 samples from 5 such storage chambers were studied (Diffey et al., 2017). Normally, the grain covered in these chambers weighed 4 tonnes, however, only 100 kg of them were chosen among the well-preserved grains and were exported for further analysis by the team. The results of the archaeobotanical studies showed that the chambers were mainly used to store hulled barley (*Hordeum vulgare*). Hulled wheats were also present in the chambers, but they had much lower abundance than the barley except one chamber which was completely used for hulled wheat storage. Few amounts of grass pea, lentil, bitter vetch, and Celtic bean were found as a crop contaminant in the chambers. The wild seed assemblages were very varied in the samples by including over 70 different taxa. Most of the plants of wild taxa were grown in the calcareous, loamy soils. Hattusha's environment is similar to these conditions. Additionally, all the wild taxa found local to Anatolia suggesting that the crop was locally produced.

The archaeobotanical analysis results of 45 samples from the 5 storage chambers that found intact in 1999 was published recently (Diffey et al., 2020). The chambers dated to early 16th century BC, which coincides to the phase between the end of the 4.2 ka climatic event and the start of the 3.2ka climatic event. The samples included cereal grains and chaff, legumes, and weeds. The assemblages were dominated by the hulled barley (*Hordeum vulgare*) grain, emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*) wheat grains and whole spikelets. The hulled barley was the most abundant among all. The study suggests that the high abundance of the barley might be the result of the will to avoid the food shortages in dramatic rainfall fluctuations that central Anatolia prone to. The study suggests that the great quantity of barley may be due to a desire to prevent food shortages caused by the severe rainfall swings that central Anatolia is prone to. Because barley is a drought-resistant crop, crop failures caused by a lack of rainfall were averted by farming barley. Free-threshing wheat (*Triticum aestivum/durum*) grains were also found in the samples, although they were in small quantities and were most likely agricultural contaminants. Weedy taxa were extremely varied in the samples. A total of 100 weed taxa were identified. The most common species were *Bifora radians* (wild bishop), *Ranunculus arvensis* (corn buttercup), and *Vaccaria pyramidata* (cow herb). All three most occurring weeds belongs the disturbed fields indicating that they were collected from the agricultural lands as a crop-contaminants and brought to the chambers with them.

2.5.1.12. Ortaköy-Sapinuwa

Sapinuwa is a Hittite city that is located in Çorum province of north-central Turkey. It is located in the Özderesi Valley and has 5 km distance from Çekerek River. The valley that the city was built is a fertile valley with mild climate and plenty of water sources (Süel, 2002).

The archaeobotanical study carried out in the Sapinuwa was focused on two pits discovered in the site that dated back to nearly 1400 BC. Of these pits, one of them was used as a silo and produced significant archaeobotanical data to speculate about the cereal consumption patterns in the site. The samples taken from the silo was mainly consisted of free-threshing wheat (*Triticum aestivum/durum*) with nearly 400000 grains. There were also barley grains (*Hordeum vulgare*), but their number was very low (~1000) comparing to free-threshing wheat. The only wild plant found in the silo was seeds of *Galium* sp., and the number of these seeds were also very low (~60) (Oybak Dönmez, 2014). Since the plants of this genus grows in arable lands, it can be assumed that these seeds were brought to the silo as a crop contaminant. Considering the low number of contaminants -*Galium* sp. (bedstraw) seeds- it can be argued that the cereals brought to the site was relatively cleaner especially when it is compared to silos found in the Hattusha which was mentioned in the previous section. The other pit did not contain any remains of cereal, only few remains of olive (*Olea europaea*) and oak (*Quercus* sp.) seeds were found in this pit (Oybak Dönmez, 2014).

It's noteworthy that although Hattusha and Sapinuwa were both Hittite cities, their cereal consumption habits vastly varied from one another. Barley and hulled wheat predominated in Hattusha silos, whereas free-threshing wheat predominated in Sapinuwa. The samples from the latter contained barley as well, albeit its significance was less obvious than in the samples from Hattusha. Oybak Dönmez (2014) suggests that even barley grains might be mixed to the free-threshing wheat grains during the harvest as a crop contaminant like bedstraw seeds. This difference might the result of dating of the samples. Hattusha silos were dated to early 16th century whereas

Sapinuwa silo was dated to 1400 BC. As a result, the shift in grains in storage may be the result of evolving agricultural storage and consumption practices in the Hittite lands throughout time. However, speculating on the reasons for this development is difficult. It is also possible that the differences are the result of different character of the cities. Hattusha was the capital city and Sapinuwa was a religious center. This difference in the character might cause the difference between the contents of the silos found in these two cities. The hulled wheat and barley might be preferred mainly for the human consumption whereas free-threshing wheat might be kept for the religious offerings. Oybak Dönmez (2014) also points to the possibility of usage of the cereals in the silo as offerings in Sapinuwa. She supports the idea by pointing the cleanness of the stored grains (no chaff remains and low amount of contaminant wild plants) and suggests that the grains should be cleaned with care and placed in the silos cleanly.

2.5.1.14. Çadır Höyük

Çadır Höyük is a Hittite settlement that is located in the Yozgat province in central Turkey. Çadır Höyük is supposed to be the ancient city Zippalanda (for references see; Smith, 2007), which is referenced in Hittite written records. It is located in the Kanak Su Basin, in a flat valley. The site was first populated in the Late Chalcolithic, and the habitation lasted virtually uninterrupted until the Islamic Periods (Gorny et al., 2000).

In the archaeobotanical work carried out in the Çadır Höyük (Smith, 2007), 5 samples coming from Hittite Periods were investigated. The total soil volume of these samples was 146 L, and the contexts of samples included pot content, pit, floor, oven, and hearth. The exact numbers of the material found in the samples were not presented in the study rather the presence/absence information did. Einkorn wheat (*Triticum monococcum*), emmer wheat (*Triticum dicoccum*), free-threshing wheat (*Triticum aestivum/durum*), and hulled barley (*Hordeum vulgare*) grains were among the cereals that were found. Cereal culm nodes, culm bases, spikelet forks, and rachis fragments were also present in the samples. It is difficult to debate about agricultural preferences or changing agricultural products because there is no comparing data from prior or later period samples. Only one thing can be claimed about wheat production during the Hittite period: all sorts of wheats were still produced. Because the location was in the Kanak Su Basin, water supply was unlikely to fluctuate considerably enough to impair wheat output.

Buglossoides arvense (field gromwell), *Echium* sp. (viper's bugloss), *Carex* sp. (sedge), *Erodium* sp. (cranesbill), *Galium* sp. (bedstraw), *Bromus* sp. (brome grass), *Phalaris* sp. (canary grass), *Stipa* sp. (feather grass) were among the frequently found species of the wild seed assemblages. Most of these species grow in arable lands. Thus, they are more likely to brought to the site among the other crops by being harvested with them. In addition to this, they might be brought to the area with dung that used as a fuel, then they were burnt and remained in the contexts. However, the way of their transportation is not important rather their habitat is. The weeds that grow among the crops does not tell much in this case. But the presence of *Carex* sp. in the assemblage points to the presence of wet soil in the region that enables the sedges to grow. Since the mound is located in the Kanak Su Basin it is not surprising but still it can be said that the stream was strong enough to create wetland environment in its surroundings.

2.5.1.2. Sos Höyük

Sos Höyük is a site located in the Pasinler Valley in northeastern Turkey which was settled from Late Chalcolithic to Medieval period. The site has Aras River in its south. It was a small rural settlement from the Chalcolithic until the Iron Age.

The archaeobotanical work carried out by Longford et al. (2009) in Sos Höyük shed light on the plant usage in the site during MBA period. The MBA sample was taken from a secondary deposit in a rubbish pit, and it was dated to ca. 2580-2340 BC. The crop seeds found in the sample only include barley (*Hordeum vulgare*) and free-threshing wheat (*Triticum aestivum/durum*). The most abundant seeds are of barley.

Free-threshing wheat was represented with much less seeds than barley. On the contrary to the argument of Zohary and Hopf (2000) that the value of free-threshing wheat increased during the Bronze Age, the Sos Höyük MBA archaeobotanical data points to the quite opposite situation. The barley seems remained as a dominant staple crop for Sos Höyük population. The hulled wheat types (*Triticum monococcum/dicoccum*) were not even present in the sample.

The wild plant species included *Galium* sp. (bedstraw), *Asperula* sp. (woodruff), *Polygonum* sp. (knotweed), *Lolium* sp. (ryegrass), Boraginaceae (borage) family, Caryophyllaceae (carnation) family, Convolvulaceae (morning glory) family, Fabaceae (pea) family and Poaceae (grass) family. All the wild seeds were in low amounts to suggest any theory about the water availability.

The grains were not the only botanical samples analyzed in that study; charcoal samples were also assessed to reconstruct the environmental history of Pasinler Valley. According to the charcoal analysis, the area during Bronze Age was probably an oak-dominated woodland. In the MBA period, this open oak woodland was exploited heavily, and there was no charcoal belonging to this type of wood in Iron Age samples indicating that this woodland disappeared. The article suggests that besides human impact by overexploitation, the depletion of oak woodland might be caused by increasing climatic aridity during the MBA.

2.5.1.5. Salat Tepe

Salat Tepe is a mound with 115 x 100 m extensions in the Diyarbakır province of Southeastern Turkey. The site occupied from 5th millennium BC until Hellenistic period (Ökse et al., 2001). Being located in the north of the Tigris River makes Salat Tepe an important site to understand the agricultural dynamics in Upper Tigris region. The archaeobotanical studies carried out in its MBA floral samples (Ökse et al., 2012) tries to shed light on the MBA farming economy in the site and its surroundings. The

MBA taken from the Salat Tepe were dated to 18th and 17th centuries. In that means, the samples coincide with the end of the 4.2 ka event, thus, they are important to understand the main cereals of the time in the Upper Tigris regions. Additionally, even though the archaeobotanical and archaeological data suggests that Salat Tepe had dry farming practices, the effect of Tigris River might be visible in the contents of archaeobotanical samples.

In total, 158 samples from the MBA contexts of the site were analyzed for the above-cited study. The average initial soil volume for every sample was 40 L. The samples were mainly coming from floors, hearths, and pits. Among 158 samples checked, only 4 of them produced enough plant material to make an assessment. The rest was rather scarce in plant remains or did not contain any plant remains at all. The most abundant seeds belonged to barley in the samples and according to the rachis internodes, they might be two-rowed barley (*Hordeum distichum*). However, because of the high distortion levels of the seeds, it was not possible to make exact identification of barley seeds in species level. Bread wheat (*Triticum aestivum*) was present with grains and rachis internodes. Emmer wheat (*Triticum dicoccum*) and einkorn wheat (*Triticum monococcum*) were also found in the samples, but their number were much lower than the bread wheat. The assemblages had the spikelet forks and glume bases of the former ones as well.

Among the wild plant taxa, the most numerous seeds in the samples were belonging to *Galium* sp. (bedstraw). It was followed by Poaceae (grass) family plants, but their number was nearly one-third of the previous species. Other species were presented in small numbers but both wetland and dryland species were present.

The dominancy of barley over other cereals is an interesting result. It is already evident in geomorphologic and pedologic studies that Euphrates Basin started to witness drier conditions beginning in 2nd millennium BC (Rosen, 1997). The mentioned drought is probably the reflections of the well-known 4.2 ka event in Euphrates Basin. Even though, the MBA samples represented the time period that coincides with the end of the 4.2 ka event, its effects on agricultural decision making seems to continue in Salat Tepe. Consequently, it is possible to say that the preference of barley reflects agricultural precaution taken against the effects of this ongoing drought.

2.5.1.6. Mezraa Höyük

Mezraa Höyük is yet another site in the Euphrates region, this time on the river's eastern bank. The site is now located in Şanlıurfa, Southeastern Turkey, in the Euphrates floodplain. Its dimensions are approximately 180x140 m (Oybak Dönmez, 2006). The site was continuously occupied from the Late Chalcolithic Period to the MBA (Yalçıklı, 2016).

In the archaeobotanical study carried out in Mezraa Höyük (Oybak Dönmez, 2006) 2500 L samples were floated. The number of samples that produced carbonized seeds was 48 but half of them were scarcely had seeds. The samples were belonging to EBA I (3000-2800 BC), EBA III-IV (2600-2000 BC), EBA III-IV/MBA (2600-1500 BC), MBA (2000-1500 BC) and Medieval Periods. The EBA III-IV, EBA III-IV/MBA and MBA samples are included in this section because they represent floral conditions in Mezraa Höyük slightly before, during, and after the 4.2 ka event. There are two samples from EBA III-IV. One of these samples came from a context that was identified as a workplace. There was only one sample from the EBA III-IV/MBA context. The number of MBA samples was also two, with one coming from a vessel discovered in a grave.

In the EBA III-IV samples, barley (*Hordeum vulgare*) and free-threshing wheat (*Triticum aestivum/durum*) were the only cereals found. The number of free-threshing wheats was slightly higher than barley. However, since both types were very low in number, this highness of wheat might not be a good indicator for any interpretation. The EBA III-IV/MBA sample had mainly barley grains with few free-threshing wheat seeds. One of the MBA samples (vessel sample) had only grape probably indicating the importance of grape (*Vitis vinifera*) of the time by being offered as a burial gift.

The other MBA sample contained barley and not identifiable wheat at all. But, again, since the number of barley grains is too low, it is hard to interpret the situation. The lack of wheat might be either the indicator of preference of barley because of the drier conditions brought by 4.2 ka event, or it is just might be the result of low number of samples. The latter explanation seems more likely in this case.

The number and variety of weedy taxa in EBA III-IV samples were low. One of the samples had only one seed of *Fumaria* sp. (fumitory). The other sample was relatively richer by having *Aegilops* sp. (goat grass), *Lolium* sp. (ryegrass), *Avena byzantina* (wild oat), *Chenopodium* sp. (goosefoot), *Filipendula ulmaria* (meadow sweet), *Ajuga* sp. (bugle), and *Potentilla* sp. (cinquefoil). Among these, the most abundant species was *Lolium* sp., and most of the rest were represented with only one seed. First four of these plant species are grown in the cultivated grounds. They were highly likely brought to the mound from the lands that crops were grown. The latest three species, on the other hand, grows in meadows and damp grassy fields. They can be the crop contaminants as well, but their presence in the samples also indicates the availability of the water around the mound. Considering the fact that the site is located near Euphrates River, it is expected to see such types of wetland-grown wild plant species. The only sample that dated to EBA III-IV/MBA period only had one seed of *Adonis* sp. (pheasant's eye). Among the MBA samples, the one that came from grave vessel did not contain any wild plants. When the context is considered, it is expected. The other MBA sample, on the other hand, contained only one seed of *Galium* sp. (bedstraw). *Galium* sp. are another group of plants that grown in cultivated soils. Although the number of wild seeds in all samples are too low to make solid interpretations, the scarcity of wild species in the MBA samples might give clues about the crop influx to the mound in that time. The amount of crop produced, stored, and cooked in the mound might be significantly decreased because of the 4.2 ka climatic change, and the low numbers of wild seeds might be simply the reflection of the low amounts of crop circulation in the site. When this condition is considered in light of the fact that the site was abandoned towards the end of the MBA and was not settled until the Iron Age (for the references see; Oybak Dönmez, 2006), the likelihood of a drop in agricultural output and food shortages as a result of the drought becomes more plausible.

2.5.1.7. Gre Virike

Gre Virike is a settlement that is nearly located to Mezraa Höyük. By measuring 70x60 m, it is a smaller settlement than Mezraa Höyük. It is thought that the mound served as a sanctuary for the surrounding settlements, including Mezraa Höyük. The occupation at the site began in EBA I-II (3000-2600 BC) and lasted until the end of the 3rd millennium BC (Ökse & Bucak, 2003).

For the archaeobotanical analysis, 600 L of soil was floated coming from 196 contexts of Gre Virike (Oybak Dönmez, 2006). There were 30 archaeobotanical samples that produced carbonized seeds, however, 12 of them were ignorable due to the scarcity of the seeds. The samples dated back to EBA I (3000-2800 BC), EBA I/II (3000-2600 BC), EBA II (2800-2600 BC), EBA II/III (2800-2250), EBA III (2600-2250 BC), EBA III/IV (2600-2000 BC), and Medieval Periods. Here, EBA II/III, EBA III and EBA III/IV samples will be included and focused as they represent the time period before and the beginnings of the 4.2ka event. There was only one sample belonging to EBA II/III period and it was coming from an ashy layer. However, it did not produce any cereal grain or chaff. The scarce number of seed found in the sample were belonging to several types of legumes, olive, and few taxa of weeds. One other sample belonged to EBA III period coming from a pit. On the contrary to previous sample, it has cereals. The most abundant cereal type was barley (*Hordeum vulgare*). There were also few free-threshing wheat (*Triticum aestivum/durum*) grains in the sample. EBA III/IV layers were represented with five samples coming from the contexts such as room floor, pit, grave, and ashy layer. The dominant cereal was barley as in the samples similar to the case in the previous samples. Interestingly, no naked wheat grain or chaff was found in the samples. Only wheat type occurred in the samples was emmer wheat, but it was present with few grains. Thus, their occurrence can be considered as a crop contaminant rather than a crop product. The sample coming from the grave had the highest number of barley grains among the EBA III/IV samples. It might be the reflection of the importance of the barley as being a staple crop in the period. Thus, people might choose barley over other type of cereals, legumes, or fruits to put in a grave as a grave offering.

Among the wild seeds, EBA II/III sample had *Aegilops* sp. (goat grass), *Galium* sp. (bedstraw), *Lolium* sp. (ryegrass), and *Avena byzantina*-type (wild oat). Their numbers were very low, and they were probably brought to the site as a crop contaminant. EBA III sample produced a more variable and richer weed assemblage. Besides the mentioned weed species for the previous sample, EBA III sample also had *Adonis* sp. (pheasant's eye), *Astragalus* sp. (milk-vetch), *Filipendula ulmaria* (meadow sweet), *Medicago radiata* (calvary dover), and *Neslia* sp. The most abundant seeds were belonging to *Galium* sp. and *Aegilops* sp., and the rest were only represented with one seed for each species (Oybak Dönmez, 2006). Both of these species grown in the disturbed field with other crops. Thus, they were more likely carried from the agricultural fields to the mound. Even though the number of EBA III/IV was the highest among the periods that is included here, the variety and the number of the weedy taxa in these samples were very low. Only few *Aegilops* sp., *Galium* sp., and *Filipendula ulmaria* were found in the samples (Oybak Dönmez, 2006). as can be implied from its name, *Filipendula ulmaria* grows in swamps, marshes, wet rock ledges and near rivers. Since Gre Virike is very closely located to Euphrates River, its presence in the samples is not surprising. But it is still important to note that its presence with other agricultural contaminants shows that the agricultural fields were not located far away from the river as well. The society of Gre Virike was probably using the advantage of Euphrates River when making agriculture. On the other hand, while they could use the advantage of the river, it is interesting that they still preferred the barley as a staple cereal.

2.5.1.8. Hirbemerdon Tepe

Hirbemerdon Tepe is a 10-hectare site located along the west side of the upper Tigris River Valley, roughly 100 kilometers southeast of Diyarbakır province. The site started to be occupied in the first half of the 4th millennium BC and abandoned during MBA. The was not settled until the end of 2nd millennium BC (Laneri et al., 2008). The MBA layers of the site dates back to late 3rd and first half of the 2nd millennium BC.

The archaeobotanical work at Hirbemerdon Tepe was carried out with 23 samples coming from the MBA samples (Laneri et al., 2008). The samples reflect the products of the conditions introduced by the 4.2 ka event and those that followed it, as evidenced by the dating of the MBA strata in Hirbemerdon Tepe. The amount of soil processed was 149 L. The samples were mostly filled above the floor in areas that were utilized for food preparation and storage, however, they were not rich in remains. The cereals grains found in the samples consisted of barley (*Hordeum vulgare*), emmer wheat (*Triticum dicoccum*), and oat (*Avena sativa*) grain. The most abundant species was barley, and it was followed by emmer wheat. There were other hulled wheats, but their species level identification was not possible. The oat also represented with one grain. There was one seed that identified as “possibly” naked wheat in the assemblages. Among the cereal chaff, the mostly found was belonging to emmer wheat. There were also chaffs that the species attribute could not be done. They were included as *T.* cf. *monococcum, T. dicoccum/monoccum*, and glume wheat indetermined. Overall, the number of plants remains were too low to compare the abundance, but it gives general information about the staple crops of the time. By looking at the data in hand, it can be said that barley and hulled wheat were among the most frequently used cereals in Hirbemerdon Tepe in MBA (Laneri et al., 2008).

The wild taxa assemblages included grasses, *Rumex* sp. (docks), *Galium* sp. (bedstraw), *Trigonella* sp. (fenugreek) and *Trifolium* sp. (clovers). These wild plants are frequently found in the agricultural fields and most likely entered the rooms with crops. They could also be brought to the site in the dung that used as a fuel to fire up the hearths.

2.5.1.9. Kurban Höyük

Kurban Höyük is a highland settlement that was located in the Şanlıurfa province of southeastern Turkey before it submerged under the Atatürk Dam. It was another site that was located near the Euphrates River. The site was settled from the late 4th millennium BC to early 2nd millennium BC (Miller, 1997).

The archaeobotanical research of crop utilization from two separate eras of Kurban Höyük is presented in this section. The mid-3rd millennium BC is one of these periods, while the late 3rd-early 2nd millennium BC is the other. The former provides information on crop use prior to the 4.2 ka event, while the latter sheds insight on agricultural operations at Kurban Höyük during the event. The number of samples analyzed belonging to middle of the 3rd millennium BC was 71, whereas 50 samples belonged to late 3rd-early 2nd millennium BC (Miller, 1997). In both periods, barley was the most frequent cereal. However, the difference between their frequencies was lower in the mid-3rd millennium BC samples. When coming to the late 3rd-early 2nd millennium BC samples, the discrimination between their frequencies increased. When the percentage calculations were made by using total weights of the cereals, in the earlier samples the relative percentages of barley to wheat were 68:32. In the following period, this ratio became 78:22. It is impossible to make a final conclusion about the agricultural change just by looking at the change in barley. However, given the fact that in the mid-3rd millennium BC, Kurban Höyük population reached its maximum population density and in the following periods it became relatively smaller until it was finally abandoned (Wilkinson, 1990), the explanation for the preference for barley in later times might be linked to the changed climatic circumstances brought along by the 4.2 ka climate shift.

2.5.1.10. Kaymakçı

Kaymakçı is located in Western Anatolia and was occupied in both MBA and LBA (cal. 2000-1200 BC). Lake Marmara lies nearby the site. In the preliminary report coming from Kaymakçı, 263 floated samples that belongs to LBA citadel were analyzed (Roosevelt et al., 2018). Barley (*Hordeum vulgare*), free-threshing wheat (*Triticum aestivum/durum*), einkorn wheat (*Triticum monococcum*), emmer wheat (*Triticum dicoccum*), several types of legumes and grape were among the cultivated plants found in the samples. The most abundant cereal was barley, and it was followed by free-threshing wheat. However, the number of the latter was nearly a third of the former. Einkorn and emmer seeds were both less than the free-threshing wheat. Whereas, the number of einkorn wheat was half of the free-threshing wheat, the emmer wheat was presented with only a few seeds. Additionally, some grains of wheat were identified only to genus level and left as *Triticum* sp. Overall, the number of grains found in the samples was quite low considering the high number of samples that were studied. Among wild seeds, only the Cyperaceae (sedge) family was included, the identification of rest of the wild species was not included in the article, they were only given as a total count. In the total 604 seeds, 117 was belong to sedges.

The low numbers of hulled wheat species (einkorn and emmer wheat) are expected considering their decreasing importance in LBA, however, the lowness of the number of free threshing is interesting when comparing with the number of barleys. One can expect to see an increasing preference towards free-threshing wheat over other cereals as it started to be cultivated in wider range starting from EBA (Riehl, 2014). Nonetheless, it is hard to talk about a real preference towards barley since the contexts of the data are not clear. The reason behind the relatively much abundance of the barley might be caused by the places that the samples were taken. For instance, the samples might be taken from the places near the barns where the animals were fed with barley. Thus, the human consumption places should be included in the sample contexts to be more confident to talk about a real preference towards barley.

A more recent article from Kaymakçı, again, analyzes the samples coming from LBA occupations to understand the agricultural practices in the site and to gain a perspective for understudied LBA eastern Mediterranean agriculture (Shin et al., 2021). 328 samples that comprise 2760 L of soil were analyzed to carry out this study coming from 3 different structures namely fortification system, inner citadel and surrounding slopes, and southern terrace of the site. However, it is not clear that if this samples contained the samples of the previous study (Roosevelt et al., 2018). Nevertheless, the result of this study as well is included in here. Barley, free-threshing wheat, einkorn wheat, emmer wheat grains and their chaffs, several types of pulses, fig, and grape were the findings. Barley grains were the most abundant cereal crop like in the case for previous report. The second most abundant cereal was free-threshing wheat. Free-threshing wheat was followed by einkorn wheat in abundance. The least abundant type of plant was emmer wheat with few grains. Some of the grains were identified as indetermined wheat (*Triticum* sp.). The results were correlated with the results of previous report. The article also includes the ratio of barley number to wheat number. When all the samples are included, this ratio is calculated as 2.207, indicating the wider consumption of barley than wheat. Chaff found in the site comprises all the mentioned cereal types. Again, the chaff of barley was the most abundant, followed by emmer wheat, einkorn wheat, and free-threshing wheat.

The total number of wild seeds was calculated as 821. The most abundant wild plant seeds belonged to *Bolboschoenus* sp. (Bulrush, a type of sedge). It's worth noting that the research (Shin et al., 2021) states that all of the samples containing bulrush also include crop seeds, which might be interpreted as that the bulrush originated as a contaminant in the crops on agricultural grounds. Since sedges grow in wetlands, their high abundance might be the indicator of well-watered lands that Kaymakçı people did agriculture. Or maybe that the people at Kaymakçı preferred to have agricultural lands only near water sources. Several types of grass seeds were also present in the assemblages; however, they were not identified to any genus as most of them were small.

Another most ubiquitous crop found in the site, bitter vetch, is also known for its durability in poor and dry soils likewise barley. The preference of barley and bitter vetch which are suitable to dry farming and the high abundance of wetland sedges in the assemblages seems contradictory. This contradiction suggests that the wider consumption of these species was probably because of the cultural choices rather than climate forcing drought. Or another explanation might be that climatic conditions might force farmers of Kaymakçı to cultivate the free-threshing wheat species nearby the Lake Marmara. Thus, the main staple crops were drought tolerant barley and bitter vetch, but they were also able to farm free-threshing wheats that were grown in lands near the water source, thus, there are also wetland wild plants in samples.

2.5.1.15. Troy

Troy is a famous archaeological site of western Anatolia (Çanakkale Province of Turkey) that started to be occupied in the Early Bronze Age. It is located near the Scamander River. The occupation in the site lasted until the Roman Period. The modern mean annual precipitation in the site is around 680 mm (Riehl, 1999). Riehl (1999) focused on the Bronze Age occupations in the Troy and she worked on samples coming from EBA (Troy I-III), MBA (Troy IV/V), LBA (Troy VI/VII). Each archaeobotanical sample were retrieved from 30 L of soil samples in average.

Because some of the samples from Troy did not have enough material to conduct statistical analysis, not all of them were statistically evaluated. As a result, only the statistically evaluated samples are provided here. There were 19 such samples from EBA layers, 27 from MBA levels, and 64 from LBA layers. The quantity of barley remains in EBA samples was relatively low, however this species increased significantly during MBA. Barley was more ubiquitous in MBA samples, in addition to an increase in its quantity. Except for a brief period (Troy VIIa) when emmer and einkorn became more preferred crops, its importance appears to be rose during LBA. Riehl (1999) indicated that the relative rise in emmer and einkorn during the Troy VII period was due to a desire for these grains among the elite. This preference, however, did not continue until the end of LBA, when barley regained prominence. The most ubiquitous crops in mid-EBA samples were hulled wheats. Emmer was a little more plentiful than einkorn. Both species had lower percentages in MBA samples, but they remained to be as major crops until the end of the Bronze Age. In EBA samples, free-threshing wheat grains were few. They were presumably not widely grown during this time. However, in early MBA samples, their number rose, as did the number of rachis remnants. This growth was most likely due to the advent of more extensive wheat growing and local processing. The number of grains increased in LBA samples as well, although when compared to the number of other cereals, the difference was insignificant. It might be stated that free-threshing wheat was never as important as other cereal crops.

Overall, barley, a drought tolerant cereal, seems had a major importance in Troy. Besides barley, another drought tolerant cereal, emmer, was also cultivated throughout the Bronze Age. They were presumably chosen for consumption for cultural/economic reasons rather than climatic factors, as drought susceptible einkorn was farmed almost as much as emmer wheat throughout history. As a matter of fact, Troy is located in well precipitated region, and it might never be affected by the climate changes as much as the other regions that are located in already drought-prone environments.

2.5.1.13. Oymaağaç - Nerik

Oymaağaç Höyük is a 4-ha settlement located in Samsun province of northern Turkey. The earliest occupational phase is Chalcolithic period in the site. The site is located 25 km away from Tavşan Dağları. The distance between the site and Kızılırmak River is 7 km (Ulaş, 2019).

The archaeobotanical studies carried out in the Oymaağaç focused on Old Hittite, Hittite Empire and Iron Age periods (Ulaş, 2019). The Old Hittite Period samples belong to 17th and 16th centuries BC. The samples were coming from 14 different plan-squares belonging to this period. The preliminary observations showed that the plants consumed in this period was highly variable. Archaeobotanical data suggests that more wheat consumed than barley. Free-threshing wheat (*Triticum aestivum/durum*) and naked barley (*Hordeum vulgare* var. *nudum*) dominated the assemblages. The Hittite Empire Period samples dated back to 13th century BC. This time coincides with the beginning of the 3.2 ka BP climatic event. Consequently, it is important to consider changes from previous period to this period and to following period. The total number of areas studied was 13 for this period. Similar to the samples belonging to the previous period, this period samples also mostly contain free-threshing wheat and naked barley (Ulaş, 2019). These results suggest that the effects of 3.2 ka event did not start to be seen in this time period, yet. Changes might start to be seen in the following periods. Thus, the results of Iron Age samples of the archaeobotanical study carried out in Oymaağaç also included in this thesis to understand the changes that happened in the transition between LBA to Iron Age. In IA Period excavations over 300 silos or trash pits were excavated in the site. The samples of IA phase were coming from 7 different trenches. It was found that free-threshing wheat remained to be the main staple crop of the period. While the wheat species had 48% percentage in the assemblages, the abundance of barley was slightly lower, having 43% percentage. However, the research states that the IA samples pointed to the higher production rates of einkorn and barley when compared to the MBA. Additionally, broomcorn millet (*Panicum miliaceum*) was found in the samples of this period for the first time. The introduction of millet indicates certain changes in agriculture and agricultural economy. The agriculture of broomcorn millet was evaluated as a risk management strategy for the times of drought and famine because of its short life cycle and low water need. Since the millet is sown in spring and harvested in summer, it is an advantageous crop for people who lived in semi-nomadic groups (Ulaş, 2019). Thus, the human mobility that occurred in the Bronze Age collapse might be correlated with the first occurrences of broomcorn millet in the same period.

The wild seed assemblages of Old Hittite Period dominated by the *Fumaria officinalis* (common fumitory) and *Heliotropium europaeum* (European heliotrope). The same species with *Medicago polymorpha* (toothed bur clover) were the dominant species in the following Hittite Empire Period as well. *Fumaria officinalis* remained to be the main wild species in the Iron Age with *Medicago polymorpha*, however, *Heliotropium europaeum* completely disappeared from the samples.

2.5.1.16. Tell Tayinat

Tell Tayinat is a nearby settlement to Tell Atchana. It also has a close proximity to the Orontes River. As mentioned in Section 2.4.3. Tell Tayinat and Tell Atchana were occupied alternately, most likely by the same human community. The fluctuating Orontes riverbed was considered as the basis for this alternating habitation (Casana & Wilkinson, 2005; Manning et al., 2020). People located themselves in one of these settlements when the Orontes changed its course. During EBA, Tell Tayinat witnessed an occupation, but during MBA, population moved to Tell Atchana. After occupation of Atchana until the end of LBA, population moved back to Tayinat. Thus, having an insight about the archaeobotanical studies carried out in Tayinat helps to interpret the results of Atchana better. Additionally, archaeobotanical samples of Tayinat gives better understanding about the crop consumption patterns in transition from LBA to Iron Age when it is compared with Atchana. Identifying the changes in agricultural decision making -if there was any- also helps to understand the possible effects of 3.2 ka climatic change on Atchana community.

In his PhD dissertation Karakaya (2019) provided a detailed insights on EBA and Iron Age crop consumption patterns. The study included 66 samples belonging to EBA period (EBA IVB- ca. 2350-2200 BC) and 54 samples belonging to Iron Age Period (Iron I- ca. 1200-600 BC). The volume of sediment floated was 638 L for EBA samples, and 683,75 L for Iron Age samples. The EBA samples were relatively richer than the Iron Age samples in means of plant remains per liter soil. The total count of plant remains retrieved from the samples was 9872 for EBA, and 6364 for Iron Age. When the samples were evaluated indiscriminately from their periods, it was seen that dominant cereals were two-row barley, free-threshing wheat, and emmer wheat. The number of emmer wheat was usually low in samples, and einkorn wheat was occasionally found. In EBA samples, the most proportionate cereal was two-rowed barley. Its percentage was over 30% during this period. Free-threshing wheat proportion was fluctuated between 10-30% during several sub-phases of EBA. During Iron Age, the proportion of free-threshing wheat was higher than barley and emmer wheat. In the beginning of the Iron Age, the ubiquity of barley increased. Emmer wheat was ubiquitous throughout that period. The proportion of free-threshing wheat was around 40% during Iron Age I period except a time period that corresponds to middle-Iron Age I when its proportion decreased to 25%. During the mentioned period that free-threshing wheat proportion decreased, the proportion of emmer and einkorn wheat increased.

Rachis remains were also present in the samples. The proportion of barley rachis showed a decrease in Iron Age samples. Free-threshing wheat spikelet bases slightly increased during Iron Age whereas emmer wheat spikelet bases decreased significantly during that period. There was not any chaff belonging to einkorn wheat.

The study (Karakaya, 2019) also mentioned the cereal proportions. When barley compared with wheat species in general, it was seen that the barley was never found more than wheat species. While barley was more numerously found during EBA, its ratio decreased significantly when it comes to the Iron Age. When barley compared specifically with free-threshing wheat, the results showed that the latter started to be presented in higher ratios throughout the time.

The most proportionate and ubiquitous wild plant taxa were *Lolium* sp. (ryegrass), *Phalaris* sp. (canarygrass), *Melilotus/Trifolium* (clover), and *Anthemis cotula* (stinking chamomile). The *Phalaris* sp. had the highest proportion among these four species, but its proportion slightly decreased from EBA to Iron Age. The percentage of

Phalaris sp. increased in Iron Age samples whereas the proportion of *Melilotus/Trifolium* sp. decreased. Finally, *Anthemis cotula* was also among the wild plants that increased in proportion during Iron Age period. In his research, Karakaya also showed an increasing representation of wild plant types that grow in the moisturized environments (e.g., *Rumex* sp. and *Scirpus maritimus*). These types of wild plants had higher proportions in the samples coming from Iron Age layers. The increase in their proportion might indicate higher levels of water availability in the surrounding regions of Tayinat.

In EBA samples of Tell Tayinat barley dominated the cereals as was the case for many Near Eastern sites. But, in the beginning of the Iron Age, the importance of barley seems to be decreased and replaced by free-threshing wheat types. Increase in both drought susceptible free-threshing wheat and wetland growing wild plant species might be an indicator of better environmental conditions and moisture availability during Iron Age. But still, to understand if environmental conditions were always good throughout Bronze Age or did they changes during 3.2ka event and then turned back to normal, the archaeobotanical data gathered from Tell Tayinat excavations should be compared with Tell Atchana data.

2.5.1.17. Tell-Atchana

Tell-Atchana, one of the mounds researched for this thesis, has a long history of archaeobotanical research. The previous studies mainly focused on the Late Bronze Age layers of the site. The samples of the höyük coming from these layers were analysed and presented in two MSc thesis (Çizer, 2006; Stirn, 2013) and in an article (Riehl, 2010a). In her thesis, Çizer (2006) studied on 35 samples in total. The samples were coming from the LBA contexts of Atchana. The contexts of the samples included floors, kilns, tabuns, bins and pits. All the samples were dated back to 14th century BC (Çizer, 2006). In this respect, the samples represent the time period directly before to the 3.2 ka climatic transition, making it crucial to comprehend agricultural decisions prior to the climatic change. Free-threshing wheat was the most abundant species in the samples. It was followed by the barley. Emmer wheat seeds were occasionally found. In the assemblages and einkorn wheat was totally absent. Remarkable number of seeds were identified either as a *Triticum* sp. or indetermined *Cerealia* pointing out the bad preservation levels of the seeds and impossibility of the species level identification. Among the weeds and wild seeds found in the Atchana LBA layers, the most abundant crop weed was *Lolium remotum* (flaxfield). There are few more other crop weed species such as *Galium* sp. (bedstraw), *Lithospermum* sp. (gromwell), however, their number was much lower than the mentioned weeds. The study also separated the eco-groups and presented the weed abundance in each eco-group. Accordingly, the highest number of wild seeds were belonging to open vegetations. Interestingly, the number of wild seeds belonging to the freshwater ecology was very low in the samples. As Atchana is very near to the Orontes River it is an unexpected result.

Riehl (2010a) analysed 248 samples from LBA layers of Atchana. Each sample was obtained from nearly 32 L soil sample. Most of these layers were dated back to 1450-1300 BC. Similar to the samples analyzed by Çizer, these samples also might give an impression on the agricultural preferences just before the 3.2 ka event. Out of 248 samples, 48 samples did not contain any seed remain. The most abundant and most ubiquitous cereal was free-threshing wheat. Barley was the second most ubiquitous and numerous cereal species in the samples. On the other hand, only one emmer wheat and one einkorn wheat were found. Riehl interpret the results that the moisture conditions in Atchana must be particularly favorable in that period because free-threshing wheat is less drought resistant than hulled wheat and barley. Among the cereal chaff, only one could be identified to the species level which is *Triticum aestivum* (bread wheat) rachis. The rest of the rachis were identified as *Triticum aestivum/durum* rachis. In general, chaff remains were rare in the samples. They only represented the 1.2% of the samples. The low quantity of chaff indicates that post-harvest crop-processing took place outside the deposition area. The wild seed assemblages of the Atchana shed light on different perspectives of the environment surrounding the mound. The *Phalaris* sp. (canary grass) was discovered in the maximum abundance in the wild seed assemblages. Seeds of the *Phalaris* genus were only seldom recognized to species level. However, it is known that certain *Phalaris* species are indicators of wet habitats. Thus, the quantity of *Phalaris* sp. seeds reflects the water availability in the region, given the prevalence of water-demanding free-threshing wheat. The *Phalaris* was not the only plant genus found in Atchana samples that is associated to the wetland. Other plant kinds discovered in the samples were *Rumex* sp. (dock), *Scirpus maritimus* (bulrush), *Fimbristylis* sp. (fringe-rush), and *Eleocharis* sp. (spikerush), which all grow in damp or moist environments. The second most ubiquitous and numerous wild plant species was *Lolium* sp. (ryegrass). *Lolium* sp. is a typical weed of arable lands growing among crops. With *Silene* sp. (campion), *Galium* sp. (bedstraw), *Bromus* sp. (brome grass), *Sherardia arvensis* (field madder), and *Asperula* sp. (woodruff) (Riehl, 2010a). *Lolium* sp. were transported to the area with the crops.

Stirn (2013) worked on 45 samples from Atchana's LBA levels. The samples were coming from 4 different archaeological time periods dated between 1550-1240 BC. In this way, the samples he examined provide a broad time range for plant consumption habits prior to the 3.2 ka event and in the beginning of it. The samples were collected from wide range of contexts including rooms, ovens, pits, ceramic vessels, and fills. In total, 16331 charred botanical remains were identified. The cereal preservation was poor, with indeterminate cereals accounting for 65 percent of the entire cereal assemblage. Most dominant cereal among the identified seeds was free-threshing wheat. Although precise species identification of free-threshing wheat was unattainable, rachis remnants revealed that macaroni wheat (*Triticum durum*) was rather more abundant in the samples than bread wheat (*Triticum aestivum*). The second most common grain type observed in the samples was barley. Unlike earlier research, emmer wheat was the third most prevalent crop in the samples, and it was not a rare occurrence; rather, it was more abundant. In the samples, there was a new variety of wheat called "New Glume Wheat," which is a hulled wheat species that is now extinct. However, it was only found on rare occasions, implying that it was not mass-produced in that time. Stirn claims that, despite variations in amounts, the primary grains were consistently present in Atchana throughout the archaeological levels studied. Thus, it can be said that the approaching climatic event did not affect the agricultural preferences in Atchana Höyük. At the archaeobotanical evidence in the hand does not support such an argument. Among the wild taxa, *Lolium temulentum* (darnel ryegrass), small-seeded legumes, *Phalaris* sp. (canary grass), unidentified large wild grass, *Medicago* sp. (burclover), *Rumex* sp. (dock), *Galium aparine* (bedstraw), *Coronilla* sp. (scorpion vetch), *Thymelaea* sp. (sparrow-worts). As in the case for previous studies, most of these wild plants grow in the disturbed lands indicating that they were crop contaminants.

The cereal abundance results were consistent in all archaeobotanical studies carried out in the site. The research conducted in the Atchana showed that free-threshing wheat was the main cereal crop throughout the LBA. According to the archaeobotanical data, barley has the secondary importance. Even though the written evidence points that the most imported product of the city (for references see; Riehl, 2010a), this importance and preference towards barley is not evident in the archaeobotanical samples. Emmer wheat was present but occasionally. Thus, the agricultural production of the emmer is ambiguous. They might be present merely as agricultural pollutants. The einkorn wheat was never encountered in samples of Atchana at all. On the other hand, the wild plant taxa draw different pictures in studies of Çizer and Riehl. The number of seeds of plants that grow in freshwater environment was relatively low when comparing to plants seeds growing other habitats. However, Riehl found seeds of wetland plants in high amount even they were the second most abundant group after the crop plant group. The dating of Riehl's and Çizer's samples are close to each other, even some samples' dates should overlap. The reason behind this differential result in wild seed assemblages might be caused by the differential contexts and even differential trenches that the samples taken from.

The previous archaeobotanical studies carried out in Anatolia are given to understand the general trends in plant usage during the MBA and LBA. The archaeobotanical data of Anatolia in the corresponding periods shows no particular trend for any of the cereal types rather each cereal was used with changing intensity in different periods. The summary of previous research is given in Appendix A.1.

2.5.2. Archaeobotanical Record of MBA and LBA Syria

2.5.2.1. Tell Mardikh- Ebla

Tell-Mardikh one of the important sites of Northwestern Syria. It was systematically occupied from EBA to late MBA. Ebla experienced a succession of social and political turmoils during the transition from EBA to LBA, culminating in the downfall of the city around 2000 BC. This time corresponds to the 4.2 ka climatic event, which impacted the Near East, including most likely Ebla (Caracuta & Fiorentino, 2014).

The archaeobotanical investigations carried out on the samples coming from a refuse dump gave insights about the crop consumption patterns of MBA Tell Mardikh (Caracuta & Fiorentino, 2014). The radiocarbon dating carried out the samples showed that the dump was used between 2000-1900 BC. As a result, the dump should represent the latter third of the 4.2 ka climate transition. Total amount of the wet-sieved material analyzed for this study was 34.5 L. The samples consisted of 854 seed/fruit remains in total. Among the cereals, the most ubiquitous ones were both six-row type barley (*Hordeum vulgare*) and two-row type barley (*Hordeum vulgare subsp. distichum*). Naked wheat species (*Triticum aestivum/compactum*) was less frequently found than the barley. Einkorn and emmer wheat were present in the samples but in small quantities.

The weedy taxa included *Polygonum* sp. (knotweed) and *Cyperus* sp. (flatsedges) in high quantities. There were also *Galium* sp. (bedstraw), *Chenopodium* sp. (goosefoot), and *Silene* sp. (campion), however they were rare. *Cyperus* sp. grows in the freshwater habitats. Its abundance in the Tell Mardikh samples indicate the availability of the freshwater around the site in the corresponding period. *Polygonum* sp., on the other hand, thrive in open habitats and they might be collected by the inhabitants of the site for consumption or if they dump the dung of the animals that consumed these plants into the middens, these type of plant seeds might be entered to samples.

In general, barley seems to be produced as a main crop in MBA Tell Mardikh, but presence of water demanding free-threshing wheat with freshwater-loving wild plants also points to the presence of the moisture environment during MBA in the proximity of Tell Mardikh.

2.5.2.2. Tell Umm el-Marra

Tell Umm el-Marra is located in the Jabbul Plain of western Syria between Aleppo and Euphrates Valley. It is near the Jabbul Lake. Tell Umm el-Marra is in the steppe zone area of Syria. The region that is located is suitable for dry farming with 300 mm annual precipitation (Schwartz et al., 2000). With its 25-ha area, it is the largest Bronze Age site in the Jabbul Plain and some argues that the site might be ancient Tuba. The site was occupied throughout Bronze Age and after a hiatus the occupation continued in Hellenistic and Roman Periods. Archaeological evidence showed that the site was under a central power in MBA II period and resultantly there are public constructions in the archaeological record belonging to this period. The MBA II period also marked by the rise of complex urban societies such as Yamhad, Mari, and Shamshi-Adad in the surrounding region. However, the layers from LBA only give the evidence of small-scale domestic structures. The EBA occupation in the site dated back to ca. 2500-2300 BC, MBA II is dated to ca. 1800-1600 BC, and lastly LBA is dated to ca. 1600-1200 BC (Schwartz et al., 2000).

In the archaeobotanical study carried out in the site, the coverage of the whole Bronze Age archaeobotanical data was possible (Schwartz et al., 2000). The number of samples analyzed from EBA was 4 and this number was 9 for MBA layers of the site.

The contexts that the samples were taken included ashy pits and deposits, open areas, rooms, and oven. Rather than the number of the cereals, the weight of them were given in the results of the study. Thus, the abundance of the cereals is resulted from their weights. Two-row barley (*Hordeum distichum*) had the highest weight in both EBA and MBA samples. Free-threshing wheat (*Triticum aestivum/durum*) was the second most abundant cereal in weight in the MBA II samples whereas this species was not present in the EBA samples at all. The wheat found in the samples were not identified to species level, and labelled as *Triticum* sp. In EBA, nearly 95% of the identified cereal remains was barley, however, in MBA II samples, this percentage decreased to 85%. Among the chaff rachis fragments of barley, free-threshing wheat and hulled wheat were found. Additionally, silicified cereal awns were also present in the samples. In both EBA and MBA II samples, the barley rachis fragments outnumbered the wheat rachis.

The data retrieved from the EBA samples represents the time period just before the 4.2 ka event, but since it comprises 2300 BC, the effects of the oncoming climatic change might be perceived by Umm el-Marra society. On the other hand, the MBA II samples are the representation of the afterwards of 4.2 ka event. In that period, the effects of the climate change might start to be erased among the society. By looking at the grain and chaff remains, it can be said that the barley was the dominant staple crop in both periods, with decreasing percentage in MBA. Additionally, free-threshing wheat enters to the samples when it comes to the MBA period. Thus, the archaeobotanical data might be the indicator of the approaching bad climatic conditions in EBA and the barley choice of people rather than the drought susceptible naked wheat, but, when the climate got better in the following periods, the society of Tell Umm el-Marra had chance to grow naked wheat in higher amounts.

The most abundantly found wild plants in EBA samples were *Centaurea* sp. (knapweeds), *Trigonella* sp. (fenugreek), *Astragalus* sp. (milkvetch), *Eremopyrum* sp. (annual wheatgrass), and *Scrophularia* sp. (figwort). For MBA, these plants were

Arnebia sp., *Phleum* sp. (timothy), *Eremopyrum* sp. Additionally, high number of indetermined Poaceae (grass family) were found in the latter.

12 samples from LBA Period were analyzed in the study coming from terrace, rooms, large trash pits and ashy deposits (Schwartz et al., 2000). Among the charred cereal grain found in the LBA samples, barley had the highest weight. Naked wheat remains were also present in the samples and it was the second most abundant type. Similar to the MBA II period samples, nearly 85% of the identified cereal was barley. However, interestingly, in LBA samples, the number of wheat rachis was higher than the barley rachis on the contrary to the previous periods. Hulled wheat species were only present with their chaffs.

LBA samples seems to have the continuation of crop choices of MBA period with increasing importance of naked wheat. In both periods, cereal grains dominated by barley, however, it is not as much as important in the EBA period considering the decrease in its percentage. The greater number of wheat rachis, on the other hand, points to the increasing importance of wheat agriculture in the LBA period. Consequently, the results might be interpreted as the continuation of good climatic conditions beginning from the MBA II period through the LBA period might enable farmers to grow wheat in higher amounts.

2.5.2.3. Tell Mishrifeh- Qatna

Tell Mishrifeh -ancient Qatna is located in the central-western Syria. It was inhabited in the Chalcolithic period for a short time period and abandoned. The settlement in the site began in the Bronze Age again and continued throughout this period. Tell Mishrifeh had similar faith with Tell Atchana politically. It became Mitannian vassal in the 16th century BC, and in the 14th century BC, the Hittites takeover the city in their Syrian expeditions (Pfälzner, 2007). So, it is expected to see the similar cultural influences and traditions in the Tell Mishrifeh and Tell Atchana. Accordingly, one can also expect to see similar agricultural preferences and agricultural economy in both sites as they had very similar political and cultural backgrounds. In that sense, Qatna particularly is a good choice to compare and contrast the archaeobotanical data. When eliminating the effects of cultural preferences on the agricultural decision making, the differences in the archaeobotanical record from the two sites might be solely resulted from the differences in the environmental conditions of both sites including the climate. The effects of climate change might be visible in the one site while it did not affect the crop choices in the other site as expected. Thus, the archaeobotanical data of Tell Mishrifeh is evaluated in itself and also is compared to results of previous studies carried out in Tell Atchana to see the differences and similarities. However, since only the LBA archaeobotanical data is available in Tell Atchana, this comparison is possible in the for LBA levels of Tell Mishrifeh.

The archaeobotanical study carried out in the Tell Mishrifeh (Peña-Chocarro & Rottoli, 2007) gave insights of agriculture in 5 different time periods: EBA III, EBA IV, MBA II, LBA I, IA II-III. In the study carried out by Peña-Chocarro and Rottoli, 19 samples from EBA III, 61 samples from EBA IV and 2 samples from MBA II periods were analysed. The EBA III samples coming from the contexts such as silos, pits, floors, basins and a hearth. The EBA IV samples were retrieved from silos, granaries, basins, and storage pits. The MBA II samples were taken from a tannur and a basin.

In the EBA III samples two-row barley (*Hordeum distichum*) was the dominant cereal crop. It was followed by the emmer wheat (*Triticum dicoccum*) but its number was much lower than the barley. Free-threshing wheat and einkorn wheat was also present in the samples but only with one seed. 2 wheat seeds were able to identified to genus level (*Triticum* sp.). In general, the number of barley was much more higher than the sum of all the wheat species. No chaff remains were found in the samples, and there was only one seed of wild plant.

The EBA IV samples were relatively richer than the other period samples probably due to the high number of assemblages. They had nearly 10000 seed remains. Similar to the previous period, the cereal remains were dominated by two-row hulled barley. Nearly half of the plant remains were barley. The second most abundant cereal species was emmer wheat, but comparing to abundance of barley, their number was low. The number of naked wheat was slightly lower than the emmer wheat. The einkorn wheat was also present in the samples but its number was much lower than the other cereal types. Chaffs of all the species were found in the samples as well. Most numerous chaff again belonging to barley. Emmer wheat chaff followed barley in abundance. The number of einkorn chaff, macaroni wheat chaff, bread wheat chaff and hulled wheat (*Triticum monococcum/dicoccum*) chaff were very close. There were also few chaff remains belonging to the free-threshing wheat. The wild plant taxa was also abundant in the EBA IV samples. They also showed great variance. *Lolium* sp. (ryegrass), *Astragalus* type (milkvetch), *Galium* sp. (bedstraw), *Hippocrepis* sp. (horseshoe vetch), and *Rumex* sp. (dock) were the most abundant five species, respectively. These plants grow in disturbed fields, so they probably entered to samples as crop contaminants.

The two MBA II period samples produced a scarce amount of seeds. Barley and naked wheat were present but their total number was 10. The barley had higher number than the naked wheat in those samples as well, however, due to the scarcity of the seeds, their higher number cannot imply anything about the storage and consumption patterns of MBA II period society. There was no cereal chaff in these samples and only one seed of indetermined wild plant was found.

The archaeobotanical data of Tell Mishrifeh suggests that throughout late EBA period, the two-row hulled barley was the dominant cereal. The study suggests that the preference towards barley might be the result of its less demanding characteristics. As mentioned in the previous sections, barley is more adaptable species to drought and extreme conditions than all the other wheat species. Additionally, barley both consumed by human and is used as an animal fodder (Peña-Chocarro & Rottoli, 2007).

These advantages of barley might cause the outproduction of it in EBA. The situation in the MBA in Tell Mishrifeh, on the other hand, is less clear because of the low number of cereal remains in low number of samples. However, few remains showed that barley might remained as a main staple crop in MBA, too.

The archaeobotanical data of EBA and MBA layers of ancient Qatna is presented in above section. Here, the data of LBA and IA samples is presented and is compared with the LBA layers archaeobotanical data of Tell Atchana as they had both similar political history and correspondingly it is thought that they might also share similar cultural preferences in agriculture. Since their geographical location are close to each other, environmental factors affecting to the sites should enable the production of similar agricultural crop. Thus, the differences between the agricultural products are high likely reflecting the environmental compulsion. In the corresponding period, 3.2 ka event started to be effective climate in the Near East as a major changing environmental factor. However, it may not have the same strength and same effect in all of the sites. This variability on effects of climate change can also cause variability on archaeobotanical assemblages of the sites. Tell Mishrifeh LBA data when compared with the Tell Atchana data can provide such an assessment.

The number of LBA I samples analyzed by Peña-Chocarro and Rottoli (2007) were five. The samples were coming from pottery ovens, pits and floors. Unfortunately, the number of remains was very low found in these samples. The half of ten cereal seeds found in the samples were barley whereas the other half was naked wheat. Chaffs and weeds were absent in the samples.

The Iron Age II-III layer totally produced 43 samples. Most of these samples were coming from storage pits (Peña-Chocarro & Rottoli, 2007). The other samples belonged to contexts such as hearths, basins, and floors. Since most of the samples were taken from storage pits and also since the sample number was higher, the number of remains found in the IA samples were much higher than the LBA samples. IA samples had nearly 2100 seeds in total. Among the cereal finds, the most numerous was barley followed by emmer grain as in the case for EBA samples. Naked wheat was only represented with few seeds. The same number of wheat seeds with naked wheat were not able to assign to a species level.

The crop preferences in the LBA period Tell Mishrifeh are uncertain as the sample number is low and the samples were not very rich. The IA archaeobotanical remains, however, suggest the continuation of the preference for barley over wheat. In the previous section, it is mentioned that barley might be preferred both because it is durable in the bad climatic and environmental conditions and also it is consumed by both human and animals. Throughout the Bronze Age and in the beginning of IA barley continued to be main crop of the site. However, it is known that Near East witnessed at least two climatic changes in mentioned periods: 4.2ka and 3.2ka. However, in the times of good climatic conditions, any of the wheat types does not replace the barley, at least according to the archaeobotanical data in hand. Thus, the choice of barley might not be climate related rather it might be grown in the Tell Mishrifeh for socio-economic reasons including for its ability to feed both human and animals.

2.5.2.4. Tell-Mozan

Tell Mozan is located in Khabur Plain of northeastern Syria. The modern geography of site located in the steppe climate. Thus, it is prone to three- or four-months rainless summer in every year. The annual precipitation of the region that the Tell Mozan located is above 400 mm. Thus, the rainfed agriculture is sustainable in the site (Riehl, 2010b).

The site was started to be inhabited around ca. 2800 BC and witnessed a continuous habitation throughout EBA and MBA. It was served as a Hurrian capital in the 3rd millennium BC (Riehl, 2010b). The chronology of the site was established according to Jazirah Periodization. The time that the settlement begun corresponds to Early

Jazirah I and II. Early Jazirah IIIa is dated back to 2600-2400 BC, Early Jazirah IIIb to 2400-2300 BC, Early Jazirah IV to 2300-2100 BC, Early Jazirah V to 2100-1950 BC, Old Jazirah I to 1950-1800 BC, Old Jazirah II to 1800-1650 BC and Old Jazirah III to 1650-1500 BC (Pfalzner, 2010). The transition from Early Jazirah V to Old Jazirah I represents the transition from EBA to LBA period.

The extensive archaeobotanical studies carried out in the site shed light on crop consumption patterns of the site in EBA and MBA period. To achieve this aim and to reveal the changing trends in crop usage, Riehl (2010b) analyzed 214 samples coming from both periods. Nearly 22000 seed and chaff remain were found in these samples. The density of remains in EBA samples was nearly three times higher than in MBA samples. 65 seed/chaff per liter soil was present in the EBA samples whereas this number was 26 for the samples coming from MBA layers.

In both of the periods, two-row barley (*Hordeum distichum*) was the main crop, specifically, throughout the time period between Early Jazirah IIIa to IV, it dominated the crop assemblage. Its proportions among the crop species were ranging from 40% up to 80%. Nevertheless, the amount of barley significantly decreased in Early Jazirah V samples, in the samples that dated to 2100-1950 BC. Then, the percentage of the barley in the samples increased again in the Old Jazirah I period. Free-threshing wheat was also a founder crop of the samples. However, it was not as much frequent as two-row barley. In most of the phases, it represented the less than 20% of the crop assemblages. Rachis fragments suggested that the type of free-threshing wheat found in the samples was tetraploid form wheat (*Triticum turgidum*). There were no rachis remains belonging to hexaploid wheat. In the last phase of EBA (Early Jazirah V), when the barley percentage was decreased, the percentage of free-threshing wheat was significantly increased. But, at the beginning of the MBA, its abundance decreased again below the 10% of the crops. Emmer wheat was also present in all periods, however, it never reached more than 20% of the crops in any of the layers. It decreased to less than %1 in the last phase of EBA. Then, it was reappeared in higher percentages in the MBA samples. There was an obvious preference of free-threshing wheat over emmer wheat in the latest phase of EBA, however, it gained as much importance as free-threshing wheat again in MBA since it started to be represented in same amounts with free-threshing wheat. Einkorn wheat represented in scarce amounts in all of the phases, suggesting that its seeds were most probably crop contaminants rather than main crop products (Riehl, 2010b). The plants grow in the open habitats such as waste places, fallow fields and field margins constituted the 985 of the weedy taxa.

The most abundant wild plants were the Poaceae (grass family) plants including *Phalaris* sp. (canary grass), *Aegilops* sp. (goatgrass), *Lolium* sp. (ryegrass), *Bromus* sp. (brome grass), *Echinaria capitata* (echinaria), and *Hordeum spontaneum* (wild barley). The second most abundant family was Fabaceae (pea-family) dominated by *Coronilla* sp. (crownvetch). Other weedy plant families found in the samples included Rubiaceae (bedstraw family) dominated by *Galium* sp. (bedstraw), Boraginaceae (borage family), Asteraceae (daisy family), and Cyperaceae (sedge family). The most numerous wild plant of non-weedy character was *Poa* sp. (meadow grass). In general, the proportion of weeds in the samples increased continuously from Early Jazirah IIIa to Early Jazirah IV, however they started to decrease from Early Jazirah V until Old Jazirah II. *Aegilops* sp. was the most numerous weed type in Early Jazirah IV whereas it was replaced with *Phalaris* in Early Jazirah V (Riehl, 2010b).

According to the archaeobotanical results gathered from the work in the Tell Mozan, Riehl (2010b) suggests that free-threshing wheat was grown besides barley when the growing conditions were suitable. Thus, the increase in the free threshing wheat proportion in Early Jazirah V period in Tell Mozan indicates such growing condition allowance and successful series of cultivation. However, when the conditions were not suitable, then people chose to more durable wheat type, the emmer wheat, as in the case for Old Jazirah I period.

2.5.2.5. Tell Arbid

Tell Arbid is one of the Bronze Age sites located in northeastern Syria. The excavated areas showed an occupation int the site from the early 3rd millennium BC to mid-2nd millennium BC. The mean annual precipitation that Tell Arbid received is 380 mm. This amount of precipitation is enough for sustaining a rainfed agriculture in the region. In the archaeobotanical study carried out in the Tell Arbid (Wasylikowa & Koliński, 2013) analyzed plant remains from the Post Akkadian (Early Jazirah V) and from MBA I-II (Old Jazirah) strata. While the former period is dated back to ca. 2150-2000 BC, the latter corresponds to 1900-1700 BC. The 4.2ka climatic change should have effects on the Post Akkadian period samples, and the MBA samples are the representative of subsequent phases of 4.2 ka event.

The number of samples coming from the Post Akkadian phases was 11. These samples produced 1002 cereal remains in total. The most numerous crop type found in the samples was two-row barley (*Hordeum distichum*). It represented nearly 58% of all cereal remains. Among the identifiable cereals, barley was followed by hulled wheats. Both einkorn and emmer (*Triticum monococcum* & *dicoccum*) wheats were present in the samples, however, their number was much less than the two-row barley. The total percentage of hulled wheat types was 13.6%. Macaroni wheat (*Triticum durum*) was the dominating naked wheat type in the samples, but bread wheat (*Triticum aestivum*) was probably also present. The total percentage of naked wheat species was 2.7%.

18 samples belonging the MBA I and II period were analyzed in the same study. The MBA strata produced the same cereals with Post Akkadian levels. Total number of cereal plants remains found in the samples was 2929. The cereal finds again dominated by two-row barley. Its percentage was nearly the same with the previous period (57.2%) indicating that the barley remained to be the main staple crop throughout to EBA to MBA in Tell Arbid. On the contrary to Post Akkadian samples, MBA samples had increased amount of naked wheat (17.4%). The proportion of hulled wheat species, on the other hand, decreased to 5.7%. According to Wasylikowa and Koliński (2013),

the importance of the naked wheat, especially the macaroni wheat, should increased with time through the MBA as the samples from different sub-phases of MBA had continuously increasing percentages of naked wheat. The hulled wheat seems started to be replaced by naked wheat with the beginning of MBA in Tell Arbid. According to the study, the difference in wheat utilization between the two eras might be due to various origins of samples in agricultural regions. In other words, the hulled wheat dominated the Post Akkadian samples as the grains were mostly coming from the drylands which hulled wheat were able to grown. However, the naked wheat were grown in the wetter lands in the surrounding region and the samples taken from the MBA layers were the representation of that harvest. This is a reasonable explanation for interpreting the disparity. But, it should not be forgotten that these samples also represent the crop consumption patterns in the amidst and afterward of a major climatic event that affected nearly the whole Near East. As a result, the variation in wheat kinds consumed might be an indicator of enhanced wetland availability for use as an agricultural field in Tell Arbid's surrounding areas. If the agricultural fields got more moist after the 4.2ka event ended in the MBA period, locals may have begun to cultivate more naked wheat rather than continue to cultivate drought-resistant hulled wheat species.

Nearly 30 distinct types of wild plants were found in Post Akkadian plant assemblages. There were a total of 2245 wild plant remnants during this time period. Poaceae (grass family) and Fabaceae (pea family) were the most prevalent plant families in the samples. *Coronilla* cf. *scorpoides* (yellow crownvetch) and *Astragalus-Trigonella* type (milkvetch/fenugreek) seeds were the most numerous among the identified seeds. *Aegilops* cf. *crassa* (Persian goatgrass) came after them. When compared to the mentioned taxa, the rest of the wild plant taxa were only represented by a small number of seeds (Wasylikowa & Koliński, 2013). The wild plants that presented in the samples most numerously are grown in the disturbed and arable fields. Thus, they most likely represent the contaminants in the crops, and they do not provide specific information about the water availability in the region during the relevant period.

In the samples from the MBA period, 36 distinct wild plant species were discovered. In comparison to the previous period, the number of remains was decreased. The MBA samples yielded a total of 488 wild plant parts. Poaceae (grass family) seeds accounted for the majority of the seeds, as they had in the preceding era. The *Aegilops* cf. *crassa* dominated this family (Persian goatgrass). *Coronilla* cf. *scorpoides* (yellow crownvetch) was one of the most abundant wild plants in the samples, just as it had been in the preceding era. *Silene* sp. (campion) became one of the most common wild plants in MBA samples throughout this time (Wasylikowa & Koliński, 2013). In open vegetations, this plant thrives in sandy areas. As a result, its high frequency of entry into the samples indicates the presence of agricultural regions nearby. Furthermore, sandy areas might indicate unrecovered land following the 4.2 ka event's drought.

2.5.2.6. Tell Leilan

Tell Leilan, in Khabur plain of Syria, was one of the key places discussed in relation to the 4.2 ka climate shift that caused the demise of Akkadian Empire. Thus, the archaeobotanical study carried out in the site (Smith, 2012) focused on the change from Akkadian Period (Tell Leilan phase IIb) to post- Akkadian period (Tell Leilan phase IIc). The Akkadian period relates to the period preceding the 4.2 ka catastrophe. After the collapse of the Akkadian Empire due to climatic change (Weiss et al., 1993), Tell Leilan was held for a brief period. This era is known as the post-Akkadian period. Understanding the changes in crop consumption patterns from Akkadian to post-Akkadian times can aid in determining the magnitude of the 4.2ka event's influence.

In the first part of the research (Smith, 2012), 245 samples from the administrative building complex were examined. Samples were taken from floors, kitchens, tannurs, streets, drains, roof collapse, waste dumps, pit fills, trench foundations, vessel contents, and burials. A total of 3227.25 liters of soil were sampled. These samples included 6453.6 ml of charred plant remains. The samples coming from the different contexts were evaluated separately. Large volumes of two-row barley (*Hordeum* *distichum*) and free-threshing wheat (*Triticum aestivum/durum*) were obtained from the tannurs. Cereal chaff was also found in those samples, and rachis remnants confirmed the presence of both bread wheat and durum wheat. The number of rachises of durum wheat was higher than the other. *Aegilops* sp. was mixed to these cereals (goat grass). Dryland cereal weeds such as *Galium/Asperula* sp. (bedstraw/woodruff), *Bolboschoenus maritimus* (bulrush), *Rumex* sp. (docks), and wetland Cyperaceae (sedge-family) species were also present, in addition to *Aegilops*. The dump contexts located near the tannurs produced good amount of charred plant remains and the contents were the same with tannurs.

The second part of the research investigated to see the differences between Akkadian and post-Akkadian samples (Smith, 2012). To achieve this goal, 12 Akkadian and 13 post-Akkadian samples were studied. The samples from these two periods came from comparable contexts. The post-Akkadian samples were gathered from floors, ashy deposits, tannur, and foundation trenches, whereas the Akkadian samples were taken from a hearth, floors, foundation trenches, drain fill, pot fill, and interior occupational debris. A total of 2779 plant remnants were found in 143.75 L Akkadian period samples. In 81.75 L post-Akkadian samples, this number was 9443. Among the identifiable cereal grain, two-row barley had the highest proportion in Akkadian samples (13.3%). The number of the two-row barley collected in post-Akkadian samples was higher than that of in Akkadian samples. However, its proportion (6.7%) in post-Akkadian samples were nearly the half of the Akkadian ones. The barley in the Akkadian samples was followed by emmer wheat (3.9%). The free threshing had lower proportion (1.7%) in the Akkadian samples. However, the second most proportionate cereal grain in the post-Akkadian samples was free-threshing wheat. The emmer (1.0%) followed the free-threshing wheat in those samples. Einkorn wheat grains had the lowest proportion in both period samples. The chaff remains were also present in the samples. In both periods, the highest proportion of cereal chaff belonged to indetermined wheat glume base (20.7% in Akkadian, 29.3% in post-Akkadian samples). After the wheat glume base, two-row barley rachis fragment had the highest value in the Akkadian samples (2.9%), and free-threshing wheat rachis fragment in post-Akkadian samples (16.0%). The number of the latter was very high indeed. Only few remains were attributed as macaroni wheat fragment and no bread wheat rachis fragment were found in the Akkadian samples. However, rachis fragments of both type of wheats were present in the post-Akkadian samples. The proportion of macaroni wheat rachis fragment (6.2%) was higher than that of bread wheat (2.9%).

The barley seems stayed as the main crop throughout the corresponding time period. The difference in cultivated plant types occurred in wheat. Drought tolerant macaroni wheat present in both of the periods. However, the archaeobotanical evidence suggests that this type of wheat started to be more heavily consumed in the post-Akkadian period. These results interpreted by the study (Smith, 2012) as the farmers in post-Akkadian period tried to adopt to more arid conditions thus the percentage of drought tolerant species increased. It can be also said that during the Akkadian period, farmers were highly dependent on drought tolerant cereals which are barley and macaroni wheat, however, by the end of 4.2 ka event (which also coincides with the fall of Akkadian Empire and start of post-Akkadian occupation), farmers became able to cultivate drought susceptible species, bread wheat, in higher amounts. However, they also continued to cultivate the others as a “back-up” crop.

2.5.2.7. Tell Bderi

Tell Bderi is located in the Khabur region of northeastern Syria. The occupation in the site started in the late 4th millennium BC. But it reached its main occupation in the Early Bronze Age. With an intervention in Middle Bronze Age, it started to be occupied again in the Late Bronze Age, in 15th and 14th century BC. The site receives 250 mm of annual precipitation. This amount is the lower limit for rainfed agriculture in the southern Khabur (W. van Zeist, 2000).

The archaeobotanical studies carried out in the site (W. van Zeist, 2000) showed agricultural trends over many periods of habitation, including the Mitanni Period. This period began in the 14th century BC and corresponded to the time period immediately preceding the 3.2 ka climate catastrophe. There were just three samples from this era, and plant remnants were limited. As a result, the findings did not provide much insight into the consumption habits of this age, which had generally regular climatic circumstances. Nonetheless, the findings may provide a broad view on some of the most common cereal varieties utilized on the site. Six-row barley was the most common cereal detected in the samples (*Hordeum vulgare*). There was also some free-threshing wheat (*Triticum aestivum/durum*), but just a few seeds. The samples were completely devoid of hulled wheats. *Aegilops* sp. (goat grass) was the sole wild seed found in the assemblages, and it was most likely mixed in with the crops in the field.

2.5.2.8. Tell Schech Hamad

Another site in the Khabur area of northeastern Syria is Tell Schech Hamad. The location was occupied during the Bronze Age. The site is ancient Assyrian Dur-katlimmu, which served as a regional administrative center under Assyrian rule. During that time, the site's citadel grew to a size of 15 hectares. The yearly precipitation ranges between 150 and 200 mm at this location. As a result, rainfed agriculture was impossible, and the Assyrians had to rely on an irrigation system to keep their agricultural grounds irrigated (W. van Zeist, 2000).

Archaeobotanical materials from the Middle Assyrian Palace period (ca. 1275-1075 BC) give insight on LBA agriculture in the area. Ten samples from the relevant time were studied in the archaeobotanical investigation (W. van Zeist, 2000). Large quantity of barley grains was discovered in the floor of an Assyrian governor's palatial chamber. The type of barley found in the chamber was two-row. Barley rachis internodes and glume remains were also present in the samples. Except the few seeds of legumes, the samples did not any other crop plants. Different sorts of wild plants, on the other hand, were present in significant quantities. Arable weed seeds such as *Aegilops* sp. (goatgrass), *Lolium* sp. (ryegrass), *Phalaris* sp. (canary grass), *Melilotus* sp. (sweet clover), and *Vaccaria* sp. (cowherb) predominated among the wild plants discovered intermingled with barley. The study points out that the barley in the samples was of poor quality, and the weeds were small. Each circumstance suggests that these plants were cultivated in poor conditions, most likely due to a lack of water caused by political upheaval and war, which interrupted the regional irrigation system (W. van Zeist, 2000). However, it is important to remember that there was an ongoing climate shift over that time period. As a result, adjacent water sources that feed the irrigational system are likely to be damaged by the drought and lose their ability to support agriculture. The drought caused by 3.2 ka climate change may also be the factor behind the low quality of barley and small seeded weeds.

The summary of archaeobotanical research carried out in Syria is given in the Appendix A.2. It is well known fact that most of the sites in Syria were abandoned at the end of the EBA, and Weiss et al. (1993) suggest that it is resulted from the desertification in the region during the 4.2 ka BP climate change. However, Anatolia does not seem to be affected from this climate change as much as Syrian sites did. Massive abandonments of the sites -as was the case for Syrian sites- is not evident in the Anatolia. Archaeobotanical evidence from Anatolia also does not suggest any major shift in plant production/consumption patterns in the transition from EBA to MBA.

For the 3.2 ka event, the situation is a little bit different. Even though the weakly reduced precipitation from 1200 BC onwards is evident for central Anatolia in the climate model created by Bryson, it did not affect the Çanakkale region (Riehl, 2009). However, both Anatolian and Syrian civilizations experienced collapse at the end of the LBA. Some argued that this was the result of a climate change, but the reason cannot be solely reduced to climate change as many other factors -including cultural, economic, and political- were in play in that time.

CHAPTER 3

METHODS AND MATERIAL

3.1. METHODS

3.1.1. Sampling Strategies of Tell Atchana and Toprakhisar Höyük Excavations

Every sample taken in the field at Tell Atchana and Toprakhisar Höyük is given a unique label. These labels include information such as the sample number, plan-square, locus, lot from which the sample was taken, the date the sample was collected, the local phase to which the sample belonged, and the team that collected the sample. In both sites, the locus-lot system is employed to keep track of every stage of the excavation. Every archaeological feature unearthed in a certain plan-square has a unique locus characteristic in this method. A wall, a room floor, and a hearth on a room floor in an archaeological trench, for example, are distinguished by the unique locus numbers assigned to them. The lot numbers basically show the working days in the field. All types of samples found in the same day is given the same lot number. With the specific sample numbers, locus and lot information, a sample become totally distinguished from the others. The chosen sampling strategies in the site are systematic and judgemental sampling (Çizer, 2006). From every locus, 3 buckets (~30 L) of soil are taken for flotation (systematic sampling). Additionally, the soil from the contexts that potentially contain archaeobotanical samples (from the areas that have ashes or burnt seed) is also taken to float (judgemental sampling). If a locus shows evidence of extensive fire activity, the excavators may decide to increase the sediment volume collected as a flotation sample.

3.1.2. Separation of Archaeobotanical Remains from the Soil Samples

After the soil samples are collected from the excavated areas, the first step is the flotation of the soil samples to separate botanical remains from the soil. Flotation of Tell-Atchana and Toprakhisar samples are carried out in the Ankara type flotation machine in the Atchana excavation house (Figure 10). This machine consists of 2 tanks. One of these tanks is bigger, and the water comes from the lower part of it. A mesh is placed on this tank to pour the soil. The smaller tank is used for the placement of tight weaved chiffon fabric and the water is disposed of from this tank. The water that comes from the bottom of the large tank causes a rise in the light elements, including the plant seeds, other plant parts, and charcoal in the soil. Then, this light fraction flows into the chiffon fabric in the smaller tank and is collected in it. The collected light fraction of the samples is first dried within the chiffon fabric and then is placed into a plastic bag. During flotation, the volume of soil sediment is recorded for every sample and these volumes are entered to the databases of the excavations.

Figure 10. Ankara type flotation machine used in Tell Atchana Excavation House.

3.1.3. Identification Procedure

After the archaeobotanical remains are separated from the soil, the light fractions are sieved into 4 mm, 2mm, 1mm, 500 micron, and 250-micron sizes. Then, the 4-, 2-, and 1- mm samples are sorted to separate the seeds and plant parts from the charcoal. Most of the crop seeds are found in the 4- and 2-mm sieves. 1 mm sieve, on the other hand, generally contains seeds of wild plant taxa.

The last step of identification is the examination of the separated seeds under the Leica S8AP0 model stereo microscope. The seeds are separated according to their species when it is possible. If the species level identification is not possible, the seeds are identified to genus or family level. Among the cereal seeds only the ones that have embryo part are counted and recorded in the database for this study. The grains that do not have an embryo part are separated from the others and are not recorded. For the other crop plant taxa, all the fragments are counted as one since identifying the presence of embryo is more complicated in the other crops such as legumes and olive. Thus, every fragment is evaluated as one individual seed.

When the identification is done, the seeds belong to different plant species are placed in different Eppendorf tubes. For identification the cereal identification manual of Jacomet (2006), the economic plant atlas of Neef et al. (2012), and the plant seeds and fruit identification manual of Cappers & Bekker (2013) are benefitted. Additionally, the plant reference collection of the Environmental Archaeology Laboratory of METU is used to double-check the species.

3.1.4. Morphometric Measurements

The size of these two major crops throughout the different phases is measured to reveal any potential change in the size of the wheat and barley seeds resulting from colder temperatures and water stress brought by climate changes that restrict the growth of the grains during their grain filling period.

Morphometric analysis in botany is usually carried to reveal the taxonomy of the plants and includes the measurements of size and shape (Ball et al., 2019). In archaeobotanical studies, it is also used to differentiate the wild plants and domesticates. Traditional morphometrics and geometric modern morphometrics are the sub-categories of morphometrics. Traditional morphometrics is the earliest technique and mostly focuses on variations in size rather than shape (Seetah, 2014). Size-dependant variables are also the focus of traditional morphometrics, including volume, surface area, and dimensional ratios (length: breadth, length: width, etc.) (Ball et al., 2019). Thus, in this thesis, the chosen method is traditional morphometrics, and only the size of the seeds is in focus. The complete and well-preserved wheat and barley seeds are separated from the fragmented ones for morphometric measurement. Firstly, ventral, dorsal, and side photographs of these seeds are taken with a camera connected to the microscope. Then, their length from the seed axis, width, and breadth is measured from the photographs with a Leica Application Suite X (LAS X) software conjoint to the camera. The measurements are carried out by conforming to some standards. The length measurements were done by creating a linear axis at the top and the bottom of the seed as shown in the Figure 11a red line. Similarly, the width measurements were done with a line located at the very middle of the seed and ranging from its left to right (Figure 11b). Lastly, the breadth measurements are carried with an axis located in the middle of the seed and adjusted to its dorsal ridge (Figure 11c). Since the material under the study is too small, every micrometre is important to achieve more accurate results. Thus, the seeds with distortion are excluded from the measurements (Figure 12). Again, in theory, if the results of these measurements on barley and wheat show a decrease in the seed size in the periods of interest, it might be a sign of climatic catastrophe that was experienced by the plants.

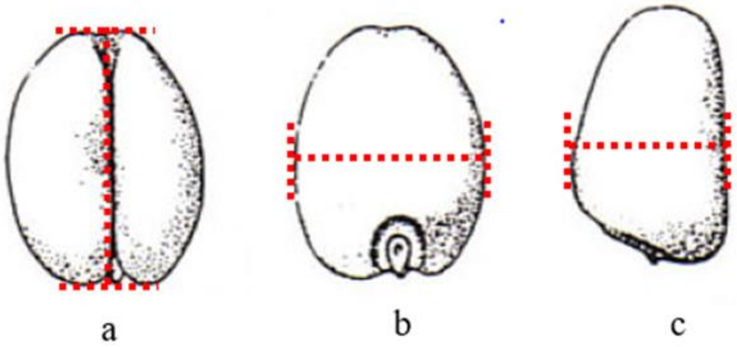

Figure 11. Ventral, dorsal and side drawings of wheat grain. the red lines show the axis that used to measure a) length, b) width and c) breadth.

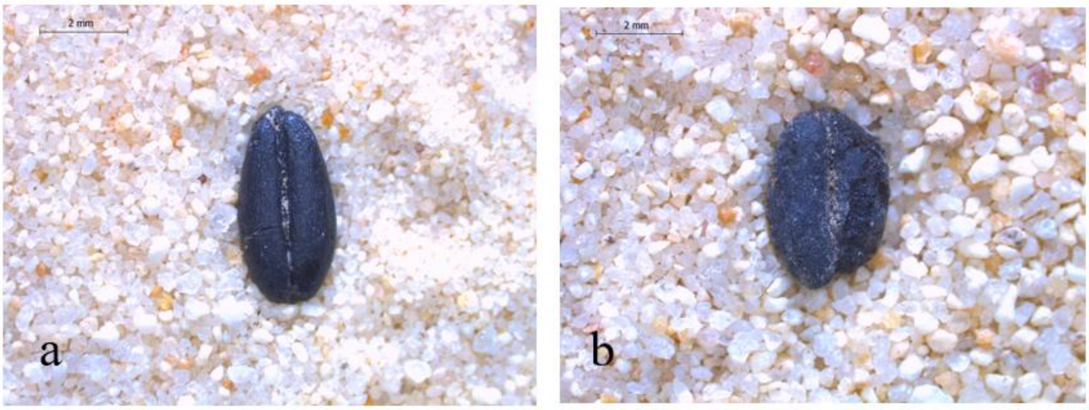

Figure 12. Photo (a) shows an example of well-preserved hulled wheat from Tell-Atchana. The measurement is performed on this seed. Photo (b) shows an example of highly distorted free-threshing wheat from Tell-Atchana. The measurement could not be performed on this seed.

As noted in Section 2.1.3, the formulae used to determine the size of the modern wheat are utilized for calculations of volume and surface area. Although it cannot be argued that the calculations derived from the modern uncharred seeds are accurate for charred ones because charring alters the shape of the seeds to varying degrees depending on temperature and charring conditions (such as oxygen availability), the calculations are still done on the assumption that if all the seeds are charred, the changes caused by charring will be more or less similar. In addition, only undistorted grains were examined to take precautions against the various charring situations mentioned above. This calculation is expected to give an indication of whether or not the size of grains was reduced in periods of drought due to less favourable growing conditions.

3.1.5. Stable Carbon Isotope Analysis

Stable carbon isotope analysis is carried out in the free-threshing wheat, hulled wheat, and barley grains. The samples are taken from wide range of archaeological layers and different contexts as much as possible to see the change more clearly. Additionally, multiple seeds are sent to analysis, when possible, to identify the intra-sample deviations.

3.1.6. Determination of Plant Ecology

The plant ecology is a wide and complicated topic, but it is kept rather kept simple in this thesis just to understand the general characteristic of the wild plant taxa in the samples. By following the method in (Riehl, 1999, 2010a), the wild plants found in the samples are grouped according to their autecological behaviours (Riehl, 1999). These groups are called as eco-groups and there are four major eco-groups: open vegetation, dryland, wetland, weeds, and an unknown group. Open vegetation comprises a wide range of habitats. Normally, Riehl (1999) takes the dryland species under the open vegetation category. However, since knowing the dryland species is very essential to know for the scope of this thesis, it is taken as a separate eco-group. Thus, the plants that grow in the dry habitats are evaluated on their own. Wetland species basically refers to the plants that loves moisture and grows either in freshwater or coastal ecosystems. Weeds are the plants that grow in disturbed/arable lands, usually nearby the crops. The wild plants that are not identifiable to the genus level are categorized under the unknown group, so their ecological meaning is not clear.

3.1.7. Statistical Methods

The Correspondence Analysis is performed to see if the certain cereal plants are associated with certain strata. This statistical method is a data visualization and summarization technique introduced by Hirschfeld (1935) and has been used in many archaeobotanical studies before. The purpose of the Correspondence Analysis is to divide a data table into two groups (rows and columns) and show the connections between the values of these two groups on a two-dimensional graph (Abdi & Williams, 2010).

The Mann-Whitney U test is a statistical test that analyzes whether there is a statistically significant difference between two independent groups (Mann & Whitney, 1947). This test was chosen to test the relationship between morphometric measurements made on seeds because it is a non-parametric test. Non-parametric statistical tests are applied on samples that do not have a specific distribution, similar to the data studied in this thesis**.** The statistical analysis of the thesis is carried out with the XLSTAT plug-in in the Microsoft Excel.

3.2. DESCRIPTIONS OF SAMPLES AND THE LOCAL PHASES

This study excluded a number of contexts from Toprakhisar and Tell Atchana due new regulations of the Directorate of Cultural Heritage and Museums (under the Ministry of Culture and Tourism of Turkey) that prevent the circulation of the archaeobotanical samples in the country. Thus, the samples could not be brought to Middle East Technical University to be studied.

It also should be noted at the beginning that the dating of the local phases mentioned here are the revised and exact dating if they are based on a published study. The chronology of the local phases that are based on the excavation reports, however, may change following their assessment and reevaluation in the future.

3.2.1. Toprakhisar Samples

There is a total of 75 Toprakhisar samples analyzed in this thesis. These samples are coming from two separate Toprakhisar plan-squares: 51/52.37 and 54.38 (Figure 13). 67 of the samples belonging to the former whereas 9 of them are collected from the latter.

Figure 13. Photo shows the locations of 51/52.37 and 54.38 plan-squares. Photo: Murat Akar

3.2.1.1. 51/52.37 Plan Square

The excavations in this square started in 2016. At first, this trench was started to be excavated as two separate plan-squares: 51.37 and 52.37. However, since the stratification was same and construction groups were interrelating with each other for both trenches, they were merged and started to be evaluated as one trench. There were samples coming from 4 distinct phases of this plan square and they are as follows. The Local Phase 5 samples in Toprakhisar which coincides with the Early Bronze Age IVB period was unfortunately excluded from this study due to the new regulations of the Ministry of Culture and Tourism of Turkey.

3.2.1.1.1. Local Phase 1

This is the earliest phase in this trench. This phase is an architectural phase characterized by a usage of stone, and there are the remains of a modern period barn that was built after the area was leveled recently. There are no archaeobotanical sample coming from this phase of the trench.

3.2.1.1.2. Local Phase 2

This phase is dated to Middle Bronze Age. Phase 2 is marked by deep rubbish and pits, with no indications of structure remnants discovered. Because of their size and organic remains inside, some of these pits can be classified as silos (Akar & Kara, 2018b). Five samples coming from this phase is included in this study (Figure 17).

3.2.1.1.3. Local Phase 3

This phase is also dated back to MBA I period and represents the beginning of the 2nd millennium BC. This phase is characterized by the presence of a monumental building, Building 2 (Figure *14*). This structure was built entirely of sun-dried mudbrick without a stone foundation and more than one floor level. An outer space, a passageway, several narrow rooms, courtyards were the archaeological features related with the building. Building 2 fill and floor deposit contained variety of small finds related with food processing including grinding stones, pestles, weights, and chipped stones. In addition to small finds, the courtyards had 4 four distinctive decorated horseshoe shaped hearths that are closely placed to the storage jars, cooking pot, and grinding stones indicating that the courtyards were also engaged with cooking activities (Akar

& Kara, 2018a).

The several floor levels of the building indicates that the building was in use for a long time period with small changes and adaptations. The sub-levels of the building are identified as “3a, 3b, 3c” from the latest to the earliest. The latest phase, 3a, had the signs of fire destruction. This phase also produced the highest amount of archaeobotanical data for this study. The total number of samples coming from this phase and analyzed is 59.

Figure 14. Aerial view of Phase 3 monumental building, Building 2, in 51/52.37 plan square Retrieved from (Akar & Kara, 2018a, p.271)

3.2.1.1.4. Local Phase 4

The Local Phase 4 represents the level that coincides either with the end of EBA or the beginning of the MBA (Akar & Kara, 2020). The ceramic finds suggested that this layer was occupied during the end of the 3rd millennium BC and beginning of the 2nd millennium BC. Thus, the traces of the collapse at the end of the EBA that affected the Near East is visible in the Phase 4 of Toprakhisar Höyük. The existence of granaries, irregular industrial type ovens and hearths suggests that the area was used as a workshop or shared space by the people. Besides these finds the architecture in this phase was weak. This phase also has two sub-levels, 4a and 4b, from earliest to latest. The total number of samples in this thesis coming from Phase 4 is 3 (Figure 17).

The pits of Phases 2 and 3 obliterated Phase 4b. The existence of four separate structures in 4b level (Figure 15) was indicated by the remains of stone foundations contacting one other but demolished by the pits. Two small-scale structures labeled 4b-1 and 4b-2, as well as adjacent furnace and kiln remnants, suggested that the structures might be connected to ceramic and metal production. As the majority of the 4b-3 and 4b-4 structures were beyond the borders of excavation area, the excavators were not able to identify them in detail.

Figure 15. Relationship between Phase 4b (left, on 52.37) and Phase 3 (right, on 51.37)

(Photo: Toprakhisar 2018 Season Excavation Report).

Phase 4a (Figure 16) had scarce in architectural remains just was the case for the 4b level. Besides having a structure small in scale, the 4a level also had distinctive stone foundations suggests that there were numerous stone structures. The presence of an oven which had vitrified inner surface points that this level was also used as a workshop. The loci descriptions of all the phases from 51/52.37 plan square are given in the Table *27* and Table *28* in Appendix B.1.

Figure 16. Aerial view of the Phase 4a on 52.37 plan square. (Photo: Toprakhisar 2018

Season Excavation Report)

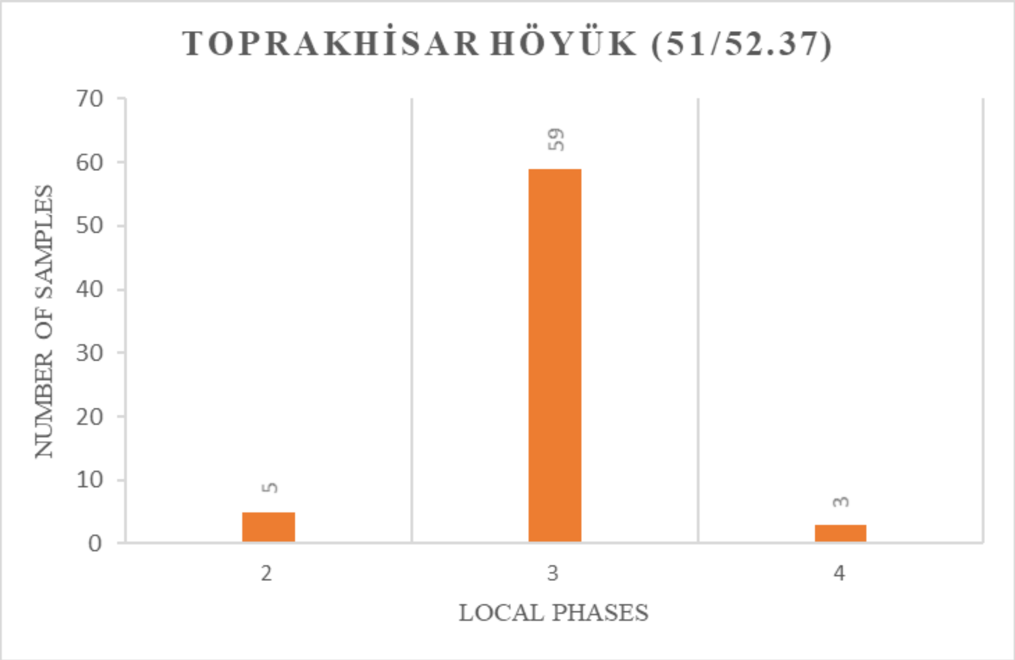

Figure 17. Graph shows the number of Toprakhisar samples coming from different phases of 51/52.37 plan square.

3.2.1.2. 54.38 Plan-Square

The excavations in the 54.38 plan-square were started in 2018. This plan-square has two phases that their samples are included in this study. This trench was characterized by the presence of large and small scaled grain silos/granaries. The discovery of large-scale storage facilities prompted excavators to consider the impact of the 4.2 ka BP climate shift at the end of EBA (Toprakhisar 2018 Season Excavation Report). As a result, this plan-square is crucial for understanding these impacts at Toprakhisar Höyük.

3.2.1.2.1. Local Phase 1

Phase 1 is dated to the transition period from 3rd millennium-2nd millennium BC. In this phase, many pits were discovered. These pits were classified as garbage pits because of the abundance of bone and pottery discoveries. There were also the skeletal remains of two people discovered. The burial positions of the skeletons showed that they were dumped in the pit rather than properly buried. According to the researchers of the site, this kind of mortality might be reflection of the collapse and turmoil in Toprakhisar Höyük at the end of the EBA, which impacted most of the Near East (Toprakhisar 2018 Season Excavation Report). Only 2 archaeobotanical samples from this period were analyzed (Figure 19).

3.2.1.2.2. Local Phase 2

As was the previous phase, Phase 2 also represents the transition period from 3rd millennium BC to 2nd millennium BC. Several silos used for the storage of grain were found in Phase 2. One of these silos (Figure 18, L.3) was particularly salient because of its largeness and the care that was given during its construction. It had nearly 2.5 m depth and 1.9 m diameter. There were also structures related to this silo suggesting that it was a multi-compartment silo. There might be 3 additional silos (L.20, L.24, L.27) that might be constructed with the same technique with Silo 3, but they were not excavated as large parts of them were located outside the plan square. Another silo that was not built with the same care as Silo 3 was a basic pit, but it was a sizable structure with a depth of 1 m and a diameter of 2 m. Excavators at the site estimated that each silo could hold 7 tonnes of grain on average, based on their size (Toprakhisar 2018 Season Excavation Report). The number of samples analyzed from this phase was 6 (Figure 19). The loci that the samples taken in 54.38 plan square are described in the Table 29 in Appendix B.1.

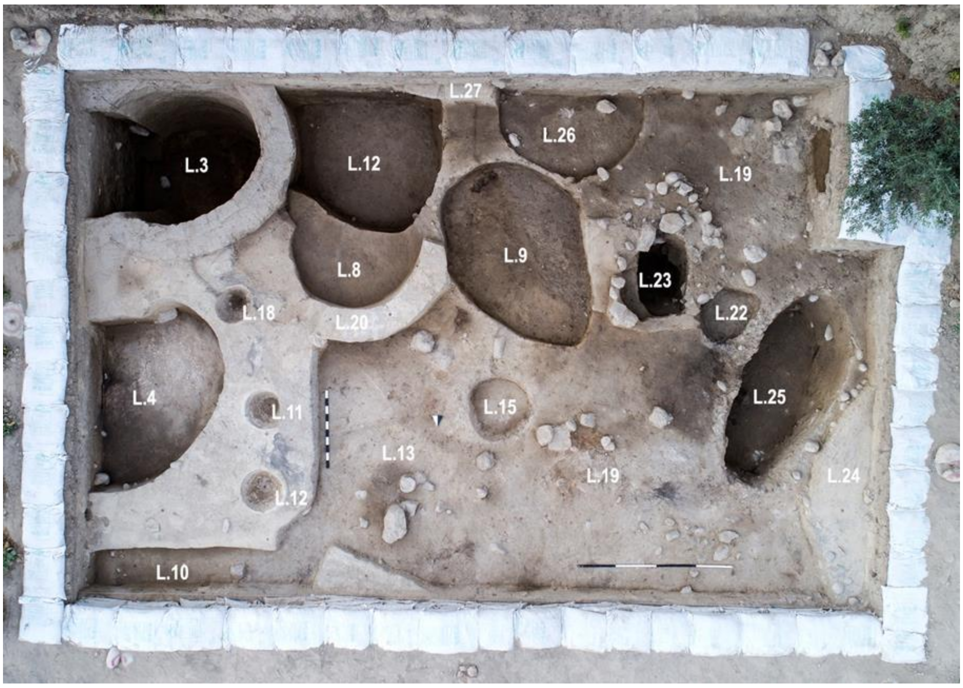

Figure 18. Aerial view of Phase 2 of 54.38 plan square.

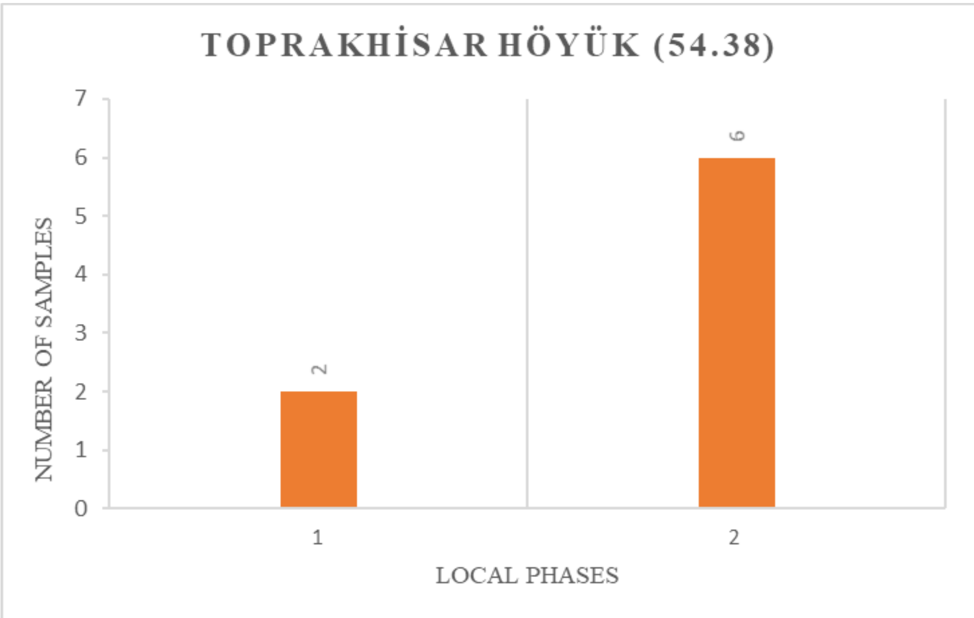

Figure 19. Graph shows that the number of Toprakhisar samples coming from different

phases of 54.38 plan square.

3.2.2. Tell Atchana Samples

The total number of samples taken from Atchana for the analysis is 209. 120 of them are coming from 42.10 plan-square, whereas 89 are belonging to 32.57 plan-square of Atchana. The plan in the beginning of this study was to include only the 42.10 samples. However, since the remains from this plan square was mostly badly preserved, additional samples were needed. Thus, the samples of 32.57 were also included. However, since they were previously studied by another team at University of Oxford and since they did not publish the data of these samples, to prevent the conflict of interests the taxonomic details of these samples are not presented in this thesis. Rather, only the morphometric measurement and isotopic results of the seeds that were chosen among these samples are presented. The 42.10 samples, on the other hand, are fully evaluated in every aspect.

In addition to 42.10 and 32.57 plan square samples, there is also one additional plan square that samples were taken for morphometric measurements, 33.32. Barley and wheat grains were selected from the samples of this trench, which originally is an MBA (17th century BC) kitchen context and studied by another graduate student, Seren Burgaç, to compare the grains size between MBA and LBA. In total, the size of 22 free-threshing wheat and 24 barley grains were measured from this trench, however, since the measurement results of barley grains are not presented in this thesis as the number of measurable barley grains of other trenches was very low to get relevant conclusions.

3.2.2.1. 32.57 Plan Square

This plan-square started to be excavated in 2006. The trench is located in the courtyard of the Level IV Palace of Alalakh. It was started to be excavated to understand the chronology between Level VII and Level IV Palaces and to understand the relation of the latter with the other parts of the mound. There are 4 distinct phases that the samples retrieved from 32.57 plan square.

3.2.2.1.1. Local Phase 2

This phase is dated back to time period between ca. 1550-1400 BC. This is the earliest phase that the 32.57 plan-square samples come from. It has three different floor levels namely 2a, 2b, and 2c from the earliest to the latest. Phase 2a level contained a structure consisted of a kitchen, and a room. The kitchen had six different fire installations. There were two cooking activity related trash deposits and two pits, two water drainage features and a silo.

In Phase 2b, a room with five surrounding rooms, and a well were the among the major structures. In addition to these, a semi-roofed area reserved for cooking or bread-making were present with active trash pits (Figure *20*).

The Phase 2c, a plastered room was found with five other surrounding rooms. This level also had an outdoor area with a trash pit and a drain or doorway. A building with a middle room, a courtyard and drainage system were also unearthed in this level (Figure *21*) (Tell Atchana, 32.57 Plan Square, 2008 Season Excavation Report). The total number of samples retrieved from this phase is 29 (Figure *31*).

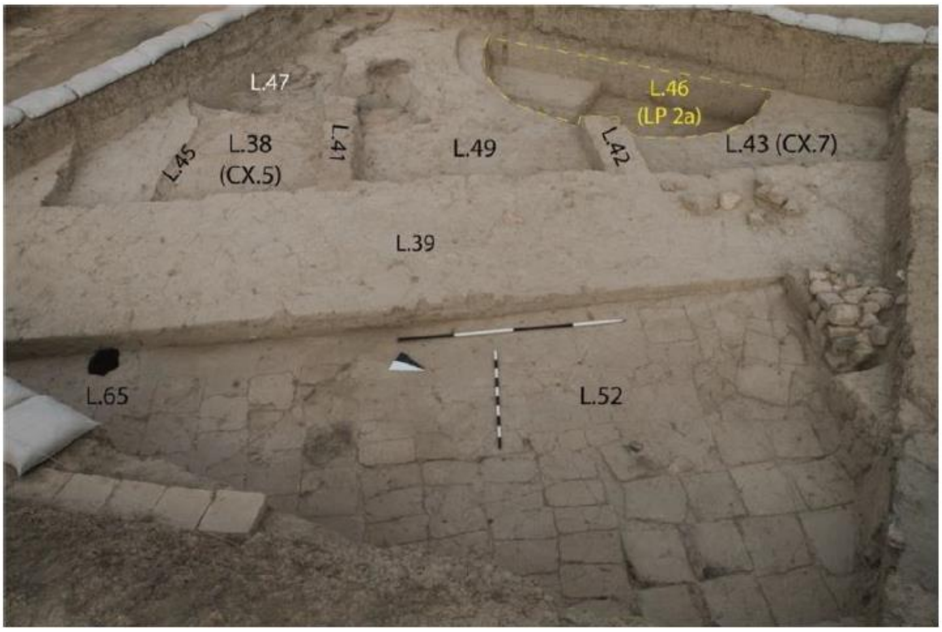

Figure 20. Aerial view of Phase 2b of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

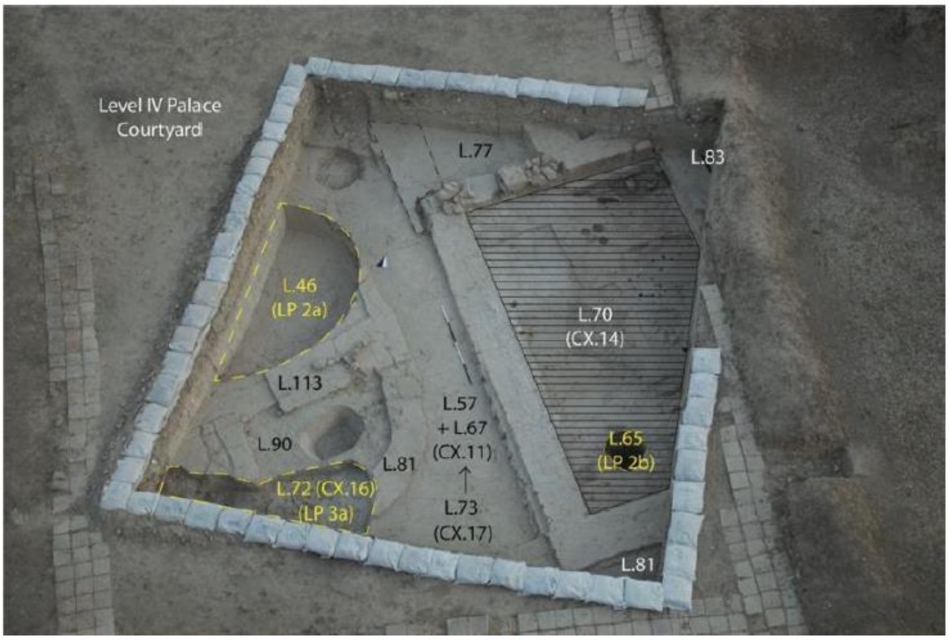

Figure 21. Aerial view of Phase 2c of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

3.2.2.1.2. Local Phase 3

This phase is dated back to the first half of the 16th millennium BC (ca. 1600-1550 BC). This period represents the transition from LBA I to MBA II period. There were 5 distinct subphases, from 3a to 3e. The Phase 3a had two rooms, one with kilns and another one with burnt floor. There was also a street surface with deposits related to outdoor. In the west of the trench there was another building with its middle room, outdoor kitchen, and drains (Figure *22*) (Tell Atchana, 32.57 Plan Square, 2008 Season Excavation Report).

The Phase 3b, the east of the plan square contained a burnt floor fill. In the middle, there was a room with a burial, and a street. The west of the trench was occupied by a building with a middle room and an outdoor kitchen and related features (

Figure 23) (Tell Atchana, 32.57 Plan Square, 2008 Season Excavation Report).

The Phase 3c was characterized by the presence of a street which contained high amounts of pottery sherds and bone remains. The west of the mound was disturbed by a silo belonging to Phase 2a. In the south of the mound, there were ashy areas indicating that there might be a tandır or hearth in that area (Figure *24*) (Tell Atchana, 32.57 Plan Square, 2009 Season Excavation Report).

The Phase 3d witnessed new architectural structures besides carrying traces from the previous period. A new street floor that had intensive bone and pottery sherds was present in this phase as was the previous phase. The southwest area of the plan square, a room with a floor covered with bones and pottery remains was newly found. A circular, partially preserved tandır was present in the south. The northeast of the trench was characterized by the patchy burnt areas and circular pits in different dimensions indicating that this area might be related to ceramic production. In the southeast part, a trash pit was unearthed which contained mixed material and burnt areas. In the west of the trench, the silo that belong to the 2a phase was still continuing to disturb the 3d level (Figure *24*) (Tell Atchana, 32.57 Plan Square, 2009 Season Excavation Report).

In Phase 3e a new street floor was excavated. The direction and structure of this newly excavated street level was same with the previous ones but only it was smaller. Similar to the mentioned phases, it had also concentrated bone and pottery sherd remains. The Phase 2a silo extended to this phase as well. The east of the had a water well that largen in the deeper parts (Tell Atchana, 32.57 Plan Square, 2009 Season Excavation Report).

The total number of archaeobotanical samples coming from Phase 3 levels was 30 in total (Figure *31*). Samples from all the sub-levels were analyzed except 3e.

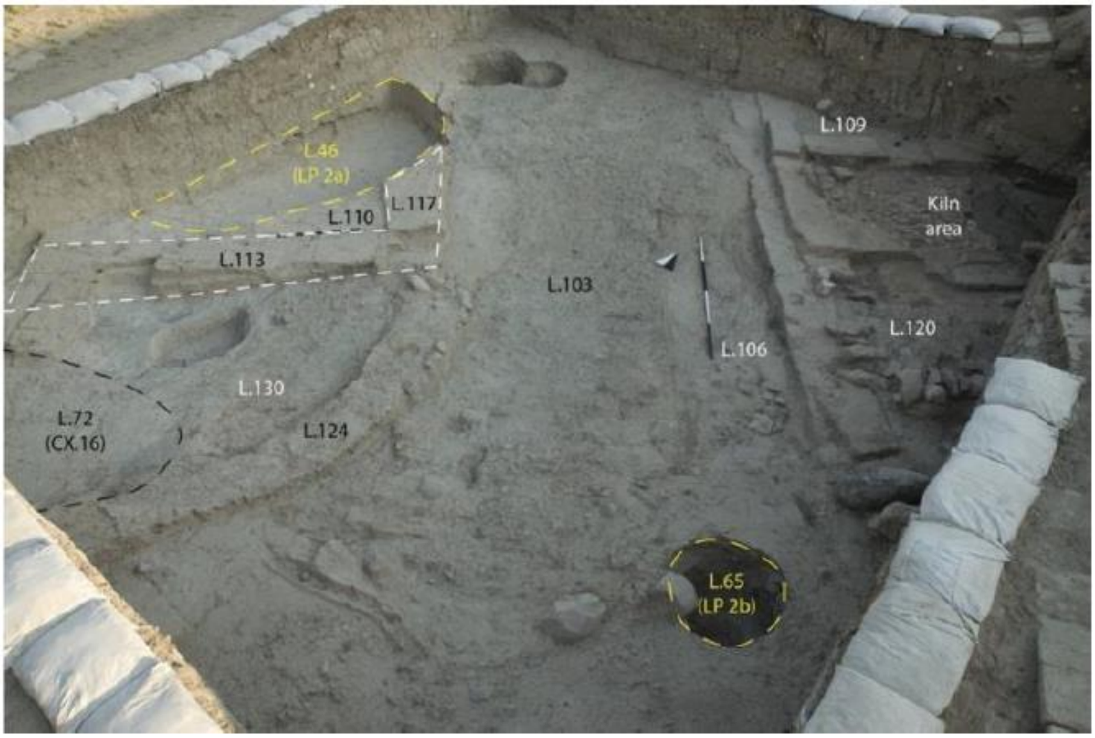

Figure 22. Aerial view of Phase 3a of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

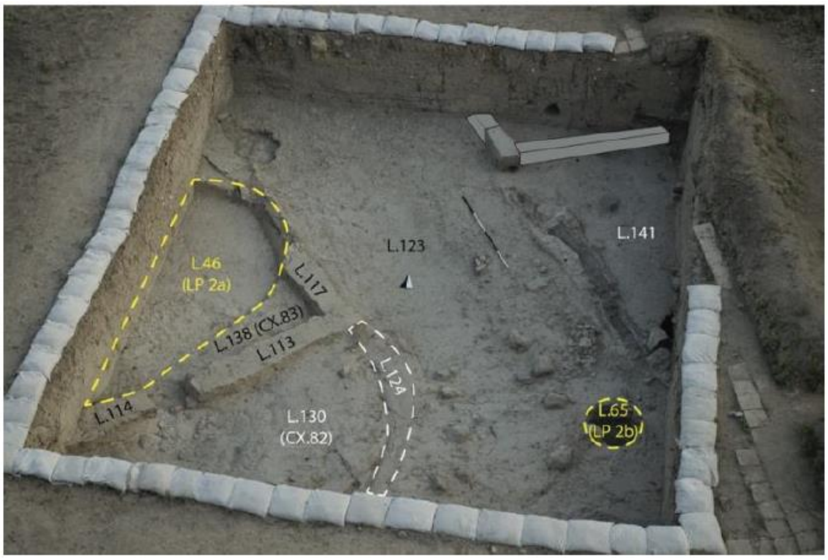

Figure 23. Aerial view of Phase 3b of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

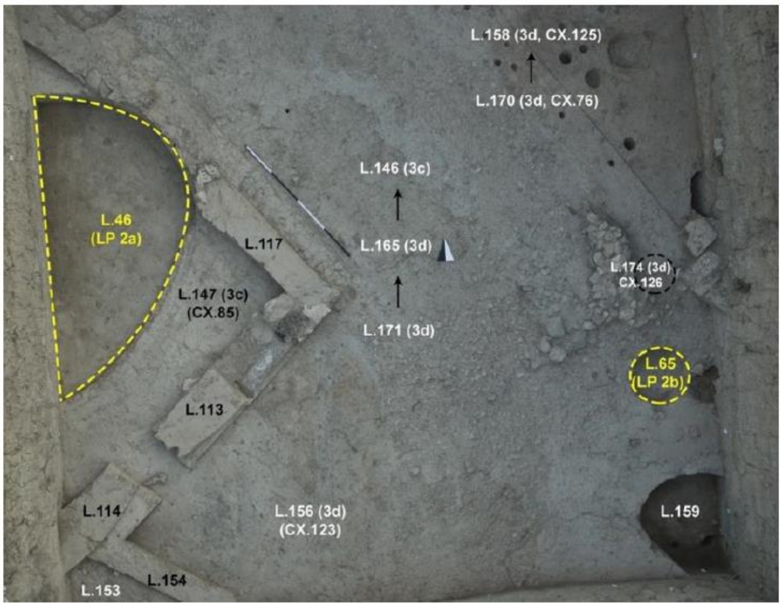

Figure 24. Aerial view of Phase 3c and 3d of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

3.2.2.1.3. Local Phase 4

This phase represents the time period between ca. 1650-1600 BC. In Phase 4, a large circular pit that bordered with burnt areas under the Phase 3e street was unearthed. It had been found that this pit was a trash pit in the continuing days of excavation. The organic refuses were probably burnt in this pit suggested by the second burnt floor level in the pit (Tell Atchana, 32.57 Plan Square, 2009 Season Excavation Report) (Figure 22). Two archaeobotanical samples were retrieved from this phase (Figure 29).

Figure 25. Aerial view of Phase 4 trash pit (at the center) and surrounding floor level of 32.57 plan square (Tell Atchana, 32.57 Plan Square, 2009 Season Excavation Report).

3.2.2.1.4. Local Phase 5

This phase dated back to MBA II period (ca. 1750-1650 BC). The Phase 5 had a long time of usage. It had six different sub-levels from 5a to 5f. In Phase 5a, a room and its surrounding walls were unearthed in the north of the trench. There were intensive burnt areas in this room probably caused by the fire that affected the walls. The main walls were disturbed by the trash pit belonging to Phase 4. In the northeast of the trench, a floor level that contained high concentration of bone and pottery sherds. Since this floor level was large and was not in the form of a room, it was identified as street. A circular trash pit was uncovered in the southeast area of the trench which was adjacent to the trash pit from Phase 3d. The silo belonging to 2a phase continued to destroy the west of the trench in this level (Figure *26*).

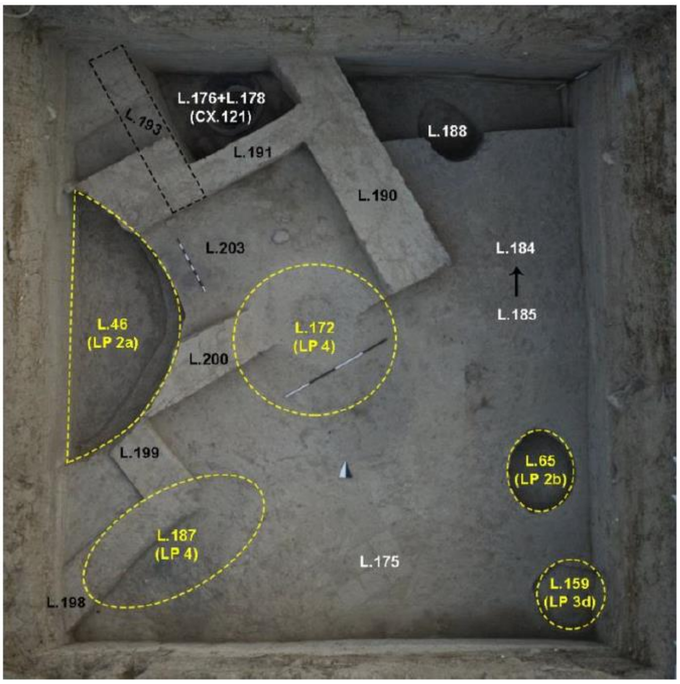

Figure 26. Aerial view of Phase 5a from the northwest of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

The major architectural structure in the Phase 5b was an apsidal wall. The east of this wall was a street. The central part of the was a floor level that was bordered with several walls. In the west, the Phase 2a silo continued to exist (Figure *27*).

The Phase 5c witnessed the enlargement of the main walls. However, to the south of the trench, the apsidal wall was interrupted and terminated by the street floor. There were unearthed a new floor and a tandır. Near the northeast corner of the trench, remains that could be a possible oven were unearthed, but it was not completely excavated as its originally located outside the borders of the trench. In the area near the southwest corner of the trench, two garbage pits that were located side by side were uncovered. The presence of Phase 2a silo was continued also in this phase in the west of the trench.

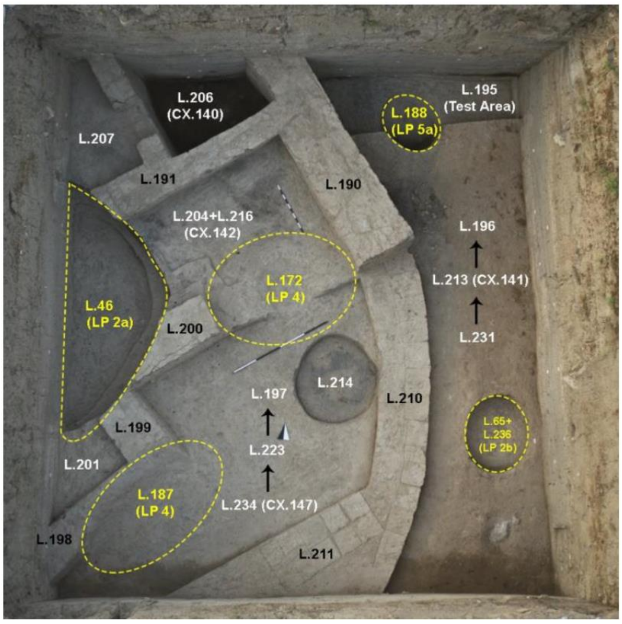

Figure 27. Aerial view of Phase 5b of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

The Phase 5d did not witnessed major changes in architecture. In the floor of 5c, there was a new floor level was unearthed belonging to Phase 5d. The 2a silo was present in this phase as well.

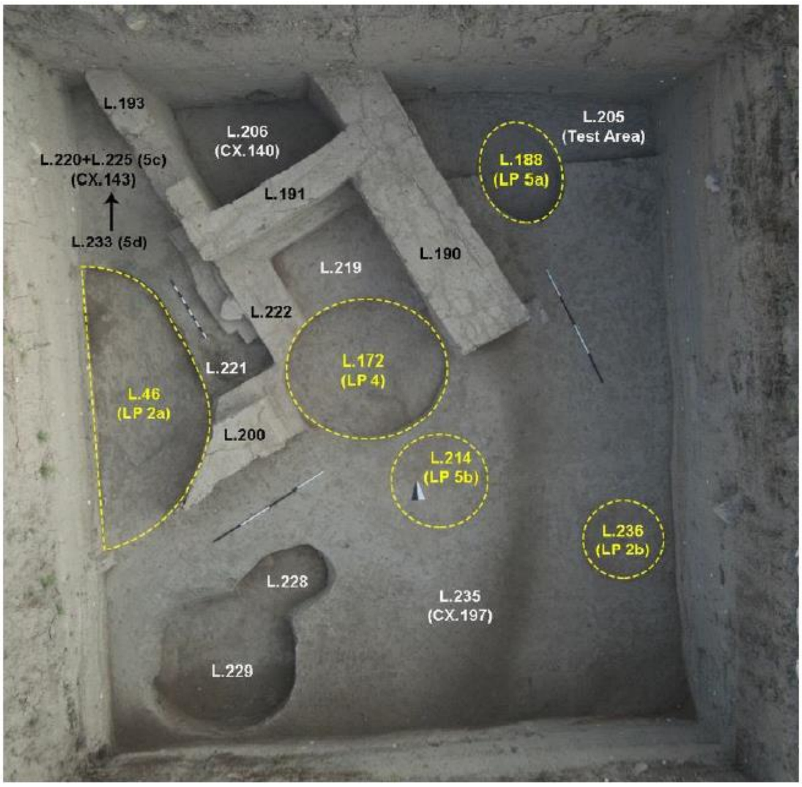

Figure 28. Aerial view of Phase 5c and 5d of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

In the Phase 5e, the main walls of the trench did not change much. In the middle of the trench, there was unearthed a room with several surrounding walls. This room was probably a furnished room. A new street floor was uncovered in the northeast corner of the trench. The Phase 2a silo ended in this phase (Figure *29*) (Tell Atchana, 32.57 Plan Square, 2011 Season Excavation Report).

In the 5f phase, there were new architectural structures unearthed. In the southeast of the newly excavated floor, there was a tandır. Excavators of the trench suggested that the existence of the tandır and its evident multiple time usage might be the indiactor of that this area might be an inner courtyard or kitchen area (Figure *30*) (Tell Atchana, 32.57 Plan Square, 2011 Season Excavation Report).

The total number of samples taken from this phase is 28 (Figure *31*). The samples were coming from all the phases except 5e.

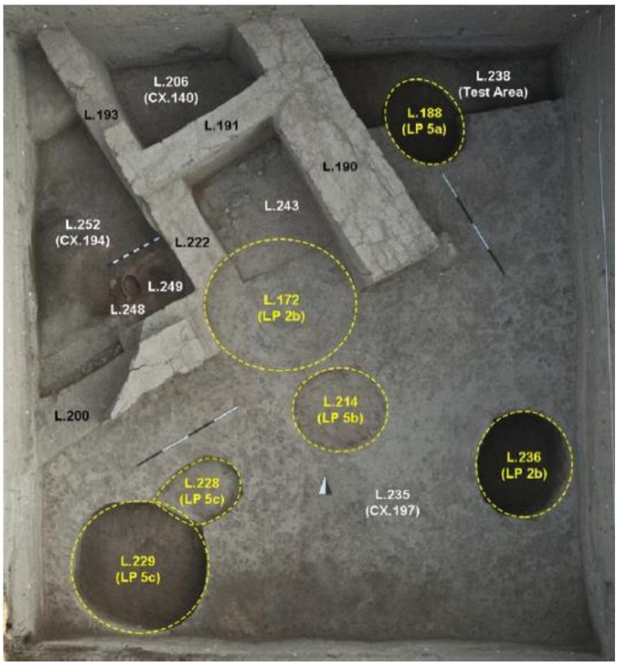

Figure 29. Aerial view of Phase 5e of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

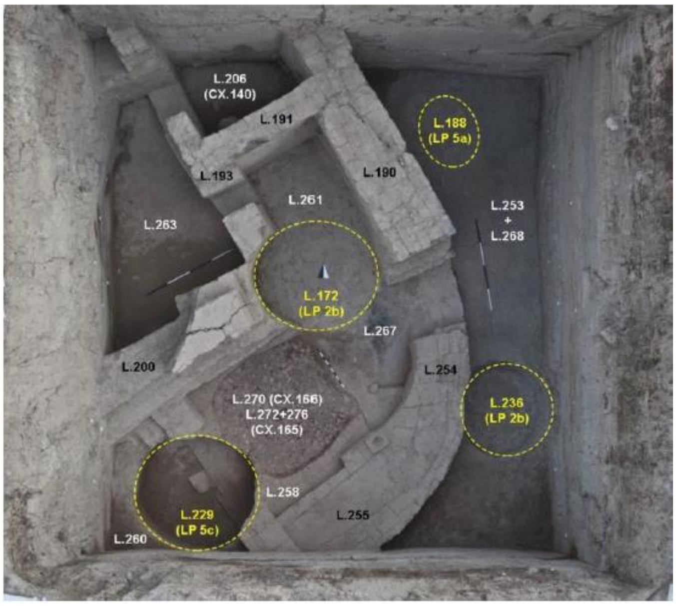

Figure 30. Aerial view of Phase 5f of 32.57 plan square. Yellow dotted areas represent the features belonging to previous phases (Alalakh Excavations Archive).

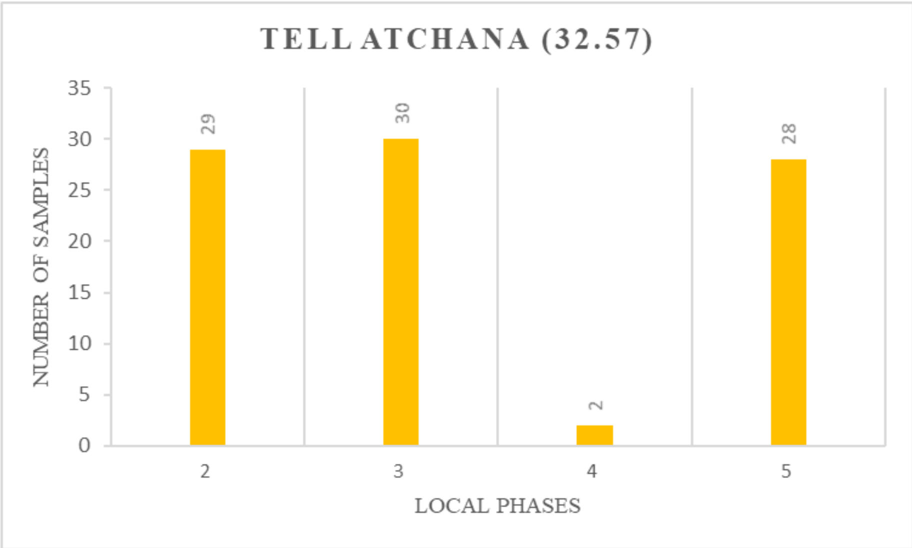

Figure 31. Graph shows the number of Atchana samples coming from different phases of 32.57 plan square.

3.2.2.2. 42.10 Plan-Square

This plan-square has started to be excavated in 2012. The trench is the part of the temple area which was continuously used throughout the several phases of occupation at Tell Atchana. There are 6 distinct phases that the samples retrieved from 42.10 plan square.

3.2.2.2.1. Local Phase 3

This is the earliest phase that the 42.10 samples are coming. This phase dated to the transition period between LBA to Iron Age. The phase was two distinct floor levels identified as 3a and 3b. In Phase 3a, the most prominent structure in this phase was burned mudbrick pieces that lined up from one edge of the trench to the another (Figure *32*, L.18). According to the excavators, this line of mudbricks might represent a foundation wall where a water canal was excavated through. In Phase 3b, there was found a floor (L. 20) that contained numerous in situ pottery and a pyrotechnical installation (L.21). This installation and the floor around it had iron and glass pieces and metal objects remains suggesting that it was related with metal and metal object production (Tell Atchana, 42.10 Plan Square, 2012 Season Excavation Report). L.20 floors also contained intensive bone and shell remains. The number of archaeobotanical samples coming from this phase was only 2 (Figure 39).

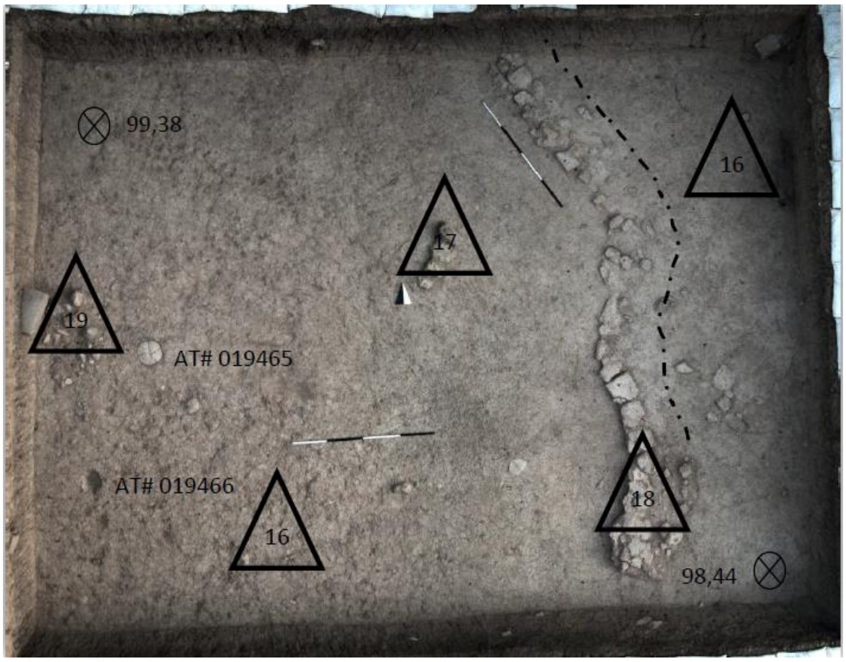

Figure 32. Aerial view of Phase 3a of 42.10 plan-square (Yener & Akar, 2013, p.7)

3.2.2.2.2. Local Phase 4

This phase is dated back to the LBA II period (1300-1200 BC). It has two sub-phases 4a and 4b. In Phase 4a, the most characteristic feature of this phase was a large domestic building. L.31 (Figure 33) was defined as the main room that daily activities took place. This room had ashy area (L. 26) which might be a hearth, pottery vessels and bones. In the other half of the trench two more floors were present (L.37, L.39). L.39 had a big circular silo (L.40) probably built for the storage of the grain outside the domestic structure. Again, L.39, also had a tandır (L.36) which one of the Phase 4 archaeobotanical samples came from. In addition to these, the L.39 floor had small traces of pavement with fire activities that appeared with circular ashy areas. These ashy areas contained bones and sherds which some of them were burnt. The total number of samples retrieved from this phase is 18 (Tell Atchana, 42.10 Plan Square, 2014 Season Excavation Report, Figure *41*).

Figure 33. Aerial view of Phase 4a of 42.10 plan-square (Yener et al., 2016, p.323)

The Phase 4b (Figure *34*) was the phase that the domestic structure in 4b first appeared. As in the case for Phase 4a, the main room in the 4b also used as a working area for daily activities. The floor of this room also had few complete pottery vessels and bones. The hand-stones, whetstones, and stone mortar pointed that this room was also used as a food preparation area. In the outer part of this room, there were found one small and one big tandır. Excavators noted that this tandırs probably used for cooking, but they also might be used for other purposes. In that phase, an elephant scapula was also among the finds indicating that the inhabitants of this house were prestigious people, and some of them probably were related to the temple. The total number of samples coming from the Phase 4 is 18 (Figure *41*).

Figure 34. Aerial view of Phase 4b of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2015 Season Excavation Report).

3.2.2.2.3. Local Phase 4/5

This phase was the transitional phase between the Phase 4b and 5. There were found two different floors separated by an artificial line. In both floors, there were ashy areas. This phase also contained a tandır and a circular pit, the latter had animal remains and several types of pottery. This pit was associated with the sacrificial purposes related to the closing or the construction of the building. 5 samples from this transitional phase are analyzed for this study (Figure *41*).

3.2.2.2.4. Local Phase 5

This phase (Figure 35) is dated back to the time period between ca. 1350-1300 BC. Large scale building which was probably a private residence was the major structure of this phase. Two tandırs were found in the main room of this building. As in the case for later phases, this main room was more likely used as a central court-entrance room and had the traces of daily activities with pottery vessels and bones. Several burnt areas were present in this room. Other, partly excavated, 2 rooms contained 2 tandırs, too. The other part of the plan-square had two distinct external floors. One of them contained a big tandır and a big circular ashy pit that had bones and pottery sherds in it. The number of samples coming from this phase is 6 (Figure *41*).

Figure 35. Aerial view of Phase 5 of 42.10 plan square (Yener et al., 2017, p.411).

3.2.2.2.5. Local Phase 6

This phase is dated back to the second half of the 14th century BC (1350-1300 BC). the phase has two sub-phases, 6a (Figure *36*) and 6b (Figure *37*). The Phase 6a was also characterized by a building which consists of a large inner courtyard (L.80) and four rooms attached to this courtyard (L. 71, L.72, L.79, and L.78). The inner courtyard had a sacrificial pit (L.67) that contain a skeleton of a cattle and pottery sherds, and a sunken jar. Room L.77 had ashy spots. Intensive pottery sherds and animal bones were found here (Tell Atchana, 42.10 Plan Square, 2016 Season Excavation Report).

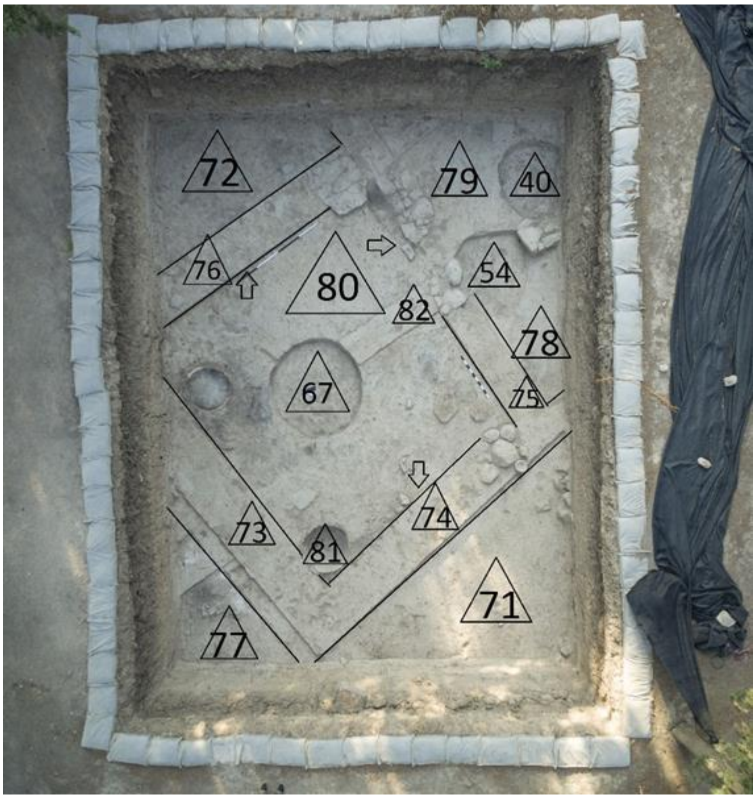

Figure 36. Aerial view of Phase 6a of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2016 Season Excavation Report)

The building in Phase 6a had its foundations in the Phase 6b. In the latter, the inner courtyard was larger. There were ashy spots in the floor of this courtyard because of three tandırs found in it. With the finds of Phase 6b, excavators suggested that this inner courtyard was the central place of a service building. Room L.72 was in use at this stage as well evidenced by the two large grinding stones placed at the floor level of it. The room also contained lots of pottery sherds and bones (Tell Atchana, 42.10 Plan Square, 2017 Season Excavation Report). Total number of the archaeobotanical samples coming from Phase 6 is 26 (Figure *41*).

Figure 37. Aerial view of Phase 6b of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2016 Season Excavation Report).

3.2.2.2.6. Local Phase 7

This phase is dated back to the first half of the 15th century BC (ca. 1400-1350 BC). One unique feature found in Phase 7a was a workshop area in L.105 (Figure *38*). This phase also had building with an inner courtyard (L.102), an outer space (L.105). The findings of the inner courtyard suggested that this place was used as a metal workshop besides food preparation. The outer space of the building contained a trash pit (L.107). Numerous animal bones were found in this pit.

Phase 7b (Figure *39*) was also characterized by a building that served for the temple as in the case for the earlier phases with one inner courtyard (L.117), two rooms (L.97 and L.98) and several workshops (L.113, L.114, L.121). The L.119 represents the outer space of the building. The inner courtyard had a trash pit and two small walls probably built to create a workshop area. The room L.97 had mudbrick platforms, again, to create a bench for a workshop area. The Room L. 98 was disturbed by a sacrificial pit belonging to the Phase 6 (L.99). The outer space L.119 produced a great number of sherds, stone objects, bones, and stone pieces. The outer space had a trash pit that contained lots of partly burnt animal bones. -

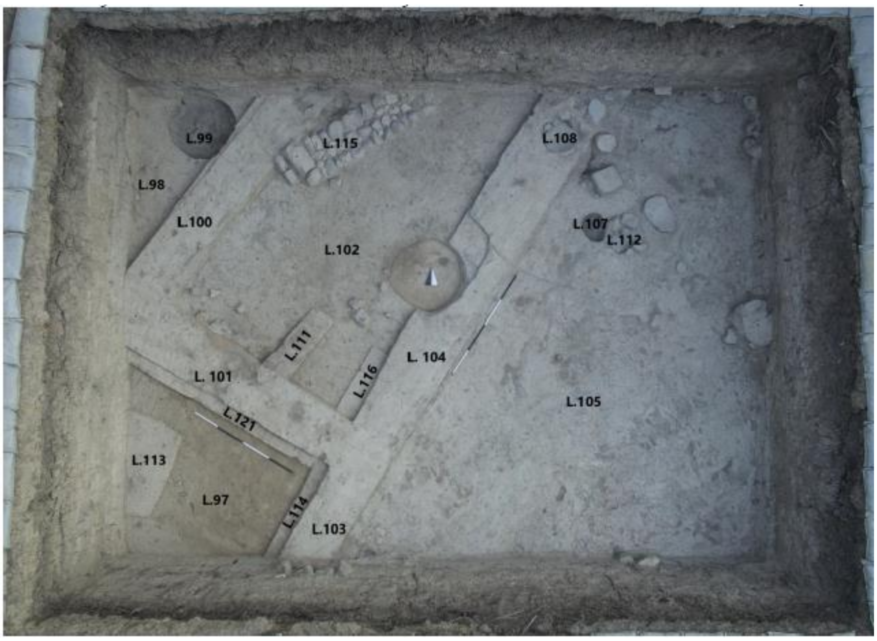

Figure 38. Aerial view of Phase 7a of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2018 Season Excavation Report)

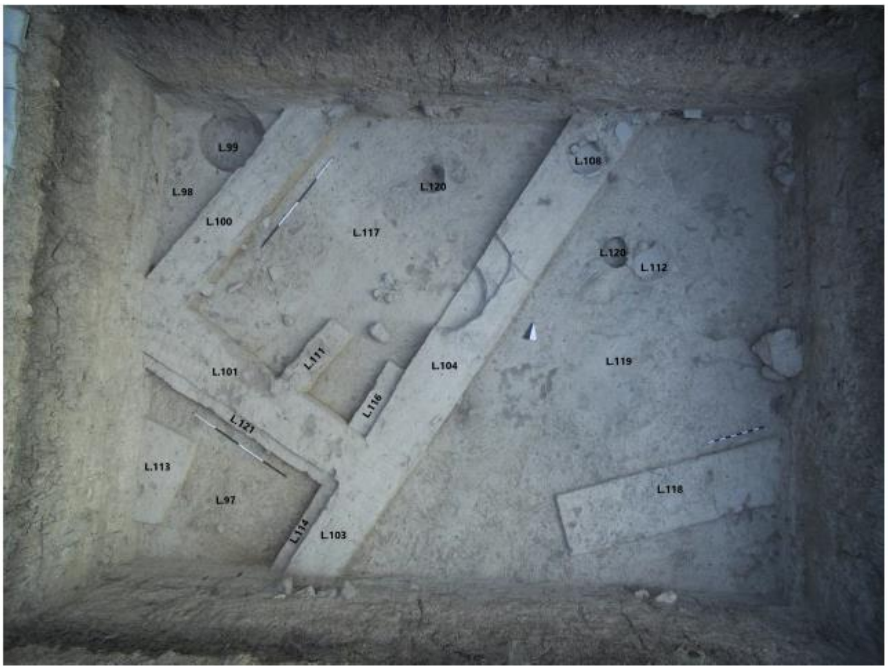

Figure 39. Aerial view of Phase 7b of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2018 Season Excavation Report).

The transition Phase 7c/7b was identified by the presence of a sacrificial pit (L.136) unearthed in Room L. 136. The pit contained animal bones belonging to the 5 different animals, pottery sherds and broken plate (Tell Atchana, 42.10 Plan Square, 2019 Season Excavation Report).

In Phase 7c (Figure *40*), the inner courtyard of the later phases was divided by a wall (L.135). The building comprised of four rooms (L.126, L.133, L.134, L.136) in this phase. The L.126 was served as an inner courtyard. It had a hearth (L. 151) in its southeast, and a burnt grain silo (L.148) in its northwest. Room L. 133 was probably related with water as there were found a water outlet and a drainage system. Totally 66 samples belonging to Phase 7 are analyzed in this study (Figure *41*) (Tell Atchana, 42.10 Plan Square, 2019 Season Excavation Report). The descriptions of loci from 42.10 plan square are given in the Table *30* in Appendix B.2.

Figure 40. Aerial view of Phase 7c of 42.10 plan square (Tell Atchana, 42.10 Plan Square, 2019 Season Excavation Report).

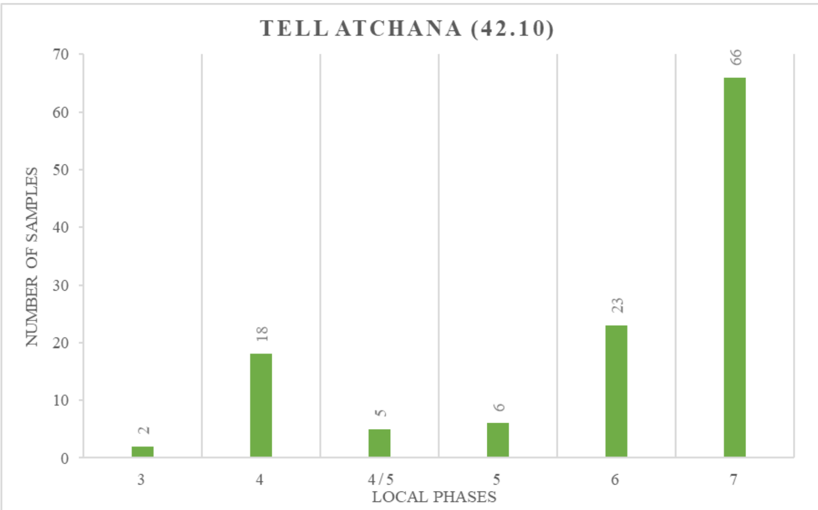

Figure 41. Graph shows the number of Tell Atchana samples coming from different phases of 42.10 plan square.

3.2.3. Summary of Samples and Analysis

ARCHAEOBOTANICAL SAMPLES OF THE STUDY							
Site	Plan-square	Local Phase	Date (ca.)	Proportion/Ubiquity Analysis	Morphometric Measurements	Weed Ecology	Isotope Analysis
Tell-Atchana	42.10	3	1200-1100 BC	✓		✓	
		4	1300-1200 BC	✓	✓	✓	✓
		4/5	1325-1275 BC	✓	✓	✓	✓
		5	1350-1300 BC	✓		✓	✓
		6	1350-1300 BC	✓	✓	✓	✓
		7	1400-1350 BC	✓			✓
	32.57	2	1550-1400 BC	✓			
		3	1650-1550 BC	✓			
		4	1650-1550 BC	✓			
		5	1750-1650 BC	✓	✓		✓
	33.32	1	1750-1650 BC	✓	✓		✓
Toprakhisar Höyük	51/52.37	2	2000-1900 BC	✓		✓	
		3	2000-1900 BC	✓	✓	✓	✓
		4	2100-2000 BC	✓		✓	
	54.38	1	2100-2000 BC	✓		✓	
		2	2100-2000 BC	✓	✓	✓	✓

CHAPTER 4

RESULTS AND DISCUSSION

4.1. DESCRIPTIVE ANALYSIS OF CEREALS

4.1.1. Toprakhisar Höyük

4.1.1.1. 51/52.37 and 54.38 Plan-squares

4.1.1.1.1. Counts & Proportion

In the 67 samples coming from 51/52.37 and 8 samples from 54.38 plan squares, the crop plant taxa are represented with oat (*Avena sativa*), hulled wheat species (*Triticum monococcum/dicoccum*), free-threshing wheat species (*Triticum durum/aestivum*), indetermined wheat grains (*Triticum* sp.), barley (*Hordeum vulgare*), indetermined cereal grains, einkorn wheat spikelet fork, emmer spikelet fork, macaroni wheat rachis segment, indetermined cereal rachis node/rachis internode/rachis segment/rachis lemma-palea, indetermined legumes (Fabaceae), grape (*Vitis vinifera*) seed fragments and pedicels and olive (*Olea europaea*) fragments (see Appendix C.1. for exact counts). Both trenches are evaluated together in the following paragraphs as they represent a continuous time period.

The samples of Toprakhisar Höyük are not very rich in plant remains, in general (Table *2*). When the count results are evaluated from the earliest phase to the latest, the samples of 54.38 plan-square produces 169 plant remains belonging to crop plants in Phase 2, this number is 59 in the Phase 1 of the same trench. The 51/52.37 plan square only has 25 remnants belonging to crop plant taxa in the three Phase 4 samples. The most numerous remnants are found in the Phase 3 (n=436) of the same trench, probably, resulted from the high number of samples. The latest phase, Phase 2, has 98 crop plant remains.

Among the cereal plants that are the focus of this thesis (namely, hulled wheat, free-threshing wheat, indetermined wheat, barley grains and cereal chaffs), the hulled wheat species are only present with one seed in the Phase 2 of 54.38 plan-square. The number of the seeds belonging to this plant taxa does not change significantly in the following phase and increases to 4 grains. The Phase 4 of 51/52.37 plan square does not have any remains of hulled wheat grain. In the Phase 3, there are found some grains belonging to these wheat type, but they are not numerous (n=11) even though the number of samples is high. Hulled wheat species are represented with few grains (n=4) in the Phase 2 as well.

Free-threshing wheat is not numerous throughout the different phases similar to the hulled wheat. 3 grains of these cereals are found in the Phase 2 of 54.38 plan square. However, they are totally absent in the samples of Phase 1. The Phase 4 samples of 51/52.37 plan square also has no grains belonging to these species. The number increases in the Phase 3 samples and reaches nearly to 20 grains (n=19). But, in the Phase 2 samples, their number decreases again nearly to half (n=8).

The number of indetermined wheat grain is not much numerous than the identifiable wheat grains in the samples coming from 54.38 plan square and from the samples belonging to the earliest phase of 51/52.37 plan square. 7 grains for each phase of the 54.38 are found. In the Phase 4 samples of 51/52.37, this number is only 1. However, in the Phase 3 of this latter trench, the number of indetermined wheat grains suddenly increases and reaches to 96 with the increasing sample number. In the Phase 2 the number decreases again to 20 grains.

Barley grains are also present in scarce amounts. The Phase 2 of 54.38 has 7 seeds of barley. In the following period, it decreases to 3 grains. The Phase 4 of 51/52.37 plan square does not have any remains of barley grain. In Phase 2 of this trench the number increases slightly (n=15) and decreases again in the latest phase (n=9).

The chaff remains are present in several forms belonging to several species even though they are scarce in number. First of all, the spikelet fork remains evidence that both einkorn wheat and emmer wheat are present in the samples. Also, one rachis segment belonging to macaroni wheat suggests that this species was present in the earliest phase of Toprakhisar samples, however, it is not clear if it was extensively produced or just mixed to the samples as a crop product as only one remain is found. Other chaffs include rachis nodes, internodes, rachis segments and lemma/palea in differentiating numbers, but they are not numerous and hard to interpret.

The proportions of the remains are calculated by finding the percentage of the number of certain plant species in the total counts of the plant group that it belongs. Thus, the proportions are calculated separately for crop plant taxa and wild plant taxa. As this section of the thesis is only dealing with the some of the cereal crops, the proportions that is given in the following paragraphs represents the proportion of the concerned plant species among the crop plant taxa (Table *2*).

The hulled wheat proportion is not high in the samples coming from Phase 2 of 54.38 plan-square (0,59%). But, in the following Phase 1, the proportion suddenly increases to 6,78%. This phase is the phase that the hulled wheat is most proportionate in all phases in focus. The Phase 4 of 51/52.37 has no remains of hulled wheat grains so the proportion is zero in this phase. In the samples belonging to Phase 3 of this trench, the proportion slightly increases to 2,52% and continues to rise in the Phase 2 samples and nearly doubles (4,08%).

Free-threshing wheat grains are more proportionate than the hulled wheat grains in the 54.38 plan-square, Phase 2 samples (1,78). The Phase 1, however, has no remains of these type of wheat. The situation in the Phase 4 of 51/52.37 is not different than the

Phase 1 of 54.38, and free-threshing wheat is not present in this phase either. The trend in the proportion of this wheat is similar to the trend of hulled wheat proportion, but the percentage of the former is higher than that of the latter. Free-threshing wheat, similar to the hulled wheat, also shows an increase in the Phase 3 of 51/52.37 (4,36%) and nearly reaches to its double in the Phase 2 (8,16%).

Proportion of the indetermined wheat grains are relatively high throughout the different periods comparing to the proportions of the other cereals in focus. For Phase 2 of 54.38, the proportion of unidentified wheat is 4,14% and it increases in the Phase 1 to 11,86%. The proportion decreases in the Phase 4 of 51/52.37 to 4,00%. The following phase witnesses a sudden increase to 22,02%. In Phase 2, a slight decrease occurs again, and the proportion becomes 20,41%.

Proportion of the barley is equal to that of indetermined wheat in the Phase 2 of 54.38 (4,14%). It slightly increases in the Phase 1 (5,08%). The samples coming from the Phase 4 of 51/52.37 does not have any barley grains. The following Phase 3 had 3,44% of barley in the samples, and in the Phase 3 its proportion reaches to 9,18%.

Einkorn spikelet forks are only present in the Phase 2 of 54.38 and Phase 4 and 3 of 51/52.37. Their proportion in the former phase is 1,18%. In the Phase 4 of 51/52.37, it reaches its maximum (4,00%) and it decreases again to 0,46% in the following period samples. Emmer spikelet forks are never represented above 1% in any of the periods in focus. In fact, they are only present in the samples belonging to Phase 2 of 54.38 and Phase 3 of 51/52.37. Their percentage in the Phase 2 is 0,59%, whereas it is 0,69 in Phase 3. Free-threshing wheat rachis segment is found only in the 54.38 plan square, Phase 2. Its value is 0,59% for that period.

Indetermined cereal rachis node is only found in the Phase 4 of the 51/52.37 plan-square with 8,00% percentage. Even though there is only couple of rachis nodes are present in these samples, as the total number of remains are also low, the proportion of cereal rachis node is found high. Indetermined cereal rachis internode is found only in the Phase 2 of 51/52.37 plan square (0,59%). But there was only one remain is present, so, its proportion is not very meaningful. Indetermined cereal rachis segment is present more consistently comparing the other types of the unidentified cereal chaff. Its proportion in the Phase 2 of 54.38 is 0,59%. The following period in this trench does not contain any cereal rachis segment. The Phase 4 of 51/52.37, too, has no remains the chaffs of this kind. However, when it comes to the Phase 3, its proportion increases to 1,15% and continues to increase in the Phase 2 as well and reaches to 2,04% in those samples. Indetermined cereal lemma/palea is only present in the Phase 2 of 54.38 plan-square with one remnant, and its proportion among the other remnants is 0,59%. But as is the case for most of the other chaff remains, its presence is not very meaningful and does not depict much about the cereal abundance or processing activities.

Table 2. Table shows the counts and proportions of crop plant taxa remains in differentiating phases of Toprakhisar Höyük 51/52.37 and 54.38 plan squares.

Square	51/52.37			54.38		51/52.37			54.38	
Local Phase	**2**	**3**	**4**	**1**	**2**	**2**	**3**	**4**	**1**	**2**
Period	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC
	Counts (n)					**Proportions**				
	Total Number of Counts									
Sample Number	5	59	3	2	6					
Total	98	436	25	59	169					
Avena sativa	2	11	0	0	0	2,04	2,52	0,00	0,00	0,00
Triticum monococcum/dicoccum	4	11	0	4	1	4,08	2,52	0,00	6,78	0,59
Triticum durum/aestivum	8	19	0	0	3	8,16	4,36	0,00	0,00	1,78
Triticum sp.	20	96	1	7	7	20,41	22,02	4,00	11,86	4,14
Hordeum vulgare	9	15	0	3	7	9,18	3,44	0,00	5,08	4,14
Cerealia indet.	32	131	9	14	19	32,65	30,05	36,00	23,73	11,24
T. monococcum spikelet fork	0	2	1	0	2	0,00	0,46	4,00	0,00	1,18
T. dicoccum spikelet fork	0	3	0	0	1	0,00	0,69	0,00	0,00	0,59
T. aestivum rachis segment	0	0	0	0	1	0,00	0,00	0,00	0,00	0,59
Indet. *Cerealia* rachis node	0	0	2	0	0	0,00	0,00	8,00	0,00	0,00
Indet. *Cerealia* rachis internode	1	0	0	0	0	1,02	0,00	0,00	0,00	0,00
Indet. *Cerealia* rachis segment	2	5	0	0	1	2,04	1,15	0,00	0,00	0,59
Indet. *Cerealia* rachis lemma/palea	0	0	0	0	1	0,00	0,00	0,00	0,00	0,59
Indet. Legume	12	82	11	2	12	12,24	18,81	44,00	3,39	7,10
Vitis vinifera fragments	5	36	0	2	14	5,10	8,26	0,00	3,39	8,28
Vitis vinifera pedicel	0	2	0	0	0	0,00	0,46	0,00	0,00	0,00
Olea europaea fragments	3	23	1	27	100	3,06	5,28	4,00	45,76	59,17

4.1.1.1.2. Find Density & Ubiquity

Since the sediment volume of the samples taken are not available for every sample, the calculation of find density is not possible. Consequently, the density of the material found in the samples are not included for Toprakhisar samples.

When the ubiquity of the cereals (Table *3*) is evaluated, it is seen that hulled wheat species are present in the 16,67% of the samples coming from Phase 2 of 54.38. Then, these plant grains reach to their maximum ubiquity in the samples belonging to Phase 1. They are present in the half of the samples in this period (50%). The grains of hulled wheat become totally absent in the Phase 4 of 51/52.37. Their ubiquity increases again in the Phase 2 to 13,56% and continues to rise. %40 of the Phase 2 samples has the grains of these plants.

Free-threshing wheat species are present in the half of the 54.38 plan square, Phase 2 samples (50%). But they are totally absent from the samples of the following period. In 51/52.37 trench, the one third of the samples had these grains in the Phase 4 (33,33%), then, their ubiquity decreases to 25,42% in the Phase 3. In the last phase, Phase 2, all the samples have free-threshing wheat grains (100%).

The indetermined wheat species are present in the two third of the Phase 2 samples of 54.38 plan square (66,67%). But, the following period, their ubiquity reaches to 100%. In the 51/52.37 samples, the ubiquity decreases to 33,33%. However, in Phase 3 samples, they are present in the 44,07% of the samples. And their ubiquity rises to 80% in the latest phase.

The ubiquity of the barley grains is 66,67% in the Phase 2 of 54.38 samples. All of the following phase samples contained barley (100%). Their ubiquity decreases again to 66,67% in 51/52.37, Phase 4 samples. In the following period, there are no remains of barley grains. When it comes to the Phase 2, nearly two third of the samples produces barley grains (60,00%).

One third of the samples (33,33%) contains einkorn spikelet fork in the Phase 2 of 54.38 plan square. These spikelet forks are also present in the samples coming from Phase 4 and Phase 3 of 52.37 square. In the Phase 4, the ubiquity is same with the Phase 2 of 54.38 (33,33%). However, the ubiquity is very low comparing to the other period (3,39%). The ubiquity of the emmer spikelet fork than the einkorn spikelet fork is lower in the 54.38 plan-square, Phase 2 samples (16,67%). In the Phase 3 of 52.37, their presence decreases to 5,08%. In the other phases they are not present. The ubiquity of free-threshing wheat species rachis segment is equal to the ubiquity of emmer spikelet fork in the Phase 2 of 54.38 (16,67%). This is the only phase that the free-threshing wheat rachis segment is found.

Indetermined cereal rachis node is only present in the Phase 4 of 51/52.37 plan square and its ubiquity is 33,33%. Indetermined cereal rachis internode is found Phase 2 of the same trench and its ubiquity is 20%. Indetermined cereal rachis segment has 16,67% ubiquity in the Phase 2 of 54.38 plan square, but it is not present in the following phase of the same trench. The Phase 4 of the 51/52.37 plan square also does not contain any of these rachis segment remains. The ubiquity slightly increases to 8,47% in the Phase 2 of this plan square. In the last phase, Phase 2, 40% of the samples have cereal rachis segment. The indetermined cereal lemma/palea is only present in the Phase 2 of 54.38 and its percentage is 16,67%.

Table 3. Table shows the ubiquity of crop plant taxa remains in differentiating phases of Toprakhisar Höyük 51/52.37 and 54.38 plan squares.

Square	51/52.37			54.38		
Local Phase	**2**	**3**	**4**	**1**	**2**	
Period	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC	
	Ubiquity Total Number of Samples					
Sample Number Total	5	59	3	2	6	Change
Avena sativa	40,00	11,86	0,00	0,00	0,00	
Triticum monococcum/dicoccum	40,00	13,56	0,00	50,00	16,67	
Triticum durum/aestivum	100,00	25,42	0,00	0,00	50,00	
Triticum sp.	80,00	44,07	33,33	100,00	66,67	
Hordeum vulgare	60,00	16,95	0,00	100,00	66,67	
Cerealia indet.	100,00	49,15	66,67	50,00	66,67	
T. monococcum spikelet fork	0,00	3,39	33,33	0,00	33,33	
T. dicoccum spikelet fork	0,00	5,08	0,00	0,00	16,67	
T. aestivum rachis segment	0,00	0,00	0,00	0,00	16,67	
Indet. *Cerealia* rachis node	0,00	0,00	33,33	0,00	0,00	
Indet. *Cerealia* rachis internode	20,00	0,00	0,00	0,00	0,00	
Indet. *Cerealia* rachis segment	40,00	8,47	0,00	0,00	16,67	
Indet. *Cerealia* rachis lemma/palea	0,00	0,00	0,00	0,00	16,67	
Indet. Legume	20,00	30,51	66,67	50,00	50,00	
Vitis vinifera fragments	60,00	27,12	0,00	50,00	33,33	
Vitis vinifera pedicel	0,00	3,39	0,00	0,00	0,00	
Olea europaea fragments	20,00	10,17	33,33	50,00	83,33	

4.1.1.2. Interpretation of Changes

As the main focus of this thesis is particularly the changes in free-threshing wheat, hulled wheat, and barley in different phases of occupation, it is important to evaluate them one by one according to proportions (Figure *42*) throughout the changing levels. The samples coming from these trenches represents the very end of the EBA the beginning of the MBA. It should be noted that the samples from phases 1 and 2 of the trench 54.38 are given as EBA but it is possible that they may represent the very beginning of MBA, however, since their chronology (2100-2000 BC) fits with the EBA in Syria-Palestine (Johnson et al., 2020), they are evaluated as EBA phases. Any change in the crop consumption patterns in these phases might be related to the changing environmental conditions resulted from 4.2 ka BP climatic event. Thus, the results should be evaluated accordingly.

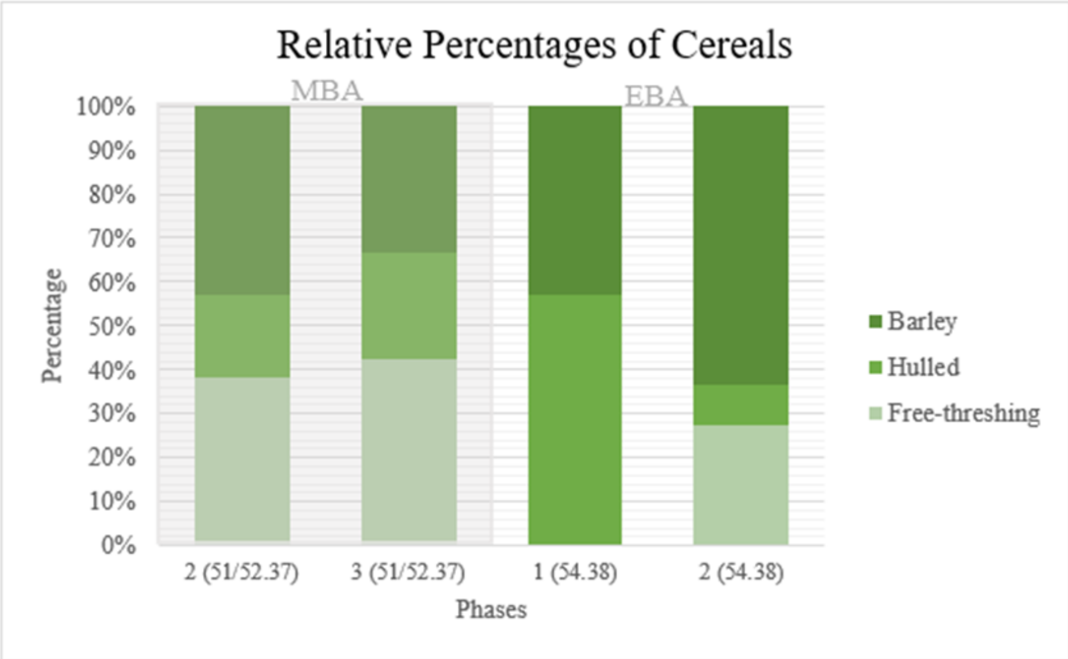

Figure 42. Graph shows the relative percentages of the barley, hulled wheat, and free-threshing wheat in different phases of 51/52.37 and 54.38 plan-squares of Toprakhisar Höyük.

4.1.1.2.1. Free-threshing Wheat

One of the main changes in free-threshing wheat count and proportion is that both parameters are higher in the MBA samples then in the EBA samples. Free threshing wheat is only present in the Phase 2 of 54.38 plan square (2100-2000 BC), but it disappears in the samples of Phase 1 (2100-2000 BC). On the other hand, in the Phase 3 of the other trench, with the beginning of the 2nd millennium BC, the free-threshing wheat becomes more numerous again and reaches to the highest amount in this phase. So, it can be argued that at the end of the EBA, the free threshing somehow started to be less abundant in the houses of Toprakhisar. But it is highly likely that with the beginning of the 2nd millennium BC, free-threshing wheat becomes favorable and widely cultivated again, as it is even more numerously found than the barley.

4.1.1.2.2. Barley

When compared to the free-threshing wheat, barley seems to be used more widely in the EBA Toprakhisar considering that it was more numerous/proportionate than free-threshing wheat in Phase 2 of 54.38 plan square (2100-2000 BC). Additionally, whereas the free-threshing wheat disappeared from the samples of Phase 1 (2100-2000 BC), barley continued to be present in the samples. Both results suggest that the favorable crop of the EBA Toprakhisar was barley as in the most case for most of the Near Eastern sites reviewed in this thesis. However, in the MBA, the decreasing importance of the barley is evident. In the Phase 3 of the 51/52.37 (2000-1900 BC), it is less numerous and less abundant than the free-threshing wheat and in the Phase 2 (2000-1900 BC), they are found nearly in the same amounts suggesting that barley started to be of the same importance as free-threshing wheat.

4.1.1.2.3. Hulled Wheat

Hulled wheat species gained importance at the very end of the EBA occupation at Toprakhisar, since when free-threshing wheat is disappeared completely in the Phase 1 of 54.38 (2100-2000 BC), hulled wheat is present in these samples with increased amount comparing to Phase 2 (2100-2000 BC). It is even in higher amounts and percentages than the barley in the Phase 1. Nevertheless, in the MBA, hulled wheat was still present, but it seems that it never became as important as the other two cereals: free-threshing wheat, and barley.

4.1.2. Tell Atchana

4.1.2.1. 32.57 Plan-square

4.1.2.1.1. Counts and Proportions

The exact counts of the 32.57 plan square are not included in this thesis to prevent a conflict of interest as mentioned in the Section 3.2.2.1. In the total of 89 samples coming from 32.57, there are 4 phases represented. The samples are distributed relatively evenly among the phases except one phase, Phase 4 where only 2 samples retrieved from. On the other hand, there are 28 samples coming from Phase 5, 30 samples from Phase 3 and 29 samples from Phase 2 (Table *4*). The samples produce large range of crop species from oat (*Avena sativa*) to fig (*Ficus carica*). Unlike the samples coming from the other trenches, the 32.57 samples also have variety of cereal chaff belonging to both wheat and barley.

The proportion of hulled wheat 1,27% for the Phase 5. It decreases more than two times in the Phase 4 and reaches to 3,83%. In Phase 3, the proportion decreases again to 1,09%. In the last phase, Phase 2, the proportion of hulled wheat rises again to 2,05%. Throughout all the phases, hulled wheat species are the less widely consumed cereal species in 32.57 plan square.

Proportion of the free-threshing wheat grains is much higher than the hulled wheat grains in all of the phases indicating its importance for the palace kitchen. The proportion of this cereal in the Phase 5 is 20,43%. In the following phase it rises significantly to 32,42% and continues to increase until Phase 3 when it reaches to 38,58% of the crop plant taxa. The proportion of the free-threshing wheat decreases again nearly to the Phase 5 levels in the Phase 2 and become 20,90%.

Unidentified wheat (*Triticum* sp.) has 7,62% of proportion in the oldest Phase 5. Its proportion increases significantly to 16,48% in the following Phase 4. Then, in the Phase 3, the proportion of indetermined wheat suddenly decreases to 2,19%. Its proportion increases again in the Phase 3 but does not reach to the previous levels.

Barley is the second most abundant cereal after free-threshing wheat in almost all of the phases. It constitutes the 10,95% of the crop plant taxa in the Phase 5. Its proportion decreases in the next phase to 8,79%. In the Phase 3, the proportion doubles and reaches to 18,19%. The last phase, Phase 2, witnesses a decrease again and proportion falls to 13,11%.

Emmer wheat (*Triticum dicoccum*) spikelet fork was only present in the Phase 5 and Phase 4 samples. While its proportion is 0,44% in the former, it increases to 1,65% in the latter. The hulled wheat is also represented with einkorn/emmer (*Triticum monococcum/dicoccum*) spikelet fork and glume base. Spikelet fork is only found in the Phase 5 with small proportion (0,05%). Glume base, on the other hand, is present in both Phase 5 and Phase 4. In Phase 5, its proportion is 0,34% and in Phase 4, the proportion increases to 1,65%.

The free-threshing wheat species (*Triticum aestivum/durum*) also has several kinds of chaff in the samples including rachis node, rachis internode, and rachis. Free-threshing wheat node is only retrieved from the Phase 5 and its proportion is 0,15%. The rachis internode is also only present in the Phase 5 with 0,34% of proportion. Some of the chaff remains identified to the species level and indicated that the macaroni wheat (*Triticum durum*) is present at least in the Phase 5 and Phase 4 of 32.57. Macaroni wheat rachis internode and rachis are among the finds. The proportion of the former is 0,83% in Phase 5 and it decreases to 0,55% in the Phase 4. The latter is only found in the Phase 5 and the proportion is 0,83%.

Barley chaff is present with rachis remains in the samples of Phase 5 and Phase 4. In the Phase 5, their proportion is 0,24%, and it increases slightly to 0,55% in Phase 4.
Indetermined cereal chaff, culm node and culm node base are also found in the

samples. Especially, culm node of unidentified cereals is very common in the samples of Phase 5 and Phase 4. The proportion of cereal culm node is 6,84% in the Phase 5. It remains to be presented in higher proportion than the other chaff remains in Phase 4 but with a slight decrease comparing to the previous period (6,59%). Indetermined cereal culm node base is only present in the Phase 5 with small proportion (0,34%). Cereal chaff, on the other hand, was present in the Phase 5 (1,76%) and interestingly in Phase 3 (1,23%).

4.1.2.1.2. Find Density & Ubiquity

Find density is also not available as not all the soil sediment volume taken as a sample is available. Since this information is absent for some of the samples, the find density of the samples cannot be calculated and included here. Thus, for 32.57 plan square samples, only their proportion and ubiquity values are presented.

When it comes to the ubiquity of the samples (Table *4*), the hulled wheat is present in over the one third of the samples in Phase 5 (35,71%). In the following Phase 4, one of the two samples has hulled wheat grains, so its ubiquity is 50,00%. In the Phase 3 samples, the ubiquity of the hulled wheat species is only 13,33%, and in the Phase 2, their chance to be present in the samples even decreases to 10,34%.

The free-threshing wheat grains are the most ubiquitous cereal in all the phases as was the case for their proportion. In Phase 5, these grains are present in the 85,71% of the samples. In the following phase, they are found in all of the samples (100%). In the Phase 3, their ubiquity decreases to 76,67%. The last phase, Phase 2, witnesses even more significant decrease and only nearly half of the samples contains free-threshing wheat in this phase (48,28%).
Indetermined wheat grains are present in the 60,71% of the samples of Phase 5. In the Phase 4, they are found in both of the two samples retrieved from this phase (100%). However, in the following Phase 3, the ubiquity of these grains decreases significantly

to 13,33%. In the Phase 2, it increases again (17,24%) but does not reach to the Phase 5 and Phase 4 levels.

Barley grains are the second most ubiquitous cereal in most of the phases. In the Phase 5, it is as ubiquitous as free-threshing wheat (85,71%). Phase 4 have barley in half of its two samples (50%). In the Phase 3, the 63,33% of the samples have barley grains which is slightly lower than the ubiquity of the free-threshing wheat. The ubiquity decreases significantly in the Phase 2 to 27,59%.

Emmer wheat (*Triticum dicoccum*) spikelet fork ubiquity is 21,43% in the Phase 5 and is 50% in the Phase 4 samples. The hulled wheat (*Triticum monococcum/dicoccum*) spikelet fork is only found in the Phase 5 with small ubiquity (3,57%). On the other hand, hulled wheat glume base, is present in both Phase 5 and Phase 4. In Phase 5, its ubiquity is 14,29% and in Phase 4, the ubiquity increases to 50,00%.

The free-threshing wheat species (*Triticum aestivum/durum*) rachis node is only found in the Phase 5 and its ubiquity is 3,57%. The rachis internode is again only present in the Phase 5 with 14,29% of ubiquity. The species level identifiable macaroni wheat (*Triticum durum*) rachis internode has 21,43% ubiquity in the Phase 5 and 50,00% in the Phase 4. Macaroni wheat rachis, on the other hand, is only present in the samples of Phase 5 with 3,57% ubiquity.

Barley chaff is present in the 10,71% of the Phase 5 samples. However, in Phase 4, its ubiquity increases to 50,00%.

The ubiquity of indeterminate cereal culm node is 53,57% in the Phase 5. Its ubiquity decreases to 50,00% in the following phase. Indetermined cereal culm node base is only present in the Phase 5 with small ubiquity (3,57%). Indetermined cereal chaff is present in the samples of Phase 5 and Phase 3. Its ubiquity is 32,14% in the former and is 23,33% in the latter.

Table 4. Table shows the proportions and ubiquity of the crop plant taxa remains in differentiating phases of Tell Atchana 32.57 plan square.

Square	32.57				32.57			
Local Phase	2	3	4	5	2	3	4	5
Period	1550-1400 BC	1600-1550 BC	1650-1600 BC	1750-1650 BC	1550-1400 BC	1600-1550 BC	1650-1600 BC	1750-1650 BC
	Proportions				**Ubiquity**			
					Total Number of Samples			
					29	30	2	28
Total								
Avena sativa	0,00	0,00	0,00	0,49	0,00	0,00	0,00	10,71
Triticum monococcum/dicoccum	2,05	1,09	3,85	1,27	10,34	13,33	50,00	35,71
Triticum durum/aestivum	20,90	38,58	32,42	20,43	48,28	76,67	100,00	85,71
Triticum sp.	6,15	2,19	16,48	7,62	17,24	13,33	100,00	60,71
Hordeum vulgare	13,11	18,19	8,79	10,95	27,59	63,33	50,00	85,71
Cerealia indet.	7,38	8,89	0,00	2,79	17,24	33,33	0,00	10,71
Triticum dicoccum spikelet fork	0,00	0,00	1,65	0,44	0,00	0,00	50,00	21,43
Triticum monoccoum/dicoccum spikelet fork	0,00	0,00	0,00	0,05	0,00	0,00	0,00	3,57
Triticum monoccoum/dicoccum glume base	0,00	0,00	1,65	0,34	0,00	0,00	50,00	14,29
Indet. *Cerealia* chaff	0,00	1,23	0,00	1,76	0,00	23,33	0,00	32,14
Indet. *Cerealia* culm node	0,00	0,00	6,59	6,84	0,00	0,00	50,00	53,57
Indet. *Cerealia* culm node base	0,00	0,00	0,00	0,34	0,00	0,00	0,00	3,57
Triticum durum/aestivum node	0,00	0,00	0,00	0,15	0,00	0,00	0,00	3,57
Triticum durum/aestivum internode	0,00	0,00	0,00	0,34	0,00	0,00	0,00	14,29
Triticum durum internode	0,00	0,00	0,55	0,83	0,00	0,00	50,00	21,43
Triticum durum rachis	0,00	0,00	0,00	0,83	0,00	0,00	0,00	3,57
Hordeum vulgare rachis	0,00	0,00	0,55	0,24	0,00	0,00	50,00	10,71
Indet. Legume	9,84	27,91	26,92	40,81	34,48	76,67	100,00	85,71
Vitis vinifera fragments	0,00	1,78	0,00	0,44	0,00	26,67	0,00	10,71
Vitis vinifera pedicel	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Olea europaea fragments	40,57	0,14	0,55	2,98	6,90	3,33	50,00	25,00
Ficus carica	0,00	0,00	0,00	0,05	0,00	0,00	0,00	3,57

4.1.2.2. Interpretation of Changes

The three of the phases that the 32.57 samples coming from dated to MBA (Phases 5,4, and 3), and one phase dated to LBA (Phase 2). Thus, the change in the cereal consumption patterns from the MBA to LBA can be traced in the 32.57. This trench also gives unique opportunity as the samples are evenly distributed among most of the phases which makes the sample size closer in the phases. Also, even though it is not represented here, the samples of 32.57 are relatively rich in content. This brings a better understanding about the crop consumption patterns in Atchana.

4.1.2.2.1. Free-threshing Wheat

The free-threshing wheat is the most widely used cereal species throughout time in 32.57 plan square (Figure *43*). Its presence slightly increases from Phase 5 (1750-1650 BC) to Phase 4 (1650-1550 BC). In Phase 3 (1650-1550 BC), it shows a slight decrease again. In the transition from Phase 3 to Phase 2 (1550-1400 BC) (which is also transition from MBA to LBA), the relative percentage of the free-threshing wheat continues to fall. This last phase is the phase that the free-threshing wheat has its lowest presence. Even though, the percentage of this drought susceptible species is never fall behind the total percentage of drought tolerant hulled wheat and barley, it seems that these species started to lose its importance in LBA. But these results would be clearer when they are co-evaluated with the LBA samples of 42.10.

4.1.2.2.2. Barley

Barley is the second most important crop after free-threshing wheat in 32.57 plan square (Figure *43*). Its relative proportion decreases during the Phase 4 (1650-1550 BC) comparing to the previous period as both free-threshing wheat and hulled wheat representation increased in that period. Then, its proportion increases again and continues to increase in both Phase 3 (1650-1550 BC) and Phase 2 (1550-1400 BC). Although the barley never became dominant crop in 32.57 plan square, its importance appears to increase in time on the contrary to free-threshing wheat.

4.1.2.2.3. Hulled Wheat

Hulled wheat species was never as widely consumed as free-threshing wheat and barley (Figure *43*). Its presence is also very fluctuated in different phases and shows no significant pattern. Hulled wheat occurrence in 32.57 seems random rather than pointing that the hulled wheat was a regularly consumed wheat type with being less preferred or widely preferred in different time periods. Considering its counts and its rareness comparing to free-threshing wheat and barley, these grains might even enter the site as crop contaminants brought from agricultural fields.

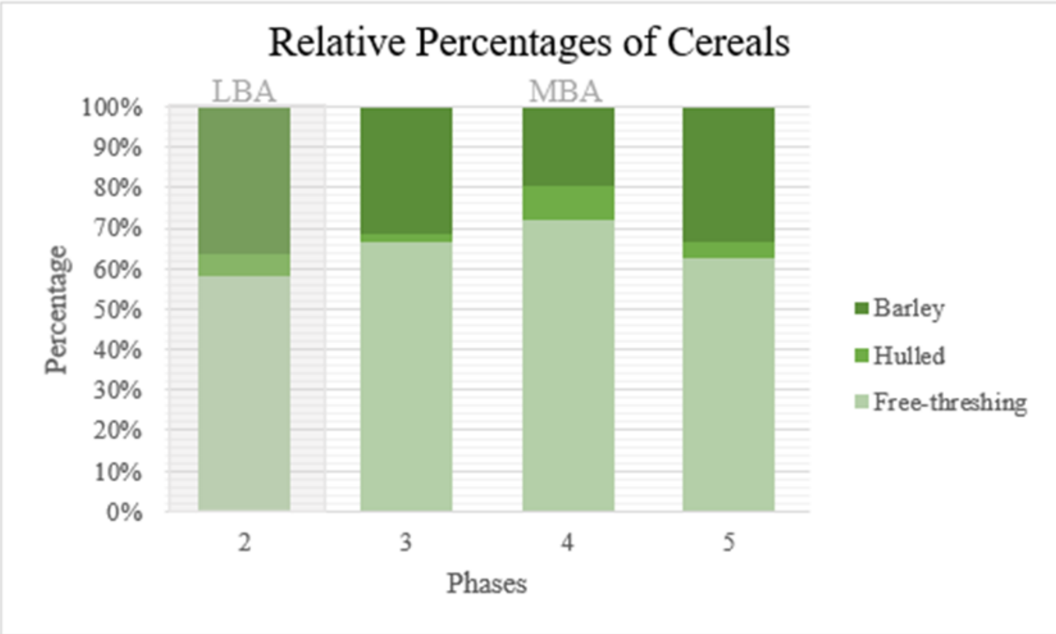

Figure 43. Graph shows the relative percentages of the barley, hulled wheat, and free-threshing wheat in different phases of 32.57 plan-square of Tell Atchana.

4.1.2.3. 42.10 Plan-square

4.1.2.3.1. Counts and Proportion

Among the 120 samples coming from 42.10 plan square, the average number of remains per liter soil was 0,94. The crop plant taxa coming from these samples includes few remains of oat (*Avena sativa*), hulled wheat species (*Triticum monococcum/dicoccum*), free-threshing wheat species (*Triticum durum/aestivum*), indetermined wheat grains (*Triticum* sp.), barley (*Hordeum vulgare*), indetermined cereal grains and chaff, indetermined legumes (Fabaceae), grape (*Vitis vinifera*) seed fragments and pedicels and olive (*Olea europaea*) fragments (see Appendix C.2. for exact counts). Since the number of samples coming from different phases varies greatly in number, the counts of the remains also vary greatly from one phase to another (Table 5). The crop plan taxa are highest in the oldest Phase 7 (n=897). As the number of samples decreases in the Phase 6, the number of finds also decreases in this phase as well (n=156). The Phase 5 samples produces very scarce amount of crop plant taxa seeds (n=15). Even though the number of the samples is close to the Phase 5 samples, Phase 4b/5 have much higher number of remains (n=100) than Phase 5. The Phase 4 produced relatively good amount of remains (n=287) considering the previous three phases. As only couple of samples retrieved from Phase 3, the number of remains decreases to the below 50 again in this earliest level (n=31).

Hulled wheat grains are present from the Phase 7 until the Phase 4. But in the Phase 3, there is grain finds of this species. Throughout these phases the number of grains not very much, substantially below 10 grains until the Phase 4. However, in that phase its number increases and reach to the 20 grains.

Number of free-threshing wheat species were highest in the Phase 7 samples (n=142), but the number of grains suddenly decreases to below 15 grains in the Phase 6. Phase 5 samples produces only 1 seed of these species and their number in the following two phases never reaches above 10. No seed of free-threshing wheat are found in the Phase 3 samples.

Counts of indetermined wheat species are relatively high comparing to the identifiable ones throughout all phases. The Phase 7 samples produces the highest number of unidentified wheat grains (n=138). Its numbers decrease below 50 in the following period Phase 6 (n=46). The Phase 5 witnesses a dramatic decrease in the number of indetermined wheat species and their number falls below 10 (n=4). Their number increases again in the following two periods (n=44 for Phase 4b/5, and n=94 for Phase 4) and decreases to four again in the Phase 3.

Barley grains are only numerous in the Phase 7 and its number are always below 20 grains throughout the following phases (n=4 for Phase 6, n=1 for Phase 5, n=13 for Phase 4/5, and n=15 for Phase 4). As is the case for hulled and free-threshing wheat grains, barley grains are totally absent from the Phase 3 samples.

Cereal chaff is only present in the samples coming from Phase 7. The species level identification on these cereals is not possible but considering to the absence of it in the following periods, they are numerous in the oldest phase. The possible reasons of their presence in this phase are open to argument.

The proportion of hulled wheat grains (Table *5*) in the Phase 7 is 0,11%. Their proportion increases during the following period and reaches to 4,49% in the Phase 6 and 13,33% in the Phase 5. The latter is the maximum proportion that hulled wheat reaches throughout all occupational levels. The proportion decreases dramatically to 2,00% in the Phase 4/5 samples. The grains become represented in higher proportions in Phase 4 again (6,97%) before it totally disappeared from the Phase 3 samples. The hulled wheat proportions fluctuate very much throughout time.

Free-threshing wheat grain proportion is the highest in the Phase 7 samples (15,83%). Then, it decreases nearly to half of the previous period in Phase 6 (8,33%). A slight decrease occurs in the subsequent period Phase 5 samples (6,67%). Phase 4/5 and 4 samples has close proportions of these type of wheat (2,00% for Phase 4/5, and 2,09% for Phase 4). The phase 3 samples have no free-threshing wheat remains at all. Overall, it can be said that the free-threshing wheat proportions shows a decrease from latest to earliest periods.

Indetermined wheat grain proportions has the highest proportions among the other cereals in all phases except Phase 7. In Phase 7, their proportion is 15,38%, then, it increases nearly as twice and increases to 29,49% in Phase 6. After a slight decrease in Phase 5 (26,67%), it reaches its highest value in Phase 4/5 samples (44,00%). After that phase, it starts to reduce again in Phase 4 (32,75%) and Phase 3 (12,90%).

Barley grains proportion has the highest level in the Phase 7 samples (15,83%). Then, it suddenly decreases dramatically in the Phase 6 (2,56%). In the following two periods the proportion of these grains increases but never reaches to the levels of Phase 7. For Phase 5 their proportion is 6,67%, for Phase 4/5 it is 13,00%. Phase 4 samples witnesses a decrease again and the proportion becomes 5,23%, nearly half of the previous period. The final phase, Phase 3, does not contain any barley grain remains.

The proportion of cereal chaff in the Phase 7 is 2,79%. With this value their proportion is greater than the hulled wheat for this period, but far behind the proportions of free-threshing wheat, indetermined wheat, and barley.

Table 5. Table shows the counts and proportions of the crop plant taxa remains in differentiating phases of Tell Atchana 42.10 plan square.

Square	42.10						42.10					
Local Phase	**3**	**4**	**4/5**	**5**	**6**	**7**	**3**	**4**	**4/5**	**5**	**6**	**7**
Period	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC
	Counts (n) Total Number of Counts						**Proportions**					
Total	31	287	100	15	156	897						
Avena sativa	0	0	0	0	2	0	0,00	0,00	0,00	0,00	1,28	0,00
Triticum monococcum/dicoccum	0	20	2	2	7	1	0,00	6,97	2,00	13,33	4,49	0,11
Triticum durum/aestivum	0	6	2	1	13	142	0,00	2,09	2,00	6,67	8,33	15,83
Indet. *Cerealia* chaff	0	0	0	0	0	25	0,00	0,00	0,00	0,00	0,00	2,79
Triticum sp.	4	94	44	4	46	138	12,90	32,75	44,00	26,67	29,49	15,38
Hordeum vulgare	0	15	13	1	4	142	0,00	5,23	13,00	6,67	2,56	15,83
Cerealia indet.	1	75	28	3	30	44	3,23	26,13	28,00	20,00	19,23	4,91
Indet. Legume	26	65	11	3	44	119	83,87	22,65	11,00	20,00	28,21	13,27
Vitis vinifera fragments	0	11	0	1	10	69	0,00	3,83	0,00	6,67	6,41	7,69
Vitis vinifera pedicel	0	0	0	0	0	4	0,00	0,00	0,00	0,00	0,00	0,45
Olea europaea fragments	0	1	0	0	0	213	0,00	0,35	0,00	0,00	0,00	23,75

4.1.2.3.2. Find Density & Ubiquity

The density is calculated by grouping the various kinds of plants. In other words, the crop plant taxa and wild plant taxa are separated into two categories and the density of specific plant types is determined in the plant taxa to which they belong. When the change in densities of the cereal plant taxa (Table *6*) is analyzed, it is seen that the densities are very low throughout all the phases for all the cereal plants. For any of the archaeological levels, the density of the any of the cereals never reaches a value above 1%.

Density of the hulled wheat species increases slightly from the Phase 6 (d=0,02) and it reaches its peak in the Phase 4 (d=0,06). Since only one grain is found in the Phase 7 the density is calculated nearly 0 in this phase. And in the Phase 3, the hulled wheat grains are totally absent.

Density values for free-threshing wheat grains are highest in the Phase 7 (n=0,11). The values decrease continuously in the following two periods, in Phase 6 (d=0,05) and Phase 5 (d=0,01). Phase 4/5 witnesses a slight increase in percentages (d=0,04) and the value decreases again to 0,02 in the Phase 4. The earliest level, Phase 4, has no remains of free-threshing wheat.

Density of the indetermined wheat grains is 0,11 for Phase 7, it slightly rises in the succeeding period, Phase 6 (d=0,16) and decreases again in the Phase 5 (d=0,05). The density of the unidentified wheat grains reaches to its maximum level in Phase 4/5 samples (d=0,090). Then, it decreases again in the earliest two phases. The values are close to each other in those levels (d=0,26 in Phase 4, and d=0,25 in Phase 3).

Barley density is 0,11 for Phase 7 and it decreases in the Phase 6 to 0,01. Phase 5 is the same density value with the latter one and it suddenly reaches to its maximum in Phase 4/5 (d=0,27). The barley density falls again in the Phase 4 (d=0,04) and barley becomes totally absent in the Phase 3 samples. Lastly, the cereal chaff density for Phase 7 samples was 0,02.

Ubiquity of samples is calculated by the counting the presence of a certain plant species in the samples coming from a certain archaeological phase. As is the case for proportion calculations the ubiquity is also calculated as percentages (Table *6*).

Hulled wheat ubiquity is lowest in the Phase 7. Only 1,52% of the samples coming from this phase contains hulled wheat grains. In the following three periods, the representation of the hulled wheat considerably increases. In Phase 6, the ubiquity of this species is 21,74. In Phase 5, it increases again and reaches to 33,33 and in Phase 4/5, it peaks and becomes 40,00%. In the Phase 4, its presence decreases again to 33,33%. The Phase 3 samples has no hulled wheat grains.

Free-threshing wheat ubiquity is highest in Phase 7 samples (62,12%). Then, it decreases dramatically in the following phase to 13,04%. It slightly increases in the Phase 5 (16,67%) and continue to rise in the Phase 4/5 and reaches to 40,00% in this phase. The presence of these type of plants in the Phase 4 decreases nearly as half comparing to previous phase and fall to 22,22%.

Indetermined wheat species has high ubiquity throughout the different phases. The ubiquity of wheat grains in the Phase 7 is 59,09%. With a slight decline in Phase 6, it becomes 56,52%. In Phase 5, the ubiquity percentage continues to decrease to 33,33%. With a sudden increase in Phase 4/5, it reaches to most ubiquitous phase, to 80%. The last two phases witness a decline again. The ubiquity value of these grains for Phase 4 is 72,22% and it is 50,00% for Phase 3.

Barley ubiquity is highest in the Phase 7 as its proportion is. The Phase 6 samples contains a suddenly decreased ubiquity of barley (13,04%). In Phase 5, it slightly increases (16,67%), but in Phase 4/5, it spikes to 60,00%. The decrease occurs again in Phase 4 and the ubiquity of barley in these samples declines to 16,67%. The Phase 3 samples does not contain any barley remains as mentioned in the previous paragraphs.

The ubiquity of the cereal chaff in the Phase 7 samples was 19,70% meaning that nearly one fifth of the samples had cereal chaff remains. When these results are evaluated in the light of contexts that the samples come from, it can give insights about the crop processing in the Phase 7 occupation of Alalakh.

Table 6. Table shows the find density and ubiquity of the crop plant taxa remains in differentiating phases of Tell Atchana 42.10 plan square.

Square	42.10						42.10					
Local Phase	**3**	**4**	**4/5**	**5**	**6**	**7**	**3**	**4**	**4/5**	**5**	**6**	**7**
Period	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC
	Find Density (n/L) Total Soil Sediment (L)						**Ubiquity** Total Number of Samples					
Total	16	357	49	75	284	1241	2	18	5	6	23	66
Avena sativa	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	4,35	0,00
Triticum monococcum/dicoccum	0,00	0,06	0,04	0,03	0,02	0,00	0,00	33,33	40,00	33,33	21,74	1,52
Triticum durum/aestivum	0,00	0,02	0,04	0,01	0,05	0,11	0,00	22,22	40,00	16,67	13,04	62,12
Indet. *Cerealia* chaff	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	19,70
Triticum sp.	0,25	0,26	0,90	0,05	0,16	0,11	50,00	72,22	80,00	33,33	56,52	59,09
Hordeum vulgare	0,00	0,04	0,27	0,01	0,01	0,11	0,00	16,67	60,00	16,67	13,04	72,73
Cerealia indet.	0,06	0,21	0,57	0,04	0,11	0,04	50,00	66,67	60,00	33,33	39,13	24,24
Indet. Legume	1,63	0,18	0,23	0,04	0,16	0,10	100,00	61,11	40,00	33,33	43,48	66,67
Vitis vinifera fragments	0,00	0,03	0,00	0,01	0,04	0,06	0,00	27,78	0,00	16,67	30,43	48,48
Vitis vinifera pedicel	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,55
Olea europaea fragments	0,00	0,00	0,00	0,00	0,00	0,17	0,00	5,56	0,00	0,00	0,00	68,18

4.2.1.4. Interpretation of Changes

All the samples retrieved from 42.10 plan square belong to LBA and to the beginning of Iron Age. However, as the Iron Age samples does not contain any of the cereals that are focused here, the change from LBA to the Iron Age is not traceable. But the MBA samples coming from 32.57 plan square helps to trace the change from MBA to LBA. Thus, 42.10 samples might be more meaningful when they are compared to the MBA samples coming from 32.57 plan square. The contexts of these trenches are not same, the former is an area related to the temple and the latter is related to the palace. However, as both trenches are related with elite occupation, the consumption patterns should be expected to be similar. Consequently, changes in elite crop consumption pattern in the Tell Atchana should be visible by evaluating these trenches together. In addition to this, as the earlier phases of 42.10 (i.e., Phase 4, and 4/5) coincides with the end of the LBA, a change in crop consumption pattern related to 3.2 ka BP climatic event might also be visible in these earlier phases. The relative percentages of the free-threshing wheat, hulled wheat, and barley are evaluated in following paragraphs (Figure 44).

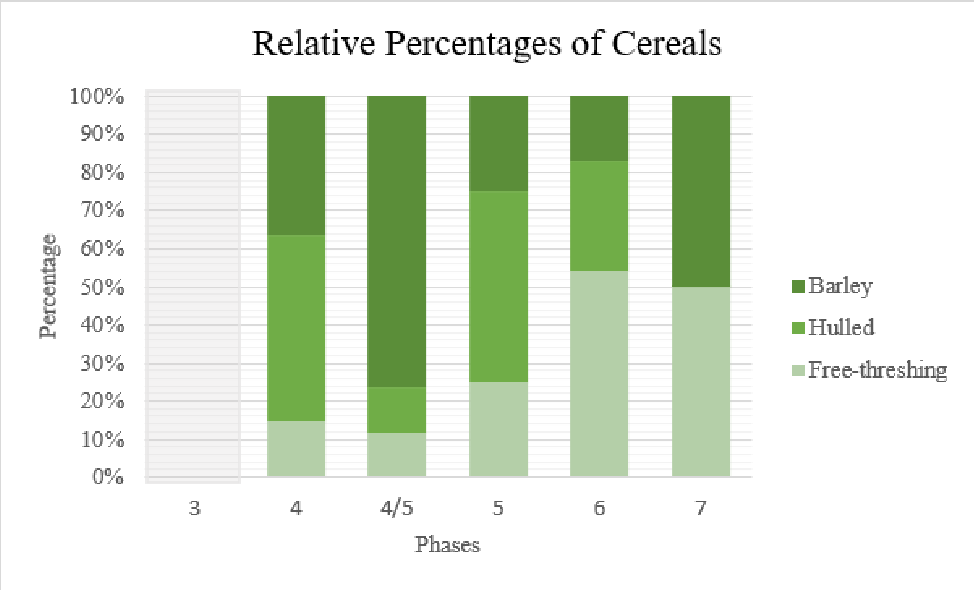

Figure 44. Graph shows the relative percentages of the barley, hulled wheat, and free-threshing wheat in different phases of 42.10 plan-square of Tell Atchana. The gray area indicates the Iron Age period whereas the rest of the phases belong to LBA period.

4.2.1.4.1. Free-threshing Wheat

Free threshing wheat seems to be preferred as a primary crop with barley in the latest phase (Phase 7, 1400-1350 BC) of the occupation in the 42.10 plan square. After a slight increase in its consumption in the following Phase 6 (1350-1300 BC), its consumption starts to decrease with the beginning of the Phase 5 in the second half of the 14th century BC. In the latest two phase of the occupation in 42.10 plan square, the free-threshing wheat species are among the more widely consumed wheat species, however, towards the end of the Bronze Age, its importance seems to decrease and replaced by the other cereals.

4.2.1.4.2. Barley

Barley consumption has an opposite trend compared to free-threshing wheat consumption in all the periods except Phase 7 (1400-1350 BC) when they are represented with the same percentages. When the percentage of the free-threshing wheat decreases the percentage of the barley increases indicating that the preference for different cereals shifted with time. When the environment was suitable for the free-threshing wheat cultivation, it was outproduced the barley. In those times, barley even might be cultivated as a "back-up" crop or animal fodder. However, with changing environment (not simply the natural environment, but also the political or socio-economic environment), barley agriculture appears to have regained relevance. With the exception of a reduction in Phase 6 (1350-1300 BC), barley consumption increased until Phase 4/5. However, by the beginning of the 13th century BC (Phase 4), its prominence diminished once more. The barley amounts/proportions reached their maximum during Phase 4/5 (1325-1275 BC). However, following that period, it begins to decline again, gives rise to hulled wheat species in particular.

4.2.1.4.3. Hulled Wheat

Hulled wheat has the most fluctuating trend comparing the other cereals mentioned. These type of wheat grains are nearly absent in the latest phase of the 42.10 plan square. Only one seed belonging to hulled wheat was found in latest Phase 7 (1400-1350 BC). However, the following phase the percentage of this kind of wheat suddenly increases even though the number does not change significantly. The hulled wheat becomes more proportionate than barley in the following Phase 6 (1350-1300 BC). In Phase 5 (1350-1300 BC), the usage of hulled wheat species appears to become more widespread than both barley and free-threshing wheat. In the Phase 4/5 (1325-1275 BC), its proportion decreases much, but in the next phase, its presence in the assemblages strengthen again. It is hard to speculate about changing preferences over hulled wheat throughout the time as the number of seeds are too small and the percentages are too fluctuated, but it is possible to argue that when barley and hulled wheat are evaluated together there can be seem that there was an increasing preference for these drought-tolerant cereals especially towards the end of the Bronze Age.

The reason behind the decreasing presence of the free-threshing wheat and increasing presence of hulled wheat and barley might be the result of Hittite takeover of Alalakh in the last third of the 14th century BC and changing crop cultivation/import policy under the new administration. It is well known that the Hittites were heavily dependent on the grain imported from the Syrian territories. The archaeobotanical evidence from the Boğazköy (Diffey et al., 2020) showed that the silos of Hattusha were mainly filled with hulled barley, emmer and einkorn. Drought tolerant hulled cereal species might be preferred because of their suitability for long term storage as these species are more tolerant to changing moisture conditions and insect activity as the hard chaff protects the grain (Nesbitt & Samuel, 1996).

To develop a better understanding about the changes in free-threshing wheat, hulled wheat, and barley consumption, it is thought that the evaluation of the data in hand altogether is essential. To achieve this aim, the percentages of all the samples coming from all the trenches of Toprakhisar Höyük and Tell Atchana are together represented in a bar graph (Figure *45*). By this way, the changes from EBA to MBA and MBA to LBA are tried to be better identified. Identifying the change from EBA to MBA would help to possible effects of 4.2 ka BP event on agricultural decision making and crop consumption before and after the change. Identifying the change from MBA to LBA, on the other hand, does not directly help to infer about the effects of climate change, as there was no major climatic change during this transition. However, the possible impacts of approaching 3.2 ka BP event might started to be visible especially towards the end of the LBA. Thus, comparing the LBA samples with the MBA samples would made any change more visible.

It has been well aware that the socio-economic character and geography of these two mounds are too different from each other. For instance, Atchana was a capital city whereas Toprakhisar was rural town. In addition, Atchana is a located in a plain, however, Toprakhisar is located in a mountainous environment. But it is believed that the central-periphery relationship between these two settlements makes such comparisons as mentioned in the previous paragraph possible. Because it is expected that such a relationship would increase the similarity between the crop and other type of products that were in circulation between two settlements. In other words, if Toprakhisar is one of those who provide the crop of its capital, Alalakh, they should send what they have sown to the capital. They also ate what they raised. Thus, the consumption patterns of Toprakhisar and Atchana should be similar. Starting from this point of view, the results of both mounds are evaluated together.

In the transition from the EBA to MBA, the presence of the free-threshing wheat increases. Significantly, in the Phase 1 of 54.38 (2100-2000 BC) that could be dated to very end of the EBA, the free-threshing wheat totally absent from the samples. However, with the beginning of MBA, these grains started to be observed again. In fact, the free-threshing wheat reaches its highest percentages in the samples belonging to MBA. It is usually over 40% of the total of the cereals mentioned here. The reason behind the increase in the importance of the free-threshing wheat might be positive environmental conditions that enables the cultivation of these drought susceptible cereal species. The barley grains proportion is very high during the end of the EBA comparing to MBA. In EBA samples, the barley represents nearly or over the half of the cereals discussed here. However, during the MBA its importance seems to decrease gradually and never become the dominant crop in MBA. The hulled wheat was present in both EBA and MBA. During EBA, its presence with the barley in the Phase 1 of 54.38 and the lack of free-threshing wheat suggests that this period might be the period that the effects of environmental pressure were strongly felt by the settlers of Toprakhisar Höyük. However, as mentioned, some of the hulled wheat species are drought tolerant (emmer) but some of them are drought susceptible (einkorn). As chaff remains evidenced that both of these species were present in the samples of Toprakhisar, it is impossible to say that the exact reason behind the presence of only barley and hulled wheat was drought and farmers were in tendency to cultivate drought tolerant species. During MBA, the proportion so as importance of the hulled wheat decreased gradually. It could be argued that its importance decreased as the good environmental conditions during MBA obviated the necessity of cultivation of hulled wheat species. Of course, it is a possibility if most of the hulled wheat consumed in

Toprakhisar was emmer wheat.

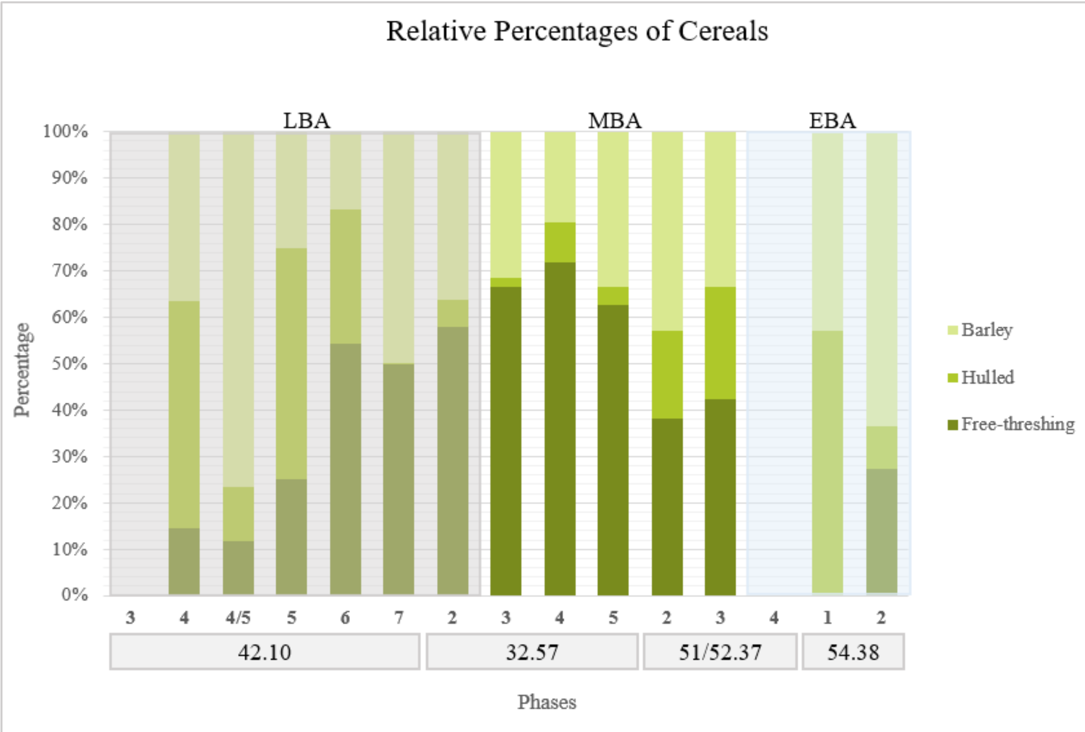

Figure 45. Graph shows the relative percentages of cereals taken from Tell Atchana and Toprakhisar throughout different ages.

In the transition from MBA to LBA, the presentation of free-threshing wheat starts to decrease again. When it is considered in phases base, it has fluctuations in different phases, it increases and decreases. But its general trend tends to decline, and it never represented in the assemblages as proportionate as it was in the MBA. With the decrease of the importance of free-threshing wheat, the barley starts to gain its importance back again in LBA. With hulled wheat species, it becomes dominant crop of the LBA. As mentioned in the previous paragraph, the importance of the hulled wheat species in the MBA decreased, but in the LBA, they started to be represented in high proportions especially in the Phase 4 of 42.10 (1300-1200 BC) which dates back to the very end of LBA. The increasing importance of hulled wheat species might be related with the increasing drought towards the end of the LBA that felt by most of the Near Eastern sites. On the contrary to Toprakhisar Höyük, Atchana does not have chaff evidence (except Phase 7 where the species level identification was not possible on chaffs) to understand what kind of hulled wheat plant was consumed in the site. However, it is assumed that the emmer wheat should be consumed as einkorn wheat cultivation was abandoned in most of the Near Eastern sites of that time. In that was the case, then, emmer wheat might be cultivated and consumed for its resistance during the increasing drought.

4.1.3. Correspondence Analysis

In order to do this analysis, an identity was given to each archaeological layer from which seeds were taken, and the proportions of free-threshing wheat, hulled wheat, and barley in each layer are used to carry out the analysis. With correspondence analysis, it is aimed to understand whether the layers associated with climate changes are related to barley and hulled wheat species. One the other hand, free-threshing wheat species are expected to be associated with layers that did not coincide with climatic changes.

Atchana and Toprakhisar are examined in tandem to accomplish the stated goal. Indeterminate wheat species are excluded in order to avoid bias that may result from including grains that have no significant meaning, only the proportions of free-threshing wheat (*T. aestivum/durum*), hulled wheat (*T. monococcum/dicoccum*), and barley (*Hordeum vulgare*) are included in the correspondence analysis (Table *7*). Since there are no grains coming from Phase 3 of 42.10 plan square and Phase 4 of 51/52.37 plan square, these phases are excluded from the analysis.

Table 7. Table shows the proportion of the samples for each phase coming from different plan squares of Toprakhisar and Atchana. The phase IDs are used to identify the different phases in correspondence analysis.

Plan Square	Local Phase	Date (ca. BC)	Phase ID	T. aestivum/durum (TAE)	T. monococcum/dicoccum (TMD)	H. vulgare (HVUL)
42.10	4	1300-1200	1	2,09	6,97	5,23
	4/5	1325-1275	2	2,00	2,00	13,00
	5	1350-1300	3	6,67	13,33	6,67
	6	1350-1300	4	8,33	4,49	2,56
	7	1400-1350	5	15,83	0,11	15,83
32.57	2	1550-1400	6	20,90	2,05	13,11
	3	1600-1550	7	38,58	1,09	18,19
	4	1650-1600	8	32,42	3,85	8,79
	5	1750-1650	9	20,43	1,27	10,95
51/52.37	2	2000-1900	10	8,16	4,08	9,18
	3	2000-1900	11	4,36	2,52	3,44
54.38	1	2100-2000	12	0,00	6,78	5,08
	2	2100-2000	13	1,78	0,59	4,14

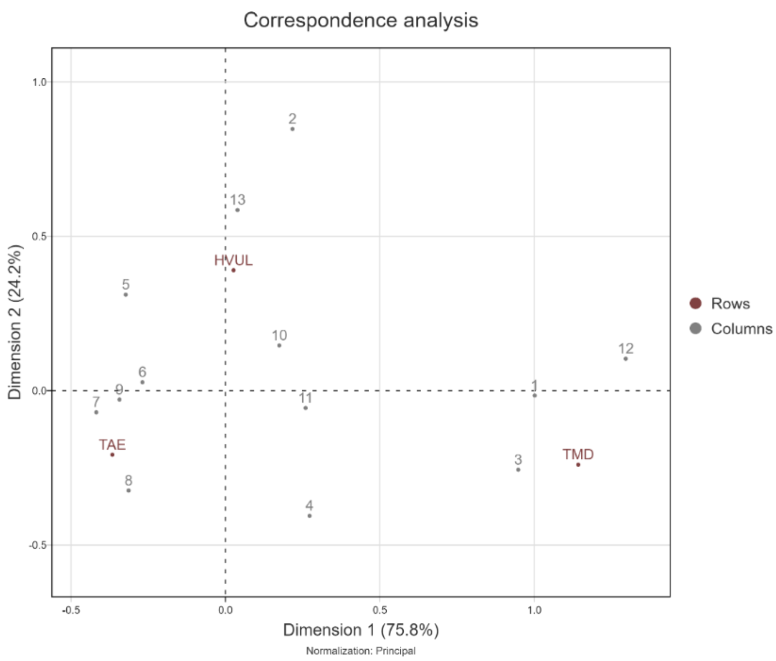

Figure 46. The correspondence analysis carried out on Toprakhisar and Atchana samples.

The horizontal axis contributed 75,8% of the variation and the vertical axis 24,2% in the correspondence analysis on seeds (Figure 46). The 100% variance value, which is the sum of these two values, shows that all of the values in the data group are represented in this graph. If this variance value, which is the sum of the two axes, was low, it could be said that the analysis did not reflect the data very strongly.

Further distance of a row from the origin shows that that row has at least one column that strongly correlates with it. The correspondence analysis performed on the Toprakhisar and Atchana samples reveals that, in particular, hulled wheat (TMD) is situated in a location that is far from the origin. This shows that some of the phases are very closely related to this wheat type. Free-threshing wheat (TAE) and barley (HVUL) is also distant from the origin but not as much as the hulled wheat. Although they are related to certain of the stages of Atchana and Toprakhisar, their relationship is not as strong as that of the hulled wheat due to their comparatively closer proximity to the origin.

When the association between the phases and plant types are evaluated, imaginary arrows from the origin is drawn to data points of plant types (columns) and phases (rows). If the arrows are long and the angle between two points is small, it indicates that the presence of strong positive association between these two. If the arrows are short and the angel is large (but still smaller than 90°), it indicates either weak association or no association at all. Lastly, if the angle between two arrows is near 180°, then the plant type and phase is negatively associated with each other (Glynn, 2014).

The proximity of hulled wheat (TMD) and Phase 5 of 42.10 (3) (1350–1300 BC) and their distances from the origin imply a significant relationship between these two variables. Similarly, hulled wheat also has a strong relatedness with Phase 4 of the same plan square (1) (1300-1200 BC). The hulled wheat grains and Phase 6 of 42.10 (4) (1350–1300 BC) appear to be associated, but this relationship is not as strong as that of the previously mentioned phases. In Toprakhisar, hulled wheat is associated with Phase 1 of 54.38 (12) (2100-2000 BC), but this association is not as significant as that of Phase 4 and 5 in the 42.10 plan square. On the other hand, hulled wheat has negative association with some of the phases as well. As may be inferred from their positions in opposing quadrants, all phases of the 32.57 plan square (6,7,8,9) (1750-1400 BC) and the oldest phase (Phase 7) of the 42.10 plan square (5) (1400-1350 BC) have a negative association with hulled wheat grains.

Barley (HVUL) appears to have strongest association with Phase 4/5 of 42.10 plan square (2) (1325-1275 BC) in Atchana. It is also related to Phase 2 of 54.38 plan square (13) (2100-2000 BC) in Toprakhisar. These two phases are the only phases that barley shows strong association. Besides these phases, Phase 7 of 42.10 (5) (1400-1350 BC) and Phase 2 of 51/52.37 (10) (2000-1900 BC) might have a weak association with barley. From the correspondence analysis, it can also be said that the barley grains are negatively associated with especially Phase 6 of 42.10 (4) (1350–1300 BC) and Phase 4 of 32.57 (8) (1650-1600 BC).

The associations of free-threshing wheat (TAE) with different phases appears to be never as strong as of the other plant types. The strongest association of this wheat is with Phase 4 of 32.57 (8) (1650-1600 BC) and Phase 3 of the same plan square (7) (1600-1550 BC). It might also relate to Phase 5 (9) (1750-1650 BC) and Phase 2 (6) (1550-1400 BC) but even this is the case, the association is even weaker than the previously mentioned phases. The graph of correspondence analysis also points to the negative association of free-threshing wheat with the phases that hulled wheat has strong association (1,3,12). From that perspective, it is also possible to assert a negative correlation between hulled wheat and free-threshing wheat. When one of them dominates a certain phase, the other one is only present in smaller proportions. However, this type of direct negative association with any kind of wheat is not valid for barley. Still, some of the phases that are associated with barley (2,13) is negatively associated with free-threshing wheat.

4.1.3.1. Remarks on Toprakhisar Results

The end of the 3rd millennium BC (2100-2000 BC, 54.38 plan square) in Toprakhisar is highly associated with the barley and hulled wheat however this association either weakens or disappears in the samples belonging to the beginning of the 2nd millennium (2000-1900 BC, 51/52.37 plan square). However, it is certain that the presence of the free-threshing wheat is higher in the latter period.

Riehl (2008) points to the decreasing presence of drought susceptible crops from EBA to MBA in the Near East, and suggests that the 4.2 ka BP climate change impacted the crop production patterns. When the samples that were dated to 2100-2000 BC in this thesis which coincides to the very end of EBA and the beginning of MBA are considered, it is seen that Toprakhisar samples are contradictory to results of Riehl's study since that samples have mainly drought tolerant species. With the transition to MBA, on the other hand, the drought susceptible free-threshing wheat increased in the samples. These results are exactly opposite of the results suggested by Riehl. The reason behind this contradiction might be related to difference in the duration of climate change in the different regions. 4.2 ka BP event might have lost its effect with the beginning of the 2nd millennium BC whereas it affected the agricultural decision making in the previous century in Toprakhisar. Thus, the reason of the preference for drought susceptible species might be associated with the improving environmental conditions with the beginning of 2nd millennium BC.

4.1.3.2. Remarks on Atchana Results

To briefly explain the results, it is seen that drought tolerant hulled wheat and barley are strongly related with the LBA layers of the 42.10 plan square in Atchana, especially from the beginning of second half of the 14th century BC until the end of the LBA (coincides with Phase 6 to Phase 4, 1350-1200 BC). On the other hand, drought susceptible free-threshing wheat appears to be mostly found in the latest Phase 7 of

42.10 (1400-1350 BC) and also LBA (Phase 2) and MBA (Phases 3,4,5) (1750-1400 BC) layers of 32.57 plan square in Atchana. Additionally, hulled wheat has strong negative association with these phases that free-threshing wheat is associated. Phase 7 of 42.10 is particularly interesting phase where the samples were rich and consequently more representative. The findings of Phase 7 points to the increasing importance of barley with the beginning of LBA where free-threshing wheat was still holding an important place amongst the crops cultivated. The results retrieved from Atchana suggest that MBA and the onset of the LBA were marked by the consumption of the free-threshing wheat whereas barley and hulled wheat consumption became prominent as time progressed in LBA. It is already expected that as MBA and the beginning of the LBA was a period that good environmental conditions were in play. So, in these time periods, the farmers were probably able to produce mainly free-threshing wheat. It was also expected that the approaching 3.2 ka climatic event might started to have an impact through the end of the LBA. The results meet this expectation as well in the later periods of LBA, as the drought tolerant species became more visible with stronger presence.

However, it should be remembered that the results might also be related with the differential taphonomic status of the samples in different plan-squares. If the number of plant remains (especially identifiable remains) in the samples are high, it directly increases the species diversity of the plants of the site under investigation. In Atchana, the number of total cereal remains in 32.57 plan square is 1618 and 1261 of them identifiable. However, the number of cereals grains in 42.10 is 882 and 371 out of 882 is identifiable. When 42.10 plan square is compared to 32.57, the underrepresentation of some species in 42.10 is a possibility. If this was the case, another result might have been obtained if the samples of 42.10 was as rich as that of 32.57 plan square.

To better understand the preference of hulled wheat and barley in the LBA period, the results also can be compared with the previous studies carried out in the Tell Atchana. The previous archaeobotanical studies carried out in Atchana (Çizer, 2006; Riehl, 2010a; Stirn, 2013) only focused on the LBA occupation in the site (for detailed information see 2.5.1.17.). Çizer suggested that in 14th century BC (LBA) Atchana, free-threshing wheat was the main cereal, and it was followed by barley in importance. Çizer suggested that emmer wheat was cultivated only in small scale based on that this wheat has low occurrences in the samples (n=~10). However, the samples that Çizer worked on were poor in general. The total number of free-threshing wheat grains was nearly 40 and of barley was nearly 25 in total of 35 samples. So, as Çizer suggested the low number of emmer wheat might be related with the suggested small-scale cultivation but also might be related with the general poorness of the samples. The work carried out by Stirn also shows a similar cereal consumption pattern during the LBA occupation in Atchana. He found that free-threshing wheat is the most abundant wheat throughout the different LBA phases (Level V to Level II, ca. 1550-1240 BC). Barley followed the free-threshing wheat in abundance until in Level V to Level III, but in Level II (ca. 1313-1240 BC), emmer wheat replaced the barley and become the second most abundant cereal in that period. The study carried out by Riehl also suggested the dominance of free-threshing wheat in LBA (1450-1300 BC). Similar to the previous phases, the samples studied in this research also identify the barley as the second most abundant cereal. On the other hand, emmer and einkorn wheat were only found with a single grain. In brief, archaeobotanical evidence suggests the dominance of free-threshing wheat and barley whereas emmer was only occasionally found. The results of this study suggests similar picture with the results of Stirn (2013) for LBA occupation between 1350 and 1200 BC. Especially with the beginning of Phase 6 in 42.10 plan-square when the stronger presence of hulled wheat and also barley is evident, findings of Stirn also supports the greater presence of hulled wheat species between ca. 1313-1240 BC. The other two studied are expectedly does not cover this pattern as the studied samples are coming from the prior occupational levels of Atchana.

Unfortunately, there is not previously carried archaeobotanical study that includes the MBA levels of Atchana. Nevertheless, the written evidence suggests that the mostly consumed cereals were barley and emmer in the site. Especially, rations of people were disbursed with these cereals (Lauinger, 2015). By emphasizing that higher class individuals often received emmer, albeit barley could occasionally be consumed by them as well and the ruler of the city always received emmer, tablets from Atchana MBA levels demonstrate the importance of mainly emmer and barley (for references see Riehl, 2010a). On the other hand, the instances mentioned in the texts are not visible in the archaeobotanical data coming from the MBA phases. Rather, it appeared that the free-threshing wheat was the predominant cereal and hulled wheat occasionally occurred. Barley was the second most important crop after free-threshing wheat.

The results from Atchana of this study suggests the exact opposite situation for MBA and LBA occupation when they are compared to the previous archaeobotanical studies and written texts. LBA samples dominated by the hulled wheat in this study whereas the previous studies most abundantly found the free-threshing wheat. The MBA samples, on the other hand, have dominantly free-threshing wheat whilst the written evidence suggest that the mostly circulated wheat type was emmer wheat.

Given that Tell Tayinat is the Iron Age continuation of Tell Alalakh (Casana & Wilkinson, 2005; Manning et al., 2020), past research at Tell Tayinat is particularly crucial for understanding how crop consumption changed from the LBA to the Iron Age. The proportion of free-threshing wheat was found to be greater in Iron Age samples from the Tayinat than that of barley and emmer wheat in general, with the exception of a brief time (Phase FP-5, around 1050–1000 BC) where emmer wheat had a larger proportion than free-threshing wheat (Karakaya, 2019). The same study also indicated that while barley had decreasing ratio over free-threshing wheat in Iron Age compared to EBA, its ratio slightly increased in the Phase FP-5 in Iron Age. Both the increase of emmer wheat and relative proportion of barley over free-threshing wheat in Phase FP-5 of Tell Tayinat are correlated with the results coming from the final LBA phases investigated in this study. The other periods of Iron Age habitation in Tayinat, however, do not indicate an increase in the use of emmer and barley. If this were the case, it would be safer to speculate on the likelihood of an increase in drought and the subsequent tendency toward the production of drought-tolerant species. But even so, when the findings from FP5 and Atchana are compared, they may also point to a climatic change whose impact diminished at the start of the Iron Age but then briefly reappeared in Phase FP-5. This might be the reason why Tayinat samples from the very beginning of the Iron Age have a greater percentage of free-threshing wheat, but after a short period of time, emmer and barley proportions rose. However, even with the help of the high-resolution proxy record to track the shifting severity of climate change, it is a tenuous claim that is difficult to support.

4.2. MORPHOMETRIC MEASUREMENTS

4.2.1. Toprakhisar Höyük

4.2.1.1. Free-threshing Wheat

The total number of free-threshing wheat taken from the Toprakhisar for morphometric measurements is 15. Only two of them are coming from the 54.38 plan square whereas the rest is retrieved from 51/52.37 (Table *8*). The measurement details of the free-threshing wheat grains are given in the Table *33* in Appendix D.1.

Surface area and volume of these seeds are estimated using the formulae explained in Section 2.1.3. When surface area is compared to the volume, it is seen that they are correlated (Figure *47*). The seeds coming from 54.38 plan square, Phase 2 (2100-2000 BC) has the highest volume and surface area but in the grains taken from the 51/52.37 plan-square (Phase 3, 2000-1900 BC), the values slightly decrease. The surface area fluctuates between 26 and 51 mm^2 in the samples of 51/52.37 plan square. This value raises up to nearly 60 mm^2 in 54.38 plan square samples (Figure *48*). The volume values, on the other hand, nearly in between 3 and 20 mm^3 for the former grains, however, they are nearly 16 and 25 mm^3 for the latter (Figure *49*).

Table 8. Table shows the area and volume of the free-threshing wheat from Toprakhisar Höyük.

Site	Photo ID	Plan-Square	Phase	Date	Area (mm2)	Volume (mm3)
TOPRAKHİSAR HÖYÜK	TPH035_wheat_01	51/52.37	3a	2000-1900 BC	40,47	14,43
	TPH044_wheat_01		3a		29,02	8,91
	TPH044_wheat_03		3a		37,05	12,26
	TPH044_wheat_05		3a		33,20	6,63
	TPH006_wheat_01		3a		40,74	16,29
	TPH007_wheat_01		3a		50,19	19,77
	TPH013_wheat_02		3a		50,87	17,47
	TPH017_wheat_02		3a		33,64	6,73
	TPH020_wheat_02		3a		25,41	3,59
	TPH043_wheat_01		3a		42,11	15,50
	TPH037_wheat_02		3		26,27	6,69
	TPH042_wheat_01		3		47,90	18,03
	TPH056_wheat_01		3		49,24	17,67
	TPH054_wheat_01	54.38	2	2100-2000 BC	50,09	24,78
	TPH055_wheat_02		2		59,53	16,25

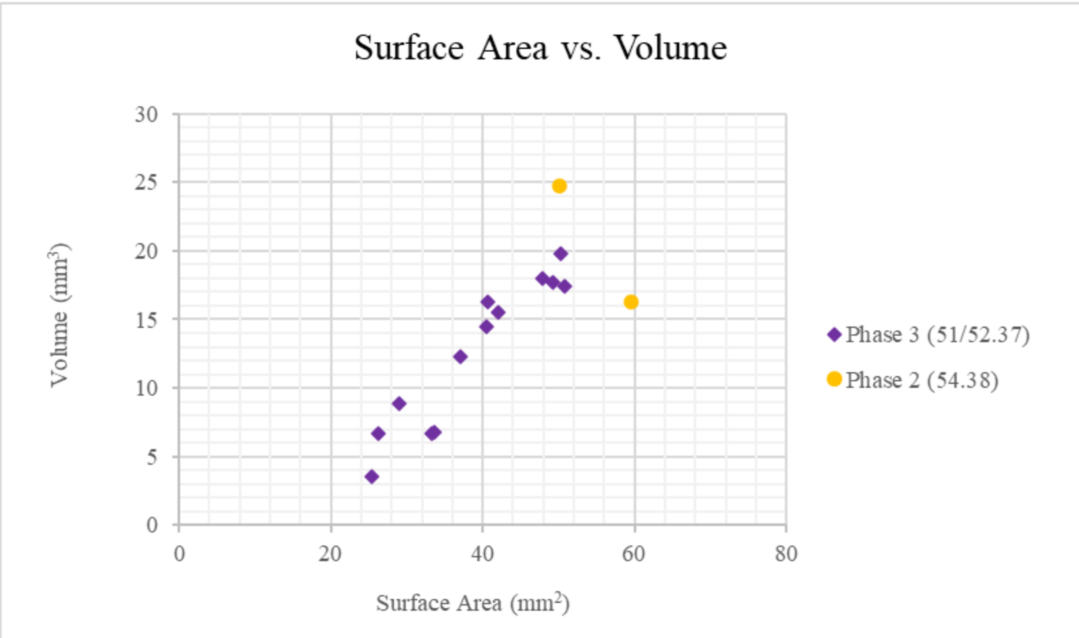

Figure 47. Scatter plot shows the individual values of volume vs. surface area of the free-threshing wheat taken from Toprakhisar Höyük.

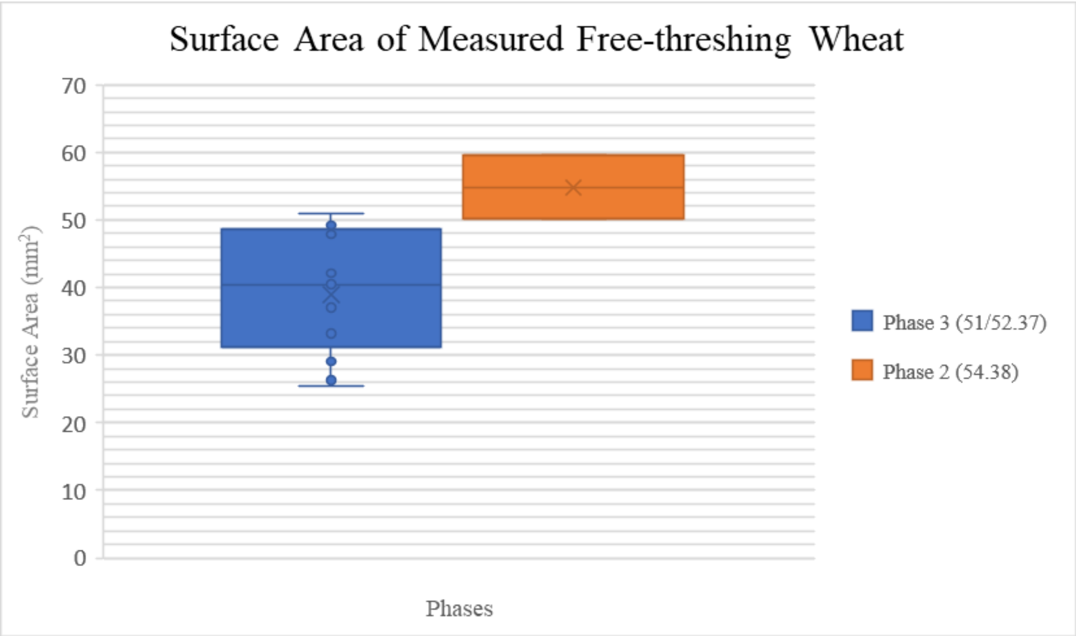

Figure 48. Boxplot shows the surface area of free-threshing wheat grains in different phases of Toprakhisar Höyük.

Figure 49. Boxplot shows the volume of free-threshing wheat grains in different phases of Toprakhisar Höyük.

When the samples of Toprakhisar are evaluated according to their surface area and volume in differentiating phases, it is seen that the average values of both parameters decrease from the Phase 2 of 54.38 to Phase 3 of 51/52.37. However, the number of measured seeds is too low, especially in the 54.38 plan square, due to the bad preservation. Consequently, it is not very safe to associate the reducing size of the grains in the transition from 3rd century to 2nd century with the environmental restrictions caused by the ongoing 4.2 ka BP climate event. However, when these results are evaluated together with the results of stable carbon isotope analysis, the measurements carried out in Toprakhisar grains might be more meaningful as any water deficiency (caused by climatic stress) should be both visible in the size and stable carbon isotope composition of grains.

4.2.1.2. Hulled Wheat

The number of hulled wheat grains taken from Toprakhisar samples for measurements is 8 in total. Six out of eight were belonging to 51/52.37, Phase 3 (2000-1900 BC) as was the free threshing wheat grains, and the rest two was taken from Phase 1 of 54.38 plan square (2100-2000 BC) (Table 9). The measurement details of the hulled wheat grains are given in the Table 34 in Appendix D.1.

Table 9. Table shows the area and volume of the hulled wheat from Toprakhisar Höyük.

Site	Photo ID	Plan-Square	Phase	Date	Area (mm2)	Volume (mm3)
TOPRAKHİSAR HÖYÜK	TPH044_wheat_02	51/52.37	3a	2000-1900 BC	21,19	3,76
	TPH001_wheat_01		3a		44,12	13,64
	TPH013_wheat_03		3a		42,97	6,95
	TPH037_wheat_01		3		28,74	6,75
	TPH037_wheat_03		3		33,44	6,72
	TPH037_wheat_04		3		21,84	5,18
	TPH048_wheat_03	54.38	1	2100-2000 BC	40,45	10,83
	TPH048_wheat_04		1		25,92	6,68

The surface area and the volume are not correlated with volume in the seeds coming from the 51/52.37 (Figure *50*). In some of these grains, even though the surface area increases, the volume does not increase with the increasing surface area. Two grains from 54.38 plan square, however, have correlated surface area and volume that when the former increases the latter also increases. The surface area of the hulled wheat in 51/52.37 ranges between 21 and 45 mm^2 whereas the 54.38 grains are between nearly 25 and 41 mm^2 (Figure *51*). On the other hand, the volume of the grains is in between nearly 4 and 14 mm^3 for 51/52.37 plan square and are nearly 7 and 11 mm^3 for 54.38 plan square (Figure *52*).

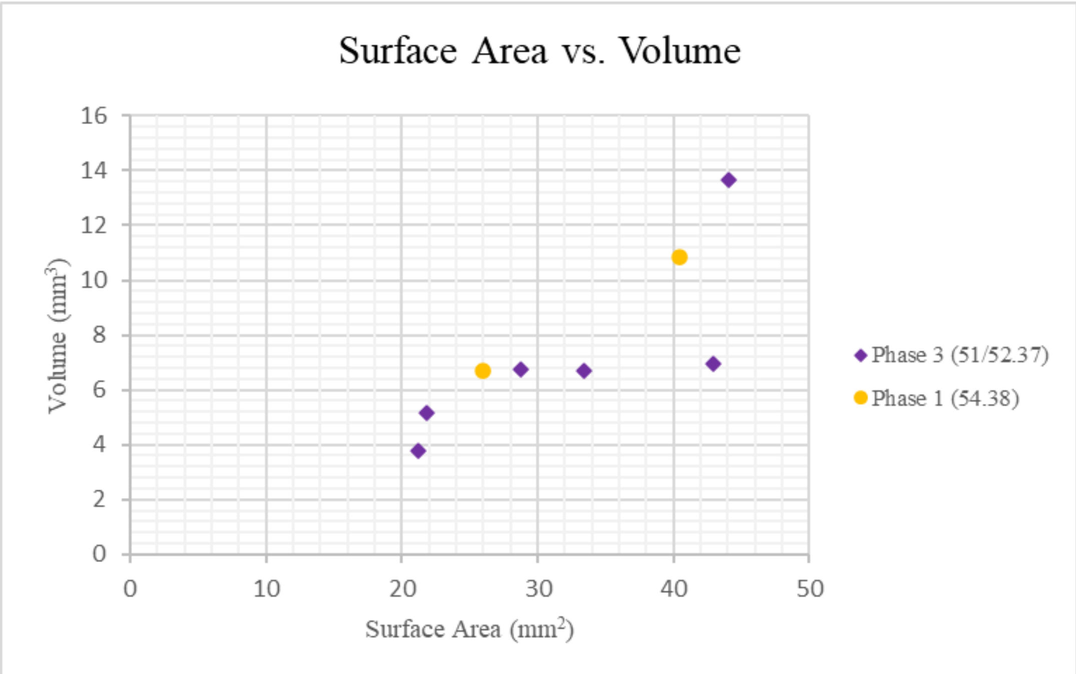

Figure 50. Scatter plot shows the individual values of volume vs. surface area of the hulled wheat taken from Toprakhisar Höyük.

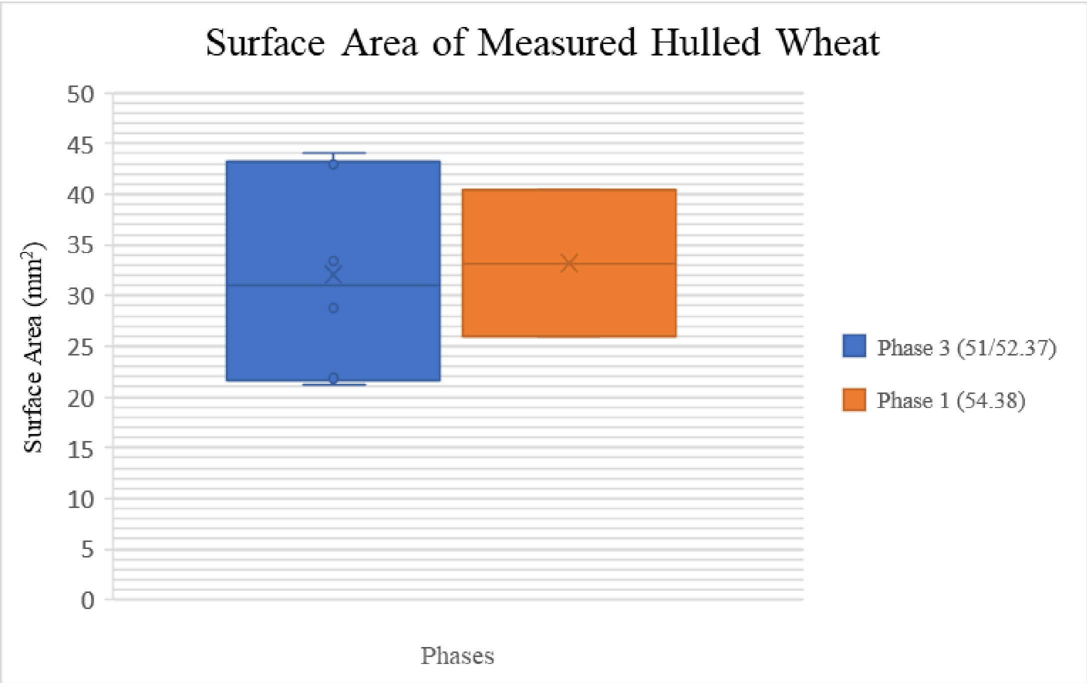

Figure 51. Boxplot shows the surface area of hulled wheat grains in different phases of Toprakhisar Höyük.

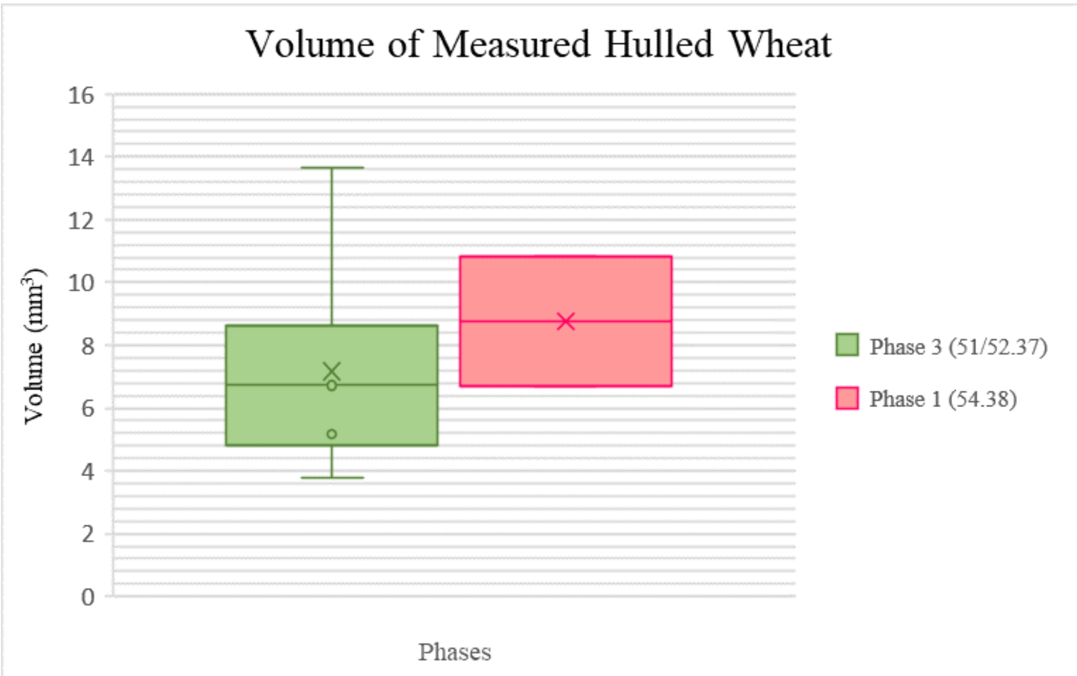

Figure 52. Boxplot shows the volume of hulled wheat grains in different phases of Toprakhisar Höyük.

The average values of both surface area and volume shows slight decrease from the samples dating to 2100-2000 BC (Phase 1 of 54.38) to the samples belongs to the time between 2000-1900 BC (Phase 3 of 51/52.37) (Figure *51* and Figure *52*). However, there are mainly two restrictions to make a meaningful assumption about the possible causes of the decrease in average values of surface area and volume of the in during this transition. First one of these restrictions is small sample size in both of the periods and the second is large range of individual values. First restriction is result from a scarcity of well-preserved samples and prevents getting closer to understand the real surface area and volume parameters of the whole population of hulled wheat grains. The second restriction indicates that the samples have both big seeds and smaller seeds and there is no particular trend for shrinkage of grains resulted from environmental restrictions. However, as it is the case for free threshing wheat, when the results of morphometric measurements are evaluated with the results of stable carbon isotope analysis, they would be more meaningful.

When the surface area and the volume of the hulled wheat grains are compared with the free-threshing wheat grains, it is seen that the average of both parameters are smaller in the hulled wheat in the grains taken from both plan squares, but especially for the 54.38, the gap between the two is very large. Considering the fact that the free-threshing wheat species are more prone to drought than the hulled wheat species, it is possible to argue that the water was available to permit the well growth of free-threshing wheat so that they became larger than the hulled wheat. Even, the farmers of Toprakhisar were might able to somehow irrigate their free-threshing wheat which an idea that suggests the availability of the water in close proximity of the mound. Otherwise, they might leave the free-threshing wheat lands for rainfed, again, suggesting that there was enough precipitation for the free-threshing wheat for their good growth.

4.2.2. Tell Atchana

4.2.2.1. Free-threshing Wheat

Total of 59 free-threshing wheat grains were retrieved from Tell Atchana for morphometric measurements. 4 of them belong to Phase 4 of 42.10 plan square (1300-1200 BC), 1 from Phase 4/5 (1325-1275 BC), 3 from Phase 6 (1350-1300 BC) of the same trench. 29 grains belong to different sub-phases of Phase 5 of 32.57 plan square (1750-1650 BC). The rest 22 grains were belonging to 33.32 plan square of the Alalakh Level VII Palace (1750-1650 BC) (Table *10*). The measurement details of the free-threshing wheat grains are given in the Table 35 in Appendix D.2.

Table 10. Table shows the area and volume of the free-threshing wheat from Tell Atchana.

Site	Photo ID	Plan-Square	Phase	Date	Area (mm2)	Volume (mm3)
TELL ATCHANA	AT002_wheat_01	42.10	4	1300-1200 BC	38,76	10,42
	AT015_wheat_02		4		46,03	13,59
	AT015_wheat_07		4		38,41	10,97
	AT015_wheat_08		4		31,92	7,61
	AT004_wheat_01		4b/5	1325-1275 BC	53,61	17,33
	AT021_wheat_02		6b	1350-1300 BC	50,24	16,84
	AT022_wheat_01		6b		46,87	13,34
	AT023_wheat_01		6b		37,35	8,36
	AT072_naked_01	32.57	5a/b	1750-1650 BC	30,61	8,72
	AT069_naked_01		5b		42,95	13,52
	AT069_naked_02		5b		20,67	5,13
	AT069_naked_03		5b		42,89	14,75
	AT069_naked_04		5b		38,63	11,94
	AT078_naked_01		5b		44,55	12,52
	AT080_naked_01		5b		31,22	8,12
	AT080_naked_02		5b		46,64	12,62
	AT080_naked_03		5b		28,78	7,89
	AT070_naked_01		5c		50,58	14,68
	AT070_naked_02		5c		46,65	13,48
	AT074_naked_01		5c		27,64	6,87
	AT076_naked_01		5c		44,91	15,87
	AT076_naked_02		5c		37,20	13,36
	AT082_naked_01		5c		41,83	11,55
	AT082_naked_02		5c		40,89	14,25
	AT075_naked_01		5d		59,39	20,56
	AT075_naked_02		5d		51,26	17,88
	AT075_naked_03		5d		50,42	16,52
	AT075_naked_04		5d		33,65	9,83
	AT075_naked_05		5d		62,40	23,49
	AT075_naked_06		5d		40,34	11,07
	AT075_naked_07		5d		45,67	17,31
	AT075_naked_08		5d		36,53	10,82
	AT075_naked_09		5d		36,56	11,98
	AT079_naked_01		5f		37,19	12,08
	AT081_naked_01		5f		47,10	17,87
	AT081_naked_02		5f		44,37	14,48
	AT081_naked_03		5f		35,82	12,98
	AT_MBA_wheat_01	33.32	VII	1750-1650 BC	58,26	18,73
	AT_MBA_wheat_02		VII		51,89	19,57
	AT_MBA_wheat_03		VII		50,70	15,45
	AT_MBA_wheat_04		VII		51,90	17,25
	AT_MBA_wheat_05		VII		44,34	13,04
	AT_MBA_wheat_06		VII		51,34	14,42
	AT_MBA_wheat_07		VII		49,18	15,27
	AT_MBA_wheat_08		VII		52,49	19,06
	AT_MBA_wheat_09		VII		52,08	17,95
	AT_MBA_wheat_10		VII		58,47	15,13
	AT_MBA_wheat_11		VII		65,80	19,74
	AT_MBA_wheat_12		VII		44,37	14,76
	AT_MBA_wheat_13		VII		53,06	18,46
	AT_MBA_wheat_14		VII		44,85	13,91
	AT_MBA_wheat_15		VII		60,64	18,59
	AT_MBA_wheat_16		VII		59,01	15,60
	AT_MBA_wheat_17		VII		35,95	10,13
	AT_MBA_wheat_18		VII		57,08	16,67
	AT_MBA_wheat_19		VII		44,66	17,28
	AT_MBA_wheat_20		VII		48,73	13,48
	AT_MBA_wheat_21		VII		44,62	12,36
	AT_MBA_wheat_22		VII		50,74	15,80

The surface area and volume of each phase are correlated when the scatter plot is drawn (Figure *53*). The grains with highest volume belong to Phase 5 of 32.57 plan square (1750-1650 BC). The seeds belonging to this period also had lowest values of volume and surface area. In other words, these grains scattered in a large scale both in volume and surface area. The Phase VII of 33.32 (1750-1650 BC) has the grains with largest surface area.

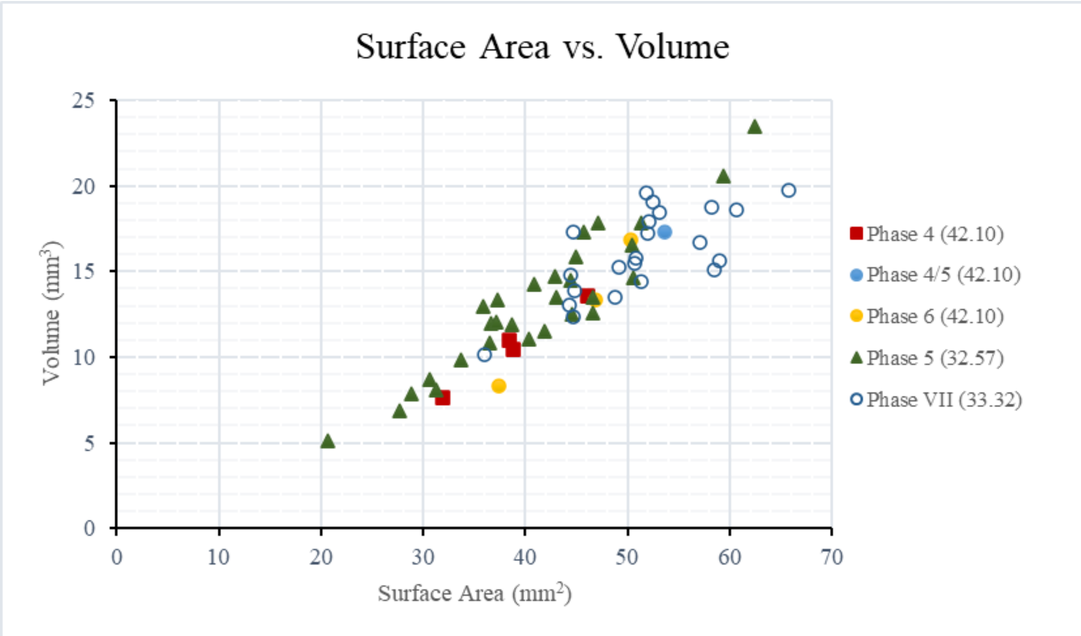

Figure 53. Scatter plot shows the individual values of volume vs. surface area of the free-threshing wheat taken from Tell Atchana.

The surface area of the free-threshing wheat grains ranges between nearly 32 and 46 mm^2 for Phase 4 of 42.10, is nearly 54 mm^2 for Phase 4/5, between nearly 37 and 50 mm^2 for Phase 6. For the grains of the Phase 5 of 32.57, the values of surface area extend in 21 and 62 mm^2. And lastly for the 33.32 plan square Phase VII samples, the values are in between 36 and 66 mm^2 (Figure *54*).

The volume of the grains is in between nearly 8 and 14 mm^3 for the Phase 4, is approximately 17 mm^3 for Phase 4/5, ranges in 8 and 17 mm^3 for the Phase 6 in 42.10 plan square. For the Phase 5 of 32.57 plan square, the volumes are in between nearly 5 and 23 mm^3. In Phase VII of 33.32, the values range between 12 and 20 mm^3 (Figure *55*).

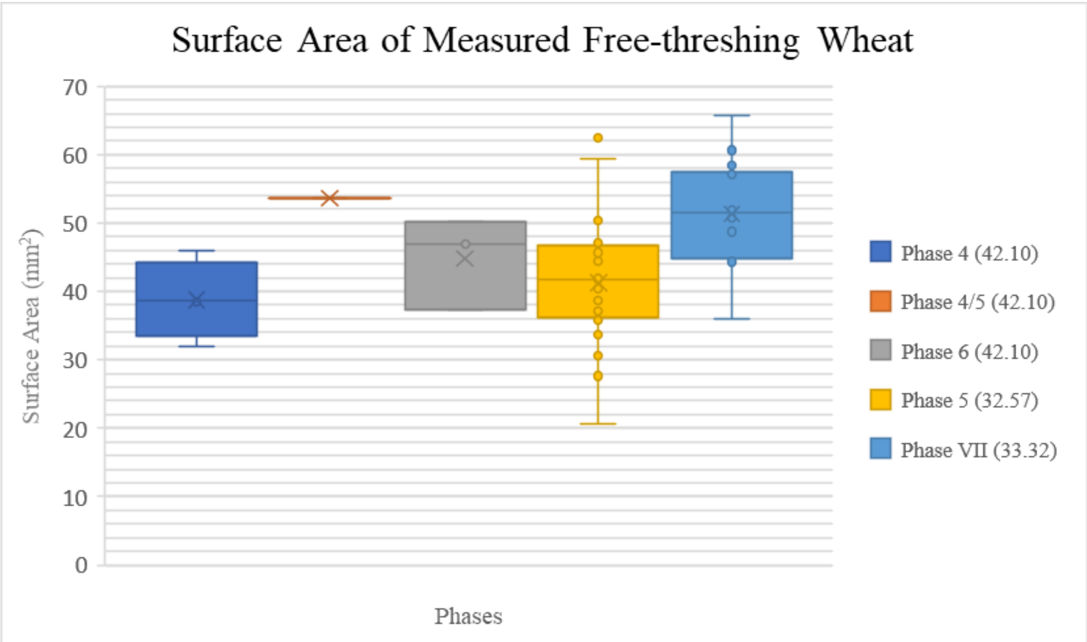

Figure 54. Boxplot shows the surface area of free-threshing wheat grains in different phases of Tell Atchana.

Figure 55. Boxplot shows the volume of free threshing wheat grains in different phases of Tell Atchana.

When the surface area values are evaluated according to the phases, it can be seen that the Phase VII of 33.32 (1750-1650 BC) had the highest average surface area among all the phases. The Phase 5 of 32.57 which dates back to the same time period, and to similar contexts, has slightly decreased average of surface volume. However, this decrease seems irrelevant considering the chronological simultaneity of both plan squares and the similarity of the contexts as both of them were part of the palace. One can expect to see that the grains in similar quality should be taken by the palace and temple that belong to the same period. Thus, the lowered average of the grains from 32.57 is the result of large range of values that is it has both seeds with large surface area and small surface area. Thus, it is impossible to argue about a changing largeness in the different contexts belonging to same period rather it is highly likely just related with the variability of the samples coming from this plan square. In the Phase 6 of the 42.10 plan square (1350-1300 BC), the average surface area of the grains increases again but does not reach to the average of Phase VII of 33.32 plan square. Since there are only three grains measured from this phase, it is again hard to draw conclusions like increasing seed size in the transition from MBA (represented by Phase 5 of 32.57) to LBA (represented by Phase 6 of 42.10). Likewise, as the Phase 4/5 (1325-1275 BC) had only one seed measurable, even though its surface area is larger than all measured grains of previous Phase 6, it is impossible to argue anything about the change. The Phase 4 of 42.10 plan square (1300-1200 BC) has smaller average of surface area comparing to all periods discussed so far. Keeping mind that this phase also has low number of measured grains, the decrease in the average surface area should be evaluated carefully as the end of this phase also coincides with the beginning of the 3.2 ka BP climatic change. The average volumes of the grains have the exact same trend with their surface area throughout the phases. The variability in grains of the Phase 5 of 32.57 plan square is more visible in the volume values with one very divergent outlier. The Phase 4 of 42.10 again has the smallest average volume.

To better understand the change in the seed size from MBA to LBA, the different phases should be evaluated together. By this way, the effect of small sample size might be reduced and also the change might be more visible from the time period that the environmental conditions are assumed good (MBA) to the period that witnessed an approaching climate change (LBA). To investigate the change in the grains coming from 42.10 are evaluated altogether as they belong to LBA, and the 32.57 and 33.32 samples are combined since they belong to MBA (Figure *56*). Both average volume and surface area very slightly and insignificantly decreased from MBA to LBA (In the following section, it is also tested statistically). However, it is important to note that the variability of the individual volume and surface area values of the MBA samples. The LBA samples does not have such variability. The reason might be either the larger sample size of MBA samples because the probability of presence of smaller or larger seeds increases with the increasing sample size. Otherwise, the diversity in the seed size might be the result of the harvest coming from different types of agricultural fields. Some fields might be drier than the others (because of the lack of additional water sources nearby except rainfall), and this might cause the undergrowth of the grains. Thus, very small seeds might be present in the MBA samples. However, in the LBA, if the small sample size is ignored, it might be assumed that the farmers of the period were cultivated their plants in less variant fields. Yet, as previously stated, the sample size for LBA is too small to convincingly support this claim. So, these results should also be evaluated with the stable carbon isotope results for better interpretations about the topic.

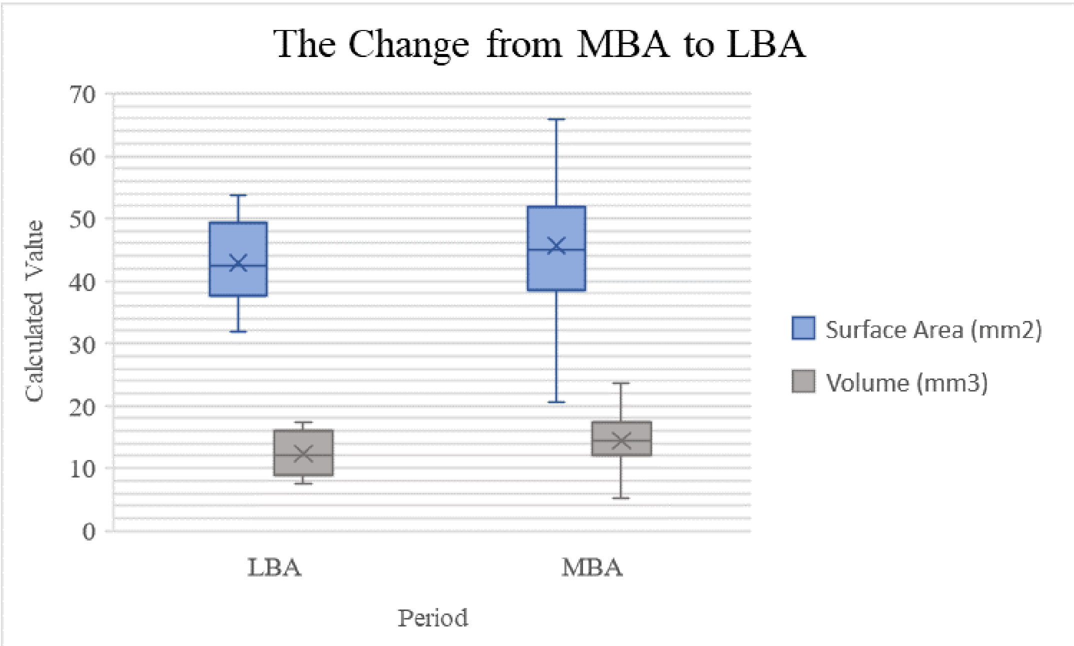

Figure 56. Boxplot shows the change of surface area and volume of free-threshing wheat grains from MBA to LBA.

4.2.2.2. Hulled Wheat

The total number of hulled wheat grains for measurement has lower number than the free-threshing wheat in Tell Atchana. The seeds were coming from 42.10 and 32.57 plan squares. Eight of the samples belonged to Phase 4 (1300-1200 BC), one to Phase 4/5 (1325-1275 BC) and another one to the Phase 6 of 42.10 plan square. The number of measured grains belonging to 32.57 plan square was eight and they were all coming from Phase 5 (1750-1650 BC) samples (Table *11*). The measurement details of the hulled wheat grains are given in the Table *36* in Appendix D.2.

Table 11. Table shows the area and volume of the hulled wheat from Tell Atchana.

Site	Photo ID	Plan-Square	Phase	Date	Area (mm2)	Volume (mm3)
TELL ATCHANA	AT015_wheat_01	42.10	4	1300-1200 BC	45,66	16,55
	AT015_wheat_03		4		41,32	7,75
	AT015_wheat_05		4		42,65	14,24
	AT015_wheat_06		4		31,01	8,33
	AT015_wheat_09		4		41,27	7,80
	AT018_wheat_05		4		40,43	11,95
	AT018_wheat_08		4		39,26	11,80
	AT018_wheat_09		4		31,63	7,53
	AT004_wheat_02		4b/5	1325-1275 BC	43,62	9,89
	AT022_wheat_02		6b	1350-1300 BC	22,29	4,47
	AT080_hulled_01	32.57	5b	1750-1650 BC	58,80	16,30
	AT080_hulled_02		5b		54,58	16,57
	AT080_hulled_03		5b		31,27	7,68
	AT071_hulled_01		5f		36,12	8,06
	AT079_hulled_01		5f		36,49	8,27
	AT079_hulled_02		5f		61,12	14,78
	AT081_hulled_01		5f		35,87	8,59
	AT081_hulled_02		5f		36,34	9,01

The volume of the measured hulled grains increases with the increasing surface area for most of the grains. The largest surface area belongs to three of the grains taken from Phase 5 of the 32.57 (1750-1650 BC). The highest volume values were shared by Phase 5 of 32.57 and Phase 4 of 42.10 plan squares (1300-1200 BC). The one seed coming from the Phase 6 of 42.10 plan-square (1350-1300 BC) is the smallest seed among the samples in means of both surface area and volume (Figure *57*).

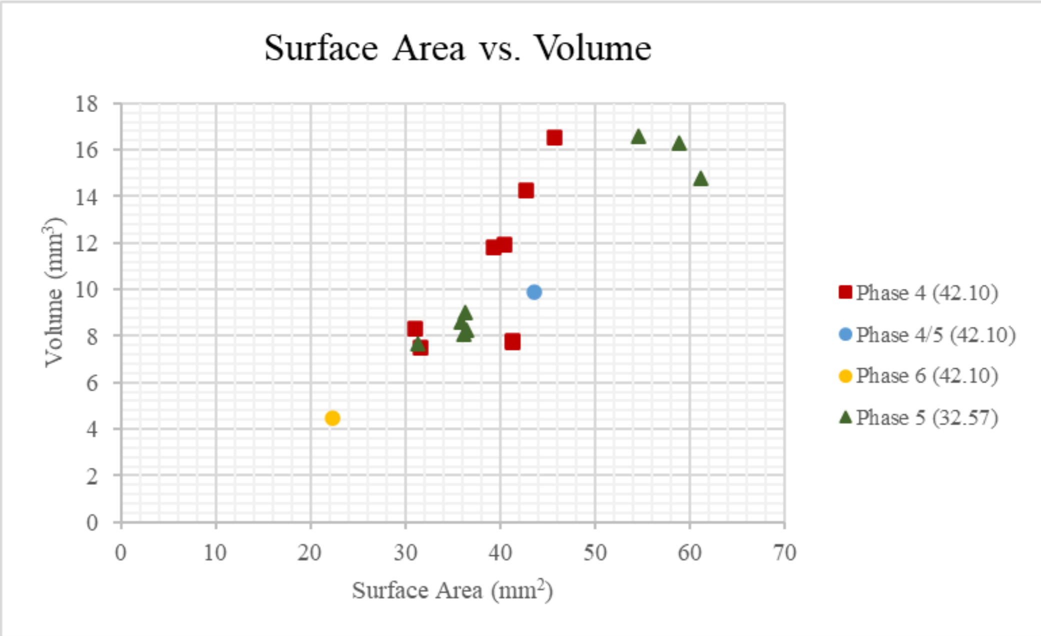

Figure 57. Scatter plot shows the individual values of volume vs. surface area of the hulled wheat taken from Tell Atchana.

The surface area of the samples coming from the Phase 4 of 42.10 plan square (1300-1200 BC) ranges between 31 and 46 mm^2. It is nearly 44 mm^2 for Phase 4/5 (1325-1275 BC) and is approximately 22 mm^2 for Phase 6 (1350-1300 BC) of the same trench. The grain samples retrieved from the Phase 5 of the 32.57 plan square (1750-1650 BC), on the other hand, have surface area values ranging from 31 mm^2 to 61 mm^2 (Figure *58*). The highest range of the surface area belongs to Phase 5 of 32.57. However, the average value is not the highest in these samples on the contrary to the free-threshing wheat grains coming from the same phase of the same plan-square where the average of surface area was higher than the other phases (Except a phase that was presented with only one seed.). Here, it should be highlighted that the Phase 5 samples are clustered in two different groups. One group have higher values of surface area and volume whereas the other group located in the lower part of the graph indicating the lower size values. This circumstance may once more indicate that grains were brought to the site from variety of fields. Additionally, the grains from the end of the ears of the cereals tend to become smaller while the grains size is generally bigger in the middle of the ear. The different clustered group might be also indicator that the presence of grains that were located in the different parts of ear. In the one grain coming from the Phase 6 of 42.10, the surface area decreases greatly comparing to the 32.57 plan square grains, and in the other Phase 4/5 grain of 42.10, the surface area increases again. The change in these last two grains, however, does not very meaningful considering the importance of the sample size. The Phase 4 of the 42.10 plan square shows slightly decreased surface area again in the transition from previous phase. But this slight decrease also seems irrelevant as the previous phase was represented with only one seed.

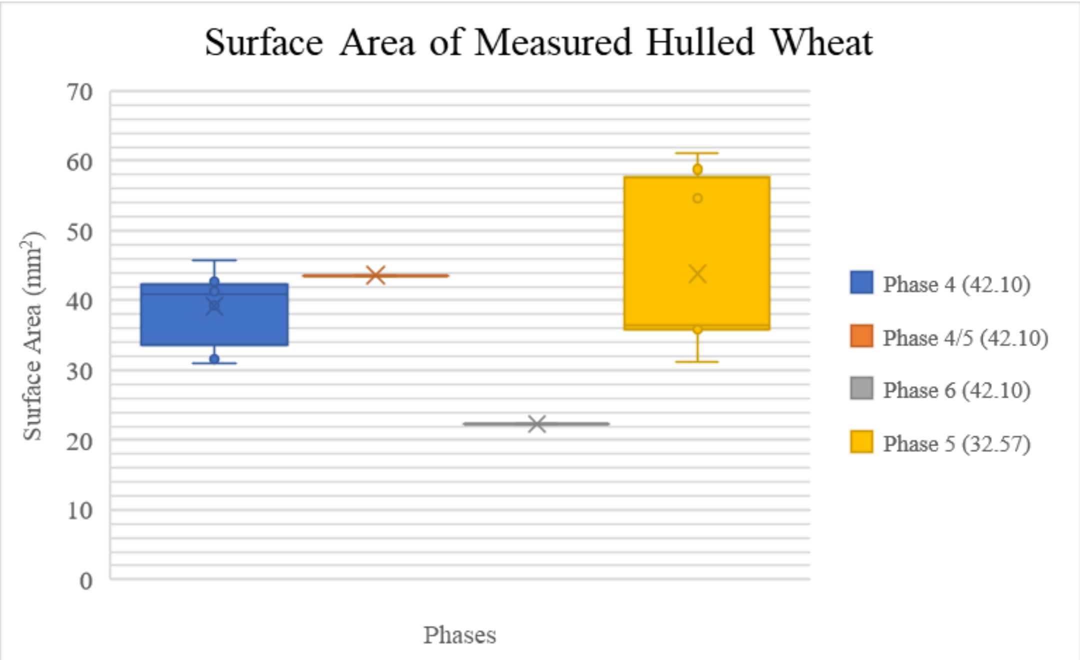

Figure 58. Boxplot shows the surface area of hulled wheat grains in different phases of Tell Atchana.

The volume values (Figure *59*) of the grains are in between nearly 7 and 17 mm^3 for the Phase 4 of 42.10 plan square (1300-1200 BC). This value is approximately 10 mm^3 for the one seed belonging to Phase 4/5 (1325-1275 BC) and is nearly 5 mm^3 for Phase 6 of the 42.10 (1350-1300 BC). For 32.57 plan square, Phase 5 samples (1750-1650

BC), the volumes of the grains range in nearly 8 and 17 mm^3. The change of average volume values follows the similar trend with the average surface area values except a small change in the transition from the Phase 4/5 to Phase 4 in 42.10. As it is the case for surface area, the volume of the Phase 5 grains of the 32.57 had the largest range. The volume in the seed coming from Phase 6 of 42.10 decreases comparing to the average of Phase 5 of 32.57. The volume increases in the seed belonging to Phase 4/5 of the same trench. On the contrary to the surface area, the average volume slightly increases again in the transition from Phase 4/5 to Phase 4. The average volume reaches its maximum in this earliest period.

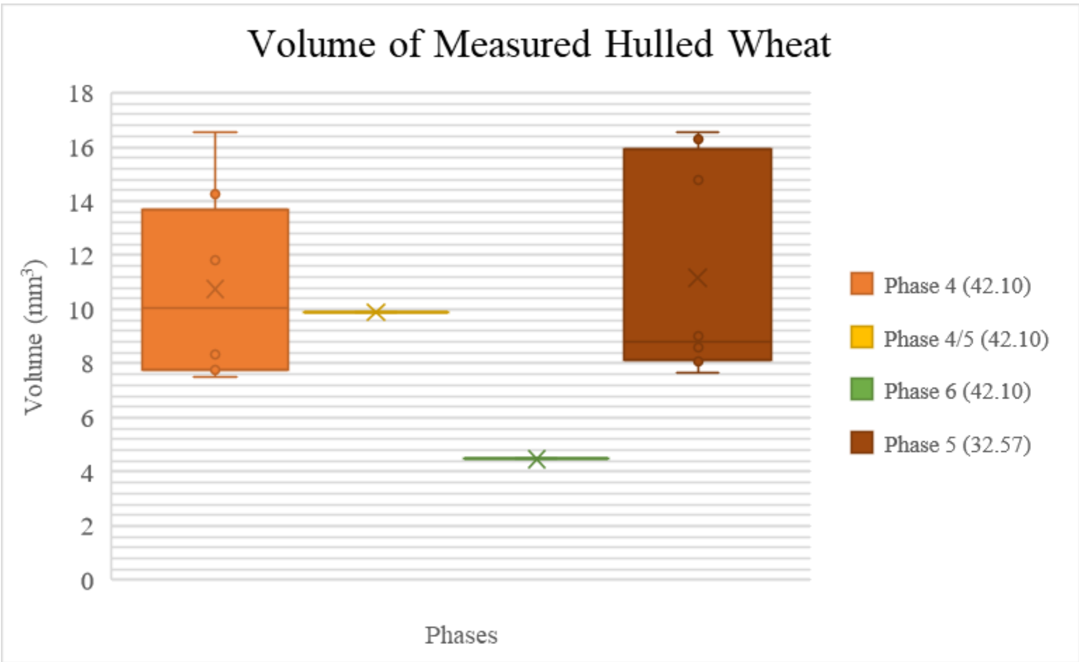

Figure 59. Boxplot shows the volume of hulled wheat grains in different phases of Tell Atchana.

The Phase 4 of 42.10 was the phase that the free-threshing wheat grains had the lowest average surface area and volume comparing with the other phases, however, in hulled wheat grains, the highest average surface area and volume belongs to the grains coming from Phase 4 of 42.10. It is not very reliable assumption but still it is worth to note that the reason behind the highest average in this phase might be related with the drought tolerance of the hulled wheat species (especially emmer). Because of the poor preservation conditions, the species-based identification of the hulled wheat species was not possible in the 42.10. Additionally, the lack of the cereal chaff in Phase 4 of this trench complicates the situation by preventing the estimations about the type of hulled wheat species that can be made by the identification of the cereal chaff. But it is highly likely that the most proportionate part of the hulled wheat found in the 42.10 is emmer wheat (*Triticum dicoccum*) considering the fact that the consumption of einkorn wheat (*Triticum mocococcum*) was abandoned during that time in most parts of the Near East (Riehl, 2008). So, if it is assumed that the most of the hulled wheat measured was the emmer wheat, the largest average surface area and volume in the Phase 4 of 42.10 (1300-1200 BC) might be the result of drought tolerance of this wheat and it can be said that these wheat grains were able to grow during the time of water stress, but as free-threshing wheat is drought susceptible, they were not able to grow and had lowest average value in the same period. However, to be more precise about the assumptions, the results should be cross checked with the results of the other analysis.

When all the LBA and MBA samples are evaluated together to see the changes between these two periods, it is seen that neither surface area nor volume average values change drastically as in the case for free-threshing wheat (Figure *60*). When only average values are considered, for both of the parameters, the average slightly decreases from MBA to LBA. However, the individual surface area values in MBA have a wider range and are often higher than the LBA values. Therefore, it is reasonable to claim that MBA samples have larger grains when the individual values are considered.

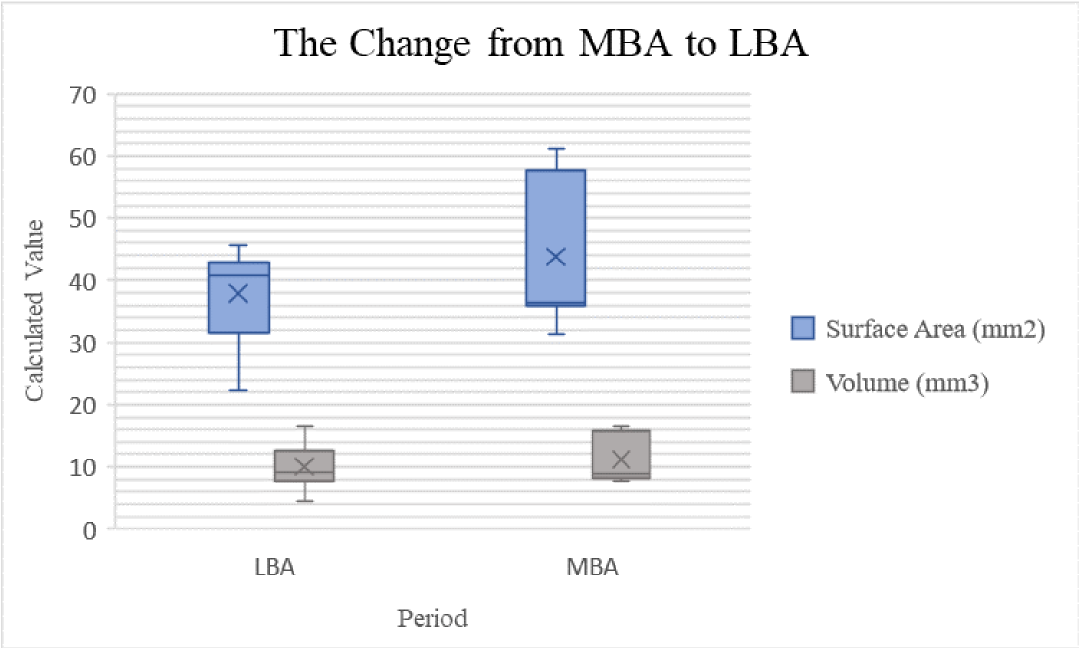

Figure 60. Boxplot shows the change of surface area and volume of hulled wheat grains from MBA to LBA.

4.2.3. Mann-Whitney U Test

As mentioned before, the effects of 3.2 ka climate change dated to 1200 BC and thought to last for about 300 years are expected to be seen on the samples from Tell Atchana, whereas the impacts of the 4.2 ka event -which is evidenced that it started in 2200 BC and continued until 1900 BC- should be seen in the samples of Toprakhisar Höyük. Since the measurable seed numbers are high in some of the phases and low in the others, to balance the sample size as much as possible, the size measurement results from the mounds are not kept separately from each other in application of this test. However, different tests are carried out for free-threshing and hulled wheat grains. This test is carried out on volume values as it is thought to give more information about the size of the seeds.

In the first group of tests, the LBA layers of 42.10 plan square (Phase 4, 4/5 and 6) is compared to MBA samples taken from 32.57 and 33.32 plan squares to see if the approaching 3.2 ka BP event caused a statistically significant change on the free-threshing and hulled wheat seed sizes of Atchana samples.

In the Mann Whitney U test carried out on free-threshing wheat species, the results showed that there is no statistically significant difference between the volume of LBA and MBA seeds of Atchana (Table *12*, p-value=0,150, for summary statistics see Table *37* in Appendix E.2.).

Table 12. Table shows the result of Mann-Whitney test on free-threshing wheat grains of Atchana.

U	138
U (standardized)	0,000
Expected value	204,000
Variance (U)	2040,000
p-value (Two-tailed)	0,150
alpha	0,050

When the test is applied to hulled wheat species, similar to the results of the test on free-threshing wheat, there is found no statistically significant difference between the volumes of MBA and LBA hulled wheat grains (Table *13*, p-value=0,515, for summary statistics see Table *38* in Appendix E.2.).

Table 13. Table shows the result of Mann-Whitney test on hulled wheat grains of Atchana.

U	32
U (standardized)	0,000
Expected value	40,000
Variance (U)	126,667
p-value (Two-tailed)	0,515
alpha	0,050

In the second group of tests, the possible effects of ongoing 4.2 ka BP climate change is investigated statistically on Toprakhisar seeds. Since all the phases studied on Toprakhisar is coincides with 2200-1900 BC time interval, Toprakhisar samples are compared to MBA samples -the samples coming from 32.57 and 33.32 plan squares- of Atchana.

The first test carried out in the free-threshing wheat grains of Toprakhisar showed that there is no significant difference between the MBA samples of Toprakhisar and MBA samples (but later periods) of Atchana (Table *14*, p-value=0,868, for summary statistics see Table *39* in Appendix E.1.).

Table 14. Table shows the result of Mann-Whitney test on free-threshing wheat grains of Toprakhisar.

U	394
U (standardized)	0,000
Expected value	382,500
Variance (U)	4271,250
p-value (Two-tailed)	0,868
alpha	0,050

Toprakhisar hulled wheat grains are the only sample group that are statistically significant from the Atchana hulled wheat (Table *15*, p-value=0,021, for summary statistics see Table *40* in Appendix E.1.). The mean value of volume in the Toprakhisar hulled wheat is 7,56 whereas that value is 11,15 for the Atchana grains. This indicate that the grains belonging to the end of the 3rd millennium and to beginning of the 2nd millennium (the time period that the 4.2 ka event was still in action) are significantly smaller than the seeds belonging to later periods (Atchana seeds those dates to 1750-1650 BC).

Table 15. Table shows the result of Mann-Whitney test on hulled wheat grains of Toprakhisar.

U	54
U (standardized)	0,000
Expected value	32,000
Variance (U)	90,667
p-value (Two-tailed)	**0,021**
alpha	0,050

4.3. STABLE CARBON ISOTOPE RESULTS

The stable carbon isotope results of the free-threshing wheat, hulled wheat and barley are presented in Table 16. Total of 82 grains are analyzed for their stable carbon isotope contents. The plants that were analyzed included free-threshing wheat, hulled wheat, and barley from different phases of 42.10, 32.57 and 33.32 plan squares of Atchana and 51/52.37 and 54.38 plan squares from Toprakhisar. Every grain that was chosen as an isotope analysis sample was taken from a chronologically reliable contexts from different phases. By reliable contexts, it is referred to the contexts that belongs to the certain period without hesitation. The contexts that contain filling, or mixed debris were avoided to prevent any problem that could affect the dating of the samples. Additionally, the samples were taken from the as many phases as possible to cover the largest time scale.

Free-threshing wheat was retrieved from all the trenches mentioned above. In 42.10, seven grains were taken belonging to Phase 4. The mean value for $\delta^{13}C$ in this phase is -23,69‰ ± 0,95 and for $\Delta^{13}C$, it is 17,61‰ ± 0,99. In Phase 4/5, there was only one sample taken for analysis. Its $\delta^{13}C$ value is -22,68‰ and $\Delta^{13}C$ value is 16,55‰. There were no free-threshing wheat grains taken from the Phase 5 of this trench. In Phase 6, three grains were analyzed. Their average $\delta^{13}C$ value is -23,20‰ ± 0,53 and average $\Delta^{13}C$ value is 17,10‰ ± 0,55. In Phase 7, again three seeds were analyzed. It was found that their mean $\delta^{13}C$ value is -23,40‰ ± 1,06 and average $\Delta^{13}C$ value is 17,31‰ ± 1,11. In 32.57 plan square, samples from only one phase, Phase 5, were studied. In total, 17 grains were analyzed for their stable carbon isotope contents. The average $\delta^{13}C$ value is found as -23,38‰ ± 0,59 and average $\Delta^{13}C$ value is found as 17,29‰ ± 0,61 for these seeds. The last trench of Atchana for this analysis was 33.32. Total of six free-threshing grain samples taken from Phase VII of this trench. The results shows that the mean value for $\delta^{13}C$ is -22.10‰ ± 0,55 and for $\Delta^{13}C$ is 15,95‰ ± 0,57. At Toprakhisar, free-threshing grains were taken from both of the trenches of the site. In 51/52.37, 8 samples belonging to Phase 3 were taken. The results shows that the average value of $\delta^{13}C$ is -22,78‰ ± 0,86 and of $\Delta^{13}C$ is 16,66‰ ± 0,89 in these seeds. From 54.38, three grains were taken that belonged to Phase 2 of this plan square. The mean $\delta^{13}C$ value is found -22,90‰ ± 0,43 and mean $\Delta^{13}C$ value is 16,88‰ ± 0,45 (Table 16).

Hulled wheat grains were taken from all the trenches of Atchana -except 33.32- and Toprakhisar. In 42.10 plan square of Atchana, Phase 4 had four samples analyzed. The mean value of $\delta^{13}C$ is -22,80‰ ± 0,64 and of $\Delta^{13}C$ is 16,68‰ ± 0,67 in these grains. Two seeds were analyzed from Phase 5, and the results shows that their average value for $\delta^{13}C$ is -22,24‰ ± 0,56 and for $\Delta^{13}C$ is 16,09‰ ± 0,59. Only one sample belonging to Phase 5 was analyzed. The $\delta^{13}C$ value for this seed is -23,29‰ and $\Delta^{13}C$ value is 17,19‰. In Phase 6, four samples analyzed and the mean value of $\delta^{13}C$ is -22,52‰ ± 0,84 and of $\Delta^{13}C$ is 16,39‰ ± 0,87. There was not any seeds taken from the Phase 7 of the 42.10. In 32.57, two Phase 5 samples were chosen for analysis. The results shows that their average is -23,13‰ ± 0,22 for $\delta^{13}C$ and 17,03‰ ± 0,23 for $\Delta^{13}C$. In 51/52.37 plan square of Toprakhisar, six samples were taken belonging to Phase 3. The average of $\delta^{13}C$ is -22,98‰ ± 0,69 and of $\Delta^{13}C$ is 16,87‰ ± 0,71 in these samples. In 54.38, one seed analyzed belonging to Phase 2. Its $\delta^{13}C$ value is -24,08‰ and $\Delta^{13}C$ value is 18,11‰ (Table 16).

Barley seeds were taken from all trenches of Atchana and Toprakhisar. But, in 42.10 plan square of Atchana, the samples were only taken from the Phase 4. The total number of these seeds was 2. The average value of $\delta^{13}C$ is -22,75‰ ± 0,09 and of $\Delta^{13}C$ is 16,63‰ ± 0,09. From 32.57, Phase 5, only one seed was analyzed, and the results shows that the $\delta^{13}C$ value of this seed is -23,14 and its $\Delta^{13}C$ value is 17,03‰. 33.32 plan square, Phase VII, had 6 barley grains analyzed. The mean value of $\delta^{13}C$ is found as -23,77 ± 0,58 and $\Delta^{13}C$ value is 17,70‰ ± 0,60. At Toprakhisar, three samples were coming from the Phase 3 of 51/52.37 plan square. The average in these seeds is found as -24,08 ± 0,52 for $\delta^{13}C$ and 18,01 ± 0,54 for $\Delta^{13}C$. From Phase 2 of 54.38, one seed was analyzed. The $\delta^{13}C$ value of it is -23,56 and its $\Delta^{13}C$ value is 17,58‰ (Table 16).

Table 16. Table shows the $\Delta^{13}C$ and $\Delta^{13}C$ values of free-threshing wheat, hulled wheat and barley grains coming from Toprakhisar Höyük and Tell Atchana.

Site	Plan Square	Local Phase	Date (ca. BC)	Period	# of Grains	*Triticum aestivum/durum* (Free-threshing wheat)				# of Grains	*Triticum monococcum/dicoccum* (Hulled wheat)				# of Grains	*Hordeum vulgare* (Barley)			
						$\delta^{13}C$ (‰)	±SD	Δ13C	±SD		$\delta^{13}C$ (‰)	±SD	Δ13C	±SD		$\delta^{13}C$ (‰)	±SD	Δ13C	±SD
Tell Atchana	42.10	4	1300-1200	LBA	7	-23,69	0,95	17,61	0,99	4	-22,80	0,64	16,68	0,67	2	-22,75	0,09	16,63	0,09
	42.10	4/5	1325-1275	LBA	1	-22,68		16,55		2	-22,24	0,56	16,09	0,59					
	42.10	5	1350-1300	LBA						1	-23,29		17,19						
	42.10	6	1350-1300	LBA	3	-23,20	0,53	17,10	0,55	4	-22,52	0,84	16,39	0,87					
	42.10	7	1400-1350	LBA	3	-23,40	1,06	17,31	1,11										
	32.57	5	1750-1650	MBA	17	-23,38	0,59	17,29	0,61	2	-23,13	0,22	17,03	0,23	1	-23,14		17,03	
	33.32	VII	1750-1650	MBA	6	-22,10	0,55	15,95	0,57						6	-23,77	0,58	17,70	0,60
Toprakhisar Höyük	51/52.37	3	2000-1900	MBA	8	-22,78	0,86	16,66	0,89	6	-22,98	0,69	16,87	0,71	3	-24,08	0,52	18,01	0,54
	54.38	2	2100-2000	EBA	3	-22,90	0,43	16,88	0,45	1	-24,08		18,11		1	-23,56		17,58	

4.3.1. Evaluation of the Stable Carbon Isotope Analysis Results according to Cereal Types

4.3.1.1. Free-threshing Wheat

The $\delta^{13}C$ values of free-threshing wheat ranges between -21‰ and -25‰, whereas the $\Delta^{13}C$ values are in between 15‰ and 19‰. For the free-threshing wheat species the threshold value of $\Delta^{13}C$ for severe water stress is taken as 15‰. The values between 15‰and 16‰, on the other hand, indicates a moderate water stress zone for this species. These thresholds are 1-2‰ lower than the threshold for the barley species as the likeliness of wheat species to experience drier conditions as their grain filling period is longer than the barley (Wallace et al., 2013).

Details of stable carbon isotope analysis carried out on free-threshing grains from both sites are given in the Table *41* in Appendix F.1. Some of the grains belonging to Phase 4 of 42.10 (1300-1250 BC) have the highest values of $\Delta^{13}C$. In the seven samples coming from this period, there is no seed with $\Delta^{13}C$ value under 15‰ indicating that no seeds in this period experienced a severe water stress. Only one of them has a $\Delta^{13}C$ value between 15‰ and 16‰ which is a zone for moderate water stress. The rest of the seeds have values above 16‰ indicating that they were grown in well-watered fields. One seed coming from the Phase 4/5 of the same trench (1325-1275 BC) has $\Delta^{13}C$ value above 16‰ indicating that this grain was grown in an environment under good conditions without water stress. The $\Delta^{13}C$ values of three seeds belonging to Phase 6 (1350-1300 BC) seems that this phase was also marked with good conditions. One of three seeds from Phase 7 (1400-1350 BC) has sign of moderate water stress, but $\Delta^{13}C$ values indicate that the other two seeds were grown in the good moisture conditions. The Phase 5 of 32.57 (1750-1650 BC) has samples that have no sign of water stress according to the $\Delta^{13}C$ values. Interestingly, the Phase VII of 33.32 (1750-1650 BC) which dates back to the same time with Phase 5 of 32.57 have six seeds examined that the four of them have $\Delta^{13}C$ value between 15‰ and 16‰ suggesting that there were seeds in this phase that grown in the fields with moderate water stress. Lowest value of $\Delta^{13}C$ observed also belongs to the grains from this trench. The values from Phase 3 of 51/52.37 plan square (2000-1900 BC) of Toprakhisar also between in a large range. Even though most of the seeds coming from this period have values indicating that they were grown under moderate water stress, most of the seeds were coming from well-watered fields. None of three seeds belonging to Phase 2 of 54.38 plan square (2100-2000 BC) have values under 16‰ pointing that they were all grown in good conditions (Figure *61*).

The results suggests that the free-threshing wheat brought to 42.10 plan square of Tell Atchana was coming from different kinds of sites including both moist and less moisturized sites in some of the phases of occupational history. It seems that there was no trend for better or worse conditions during the LBA by looking the results from 42.10 as it has both the grains with water stress and no water stress. However, the results are a little bit different for the MBA phases of Atchana. The two plan squares -32.57 and 33.32- where the MBA grains of Atchana were retrieved from shows opposite trends in their $\Delta^{13}C$ values. The 32.57 plan square has no grains with a sign of water stress rather all the seeds were grown in good moisture conditions pointing the availability of the water. On the other hand, most of the grains from 33.32 have signs of moderate water stress. The Phase 5 of the 32.57 was characterized by the presence of an apsidal building (for details see Section 3.2.2.1.4.). This apsidal building made think the excavators that this place might be related with sacred and ritualistic purposes. 33.32 plan square, on the other hand, is related with Phase VII Palace of Alalakh. The reason behind the signs of differential water stress in two MBA occupation is not clear but maybe it can be argued that the people of Alalakh selected the best grains that they cultivated to bring to their sacred-religious areas. Thus, the grains from 32.57 plan square does not have the signs of high-water stress as they were brought from well-watered agricultural fields. On the other hand, the palace might take the crop of the farmers as a tax. So, it can be expected that people of Alalakh might give the palace to their fewer quality crops, the crops coming from not very well watered lands. So, the reason behind the results in grains of 33.32 plan square might be related with this. So, the differences in the results in MBA seeds might be solely caused by cultural preferences of Alalakh people that affects the presence of different type of wheat grains in different contexts rather than environmental enforcements.

The results from Toprakhisar shows that the end of the 3rd millennium BC (Phase 2 of 54.38), the grains were well watered but with the beginning of the 2nd millennium BC (Phase 3 of 51/52.37), there are traces of moderate water stress in the grains. The reason behind this change might be small sample size belonging to the end of the 3rd millennium BC. If the sample size is increased the seeds with water stress might be present in these samples as well. Another explanation might be the increasing aridity with the beginning of the 2nd millennium BC in Toprakhisar as a result of 4.2 ka BP climatic change. But the results would be more meaningful when they evaluated together in the following paragraphs.

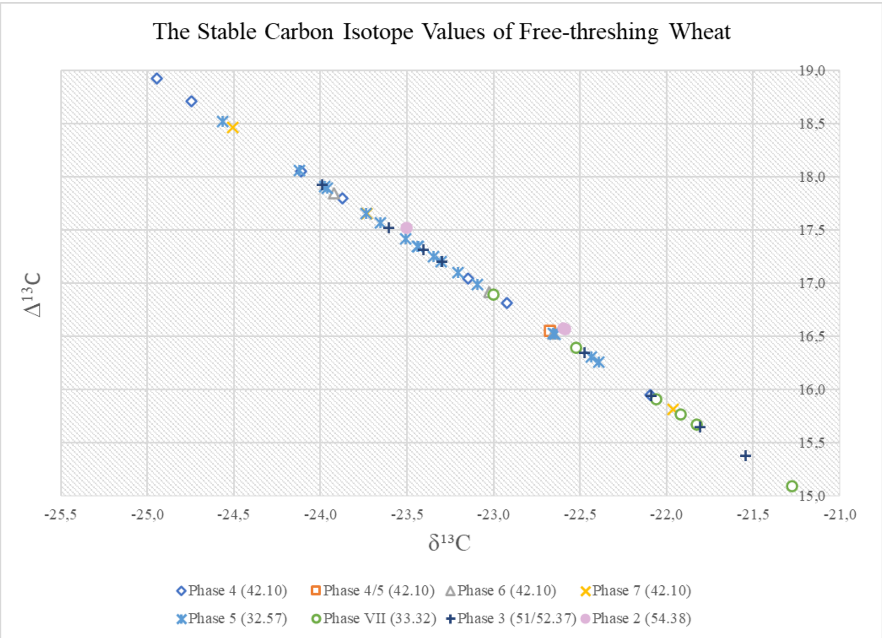

Figure 61. Scatter plot shows the $\delta^{13}C$ and $\Delta^{13}C$ values of individual free-threshing wheat grains from Toprakhisar Höyük and Tell Atchana.

4.3.1.2. Hulled Wheat

The details of stable carbon isotope analysis carried out on hulled grains from both sites are given in the Table *42* in Appendix F.2. The $\delta^{13}C$ values of hulled wheat ranges between -21‰ and -25‰, whereas the $\Delta^{13}C$ values are in between 15‰ and 18,5‰. The $\Delta^{13}C$ values of the grains taken from the Phase 4 of the 42.10 (1300-1200 BC) is scattered in a large range. Three of the seeds have values over 16‰ indicating that they were grown under good water conditions, one of them is between 15‰ and 16‰ indicating that it experienced a moderate water stress. The grains should be brought the site from different kind of fields considering the dispersion of the values. This was the case for free-threshing wheat as well for this phase where few of the seeds has sign of moderate water stress. The seeds coming from Phase 4/5 (1325-1275 BC) were either under moderate water stress or were grown in good conditions according to the $\Delta^{13}C$ results. The only seed taken from the Phase 5 (1350-1300 BC) of this trench has no sign of water stress. But it can be just the result of a small sample size. There might be seeds that were grown under water stress conditions but not included for the stable carbon isotope analysis. So, just one seed does not tell much unless it is evaluated with the other results. The Phase 6 of 42.10 plan square (1350-1300 BC) has one seed with moderate water stress and the rest of the seeds point to the good water availability. Two seeds coming from the Phase 5 of 32.57 (1750-1650 BC) were grown in good conditions indicated by their $\Delta^{13}C$ value over 16‰. The hulled wheat grains taken from the Phase 3 of 51/52.37 (2000-1900 BC) of Toprakhisar were very scattered as was the free-threshing wheat. This phase has seeds that were well watered and that were either grown moderate water stress or in good conditions. The only seed coming from the Phase 2 of 54.38 (2100-2000 BC) has value of $\Delta^{13}C$ over 18‰. In fact, this seed has the highest $\Delta^{13}C$ value among the other seeds (Figure *62*).

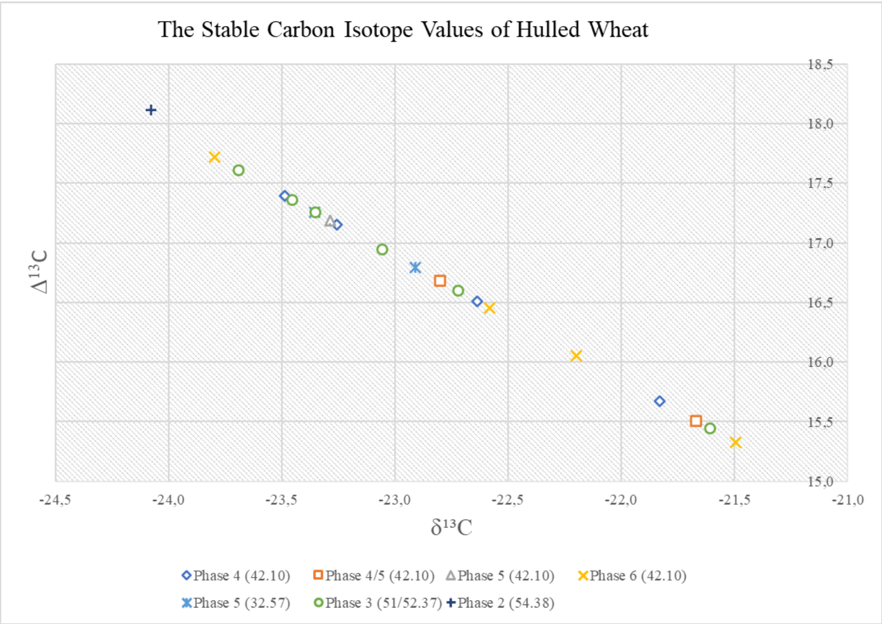

Figure 62. Scatter plot shows the $\delta^{13}C$ and $\Delta^{13}C$ values of individual hulled wheat grains from Toprakhisar Höyük and Tell Atchana.

4.3.1.3. Barley

The moderate water stress zone for the barley is taken as between 16‰ and 17‰ as its grain filling period takes shorter time than wheat. The values below 16‰ is regarded as a sign of severe water stress during the grain filling period of the plants.

The details of stable carbon isotope analysis carried out on barley grains from both sites are given in the Table *43* in Appendix F.3. The $\delta^{13}C$ values of barley ranges between -22,5‰ and -25‰, whereas the $\Delta^{13}C$ values are in between 16,5‰ and 19‰. Any of the barley seeds analyzed has sign of severe water stress. The seeds coming from Phase 4 of the 42.10 plan square (1300-1200 BC) are in zone for moderate water stress. The one seed taken from the Phase 5 of 32.57 (1750-1650 BC) were grown in well-watered conditions. All the seeds taken from 33.32 (1750-1650 BC) also has $\Delta^{13}C$ values over 17‰ indicating that they did not witness water scarcity during their growth. All the seeds taken from Toprakhisar for carbon stable isotope analysis were also not grown with water stress as their $\Delta^{13}C$ values are high in both Phase 3 of 51/52.37 (2000-1900 BC) and Phase 2 of 54.38 (2100-2000 BC) (Figure *63*).

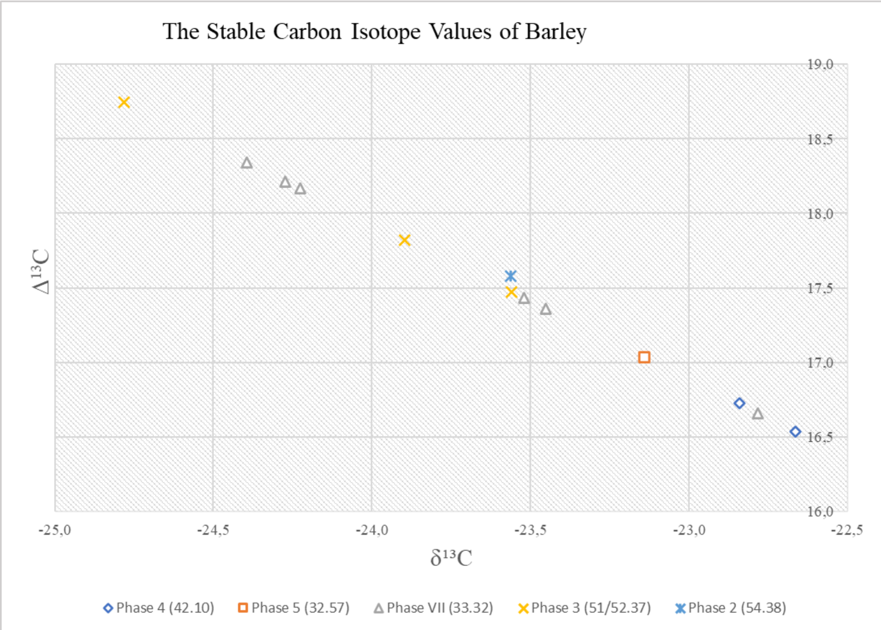

Figure 63. Scatter plot shows the $\delta^{13}C$ and $\Delta^{13}C$ values of individual barley grains from Toprakhisar Höyük and Tell Atchana.

4.3.2. Evaluation of the Stable Carbon Isotope Analysis Results according to Periods

To see the change in the carbon isotope discrimination ($\Delta^{13}C$) values throughout the time the phases from Toprakhisar and Atchana are grouped according to their dates (Figure *64*). The results shows that for all of the phases, the mean value of $\Delta^{13}C$ of free-threshing wheat grains are above 16‰. This shows that throughout their settlement history, Toprakhisar or Atchana never witnessed a severe water scarcity as enough precipitation for the well growth of their crops were available. However, there might be increasing drier conditions in Toprakhisar with the beginning of 2nd millennium BC (2000-1900 BC) since some of the seeds enter to the moderate water stress zone in this period on the contrary to the previous period (2100-2000 BC). The drier conditions might be also visible in the MBA layers of Atchana (1750-1650 BC, 32.57 and 33.32 plan squares) as some of the samples have $\Delta^{13}C$ values between 15‰ and 16‰. But, as mentioned in this situation previous paragraphs this might be simply result of the differential contexts that the samples were taken. The mean values of $\Delta^{13}C$ increases in transition from MBA to LBA in Atchana. In the LBA, there is no particular trend between phases, but the mean values of LBA phases are the highest among all the phases except for a small period (1325-1275 BC, Phase 4/5 of 42.10) where only one sample was taken. The sample taken from this phase has the smaller value than the averages of LBA phases, but this might simply because of the small sample size. In any case, the seed representing the mentioned period does not have a value that is an indicator of water stress rather it is above 16‰.

The results suggest that neither the drought caused by the 4.2 ka BP nor 3.2 ka BP climatic changes seem to severely affect the Toprakhisar or Atchana. For Toprakhisar, there is evidence for slightly drier conditions with the beginning of 2nd millennium BC, but this might only be the result of larger sample size taken from this period. The involvement of more seeds comparing to the previous period might cause the presentation of the water status of grains. When the differences between the sample sizes from different periods ignored, the presence of $\Delta^{13}C$ values in moderate water stress zone might be really points to drier environment caused by increasing effect of 4.2 ka BP event in the region. On the other hand, the results for Atchana, does not point to the increasing water stress resulted from approaching 3.2 ka event towards the end of the LBA. Rather the highest values of $\Delta^{13}C$ belongs to the LBA phases of Atchana indicating that the farmers of the time were able to grow their free-threshing wheat under good conditions.

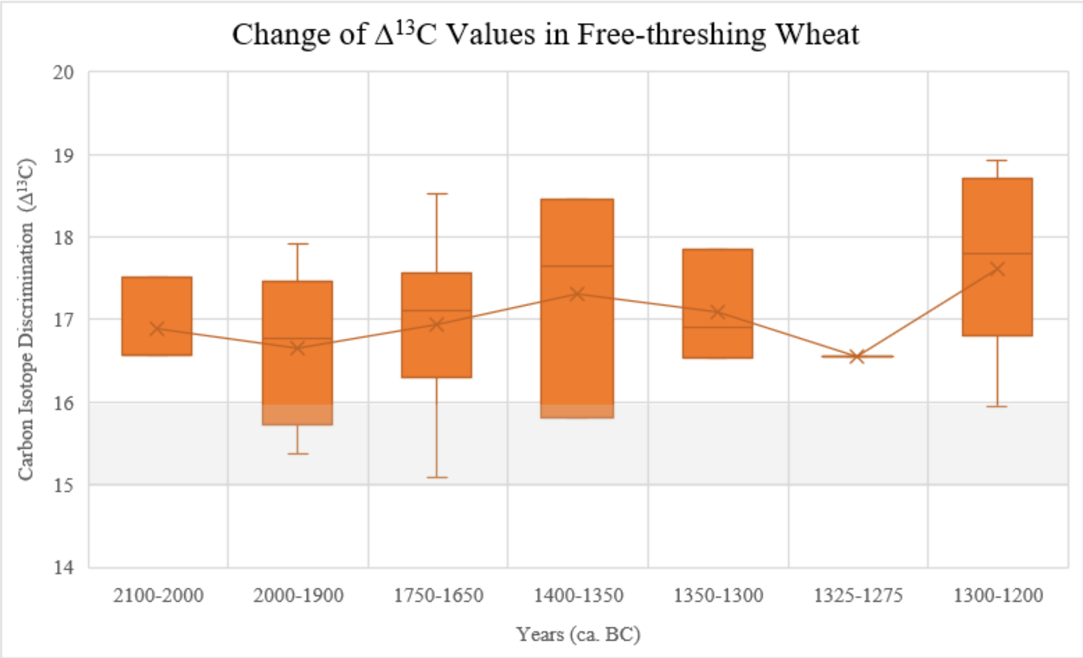

Figure 64. Boxplot shows the change of carbon isotope discrimination ($\Delta^{13}C$) values of free-threshing wheat coming from different time periods (The grey area indicates the range of moderate water stress).

The change of the water status of hulled wheat is correlated with the results retrieved from the free-threshing wheat (Figure *65*). Similar to the free-threshing wheat, hulled wheat grains have mean values of $\Delta^{13}C$ above the 16‰ in all phases. As is the case for free-threshing wheat, the hulled wheat also shows a sign of drier conditions in transition to 2nd millennium (see the change from 2100-2000 BC to 2000-1900 BC). The only seed dating to the end of the 3rd millennium BC has highest carbon isotope discrimination value among all samples analyzed indicating that there were well watered fields were available in the time. Nevertheless, the beginning of the 2nd millennium was marked by the decreasing values, even some grains are in the zone for moderate water stress. The MBA hulled wheat samples (1750-1650 BC) of Atchana have nearly the same mean value with free-threshing wheat but the values are in a smaller range because of the lower number of samples. Any of the hulled wheat coming from the MBA occupations are in the moderate water stress zone. On the contrary to free threshing wheat, the mean $\Delta^{13}C$ values of hulled wheat are lowest in the LBA samples. Additionally, more hulled wheat samples have moderate water stress during grain filling period in the LBA phases than that of free-threshing wheat.

The reason behind the increasing water stress during the transition from 3rd to 2nd millennium BC in Toprakhisar might be the same with the reasons mentioned for free-threshing wheat. It can be caused by the change in representation levels of the water status because of the increasing sample size or it can be actually the increasing effect of 4.2 ka BP event.

The reason behind the lowest $\Delta^{13}C$ average values and increased number of seeds that were grown under moderate water stress during LBA phases of Atchana might be related with the changing approaches in the agriculture in that period. With the diminishing importance of hulled wheat during that period, LBA farmers of the Atchana might prefer to cultivate the hulled wheat in drier lands, the lands that were distant from the additional water sources such as Orontes River. Rather they might choose to cultivate the free-threshing wheat species which are more water demanding and more valuable in that period. Additionally, the decrease might also be related with the imported grains under the Hittite dominion. It is previously mentioned that the silos from Hattusha have mostly hulled wheat and barley. So, it can be said that when Hittites were importing or producing crop, they were focusing on these crops mainly. If the crops were brought from the surrounding regions of Alalakh to the capital, there is possibility that the grains coming from drier regions might be present in Atchana. These regions might be places that experienced the approaching drought of 3.2 ka BP climatic change. So, the change might be both related to the Hittite policy on crop transport and the approaching climate change that already affected the water status of the crops.

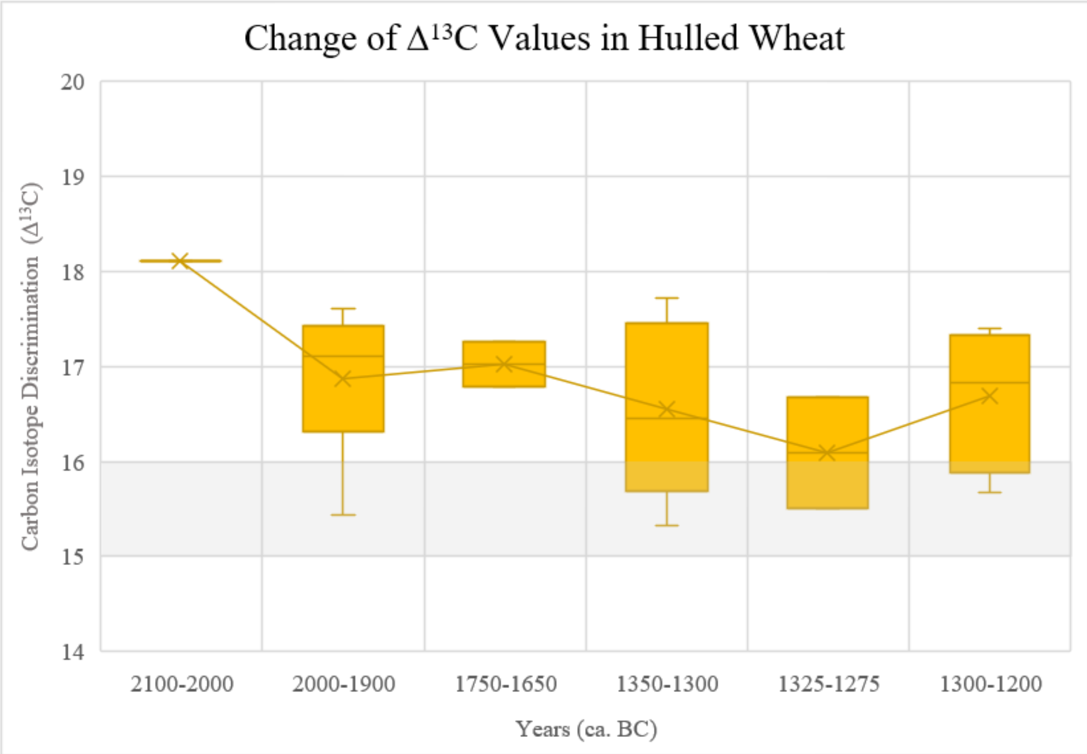

Figure 65. Boxplot shows the change of carbon isotope discrimination ($\Delta^{13}C$) values of hulled wheat coming from different time periods (The grey area indicates the range of moderate water stress).

When the change of mean carbon isotope discrimination values of barley is evaluated, it is seen that except LBA occupation of Atchana, the grains never witnessed a moderate or severe water stress (Figure *66*). On the contrary to wheat species, in the transition from the 3rd millennium to 2nd millennium (from 2100-2000 BC to 2000-1900 BC), the average value of $\Delta^{13}C$ increased in Toprakhisar. In Atchana, there are few seeds that were grown under moderate water stress during MBA (1750-1650 BC). However, the mean value is over 17‰. All the LBA samples of Atchana draws a very different picture from the rest of the samples as they are all in the moderate water stress zone.

The increase in the water availability in the transition from EBA to MBA in Toprakhisar does simply a result of small sample size. Any other particular explanation for this situation is not available with the data in hand. The presence of seeds with moderate stress and seeds that were grown with water availability might be result of crops that brought to the site from different agricultural fields during MBA of Atchana. The fields that were more dependent to the rainfall (the ones that did not have nearby water source) might experience water stress more intensively than the others and the seeds coming from such fields might be present in the site. The decrease of the mean value in the LBA, on the other hand, again might be related with the Hittite crop policy that caused the entrance of grains that were grown in drier areas to the archaeobotanical assemblages. Otherwise, it might be related with the fewness of the analyzed grains belonging to this period.

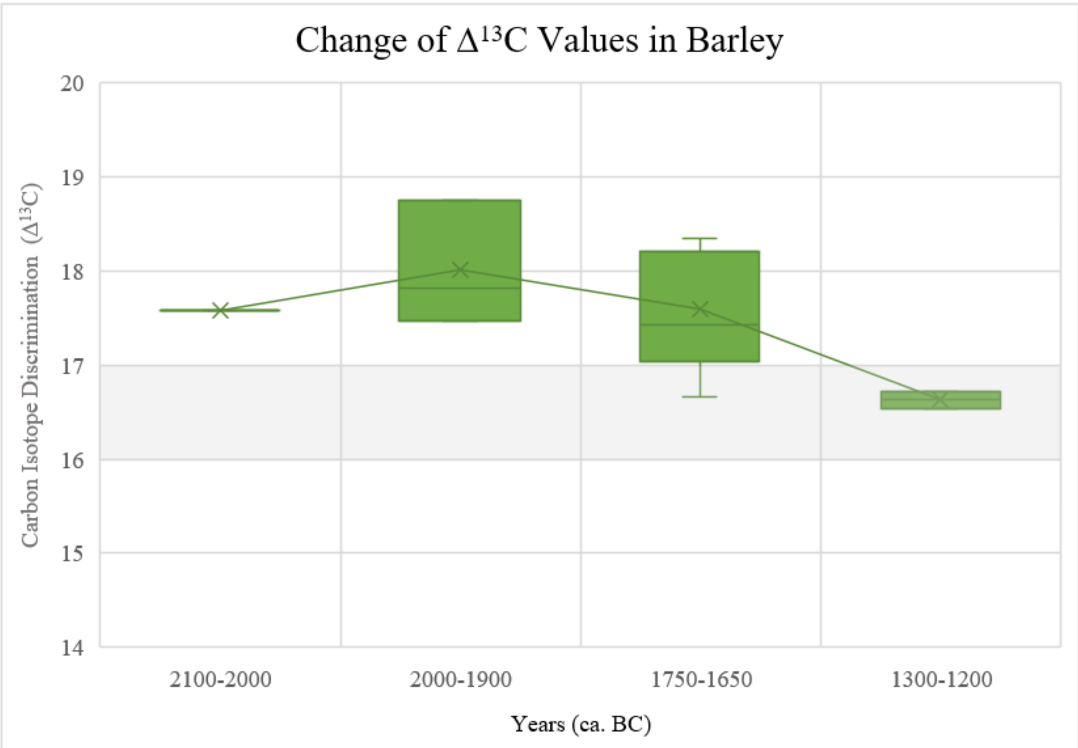

Figure 66. Boxplot shows the change of carbon isotope discrimination ($\Delta^{13}C$) values of barley coming from different time periods (The grey area indicates the range of moderate water stress).

When the findings from this study are compared to those from earlier work of Riehl (2010a), there are a few small discrepancies as well as some parallels. In the stable carbon isotope analysis that she carried out in the free-threshing and barley seeds that came from LBA levels of Atchana, Riehl found that mean and median $\Delta^{13}C$ values were higher in the free-threshing wheat grains. Similarly, when the LBA samples of free-threshing wheat and barley of this study are evaluated together, the free-threshing wheat grains have higher mean value of $\Delta^{13}C$ than that of barley. On the other hand, Riehl also indicates that individual values of $\Delta^{13}C$ were usually higher in the free-threshing wheat. Also, even though the quantities of wheat and barley analyzed are nearly equal in that study, free-threshing wheat grains were scattered in a wider range comparing to barley. The wide-ranging, higher values of $\Delta^{13}C$ in individual grains in free-threshing wheat grains are valid in the results of this study as well. Because of the greater disparity in sample sizes between the various cereal types (such as free-threshing wheat and barley), argument about the differential origin of free-threshing wheat could not be robust solely based on the findings of this study. However, Riehl's work supports the notion that cereals found at Atchana were coming from various types of fields. Riehl (2010a) suggests that free-threshing wheat might be treated differently during the cultivation and proposes three possible treatments for this species including "… *(1) irrigating selected wheat stands, (2) locating wheat fields in naturally wet alluvial soils or (3) importing wheat from other areas with better growing conditions."*

Besides suggesting the differential origin of cereals, Riehl (2010a) avoided to comment about the 3.2 ka BP climate change as the samples that were investigated in that study belonged to 1450-1300 BC. However, in the samples that dated to the very end of the LBA (the time period that Riehl pointed to the absence of samples), result of this thesis indicated an increased water stress in hulled wheat between 1350-1200 BC and in barley between 1300-1200 BC. But this type of water stress was not evidenced in the free-threshing wheat for the same time period. If the free-threshing wheat was irrigated in addition to the rainfall, or the fields where this type of wheat was cultivated were located in favorable wet alluvial soils, it is expected to see no water stress in these seeds. Then, this also points to the increasing water stress that the hulled wheat and barley grains experienced since they did not receive any water other than precipitation.

4.3.3. Water Input

Water inputs of that plants received during the grain-filling period are calculated by using the formulas mentioned in Section 2.1.5. (for details see Appendices F1-F2-F3). To compare the water inputs of different cereal types, the graph of $\Delta^{13}C$ compared to the water inputs of individual grains are drawn without considering phasing of the grains (Figure *67*). Since the number of grains taken from Toprakhisar is too low to be meaningful by themselves, they are represented in the same graph with Atchana.

The results of water input calculations showed that free-threshing wheat has the largest range of water input. The water amount that the grains of this plant received is nearly in between 50 mm and 220 mm. Because distinct phases of free-threshing wheat do not cluster around a certain water input interval, it may be assumed that the wide range of water intakes is due to the variety of fields from which the grain came, rather than water scarcity at some seeds caused by drought which is a result of climate change. The grains could be grown in areas with varying moisture levels. Some of them might be grown in areas near extra water sources like the Orontes River, and water ditches could be utilized to well-irrigate drought-prone free-threshing wheat. Others may have been obtained from areas with a smaller amount of precipitation and limited access to additional water sources.

Hulled wheat follows a pattern that is comparable to free-threshing wheat, although on a smaller range. The water input of hulled wheat species is never as high as that of free-threshing wheat; instead, it ranges between 60 and 160 mm. However, when the individual grains are considered, there are more hulled wheat grains with values of moderate water stress than that of free-threshing wheat and barley. That might again indicate the preferential treatment of cereals that is the wetter soils (either naturally wet or irrigated) may have been reserved for the cultivation of free-threshing wheat whilst hulled wheat and barley were grown in the rain-fed or drier fields.

Barley has the narrowest range of distribution in water input compared to other cereals since the number of grains selected for stable carbon isotope measurement is limited. It ranges between nearly 90 and 220 mm of water intake during the grain filling period. It is interesting that barley grains have very high levels of water intake considering that barley grains do not normally get supplemental irrigation and are supposed to be cultivated on drier terrain because of their endurance in water shortage. In addition to this, since their growth cycle is shorter than that of wheat, they can be harvested before being exposed to droughts in summer months (Wallace et al., 2013). So, the sign of water deficiency is expected to be more visible in the wheat than in the barley. The results of this study might be the indicator of this situation. Even though it is proposed that free-threshing wheat was selectively grown in the wetter lands and the hulled wheat and barley in the drier lands, barley water inputs are higher than that of hulled wheat. This might be related to the growth cycle of the barley which was grown and harvested when the environment was moister even in the drylands. On the other hand, since hulled wheat was harvested in late summer, the water scarcity might have become more visible in the grains and thusly there are more hulled wheat grains in Atchana and Toprakhisar that fell in the moderate water stress zone.

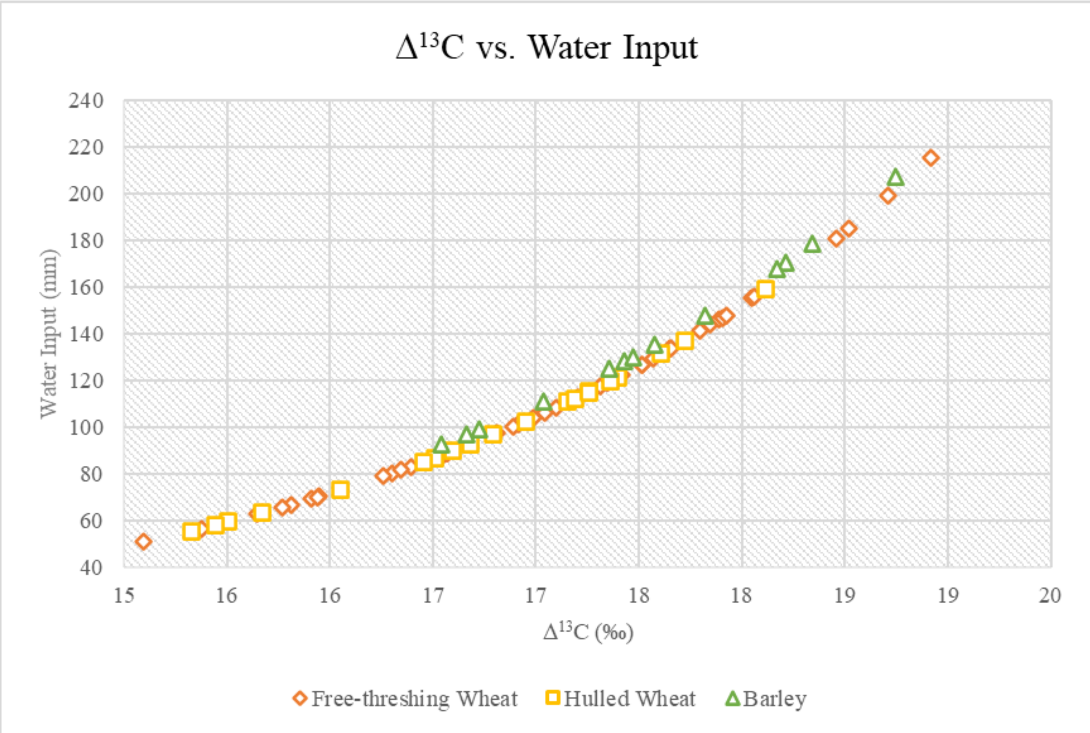

Figure 67. $\Delta^{13}C$ values vs. water inputs of free-threshing wheat, hulled wheat and barley grains taken from Toprakhisar and Tell Atchana.

4.4. WILD PLANTS

4.4.1. Toprakhisar

4.4.1.1. Count and Find Density of Wild Plants

Total of 28 different wild plant taxa and indetermined wild seeds are found in the archaeobotanical samples coming from the 51/52.37 and 54.38 plan squares of Toprakhisar (Table *17*). In seventy-five samples, 909 wild plant seeds are found. The plants can be classified under four groups according to their total number in all of the archaeobotanical assemblages. The first group includes plant genera that are represented with over hundred seeds. These genera can be regarded as highly represented genera in the samples. In the second group of plants, there are the plant genera that are found with 50-100 seeds. These plants are relatively abundant in the samples. The third group are the ones that have 50 or less seeds in the assemblages. These genera can be identified as poorly represented genera. The fourth and last of the group are the plants that have less than 10 seeds in all of the assemblages. Most of the plant genera found in the samples belong to this group as their total number of seeds in the samples are very low. These types of plants can be evaluated as scarcely represented plants.

Among all wild plant finds, the most abundant genus is *Lolium* sp. (ryegrass, n=312). Seeds belonging to this genus are also the most numerous seeds in each phase studied. The *Lolium* sp. is followed by the *Echium* sp. (viper's bugloss, n=133) in abundance. Indetermined grass species was the third group that have over a hundred seeds (n=109) in all of the assemblages. These three groups of plants dominate the samples. *Phalaris* sp. (canary grass, n=83) and *Scorpiurus* sp. (scorpion's tails, n=40) are the other plants that are relatively numerous in the samples. *Ranunculus* sp. (buttercups, n=28), *Amaranthus* sp. (amaranth, n=27), *Trifolium* sp. (clovers, n=22), *Chenopodium* sp. (goosefoot, n=16), *Scirpus* sp. (bulrush, n=16), *Galium* sp. (bedstraw, n=13) are represented with over ten seeds in the assemblages. On the other hand, the rest of the plants are only present with few seeds (below 10 seeds). 59 seeds could not be identified and left as indetermined (Table *17*).

The abundance of the *Lolium* sp. and indetermined grass in the samples is related with their weedy character. As they imitate the growth cycle of the cereal crops, they are able to grow in the arable lands. Since their morphology are also very similar to the that of cereals, the wild grasses are also hard to eliminate during the after-harvest cleaning of the cereals. So, their abundant presence in the samples is expected. *Echium* sp., on the other hand, is usually highly durable probably because of the silicon dioxide that it contains (Pustovoytov et al., 2004). Additionally, Riehl (1999) points out that this genus is among the plants that are not preferred by the livestock but they might be brought to the site intentionally by people for consumption. Considering the probability of human consumption of this genus plants, it can be expected that the possibility of occurrence of this genus seeds in the assemblages could be higher than the non-consumed wild plant seeds.

Table 17. Table shows the counts of wild plant taxa remains in different phases of Toprakhisar.

Square	51/52.37			54.38	
Local Phase	**2**	**3**	**4**	**1**	**2**
Period	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC
	Counts (n)				
	Total Number of Counts				
Sample Number	5	59	3	2	6
Total	101	713	19	20	56
Amaranthus sp.	0	26	0	0	1
Chenopodium sp.	1	15	0	0	0
Echium sp.	2	131	0	0	0
Lithospermum arvense	0	0	1	0	0
Carex sp.	0	3	0	0	6
Scirpus sp.	1	13	0	0	2
Coronilla sp.	0	2	0	0	0
Scorpiurus sp.	4	34	0	1	1
Trifolium sp.	13	8	0	0	1
Trigonella foenum-graecum	0	1	0	0	0
Lolium sp.	39	224	10	16	23
Phalaris sp.	17	66	0	0	0
Indet. Grass	12	84	8	0	5
Linum sp.	0	0	0	0	2
Aegilop sp.	0	8	0	0	0
Avena sp.	1	0	0	0	0
Bromus sp.	5	4	0	0	0
Hordeum spontaneum	0	1	0	0	0
Polygonecaea family plant	0	1	0	0	0
Persicaria sp.	0	4	0	0	0
Rumex sp.	0	1	0	0	1
Ranunculus sp.	1	26	0	0	1
Ranunculaceae family plant	0	0	0	0	1
Asperula sp.	0	6	0	0	0
Galium sp.	0	9	0	1	3
Sherardia sp.	0	0	0	0	1
Thymelaea sp.	1	1	0	0	0
Indet.	4	45	0	2	8

When the counts are evaluated for each phase separately, most of the seeds are belonging to the Phase 3 of 54.38 as this phase has the highest number of samples. The second richest sample in means of wild seeds is Phase 2 of the same square. The other phases do not have numerous seeds of this taxa. The lowest number of wild seeds is present in the Phase 3 of 51/52.37 plan square. The find densities of the individual plant taxa are not calculated as the soil sample size information is not available for all the samples. But, to get a general sense, the density of wild plants per sample is calculated. The results shows that the Phase 2 of 51/52.37 has the most numerous wild seeds per sample (20,20). It is followed by the Phase 3 of the same plan square (12,08). The least dense phase is Phase 4, again, of the same trench. The density of one sample in the Phase 1 of 54.38 is 10,00, whereas this number is 9,33 for the Phase 2 of the same trench. The details of the phases are further discussed in the following sections.

4.4.1.2. Proportion and Ubiquity of Wild Plants

As might be expected from the counts, the proportion of the *Lolium* sp. has the highest proportion in all phases of Toprakhisar. It constitutes the 41,075 of the wild plant taxa in the Phase 2 of 54.38 plan square. Its proportion reaches up to 80% in the Phase 1 of the same trench. Its proportion decreases in the Phase 3 of 51/52.37 to 52,63% and continues to decrease in the following phase, Phase 2 (31,42%). Then, it shows a slight increase in the Phase 2 of 51/52.37 and reaches to 38,61% (Table *18*).

The second most numerous group of plants, indetermined grasses has a lower proportion (8,93%) in the Phase 2 of 54.38 plan square, and interestingly, there is no remains found belonging indetermined grass. in the Phase 1 of the same plan square. Then, the proportion of the unidentifiable grass seeds climbs to 42,11% in the Phase 4 of the 51/52.37 and this phase is when indetermined grass reached its maximum proportion, then, it starts to decrease again. In the Phase 3 and Phase 2 of the 51/52.37, the proportions are close to each other (11,78% for Phase 3 and 11,88% for Phase 2).

The third most numerous plant genus, *Echium* sp. is only found in the last two phases of the 51/52.37 plan square. The proportion of this genus is 18,37% in the Phase 3, however, it drastically decreases to 1,98% in the following Phase 2.

Another relatively numerous plant group, *Phalaris* sp., is only present in the Phase 3 and Phase 2 of 51/52.37 plan square as it is the case for *Echium* sp. The proportion in the Phase 3 is 9,26% whereas with an increase it is 16,83% in the Phase 2.

Scorpiurus sp. is one of the plant genera that is present in most of the phases of Toprakhisar even though the number of seeds is not very high. Its proportion is 1,79% in the Phase 2 of 54.38 plan square, and it increases to 5,00% in the following Phase 1 of the same plan square. In the Phase 3 of 51/52.37, this seed is totally absent from the samples. In the Phase 2 of this trench, the proportion increases again to 4,77% and decreases again in the Phase 2 to 3,96%.

Amaranthus sp., which is one of the plant species that is represented with over 12 seeds in total in the samples, is only present in the Phase 2 of 54.38 with very low proportion (1,79%) and also present in the Phase 3 of the 51/52.37 plan square with slightly increased proportion (3,65%).

Trifolium sp., that is another plant group that is present in the assemblages with over 20 seeds, is found in three of the five phases studied in Toprakhisar. In the Phase 2 of 54.38 plan square, its proportion is 1,79%. However, in the Phase 1 of this trench and Phase 4 of 51/52.37 plan square, this plant genus is totally absent from the samples. In the Phase 3 of the latter, it is present with small proportion again (1,12%). In the latest phase of 51/52.37 plan square, in Phase 2, its proportion reaches to the maximum and this plant group constitute the 12,87% of the samples.

Chenopodium sp. is present in the samples with over ten seeds but less than twenty seeds. So, their proportion is very low when comparing to the above-mentioned plant genera so as their proportion. These seeds are only present in the last two phases of the

51/52.37 plan square. In the Phase 3, their proportion is 2,10%. In fact, the proportion is even smaller in the following Phase 2 (0,99%).

Scirpus sp. is another poorly represented plant genus in the samples. Its proportion in the samples is accordingly very low. Its highest proportion is in the Phase 2 of 54.38 with 3,57% percentage. In the following phase samples of this trench, this plant genus is not present. Phase 4 of the 51/52.37 also does not have any remains of this genus. In the Phase 3 of the same plan square, it starts to be observed again and the proportion in this phase is 1,83%. In the Phase 2, it represents the 0,99% of the wild plant taxa.

The last one of the poorly represented plant genera, *Galium* sp. is present in the 5,36% of the samples belonging to Phase 2 of 54.38 plan square. It slightly decreases to 5,00% in the next phase. The Phase 4 of 51/52.37 plan square does not have any remains of *Galium* sp. in its samples. The Phase 3 of this square is the only phase that has this genus with 1,26% proportion.

The proportion of the unidentifiable wild plants were 14,29% in the Phase 2 of 54.38 plan square. This proportion decreases to 10,00% in the following Phase 1. The phase 4 of 51/52.37 has no remains indetermined. 6,31% of the Phase 3 plants is left unidentified, and this percentage decreases to 3,96% in the Phase 2 of the same trench.

The rest of the wild plants were rarely present in the samples, so they are not discussed in detail here. The details can be seen in the Table *18*. As the counts are very low, the proportion of these genera in the samples are usually very small (below 5%) except *Carex* sp (sedges). This genus plants constitute the 10,71% of the wild plants coming from Phase 2 of 54.38 plan square. In addition to this phase, this genus is only present in the Phase 3 of the 51/52.37 with 0,42% proportion.

The ubiquity of the plants has similar trends with the proportions with minor differences. As was the case for proportion results, the ubiquity values are presented according to the abundance of the wild plant genera meaning the most numerously found genera is explained in detail in the following paragraphs. The ubiquity of the genera with less than ten seeds are not given in detail rather their values are only presented in the table.

Lolium sp. is the most ubiquitous genus in all the phases except Phase 2 of 54.28 where the ubiquity of *Galium* sp. and indetermined weed exceed ubiquity of *Lolium* sp. The ubiquity of *Lolium* sp. in that phase is 33,33%. In the following Phase 1 of the same trench, this genus is present in all of the samples (100%). The Phase 4 of 51/52.37 has *Lolium* sp. in the two third of its samples (66,67%). In the following phase the ubiquity decreases very slightly to 66,10%. In the Phase 2, ryegrass seeds are once more present in all of the samples (100%).

Indetermined grass seeds are present in the one third (33,33%) of the samples belonging to Phase 2 of 54.38. However, Phase 1 does not have any remains of these seeds. The ubiquity increases to 33,33% again in the Phase 4 of 51/52.37. In the following Phase 3, the ubiquity slightly falls to 32,20% and increases significantly in the Phase 1 to 80,00%.

Another numerous genus, *Echium* sp. has rather low ubiquities. Its ubiquity is only 3,39% in the Phase 3 of 51/52.37 and it raises up to 20,00% in the Phase 2 of the same plan square. The rest of the phases do not have any seeds of *Echium* sp.

The ubiquity value for *Phalaris* sp. in the Phase 3 of the 51/52.37 is 27,12%. This value reaches to 80,00% in the Phase 2 of the same trench. These are the only phases that this plant genus exists in the samples.

Scorpiurus sp. is among the poorly represented genus. Its ubiquity in the Phase 2 of 54.38 is 16,67%. However, it reaches to 50,00% in the following Phase 1 indicating that the half of the samples have *Scorpiurus* sp. seed remains. The Phase 4 of 51/52.37 does not have any remains of this genus. On the other hand, 10,17% of the samples in the following Phase 3 have these seeds. In the Phase 2, the ubiquity rises significantly and reaches to 40,00%.

The ubiquity of the *Amaranthus* sp., is 16,67% in the Phase 2 of 54.38 plan square. In addition to this phase, this genus seeds are also present in the Phase 3 of 51/52.37, and their ubiquity is 18,64% in this phase.

Trifolium sp. is present in the 16,67% of the samples of the 54.38 plan square, Phase 2. The ubiquity decreases to 13,56% in the Phase 3 of 51/52.37 plan square and continues to rise in the following phase and reaches to 40,00% in this Phase 2. The rest of the phases does not produce any Trifolium sp. seeds.

Chenopodium sp. is only found in the 51/52.37 plan square. Its ubiquity is 6,78% in the Phase 3 whereas it increases to 20,00% in the Phase 2. Considering the low number and low proportion of this genus, these results in ubiquity values are expected.

Scirpus sp. is present in the one third of the samples in the Phase 2 of 54.38. It disappears from the samples in the Phase 1 of this trench and the Phase 4 of 51/52.37 plan square. It reappears in the Phase 3 of the latter and is observed in the 11,86% of the samples. The ubiquity increases to 20,00% in the Phase 2 of this trench.

Galium sp. has an interesting trend in its ubiquity. It is the only genus that has higher ubiquity than the *Lolium* sp., but this is only the case for Phase 2 of 54.38 plan square. *Galium* sp, seeds are present in half of the samples (50%) in this phase and the following phase as well. This genus is also and only found in the Phase 3 of 51/52.37 plan square and its ubiquity is 10,17%.

Indetermined seeds are present in the 50,00% of the samples in the oldest phase of 54.38. And the situation for these seeds is the same for following Phase 1 (50,00%). In the Phase 4 of the 51/52.37, all the wild seeds were identifiable. However, in the Phase 2, the ubiquity of unidentifiable samples increases again to 33,90% and continues to increase in the Phase 2 as well (40,00%).

Other wild plant taxa are usually present with low ubiquities. *Bromus* sp. can be counted as an exception as its ubiquity reaches to 40,00% in the Phase 2 of 51/52.37 plan square. The ubiquity values for rest of the plant taxa can be seen in the Table *18*.

Table 18. Table shows the proportion and ubiquity of wild plant taxa remains in different phases of Toprakhisar.

Square	51/52.37			54.38		51/52.37			54.38	
Local Phase	**2**	**3**	**4**	**1**	**2**	**2**	**3**	**4**	**1**	**2**
Period	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC	2000-1900 BC	2000-1900 BC	2100-2000 BC	2100-2000 BC	2100-2000 BC
	Proportions					**Ubiquity** Total Number of Samples				
						5	59	3	2	6
Amaranthus sp.	0,00	3,65	0,00	0,00	1,79	0,00	18,64	0,00	0,00	16,67
Chenopodium sp.	0,99	2,10	0,00	0,00	0,00	20,00	6,78	0,00	0,00	0,00
Echium sp.	1,98	18,37	0,00	0,00	0,00	20,00	3,39	0,00	0,00	0,00
Lithospermum arvense	0,00	0,00	5,26	0,00	0,00	0,00	0,00	33,33	0,00	0,00
Carex sp.	0,00	0,42	0,00	0,00	10,71	0,00	1,69	0,00	0,00	16,67
Scirpus sp.	0,99	1,82	0,00	0,00	3,57	20,00	11,86	0,00	0,00	33,33
Coronilla sp.	0,00	0,28	0,00	0,00	0,00	0,00	3,39	0,00	0,00	0,00
Scorpiurus sp.	3,96	4,77	0,00	5,00	1,79	40,00	10,17	0,00	50,00	16,67
Trifolium sp.	12,87	1,12	0,00	0,00	1,79	40,00	13,56	0,00	0,00	16,67
Trigonella foenum-graecum	0,00	0,14	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Lolium sp.	38,61	31,42	52,63	80,00	41,07	100,00	66,10	66,67	100,00	33,33
Phalaris sp.	16,83	9,26	0,00	0,00	0,00	80,00	27,12	0,00	0,00	0,00
Indet. Grass	11,88	11,78	42,11	0,00	8,93	80,00	32,20	33,33	0,00	33,33
Linum sp.	0,00	0,00	0,00	0,00	3,57	0,00	0,00	0,00	0,00	16,67
Aegilop sp.	0,00	1,12	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Avena sp.	0,99	0,00	0,00	0,00	0,00	20,00	0,00	0,00	0,00	0,00
Bromus sp.	4,95	0,56	0,00	0,00	0,00	40,00	5,08	0,00	0,00	0,00
Hordeum spontaneum	0,00	0,14	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Polygonecaea family plant	0,00	0,14	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Persicaria sp.	0,00	0,56	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Rumex sp.	0,00	0,14	0,00	0,00	1,79	0,00	1,69	0,00	0,00	16,67
Ranunculus sp.	0,99	3,65	0,00	0,00	1,79	20,00	8,47	0,00	0,00	16,67
Ranunculaceae family plant	0,00	0,00	0,00	0,00	1,79	0,00	0,00	0,00	0,00	16,67
Asperula sp.	0,00	0,84	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00
Galium sp.	0,00	1,26	0,00	5,00	5,36	0,00	10,17	0,00	50,00	50,00
Sherardia sp.	0,00	0,00	0,00	0,00	1,79	0,00	0,00	0,00	0,00	16,67
Thymelaea sp.	0,99	0,14	0,00	0,00	0,00	20,00	1,69	0,00	0,00	0,00
Indet.	3,96	6,31	0,00	10,00	14,29	40,00	33,90	0,00	50,00	50,00

4.4.2. Tell Atchana

4.4.2.1. Count and Find Density of Wild Plants

The wild plant taxa are a little bit less varied in the samples coming from the Atchana than Toprakhisar. Total of 26 different wild plant taxa and indetermined wild seeds are found in the archaeobotanical samples belonging to 42.10 plan square of the Atchana (Table *19*). The total number of wild seeds coming from fifty-eight samples (857 L of soil sediment) is 411.

On the contrary to samples coming from Toprakhisar, Atchana samples have only one genus that is presented with over a hundred seeds in overall of the assemblages and this genus is *Lolium* sp. (n=204). Lolium sp. is followed by the indetermined grass in numerousness, these grass seeds are relatively good presented in the samples (n=76). The rest of the plant genera are either poorly or rarely present in the samples. Poorly presented genera are *Rumex* sp. (docks, n=27), indetermined wild plant seeds (n=17), *Phalaris* sp. (canarygrass, n=12), and *Scorpiurus* sp. (scorpions's tail, n=10). The seed number of the other plant genera are below 10. Thus, they are not presented here in detail, but they can be seen in the Table *19*.

The density of the individual plant taxa per sample liter of soil is very low even for the most numerous plant genus *Lolium* sp. seeds. The densities are usually below 0,10 in separate phases so, they are not discussed in detail. Only *Lolium* sp. can be mentioned here as it is the only genus that is relatively dense in the samples. Its density in the Phase 7 is 0,09 seeds/L. But it increases to 0,33 in the following Phase 6. Interestingly, this genus seeds are totally absent from the Phase 5 samples even though the sample number in this phase is not low. In the Phase 4/5, the density reaches its peak with 0,47 seeds per liter soil. In the following phases it decreases again to 0,22 in the Phase 4 and to 0,13 in the Phase 3 (Table *19*).

Table 19. Table shows the counts and find densities of wild plant taxa remains in different phases of Atchana.

Square	42.10						42.10					
Local Phase	**3**	**4**	**4/5**	**5**	**6**	**7**	**3**	**4**	**4/5**	**5**	**6**	**7**
Period	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC
	Counts (n) Total Number of Counts						**Find Density (n/L)** Total Soil Sediment (L)					
Total	3	163	53	9	151	32	16	357	49	75	284	76
Amaranthus sp.	0	0	0	1	0	0	0,00	0,00	0,00	0,01	0,00	0,00
Bupleurum sp.	0	1	0	0	1	0	0,00	0,00	0,00	0,00	0,00	0,00
Bupleurum / Carum Sp.	0	1	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00
Echium sp.	0	2	0	0	0	0	0,00	0,01	0,00	0,00	0,00	0,00
Lithospermum sp.	0	0	0	0	1	0	0,00	0,00	0,00	0,00	0,00	0,00
Silene sp.	0	3	0	0	0	0	0,00	0,01	0,00	0,00	0,00	0,00
Carex sp.	0	0	0	0	1	0	0,00	0,00	0,00	0,00	0,00	0,00
Scirpus sp.	0	0	0	1	3	2	0,00	0,00	0,00	0,01	0,01	0,03
Euphorbia helioscopia	0	2	0	0	0	0	0,00	0,01	0,00	0,00	0,00	0,00
Astragalus sp.	0	1	0	1	1	1	0,00	0,00	0,00	0,01	0,00	0,01
Scorpiurus sp.	0	1	1	0	4	4	0,00	0,00	0,02	0,00	0,01	0,05
Trifolium sp.	0	0	2	1	2	1	0,00	0,00	0,04	0,01	0,01	0,01
Trigonella foenum-graecum	0	0	1	0	0	0	0,00	0,00	0,02	0,00	0,00	0,00
Lolium sp.	2	78	23	0	94	7	0,13	0,22	0,47	0,00	0,33	0,09
Phalaris sp.	0	2	3	3	3	1	0,00	0,01	0,06	0,04	0,01	0,01
Indet. Grass	0	38	20	1	13	4	0,00	0,11	0,41	0,01	0,05	0,05
Malva sp.	0	4	0	0	0	1	0,00	0,01	0,00	0,00	0,00	0,01
Malvaceae family plant	0	0	0	0	1	1	0,00	0,00	0,00	0,00	0,00	0,01
Bromus sp.	0	0	0	0	3	0	0,00	0,00	0,00	0,00	0,01	0,00
Hordeum spontaneum	0	1	0	0	2	0	0,00	0,00	0,00	0,00	0,01	0,00
Polygonum sp.	0	0	0	1	1	2	0,00	0,00	0,00	0,01	0,00	0,03
Rumex sp.	0	19	0	0	5	3	0,00	0,05	0,00	0,00	0,02	0,04
Polygonaceae family plant	0	0	0	0	1	0	0,00	0,00	0,00	0,00	0,00	0,00
Ranunculus sp.	0	3	0	0	0	1	0,00	0,01	0,00	0,00	0,00	0,01
Galium sp.	0	5	0	0	1	1	0,00	0,01	0,00	0,00	0,00	0,01
Thymelaea sp.	0	0	1	0	4	1	0,00	0,00	0,02	0,00	0,01	0,01
Indet.	1	2	2	0	10	2	0,06	0,01	0,04	0,00	0,04	0,03

4.4.2.2. Proportion and Ubiquity of Wild Plants

Lolium sp. is the most proportionate genus in all of the phases of 42.10 plan square as it is the case for Toprakhisar phases. Its proportion in the Phase 7 is 21,88% and it decreases to 62,25% in the Phase 6. In the Phase 4/5, proportion value decreases to 43,40% again. In the Phase 4, on the other hand, with a slight increase, it constitutes 47,85 of the wild plant seeds. Phase 3 is the phase that the proportion of this genus reaches its maximum (66,67%) (Table *20*).

The second most numerous plant group, indetermined grass seeds constitutes12,50% of the wild plant assemblages in the Phase 7. Their proportion decreases to 8,61% in the Phase 6. The following two phases, Phase 5 and Phase 4/5 witnessed a rise in the proportion of these seeds and the values are 11,11% for the former and 37,74% for the latter. Then, in the Phase 4, the proportion decreases to 23,31% again and totally disappears in the Phase 3 samples. The proportion of unidentifiable seeds shows an opposite trend of change with *Lolium* sp. in each phase. In other words, when the proportion of *Lolium* decreases, the proportion of indetermined grass increases or vice versa. So, it can be said that there are chances that most of the indetermined grasses might highly likely be *Lolium* sp. seeds but due to the bad preservation, they are not able to be identified.

The third most numerous genus of wild plant taxa is *Rumex* sp. It is only present in the half of the phases belonging to 42.10 plan square. Its proportion in the Phase 7 is 9,38%, then it decreases to 3,31% in the Phase 6. The following two phases does not have remains of this genus. In the Phase 4/5, its proportion rises once more to 11,66%. And the earliest phase of this trench, again, does not have any seeds related to this genus.

Phalaris sp. is another genus represented over ten seeds, so it is included here as well. The proportion value for this genus in the oldest phase is 3,13%. Then, it falls to 1,99% in the Phase 6. In the Phase 5, the proportion peaks and this genus represents 33,33% of the wild plant taxa. Its proportion suddenly decreases again to 5,66% in the Phase 4/5 and continues its fall. In Phase 4/5, only 1,23% of the wild plant seeds belong to *Phalaris* sp., and in the last phase of the 42.10, they totally disappear from the samples.

The last of the wild plant genera that has over 10 seeds in the assemblages is *Scorpiurus* sp. It has relatively higher proportion in Phase 7 (12,50%). But it is the only phase that this genus constitutes over 10% of the wild plant taxa assemblages. In the Phase 6, its proportion falls to 2,65%, and the following phase does not have any remains belonging to this genus. In the Phase 4/5 it appears with 1,89% proportion again. The last phase that has seeds of this genus is Phase 4 and its proportion is 0,61%.

The indetermined wild seeds are not very abundant comparing to Toprakhisar. These unidentifiable seeds constitute the 6,25% of the wild plant assemblages in the Phase 7. In the following phase, their proportion becomes 6,62% with a slight increase. All the wild seeds in Phase 5 are identifiable so there is no indetermined wild seeds in this phase. The proportion increases once more and become 3,77% in the Phase 4/5. In the Phase 4, it decreases to 1,23%. The last phase, Phase 3, this type of seeds reaches their maximum. 33,33% of the wild plant seeds in this phase was unidentifiable.

As it is the case for proportion values, the *Lolium* sp. also have the highest ubiquities in all of the phases. It has highest ubiquity in the Phase 7 with 75,00%. Then, its ubiquity decreases to 65.22% in the Phase 6. The Phase 4/5 has *Lolium* sp. in 60,00% of its samples. In both of the last two phases, the half of the samples has seeds related to this genus.

Indetermined grass is present in the 50,00% of the samples belonging to Phase 7. The ubiquity decreases to 26,09% in the Phase 6, and even continues to decrease in the following phase and becomes 16,67%. It increases again in the Phase 4/5 and rise to 40,00%. The last phase that has unidentifiable grass seeds, Phase 4, has these seeds in 16,67% of its samples.

The ubiquity details of other seeds are not mentioned here in detail rather they can be seen in the Table *20*. As a matter of fact, the ubiquity of these seeds usually below or equals to 25% with few exceptions. These exceptions are *Scirpus* sp. (bulrush) and *Polygonum* sp. (knotweed) in the Phase 7 where they both have 50,00% ubiquity. This situation is probably related with the contexts of the samples that the Phase 7 samples came from.

Table 20. Table shows the proportion and ubiquity of wild plant taxa remains in different phases of Atchana.

Square	42.10						42.10					
Local Phase	**3**	**4**	**4/5**	**5**	**6**	**7**	**3**	**4**	**4/5**	**5**	**6**	**7**
Period	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC	1200-1100 BC	1300-1200 BC	1325-1275 BC	1350-1300 BC	1350-1300 BC	1400-1350 BC
	Proportions						**Ubiquity** Total Number of Samples					
Total							2	18	5	6	23	4
Amaranthus sp.	0,00	0,00	0,00	11,11	0,00	0,00	0,00	0,00	0,00	16,67	0,00	0,00
Bupleurum sp.	0,00	0,61	0,00	0,00	0,66	0,00	0,00	5,56	0,00	0,00	4,35	0,00
Bupleurum / Carum Sp.	0,00	0,61	0,00	0,00	0,00	0,00	0,00	5,56	0,00	0,00	0,00	0,00
Echium sp.	0,00	1,23	0,00	0,00	0,00	0,00	0,00	11,11	0,00	0,00	0,00	0,00
Lithospermum sp.	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	4,35	0,00
Silene sp.	0,00	1,84	0,00	0,00	0,00	0,00	0,00	11,11	0,00	0,00	0,00	0,00
Carex sp.	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	4,35	0,00
Scirpus sp.	0,00	0,00	0,00	11,11	1,99	6,25	0,00	0,00	0,00	16,67	13,04	50,00
Euphorbia helioscopia	0,00	1,23	0,00	0,00	0,00	0,00	0,00	11,11	0,00	0,00	0,00	0,00
Astragalus sp.	0,00	0,61	0,00	11,11	0,66	3,13	0,00	5,56	0,00	16,67	4,35	25,00
Scorpiurus sp.	0,00	0,61	1,89	0,00	2,65	12,50	0,00	5,56	20,00	0,00	13,04	25,00
Trifolium sp.	0,00	0,00	3,77	11,11	1,32	3,13	0,00	0,00	20,00	16,67	8,70	25,00
Trigonella foenum-graecum	0,00	0,00	1,89	0,00	0,00	0,00	0,00	0,00	20,00	0,00	0,00	0,00
Lolium sp.	66,67	47,85	43,40	0,00	62,25	21,88	50,00	50,00	60,00	0,00	65,22	75,00
Phalaris sp.	0,00	1,23	5,66	33,33	1,99	3,13	0,00	11,11	40,00	33,33	13,04	25,00
Indet. Grass	0,00	23,31	37,74	11,11	8,61	12,50	0,00	16,67	40,00	16,67	26,09	50,00
Malva sp.	0,00	2,45	0,00	0,00	0,00	3,13	0,00	5,56	0,00	0,00	0,00	25,00
Malvaceae family plant	0,00	0,00	0,00	0,00	0,66	3,13	0,00	0,00	0,00	0,00	4,35	25,00
Bromus sp.	0,00	0,00	0,00	0,00	1,99	0,00	0,00	0,00	0,00	0,00	13,04	0,00
Hordeum spontaneum	0,00	0,61	0,00	0,00	1,32	0,00	0,00	5,56	0,00	0,00	8,70	0,00
Polygonum sp.	0,00	0,00	0,00	11,11	0,66	6,25	0,00	0,00	0,00	16,67	4,35	50,00
Rumex sp.	0,00	11,66	0,00	0,00	3,31	9,38	0,00	33,33	0,00	0,00	17,39	50,00
Polygonaceae family plant	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	4,35	0,00
Ranunculus sp.	0,00	1,84	0,00	0,00	0,00	3,13	0,00	5,56	0,00	0,00	0,00	25,00
Galium sp.	0,00	3,07	0,00	0,00	0,66	3,13	0,00	11,11	0,00	0,00	4,35	25,00
Thymelaea sp.	0,00	0,00	1,89	0,00	2,65	3,13	0,00	0,00	20,00	0,00	17,39	25,00
Indet.	33,33	1,23	3,77	0,00	6,62	6,25	50,00	11,11	40,00	0,00	30,43	25,00

4.4.3. Weed Ecology

4.4.3.1. Toprakhisar

When the wild plant taxa are grouped according to habitats that they grow, it is seen that ten out of twenty-eight plant genera grow in open vegetations, three of them occupy drier lands, five lives in wetlands, seven have weedy character and grows in arable lands side by side with crops. The last three plant types -including indetermined weeds- are categorized with unknown habitats (Table *21*).

Table 21. Table shows the eco-groups of wild plant taxa retrieved from Toprakhisar Höyük.

Wild Plant Taxa	Eco-Group
Amaranthus sp.	Open
Lithospermum arvense	Open
Coronilla sp.	Open
Scorpiurus sp.	Open
Trifolium sp.	Open
Phalaris sp.	Open
Indet. Grass	Open
Linum sp.	Open
Avena sp.	Open
Thymelaea sp.	Open
Echium sp.	Dryland
Trigonella foenum-graecum	Dryland
Bromus sp.	Dryland
Carex sp.	Water-related
Scirpus sp.	Water-related
Persicaria sp.	Water-related
Rumex sp.	Water-related
Ranunculus sp.	Water-related
Chenopodium sp.	Weed
Lolium sp.	Weed
Aegilops sp.	Weed
Hordeum spontaneum	Weed
Asperula sp.	Weed
Galium sp.	Weed
Sherardia sp.	Weed
Polygonecaea family plant	Unknown
Ranunculaceae family plant	Unknown
Indet.	Unknown

Open vegetation and weedy plant taxa appear to dominate the wild plant assemblages throughout time as these plant genera are the most abundant ones in all phases of Toprakhisar (Figure *68*). In weedy plant taxa, especially, *Lolium* sp. has its highest proportions in the 54.38 plan square which has samples dates back to end of the 3rd millennium BC. The plants that grow in open vegetation have rather more irregular distribution in different phases. *Lithospermum arvense* and indetermined grass species are particularly visible in the Phase 4 of 51/52.37, the phase that is dated to the beginning of the 2nd millennium BC. *Trifolium* sp. and *Phalaris* sp., on the other hand, is mainly present in the samples coming from the Phase 2 (2000-1900 BC) of the same trench. In general, open vegetation plant genera dominate the samples belonging to 51/52.37 plan square whereas weedy plant taxa are mainly coming from the 54.38 plan square. The presence of the open vegetation and weedy plants might give clues about the grazing activities of herds, dung-fuel usage, and plant processing. However, as main focus of this thesis is climate change, the plant genera that give information about the water availability in the surrounding regions are more important.

Among the three dryland plant genera, *Echium* sp. is the most abundant one. It is also the most abundant plant genus of all the wild plant taxa in the Phase 3 of 51/52.37 plan square (2000-1900 BC). *Bromus* sp. is not as abundant as *Echium* sp. but still it characterizes the dryland species belonging to Phase 2 (2000-1900 BC) of this trench (Figure *68*). It can be said that the dryland species are mainly present in the samples coming from 51/52.37. Both of mentioned phases from this plan square belong to the beginning of the 2nd millennium BC. The results might be the indicator of increasing drier conditions, thus, the increase of dryland species in the surroundings of Toprakhisar Höyük. Considering the fact that the 4.2 ka BP event started in 2200 BC and lasted nearly 300 years, the increasing effect of this climate change towards the beginning of 2000 BC is very likely. Thus, the climate change might alter the flora of the Toprakhisar region, and this change might become visible in the archaeobotanical assemblages coming from this period. When the results are evaluated with the results of other analyses carried out in this thesis, the situation in that period might become clearer.

The wetland genera are more varied than the dryland species. The most abundant genus of this eco-group is *Carex* sp. of Phase 2 of 54.38 plan square (2100-2000 BC). Other wetland species *Scirpus* sp. and *Rumex* sp. also belong to the same phase of the same plan square. Among the wetland species, only *Ranunculus* sp. is present in both Phase 2 of 54.38 and Phase 3 of 51/52.37 (2000-1900 BC). *Persicaria* sp. is only coming from Phase 3 of 51/52.37 (Figure *68*). So, it can be said that both Phase 3 of 51/52.37 and Phase 2 of 54.38 have seeds that grow in the watery environments, however the latter have higher proportions of these plant genera. Thus, it can be argued that the end of the 3rd millennium BC, the environmental conditions were moister to enable the growth of water loving species. But during the transition to the 2nd millennium BC, most of the wetland species disappeared and replaced by dryland species. Thus, even though the wetland genera did not totally disappear, their proportion decreased, and variety of dryland species started to be observed in the Phase 2 of 51/52.37 with the beginning of drier conditions in the beginning of the 2nd millennium BC.

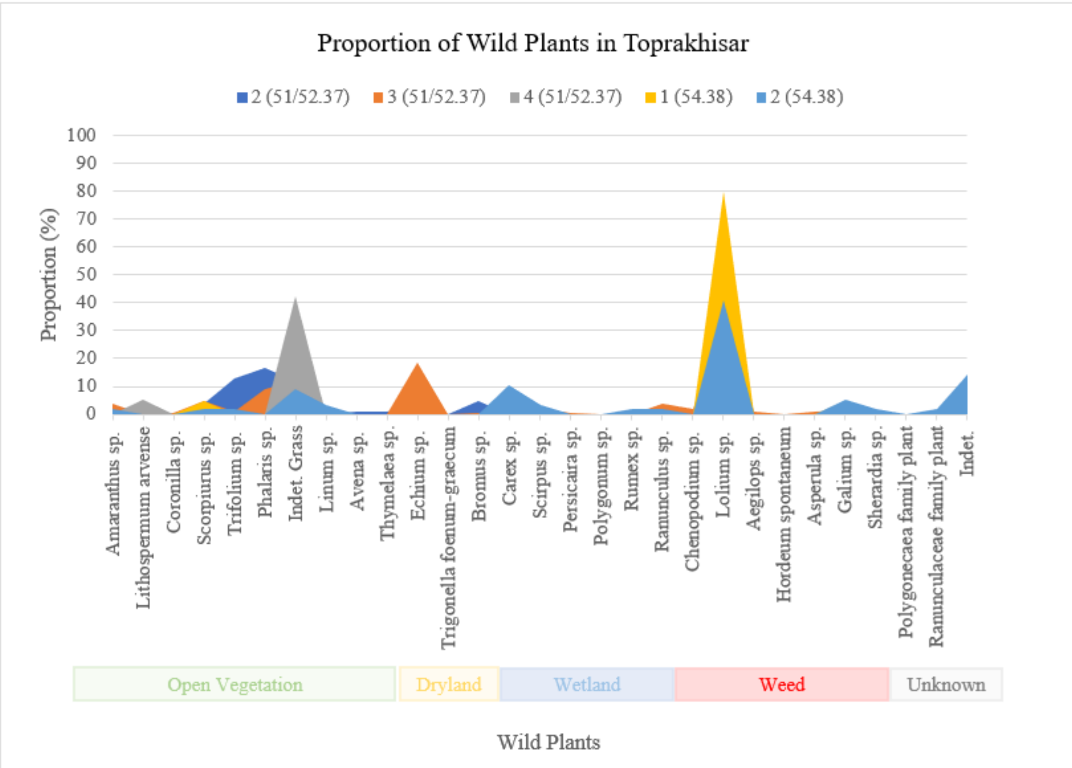

Figure 68. Area chart shows the proportions of the different eco-groups in different phases of occupation in Toprakhisar.

Besides being an indicator of wetter condition at the end of the 3rd millennium BC, the higher abundance of wetland plants during this time might also be a sign of the relocation of agricultural areas near to water sources such as rivers because of the decreased precipitation. Even if this were the case for the 3rd BC, the climate may have grown even drier since more dryland plants were present in the time that followed, which began in the 2nd millennium BC.

Some of the wetland species such as sedges, rushes, and reeds were also used for the architectural purposes in the past including roofing, matting and basketry (Riehl, 1999). Archaeological evidence suggested that some parts of the Building 2 in 51/52.37 plan square was roofed (Akar & Kara, 2018a) indicating that roofing was known and practiced by the Toprakhisar occupants. If such wetland plants were brought to the area as a roofing material, it affects the amount of presence of this plant genera as they were brought to the area in high amounts for a certain purpose, not as coincidental contaminants in the crops. The intensity of mentioned activities at the end of the 3rd millennium BC might be another factor that affected the more abundant presentation of wetland species.

The edibility, medicinal usage of the wild plants or dye production from them are other factors that influence probability/abundance of their presence. Most of the wild plants found in the samples have such usages that might have caused their intentional transportation to the site. For instance, wetland plants *Persicaria* sp. and *Rumex* sp. has some species that are used for all the purposes mentioned above: human consumption, medicinal use, and dye procurement. *Ranunculus* sp. is used as a medicine. Dryland plant *Echium* sp. is also consumed by people and used for medicinal purposes. Dye, as well, can be acquired from this genus plants. *Amaranthus* sp. which grow in the open vegetation also used for all three purposes. So, their intentional bringing to the site increases their number/proportion in the archaeobotanical samples however since many of the plants from different vegetations are used intentionally by humans it is hard to argue about the meaning of their relative presence as climatic indicators.

4.4.3.2. Tell Atchana

In the wild plant taxa taken from Atchana samples, in open vegetations, eleven out of twenty-seven genera belong to open vegetation eco-group. The dryland species are relatively more varied in Atchana than that of Toprakhisar. There are four different genera grows in dryland in Atchana samples. As was the case for Toprakhisar, five out of twenty-seven plant genera thrive in wetlands. The seeds with weedy character are less varied in Atchana, only four different genera consisted of this eco-group. The rest three plant groups -including indetermined weeds- are identified as unknown eco-group (Table *22*).

Table 22. Table shows the eco-groups of wild plant taxa retrieved from Tell Atchana.

Wild Plant Taxa	Eco Group
Amaranthus sp.	Open
Bupleurum sp.	Open
Bupleurum / Carum Sp.	Open
Lithospermum sp.	Open
Silene sp.	Open
Astragalus sp.	Open
Scorpiurus sp.	Open
Trifolium sp.	Open
Phalaris sp.	Open
Indet. Grass	Open
Thymelaea sp.	Open
Echium sp.	Dryland
Trigonella foenum-graecum	Dryland
Malva sp.	Dryland
Bromus sp.	Dryland
Carex sp.	Water-related
Scirpus sp.	Water-related
Polygonum sp.	Water-related
Rumex sp.	Water-related
Ranunculus sp.	Water-related
Euphorbia helioscopia	Weed
Lolium sp.	Weed
Galium sp.	Weed
Hordeum spontaneum	Weed
Malvaceae family plant	Unknown
Polygonaceae family plant	Unknown
Indet.	Unknown

The weedy taxa are characterized by the high proportion of the *Lolium* sp. as in the case for Toprakhisar. Particularly, in Phase 3 (1200-1100 BC), this genus reaches its most proportionate level. In the Phase 6 (1350-1300 BC), the proportion is slightly lower than the proportion in Phase 3. The other phases as well have high proportions of *Lolium* sp. The wild plant genera that grow in the open vegetation is mainly presented with *Phalaris* sp. and indetermined grass seeds. The proportion of the former is highest in the Phase 5 (1350-1300 BC) and that of latter in the Phase 4/5 (1325-1275 BC). *Scorpiurus* sp. is also among the proportionate genera of open vegetation especially during the Phase 7 (1400-1350 BC) (Figure *69*).

When the focus is turned to the dryland and wetland species of Atchana, it is seen that the dryland plants are much less proportionate than the wetland genera. The dryland species was never represented with over 4% proportion. Among these group of plants, *Echium* sp. is found in the Phase 4 (1300-1200 BC), *Trigonella foenum-graecum* species is found Phase 4/5 (1325-1275 BC), *Bromus* sp. is coming from Phase 6 (1350-1300 BC), and *Malva* sp. is coming from the Phase 7 (1400-1350 BC). And this last one is the most proportionate dryland plant genus in the samples. If the Phase 6 and Phase 7 do not have these dryland plant seeds, it could be argued that slightly increasing arid conditions might be occurred towards the end of the Bronze Age as Phase 4/5 and Phase 4 of the 42.10 plan square coincides with the end of LBA. However, the presence of dryland genera in the Phase 6 and 7 weaken this probability. Rather, the dryland species should always be present around the Atchana, but their low proportion indicates that their growth should be restricted in the certain drier areas.

Among the water-loving plant genera, the *Carex* sp. interestingly has the lowest proportion. *Scirpus* sp. is more proportionate in the Phase 5 (1350-1300 BC), but Phase 7 (1400-1350 BC) also has seeds of this genus. *Polygonum* sp. has same proportions with *Scirpus* sp. in both of these mentioned phases. *Rumex* sp. is mostly found in the Phase 4 (1300-1200 BC), and its proportion is a little bit smaller in the Phase 7. Similarly, *Ranunculus* sp. also found mainly in these two phases but with smaller proportions. The wetland plant genera, just like the dryland genera, does not follow a particular pattern or grouping in changing phases. Thus, there seems no particular trend towards increasing drought or wetter conditions in certain periods according to the wild plant taxa. Rather, both types of plants were present throughout the phases, but the wetland species were dominant. Considering the riverine environment around Atchana, the dominance of water loving species in the samples is very expected but the important thing here is that there is no obvious change in their dominance towards the end of the LBA, the period that the 3.2 ka BP climatic change begun.

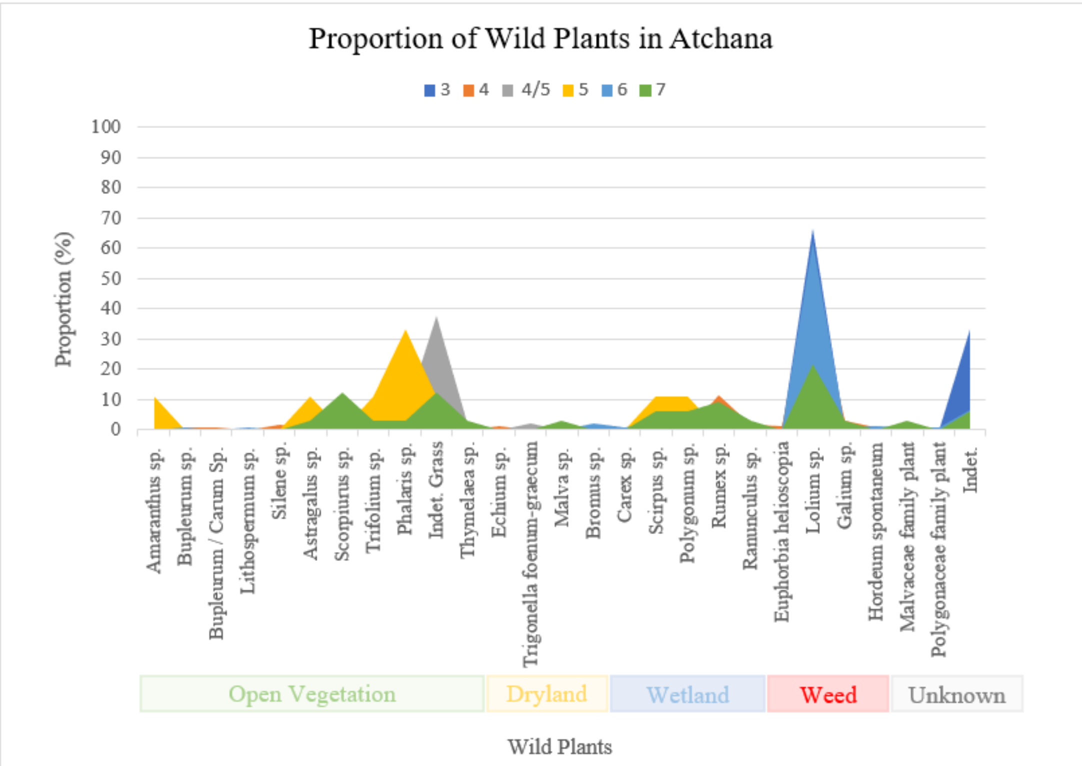

Figure 69. Area chart shows the proportions of the different eco-groups in different phases of occupation in 42.10 plan square of Atchana.

4.4.4. Crop vs. Wild Plant Taxa

To track the changes in crop vs. wild plant taxa consumption in the sites, the number of each taxon per sample was calculated in different phases. This type of calculation was preferred rather than calculating the density per liter soil sediment as some of the Toprakhisar samples does not have the information of soil sediment volume. In theory, if the wild plants are started to be represented with higher densities in the samples of a particular phase, then there might be an environmental enforcement behind this intensification of wild plants. Nevertheless, the other factors such as dung usage should also be considered to be more precise in the evaluation of the data.

4.4.4.1. Toprakhisar

The number of crop and wild seeds and their density in per sample in each phase is represented in the Table *23*. When these results are graphed (Figure *70*), it is seen that crop plant taxa are denser than the other taxa in the samples belonging to two phases of 54.38 plan square. However, in 51/52.37 plan square, the densities of both taxa decrease significantly, especially in the Phase 4 (2100-2000 BC) and Phase 3 (2000-1900 BC). In addition to this, the difference between the densities of these two taxa decreases. Even, in the Phase 3 and Phase 2 (2000-1900 BC), the density of wild plants is higher than that of crop plants. Previously presented results show that with the beginning of the 2nd millennium BC, drier conditions might be started to be more visible in the Toprakhisar environment. These drier conditions may have caused successive crop failures. The sudden decrease in crop density in 51/52.37 plan square and subsequent increase in wild plant remains might be the result of these successive crop failures. Before drawing any firm conclusion, the contexts of the samples should be evaluated. If the samples of 51/52.37 plan square were mainly taken from hearth contexts, then it is highly likely that the increase in wild plants is related with dung fuel usage. When the contexts of the samples are evaluated, it is seen that among the 66 samples belonging to 51/52.37 plan square, 48 of them have context information and only 5 out of 48 samples were taken from the hearths. The rest of the identified contexts were mainly coming from the floors or silos. And the samples coming from hearth contexts have four wild seeds at most. Thus, the possibility of dung usage in the 51/52.37 seems very unlikely. The first assumption -the increase in drier conditions in the beginning of the 2nd millennium BC- looks more solid according to these results.

Table 23. Table shows the number and density of crop and wild plant taxa per sample in different phases of Toprakhisar.

Plan Square	Local Phase	Number of Crops	Number of Wild Plants	Density of Crops	Density of Wild Plants
51/52.37	2	98	101	19,60	20,20
	3	436	713	7,39	12,08
	4	25	19	8,33	6,33
54.38	1	59	20	29,50	10,00
	2	169	56	33,80	9,33

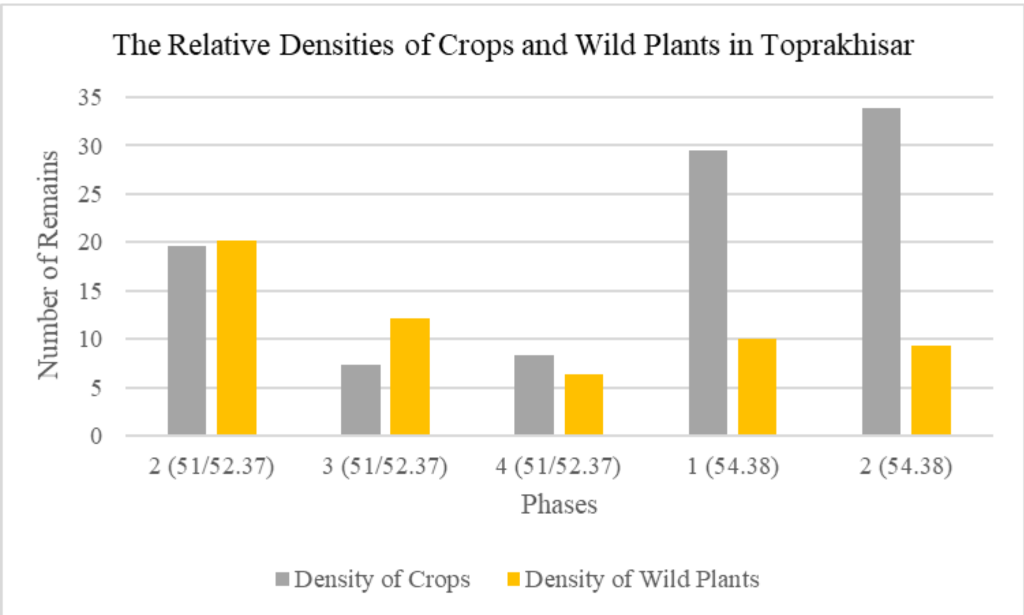

Figure 70. Bar graph shows the relative densities of crops and wild plants in Toprakhisar.

4.4.4.2. Tell Atchana

The number of crop and wild seeds and their density in per sample in each phase is represented in the Table *24*. The graph of the results (Figure *71*) shows that in all of the phases the crop remains are more plentiful than the wild plant remains. Even, the difference between the frequency of these two increases towards the Phase 3 (1200-1100 BC). From onwards of Phase 4/5 (1325-1275 BC), both taxa are represented in higher densities in the samples comparing to previous three phases. However, the densities start to decrease after its peak in the Phase 4/5. The increase in the wild plants, especially during the Phase 4/5 and Phase 4 (1300-1200 BC) is related with the increasing amounts of *Lolium* sp. and indetermined grass seeds in these phases. Thus, the increasing number of wild plants is not related to the intensification of exploitation of wild plants in Atchana case. Rather it might be related with the increased crop influx to the site during this phase, thus increasing amounts of crop contaminants. Even in the samples that are coming from the transition from LBA to Iron Age (the time period that coincides with Phase 3), the crop density does not change much. This is interesting because even in the face of 3.2 ka BP climatic event, at least 42.10 samples do not have the scarcity of crop plant remains rather slight decrease from previous period occurs. These results might be a sign for continuing agricultural stability in the Atchana throughout time, even in the times of climatic crisis.

Table 24. Number and density of crop and wild plant taxa per sample in different phases of Atchana.

Plan Square	Local Phase	Number of Crops	Number of Wild Plants	Density of Crops	Density of Wild Plants
42.10	3	31	3	15,50	1,50
	4	287	163	15,94	9,06
	4/5	100	53	20,00	10,60
	5	15	9	2,50	1,50
	6	156	151	6,78	6,57
	7	1	32	0,47	8,00

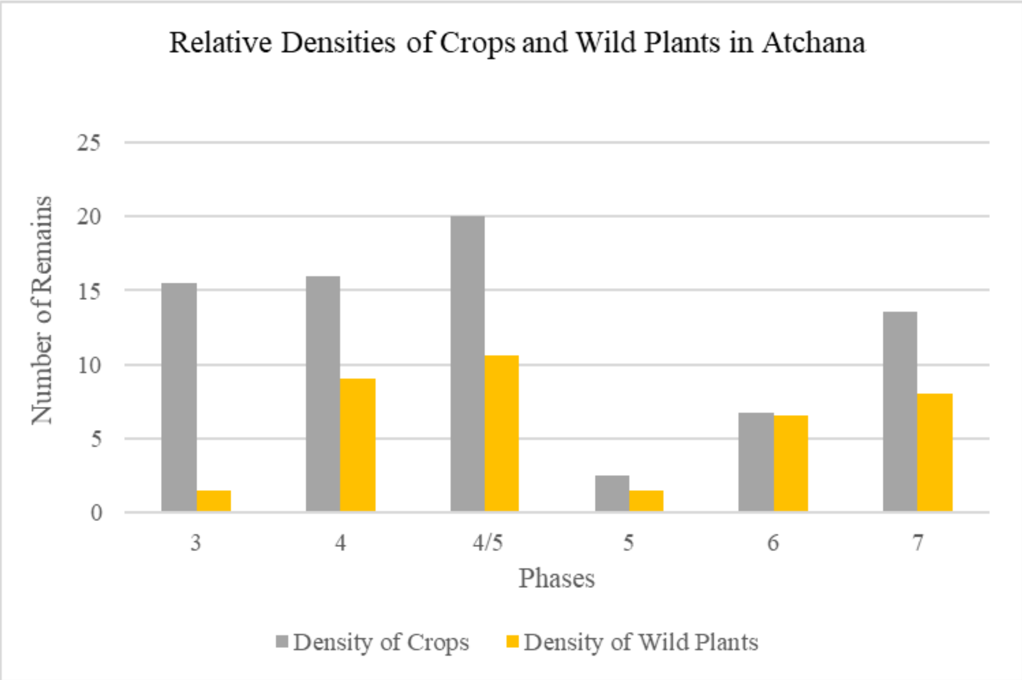

Figure 71. Bar graph shows the relative densities of crops and wild plants in Atchana.

4.5. SYNTHESIS OF RESULTS

4.5.1. Toprakhisar Höyük

When the results are evaluated in cereal base to be clearer, it is seen that archaeobotanical data indicates that free-threshing wheat was more proportionate in the samples dating to 2000-1900 BC than that of 2100-2000 BC. However, in the correspondence analysis carried out with both Toprakhisar and Atchana samples, it appears that there is not any particular relationship between free-threshing wheat and any phases of Toprakhisar. Even though a strong positive association is not present, it is also observed that negative association is present between this species and the Phase 1 of 54.38 plan square (2100-2000 BC). In the morphometric measurements, it is seen that the average size of grains is decreased from 2100-2000 BC to 2000-1900 BC. However, since the sample size is too small, this change is regarded to mean nothing.

Indeed, when the free-threshing wheat grains of Toprakhisar altogether compared to the MBA samples of Atchana with Mann-Whitney U test, it is evidenced that the mean size of grains in these two-sample group is not significantly different than each other. Considering that MBA was a period that good conditions were in play, it is expected that MBA samples might have significantly higher average value, but this is not the case. So, from this point of view, it can be argued that the Toprakhisar free-threshing wheat was grown in good environmental conditions. The stable isotope results also support this idea as analyzed free-threshing wheat grains ranges in similar values of $\Delta^{13}C$ except that the some of the samples belonging to 2000-1900 BC have some seeds with the sign of moderate water stress whilst it is not the case for any of the seed from 2100-2000 BC.

Hulled wheat has a peak in percentage in the samples belonging to 2100-2000 BC, however, its percentage decreases with the beginning of 2nd millennium BC. Phase 1 of 54.38 plan square (2100-2000 BC) is the only phase that hulled wheat grains are represented in greater amount than both free-threshing wheat and barley. Correspondence analysis also supports that hulled wheat is associated with this phase. The morphometric measurements indicate that the size of hulled wheat grains decreased in transition from 3rd millennium to 2nd millennium as it is the case for free-threshing wheat. However, on the contrary to free-threshing wheat, when the hulled wheat grains of Toprakhisar is compared to MBA hulled wheat samples of Atchana, it is seen that mean size of Toprakhisar samples is significantly smaller than that of Atchana samples indicating that there were factors in play that caused a shrinkage in seed sizes of Toprakhisar. This might be related to drier conditions that Toprakhisar experienced during that period. Nevertheless, the stress that caused the shrinkage of hulled wheat seeds of Toprakhisar is not visible in the isotope analysis carried out in the seeds. Only one seed belonging to the 2000-1900 BC (Phase 3 of 51/52.37) period has a sign of moderate water stress and the rest of the seeds were grown in good water conditions.

The archaeobotanical results suggests that barley was favored in the late 3rd millennium but with the beginning of 2nd millennium it gained similar importance as free-threshing wheat. Correspondence analysis also support this argument as barley is associated with the Phase 2 of 54.38 plan square (2100-2000 BC). Since morphometric measurements was not carried on barley grains it is not possible to say anything about the change in seed sizes of this species. But stable carbon isotope analysis shows that any of the barley grains coming from Toprakhisar were not grown under water stress conditions rather they were all cultivated in places where enough moisture was available.

The results gathered from wild plant taxa also shows that the phases belonging to 2100-2000 BC (Phases of 54.38 plan square) is characterized by the higher amounts of wetland species whereas the 2000-1900 BC (Phases of 51/52.37) is signified by the increased number of dryland plants.

At the outset of the discussion, the findings were interpreted as increasing effect of 4.2 ka BP climatic change and reinforcing drier conditions in the region, based on decreasing seed size of free-threshing wheat, encountering free-threshing wheat seeds with traces of moderate water stress, characterization of 2100-2000 BC with wetland wild plants and of 2000-1900 BC with dryland species. However, when the results are co-evaluated with the socioeconomic and political conditions of the time, it might be also possible that the results are related to the grain import or production of grain in wider range of areas with different moisture conditions rather than increasing drier conditions. In fact, even if drier conditions at the beginning of the 2nd millennium BC were present, it does not seem severely affected Toprakhisar people or its agriculture since it started to thrive politically and demographically in exact same period with an economic system that concentrates on agriculture.

It is pointed that in the transition from Phase 4 to Phase 3 in the 51/52.37 plan square, the settlement character of Toprakhisar changed significantly. Especially the architecture suggests that it has more local/self-supporting character in the former phase, but with the beginning of the Phase 3, it can be said that it became a producer center under a central administration evidence by a monumental building (Building 2). Akar and Kara (2020) argues that:

> *In the case of Building 2, the large amount of space dedicated to surplus storage and food processing is considered to indicate administrative management. The kitchen, storage and serving quarter is likely related to the large number of personnel that the administrative management was responsible for feeding in return for participation in labor-intensive activities such as olive/grape picking and oil/wine processing.*

If this was the case for Toprakhisar at the beginning of the 2nd millennium BC, it can be said that environmental, socioeconomic, and cultural conditions were suitable for Toprakhisar or for the administrator city (probably Alalakh) that Toprakhisar served. Akkermans and Schwartz (2003) also suggested that the end of the 19th century BC in Syria witnessed the regeneration of urban life and improved political powers that dominated the large areas with direct administrative control. The presence of settlements that were specialized in production of certain crops under the control of Alalakh are also evident in the textual records coming from Alalakh Level VII Palace archives (Lauinger, 2015). Hereupon, Akar and Kara (2018a) contend that in order to manage this sort of growth and administrative control, resource management strategies that might be implemented with the help of an active network of people from nearby villages to production centers were necessary. Thus, even though, the population dynamics of the Toprakhisar has not been the subject of any study yet and it remains unknown, it might be possible that the human circulation around Toprakhisar increased with becoming a production center. People from surrounding villages might be incorporated to production in Toprakhisar permanently or seasonally. To feed the increased number of people circulated around the site, administration in the Toprakhisar might have needed additional food sources. This extra resource could be provided in two ways. First, the farmers of Toprakhisar might have been encouraged to start cultivation in an expanded area where soil was in varying conditions and to produce surplus grain for the workers of administration. Second, the additional grains might have been brought to the site from the surrounding regions and stored in the silos to feed laborer. Both of these ways increase the variability of the grains gathered from the site as archaeobotanical samples since grains were cultivated in different conditions in both ways. This argument will remain ambiguous until the Toprakhisar population dynamics are known, but it is still regarded worthy of attention.

It is also important to note that another important and large occupation of the EBA in Amuq plain, Tell Tayinat (its relationship with Atchana is explained in detail in Section 2.4.3.), was continued to be occupied during the EBA IV period (2200-2100 BC) when the 4.2 ka BP event started. However, it was totally abandoned at the end of this period and the occupation shifted to Atchana (Manning et al., 2020). The occupational history of Tayinat raises different perspectives about the situation in Amuq Plain in the EBA. First, during the EBA IV period which also coincides to the beginning of the 4.2 ka event, it seems that Tayinat community was able to cope with the climatic change that they faced but after a century, they left the Tayinat. So, it can be argued that people somehow did not feel the effects of climate change at the beginning or basically adopt to new conditions. But after a certain time, the new conditions drive them to abandon Tayinat. It might be related to the increasing affects of the climate change that started to be experienced more severely as mentioned before, but it is also interesting that there is no such abandonment in the rural occupation Toprakhisar. The reasons behind this contradiction might be more clarified with the future research on Toprakhisar EBA IVB contexts as they will provide more archaeological and archaeobotanical data.

Overall, the effect of drought is visible in the archaeobotanical data coming from Toprakhisar. Since the dating of the drought coincides with the 4.2 ka BP event, it is highly likely that the event increased its effect in the Toprakhisar environment. However, archaeological evidence also suggested that Toprakhisar socio-economically thrived and became a production center in the times of this climatic change. So, it can be suggested that even though the climate change is visible in Toprakhisar, it did not affect Toprakhisar agricultural practices rigorously except for a shift in cultivated plant types in certain phases and did not cause an agricultural production catastrophe that could not been managed.

4.5.2. Tell Atchana

The archaeobotanical results retrieved from Atchana suggests that free-threshing wheat was most widely used cereal species throughout MBA occupations in 32.57 plan-square even though its percentage decreases in the LBA layer of the same trench. The decrease of free-threshing wheat proportion is also evident in the LBA layers of 42.10 which suggests that the presence of this species decreased towards the end of LBA. Correspondence analysis showed that the free-threshing wheat was never strongly associated with any of the phases as it was the case for the other cereals. However, even though it is a weaker relatedness, the analysis supports that the Phase 4 and Phase 3 of 32.57 plan square (1650-1550 BC) are associated with free-threshing wheat. The analysis also pointed to negative association of this wheat with the Phase 4 and Phase 5 of 42.10 plan square (1350-1200 BC). When results of the morphometric measurements are evaluated according to the phases, it is seen that a slight decrease in the mean free-threshing wheat size occurred in transition from MBA to LBA. Nevertheless, it is statistically proved in Mann-Whitney U test that this slight change is insignificant. However, surprisingly, the two plan squares where the MBA samples taken from (32.57 and 33.32) have different mean values. 33.32 have higher average of size comparing to 32.57 even though they were belonging to same period with the similar contexts. The free-threshing wheat is represented with large range of $\Delta^{13}C$ values. Most of the seeds from all the phases of all the plan squares have no signs of water scarcity except few seeds that had moderate stress during grain-filling period. 33.32 plan-square which has higher average value of seed size have smaller mean of $\Delta^{13}C$ value than that of 32.57 plan square.

The proportion of hulled wheat in different phases of 32.57 is so small. When the exact counts are controlled, it is also seen that in most of the phases the hulled wheat is represented with few grains in this plan square. So, it is argued that this plant was never used widely in MBA phases of Atchana. In fact, these grains might be entered to the site as a crop contaminant. In the LBA phases belonging to 42.10 plan square, on the other hand, the situation for hulled wheat is totally different than that of MBA samples. Except for the last phase, it is represented with increased proportions in all phases of this plan square. Even if the exact counts of hulled wheat are low in 42.10, because all other cereal varieties have low amounts of seeds, the low counts in this trench are most likely an issue of preservation. Correspondence analysis showed that Phase 5 and Phase 4 of 42.10 plan square (1350-1200 BC) is strongly associated with the hulled wheat. The analysis also pointed that the several phases in 42.10 are associated with hulled wheat rather than free-threshing wheat whereas 32.57 is related with free-threshing wheat. Especially, the phases belonging to 32.57 plan-square (1750-1400 BC) and the Phase 7 of 42.10 plan square (1400-1350 BC) appeared to be negatively associated with the hulled wheat species in the correspondence analysis. Unlike the free-threshing wheat grains, the hulled wheat grains show a small increase in average size from MBA to LBA. Nevertheless, Mann-Whitney U test proofs that this increase is not significant. Thus, it can be said that the hulled wheat grain size in 32.57 and 42.10 are not very different from each other. There are few seeds belonging to LBA layers (42.10 plan square) that have sign of moderate water stress and the rest of the grains -both from MBA and LBA- were grown under good moisture conditions.

Archaeobotanical investigations suggests that barley was the second most important crop especially during MBA in Atchana. Its presence increased with hulled wheat in LBA. Correspondence analysis also points to an association of this species with Phase 4/5 of 42.10 plan square (1325-1275 BC). Even though the association between the barley and LBA phases is not as distinct as the association between the hulled wheat and LBA phases, this species is still notably more important than free-threshing wheat in LBA. The barley grains sent to isotope analysis were restricted to a limited number of different phases so as results are also restricted to few phases of Atchana. Only one of the grains belonging to MBA has a sign of moderate water stress during growth, other seeds from this period were grown under good conditions. However, both of the two samples coming from LBA layers have signs of moderate water stress, thus decreased average value of $\Delta^{13}C$ comparing to the previous period.

The wild plant taxa and their ecology indicated that the water loving taxa were dominant throughout the different phases of LBA occupation in Atchana. Even though dryland genera were also present, they never become dominant as much as wetland genera. This situation is associated with the presence of wetlands around Atchana throughout time.

Archaeobotanical data from Anatolia and Syria in the literature (which is also represented in this thesis under the literature review chapter) shows that most of the sites primarily contained barley in archaeobotanical assemblages throughout the Bronze Age. The exact usage of the barley -whether used by animals or consumed by humans- is not known, but it is a well-established fact that barley was preferred by humans in their diet because of its durability in different conditions and its safe storage in silos. On the contrary to barley, free-threshing wheat species is not preferred constantly throughout Bronze Age in Anatolia and Syria. However, it seems that this was never the case for Atchana MBA occupations. It seems that the Atchana inhabitants were always able produce and protect free-threshing wheat and they never prefer barley over free-threshing wheat in this period. However, in the LBA, the barley started to be presented in greater amounts together with hulled wheat. If this is evaluated according to assumptions of the thesis, it can easily be said that the increasing presence of barley in LBA can be related with the increasing aridity caused by the approaching 3.2 ka BP climate change. Nevertheless, the results cannot be evaluated without considering the sociocultural, economic, and political background of the region in that time. It is known that Hittites took over Alalakh in the 14^{th} century BC (Yener & Akar, 2013). The Hittite takeover of the city demands to consider some alternative explanations about Atchana. First of all, Alalakh should offer some advantages so that the Hittites wanted to occupy this city in spite of their defeat in the 17^{th} century BC. Thus, Alalakh can be regarded as an attraction place for Hittites throughout the centuries. A city that was in a bad state cannot be expected to be an attraction for enemies. Thus, it could be argued that Alalakh was in a good position with its several unknown advantages throughout MBA and LBA. Secondly, as mentioned earlier in this chapter, the Hittites are known about the extensive import of goods -especially grains for this case- to their capital city, Hattusa (Bryce, 2005). Thus, the increase of hulled wheat and barley may be associated with the Hittite policy rather than an environmental change. Since archaeobotanical studies carried out in the Hattusa storage chambers already showed that the main cereals stored in these rooms were barley and hulled wheat (Diffey et al., 2020), we may argue that Hittites preferred these species. So, there can be two reasons for the rise of these species in the mentioned period. First, the Hittite ruling class in Atchana may have promoted the cultivation of barley and hulled wheat to send them to their capital or the grains started to be imported to Alalakh from somewhere else as was the other large cities under the rule of Hittites. The large range of size of grains and also large range of stable carbon isotope contents of the seeds support this argument as well. If the first assumption was the case for Atchana, then it can be said that the farmers were pushed to cultivate in expanded areas, including the lands that were distant from water sources as well, to meet the demands from Hittite heartland. This could explain the high variety of sizes and isotope contents present in the samples of LBA.

For both Toprakhisar and Atchana, bad preservation and low density of remains was the main restriction from the very beginning of this study. To overcome both of these an increased number of samples from different plan squares were examined. However, there is still a need for additional samples for morphometric measurements and isotope analysis to get more reliable results by increasing the sample size and by equalizing the sample sizes of different phases. Especially, the analyses that will be carried out in the samples coming from currently excavated EBA layers of Toprakhisar and newly investigated Iron Age layers of Atchana would carry a step forward the climate change research in these sites.

In addition to sample size, another shortcoming occurred in this study which is the contradiction between stable carbon isotope results and morphometric measurements.

This type of shortcoming might be avoided by carrying the isotope analysis on the measured seeds. By this way, these two parameters of water availability would be comparable and more meaningful results can be retrieved from the analyses.

CHAPTER 5

CONCLUSION

The effects of 4.2 ka and 3.2 ka BP event has long been debated by the scholars. There are many arguments advocating that these climate changes caused the collapse of societies in Near East (Cullen et al., 2000; DeMenocal, 2001; Kaniewski et al., 2015; Weiss et al., 1993). There are also counter arguments that criticize such an approach as environmental determinism and encourage to avoid the unidirectional explanations about the relationship between climate change and cultural/societal collapse or change (Coombes & Barber, 2005; Genz, 2015; Maher et al., 2011). Thus, rather than trying to explain the whole situation from only one small point of view, data should be investigated from different aspects and possible explanations should be argued accordingly. Thus, several possible reasons for the observed changes in the data are offered in this thesis.

To understand the possible effects of Bronze Age climatic changes and the degree of these changes in the Atchana and Toprakhisar agriculture, several aspects of archaeobotanical data was incorporated. First, archaeobotanical analysis were carried out to see the contents of the samples and relative proportions of the cereals in the crop plant taxa. Secondly, morphometric measurements were carried out in the free-threshing and hulled wheat species to detect the size changes in the periods that coincides with climate changes. Thirdly, free-threshing wheat, hulled wheat, and barley grains were sent to stable carbon isotope analysis to see the changes in isotope contents that might have been caused from the water scarcity/drought. Lastly, wild plant taxa were investigated from several aspects including weed ecology and wild:crop plant ratio.

The archaeobotanical results suggested that there was an increasing trend towards the usage of hulled wheat and barley, especially, from 1350 BC onwards until 1200 BC in Atchana and in the late 3rd millennium in Toprakhisar (2100-2000 BC). The timing of the increase in drought tolerant species in both of the mounds theoretically suggests that the changes in plant consumption patterns might be related to climate changes that are discussed. It is very likely that upcoming 3.2 ka BP climate change and ongoing 4.2 ka BP climate changes might had increased the aridity in the region and caused a tendency to cultivate these more durable species. But the preference of barley and hulled wheat in LBA Atchana might also be associated with the changing political power and its agricultural policy. Since the increase of hulled wheat and barley also coincides with the period of the Hittite hegemony in Alalakh (Stirn, 2013; Yener & Akar, 2013), it can also be speculated that the preference of Hittites for these species may had pushed farmers of Alalakh to cultivate mainly these species rather than free-threshing wheat. Hittites are known with their grain imports to their capital city of Hattusha from Mukish (Bryce, 2005) and archaeobotanical studies carried out in this site also showed that not only barley but also hulled wheat was stored in the silo complexes of the city (Diffey et al., 2017; Diffey et al., 2020). Since there is no proof that the farmers of Alalakh indeed produced cereals for transportation to Hittite capital, this is also an indecisive argument but still it needs to be considered.

The morphometric measurements and isotope analysis were based on small sample size which weakened their reliability. Nevertheless, the results of these analyses had no particular trend for reduced size or increasing drought. The size reduction was only visible for Toprakhisar hulled wheat when it was compared to Atchana hulled wheat grains. This might be related to drought that was experienced by the Toprakhisar plants during 4.2 ka BP event. Since the Toprakhisar samples were compared to MBA samples of Atchana which are dated to a period when good environmental conditions were in play, Toprakhisar grains are expected to be smaller than Atchana grains, and the results met this expectation. The reason that free-threshing wheat grains of these two mounds did not have such a significant grains size difference might be related to the irrigation of free-threshing wheat. If the Toprakhisar farmers somehow irrigated

the drought susceptible free-threshing wheat in the times of precipitation decline, it is expected that the free-threshing grains from Toprakhisar reached to greater sizes.
Lastly, weed ecology points to the increase in the genera that grows in the dry habitats in the beginning of the 2nd millennium BC in Toprakhisar. In theory, it was expected to see dryland plants in the samples more abundantly in the times of water scarcity caused by climate change. So, the increase in the proportion of dryland wild plant genera suggests that drier conditions were present in that period. As this period coincides with the 4.2 ka BP event, this argument is very possible. However, this period was also characterized by the increasing amount of the free-threshing wheat which is a find that makes the wild plant results less dependable.

Neither Toprakhisar nor Atchana have signs of severe water stress in any of the seeds. There are some seeds that were grown under the moderate water stress, still, they do not represent a high proportion of the samples. Riehl (2010a) suggests that there might be favorable conditions in LBA Atchana considering its coastal location and precipitation and additional water supplies from rivers in its surrounding that might even enable the surplus production. The Hatay region is under the influence of Mediterranean climate. Thus, on the contrary to Syrian or Anatolian inlands, the precipitation is high in Hatay region. As it is considered that 200 mm annual precipitation is the threshold for the rainfed agriculture (Charles & Hoppe, 2003), Hatay is way above this threshold with its nearly 1160 mm modern annual precipitation. However, modern annual precipitation in most of the Syrian archaeological sites is between 200 and 400 mm (Riehl, 2008). Thus, it can be expected that Hatay region was receiving more precipitation than Syria in the past as well. However, since there is no local paleoclimate record from Hatay, the degree of the climate change impact in this region is not clear from a local proxy record and this argument is remains as a weak one.

Overall, the results of this thesis show a shift to domestic and wild plants that are able to grow in drier conditions in the transition from 3rd to 2nd millennium BC (4.2 BP event) in Toprakhisar. The crop plant taxa coming from the Atchana also shows an increased exploitation of drought tolerant cereals towards the end of the LBA (3.2 BP event). In morphometric and stable carbon isotope analyses, especially, the hulled wheat gives results that are pointing to smaller sizes and increased water stress. Since these two characters of the plants are associated with the drought, these changes also support the increasing impacts of climate change in the mentioned periods. Even though, the archaeobotanical evidence suggests the continuity of the agricultural practices without a major break-down in both of the sites, the change in the types of plant that were consumed, and the isotopic content of these plants points to somewhat drier conditions during the times that coincide with the 4.2 ka BP and 3.2 ka BP events.

Even though, the archaeobotanical data testified that both climatic events have affected the crop as well as the wild flora of Atchana and Toprakhisar, the agricultural activities did not come to a halt. The abundant archaeobotanical finds (including the cultivation and possibly trade, of olives and grape at Toprakhisar) show a flourishing economy. Written texts from Atchana also show that the economy and political power of Atchana flourished in especially MBA and lasted throughout LBA. Both sites did not appear to have been devasted by the climatic change, instead the inhabitants found ways to cope with drought by replacing some of their crops with more drought resistant ones (hulled wheat and barley), relocating their fields or carefully choosing what crops to cultivate at which locations so as to achieve better yields. Perhaps irrigation was also used but at present we don’t have archaeological evidence for this. It could be argued that the two sites found the way to cope successfully with the changing environment without disrupting seriously their life which fits with the concept of resilience as mentioned in the Section 2.1.1.

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APPENDICES

APPENDIX A.1. ANATOLIAN SITES WITH ARCHAEOBOTANICAL RESEARCH HISTORY AND THE RESULTS

Table 25. Table shows Anatolian sites with previous archaeobotanical research history and their environmental settings. The results of the studies also represented in the table. The (X) refers to the presence of corresponding plant group. The number in the parentheses shows the chaff remains found.

General Information about Site									CROP CEREAL GRAIN (Chaff)				WILD SEEDS		
Site	Location	Period	Nearby Water Sources	Altitude	Modern Precipitation (mm)	Irrigation	Type of Site	Contexts	Free-threshing Wheat (*T. durum/aestivum*)	Hulled Wheat (*T. monococcum/dicoccum/spelta*)	Undetermined Wheat (*Triticum sp.*)	Barley (*H. vulgare/distichum*)	Arable Land Weeds	Wetland Wild Plants	Dry/Sandy/Stony Land Wild Plants
Kültepe (Kanesh)	Central Anatolia	EBA	Kızılırmak Sarımsaklı Rivers	Plain	389,6	Yes	Urban	Citadel	227 (165)	439 (1212)	-	375 (50)	X	X	X
		MBA						Citadel & Lower Mound	119 (304)	177 (149)	39	121 (8)	X	X	X
Büklükale	Central Anatolia	MBA	Kızılırmak River	Hilltop	388,1	No	Urban	A shaft like room in upper town	20 (35)	4 (26)	9	9 (7)	X	X	-
Kaman-Kalehöyük	Central Anatolia	EBA	Kızılırmak River 2 Small Streams Another spring	Plain	383,2	No	Urban	Domestic (?)	X	-	-	X	-	X	X
		MBA						Monumental Building	X	X	X	X	X	-	-
		LBA						Monumental Building	X	X	X	X	-	X	X
		Iron Age						?	X	X	-	X	X	X	X
Boğazköy (Hattusha)	Central Anatolia	LBA	Büyükkaya Yazır Streams	Highland	430,4	Yes	Urban	Storage Chambers	X	X	-	X	X	-	X
Çadır Höyük	Central Anatolia	LBA	Kanak Su River	Valley	571,3	NI	Cult Center	Pit, Floor, Oven, Hearth	X	X	X	X	X	X	-
Sos Höyük	Northeastern Anatolia	MBA	Aras River	Highland	429,9	NI	Rural	Domestic	16	-	-	176	X	X	X
Salat Tepe	Southeastern Anatolia	MBA	Tigris River and Salat Stream	Plain	494,9	No	Rural	Domestic	49 (204)	31 (5)	5	354 (18)	X	X	X
Mezraa Höyük	Southeastern Anatolia	EBA	Euphrates River	Plain	460,1	NI	Urban	Workplace	25 (1)	-	-	18	X	X	-
		EBA/MBA						?	-	-	-	-	-	-	-
		MBA						Grave & ?	-	-	-	25	-	-	-
Gre Virike	Southeastern Anatolia	EBA	Euphrates River	Plain	460,1	NI	Sanctuary	Pits, Grave, Room Floors	2	3 (1)	3	96	X	X	-
Hirbemerdon Tepe	Southeastern Anatolia	MBA	Tigris River	Valley	494,9	No	Rural	Architectural Complex Upper Town	1	10 (23)	1	9	X	X	-
Kurban Höyük	Southeastern Anatolia	EBA/MBA	Euphrates River	Highland	460,1	NI	Rural	?	-	-	X	X	-	-	-
Kaymakçı	Western Anatolia	LBA	Lake Marmara	Valley	747,3	NI	Urban	Citadel	30 (3)	15 (14)	13	128 (3)	X	X	X
Troy	Western Anatolia	EBA	Scamander River	Highland	625,5	No	Rural	Domestic	X	X	-	X	X	X	X
		MBA				No	Urban	Domestic	X	X	-	X	X	X	X
		LBA				No	Urban	Domestic	X	X	-	X	X	X	X
Oymaağaç (Nerik)	Northern Anatolia	LBA	Kızılırmak River	Plain	717,9	NI	Cult Center	Sanctuary	34	12 (3)	19	49	X	-	X
		Iron Age				NI		Silos	15	18	9	29 (1)	X	-	X
Tell Tayinat	Southern Anatolia	EBA	Orontes River	Plain	1161,5	NI	Urban	?	124 (116)	89 (800)	205	225 (381)	X	X	X
		Iron Age				NI		Temple	333 (94)	127 (74)	250	238 (123)	X	X	X
Tell Atchana	Southern Anatolia	LBA	Orontes River	Plain	1161,5	No	Urban	Elite Occupation Areas	-	-	-	-	-	-	-

APPENDIX A.2. SYRIAN SITES WITH ARCHAEOBOTANICAL RESEARCH HISTORY AND THE RESULTS

Table 26. Table shows Syrian sites with previous archaeobotanical research history and their environmental settings. The results of the studies also represented in the table. The (X) refers to the presence of corresponding plant group. The number in the parentheses shows the chaff remains found.

General Information about Site									CROP CEREAL GRAIN (Chaff)				WILD SEEDS			
Site	Location	Period	Nearby Water Sources	Altitude	Modern Precipitation (mm)	Irrigation	Type of Site	Contexts	Free-threshing Wheat (*Triticum durum/aestivum*)	Hulled Wheat (*Triticum monococcum/dicoccum/spelta*)	Undetermined Wheat (*Triticum sp.*)	Barley (*Hordeum vulgare/distichum*)	Arable Land Weeds	Wetland Wild Plants	High Precipitation Wild Plants	Dry/Sandy/Stony Land Wild Plants
Tell Mardikh (Ebla)	Northwestern Syria	MBA	Euphrates and Gallikh Rivers	Plain	330	No	Urban	Midden in a Rampart	46	31	26	227	X	X	-	-
Tell Umm el-Marra	Western Syria	EBA	Jabbul Lake	Plain	300	No	Urban	Acropolis	-	-	X	X	-	-	-	-
		MBA						Acropolis	X	-	X	X	-	-	-	-
		LBA						Mostly Domestic	-	-	-	-	-	-	-	-
Tell Mishrifeh (Qatna)	Central-western Syria	EBA	Orontes River	Plain	430	No	Urban	Mostly Storage Facilities	291 (59)	465 (143)	2	4612 (133)	-	-	-	-
		MBA						Tannur and Basin	2	-	-	8	X	X	X	X
		LBA						Oven, Pit and Floor	5	-	-	4	-	-	-	-
		Iron Age						Pits	5	18	5	107	X	-	-	X
Tell Mozan	Northeastern Syria	EBA	Khabur River	Plain	460	No	Urban	NI	X	X	-	X	X	X	-	X
		MBA						NI	X	X	-	X	X	X	-	X
Tell Arbid	Northeastern Syria	EBA	Khabur River	Plain	380	No	Urban	Caravanserai Building	18 (11)	20 (112)	8 (2)	215 (184)	X	-	-	X
		MBA						Houses and Graves	308	101	17	1014	X	-	-	X
Tell Leilan	Northeastern Syria	EBA	Khabur River	Plain	450	No	Urban	Administrative Building	25 (20)	76	54 (308)	198 (43)	-	-	-	-
		MBA						Administrative Building	69 (495)	65	156 (1281)	295 (221)	-	-	-	-
Tell Bderi	Northeastern Syria	LBA	Khabur River	Plain	250	NI	Urban	Mostly Jar	4	-	1	58	X	-	-	-
Tell Schech Hamad	Northeastern Syria	LBA	Khabur River	Plain	156	Yes	Urban	Palace	13	-	-	1049 (32)	X	-	-	X

APPENDIX B.1. LOCI DESCRIPTIONS OF TOPRAKHİSAR HOYUK

Table 27. Loci descriptions of 51.37 plan square of Toprakhisar Höyük..

51.37 PLAN SQUARE LOCI DESCRIPTIONS			
Season	**Locus**	**Local Phase**	**Locus Description**
2016	20	2	Pit
2016	47	2	Floor of Passageway
2016	52	2	Pit
2016	53	2	Ceramic on the Bench
2016	15	3a	Floor of Room 3
2016	16	3a	?
2016	22	3a	Floor
2016	28	3a	?
2016	29	3a	Floor of Room 1
2016	30	3a	?
2016	31	3a	Floor of Room 2
2016	32	3a	Pit
2016	33	3a	Pit
2016	34	3a	Floor
2016	38	3a	?
2016	41	3a	Hearth
2016	43	3a	?
2016	45	3a	?
2016	52	3a	Pit
2016	53	3a	Ceramic on the Bench
2016	56	3a	?
2016	57	3a	?
2016	58	3a	?
2017	63	3c	?
2017	70	3c	?
2016	14	3	?

Table 28. Loci descriptions of 52.37 plan square of Toprakhisar Höyük.

52.37 PLAN SQUARE LOCI DESCRIPTIONS			
Season	**Locus**	**Local Phase**	**Locus Description**
2017	14	3	?
2017	15	3	Floor of Courtyard 2
2017	17	3	Floor of Courtyard 1
2017	26	3	Floor of Room 4
2017	28	3	Floor of Room 5
2017	29	3	Hearth
2017	33	3	Ceramic
2017	35	3	Pit
2017	36	3	Hearth
2017	39	3	?
2017	40	3	Bench
2018	52	4	Floor
2018	56	4	Hearth

Table 29. Loci descriptions of 54.38 plan square of Toprakhisar Höyük.

54.38 PLAN SQUARE LOCI DESCRIPTIONS			
Season	**Locus**	**Local Phase**	**Locus Description**
2018	3	1	Silo
2018	16	1	Grave
2018	3	2	Silo
2018	8	2	Pit
2018	11	2	?
2018	15	2	Trash pit
2018	22	2	?

APPENDIX B.2. LOCI DESCRIPTIONS OF TELL ATCHANA

Table 30. Loci descriptions of 42.10 plan square of Tell Atchana.

42.10 PLAN SQUARE LOCI DESCRIPTIONS			
Season	**Locus**	**Local Phase**	**Locus Description**
2014	21	3b	Pyrotchnical installation in the S/W corner
2014	23	3b	External floor under the wall (L.18) and the previous one (L.16) in the eastern part of the trench
2014	25	4	Mixed floor above the domestic structure
2014	26	4	Semi-circular area of hard ash soil next to the western section
2014	27	4	Semi-circular tandir next to the southern section
2014	28	4	Trash-area near the S/E corner of the trench
2014	31	4	Main room of domestic structure near the S/W corner of the trench
2014	36	4	Big circular tandir next to the northern section
2014	39	4	Semi-external floor between the wall (loci 29, 30 and 38)
2016/18	67	4	Sacrificial pit
2017	95	4	Tandır
2015/16	40	4a	Semicircular area near the S/E corner (pit)
2015	42	4b	External floor of domestic unit
2015	50	4b/5	Transitional floor between phases 4 and 5
2015	54	4b/5	Circular pit with animal remains and banquet goods
2016	55	5	Internal floor of domestic unit
2015	57	5	Semicircular tandır next to the S/W corner
2015	59	5	Small circular tandır on floor, L. 56
2015/16	68	5	Piece of semicircular tandır next to the western section
2016	77	6	Northwestern room
2016	81	6	Sunken jar
2018	99	6	Sacrificial pit
2017	66	6a	Tandır
2017	80	6a	Inner courtyard
2017	83	6a	Inner courtyard
2017	85	6b	Large inner courtyard
2017	86	6b	Tandır
2017	87	6b	Tandır
2017	88	6b	Tandır
2018	94	7	7. Evre Dolgusu
2018	102	7a	Room
2018	117	7b	Room
2019	122	7b	Outer Space
2019	123	7b	Room
2019	124	7b	Ceramic Pile
2019	127	7b	Ceramic Pile
2019	130	7b	Grave
2019	131	7b	Hearth
2020	156	7b	Street
2020	158	7b	Room
2019	137	7c/7b	Sacrificial pit
2019	126	7c	Room
2019	133	7c	Room
2019/20	136	7c	Room
2019	140	7c	Water drain
2020	145	7c	Trash pit
2019	148	7c	Grain storage pit
2019	151	7c	Hearth
2020	159	7c	Room
2020	161	7c	Room
2020	162	7c	Street
2020	163	7c	Hearth
2020	164	7c	Post hole
2020	166	7c	?
2020	167	7c	Street
2020	169	7c	Drain fill
2020	173	7c	Street
2020	174	7c	Circular stone pile
2020	177	7c	Ceramic jar

APPENDIX C.1. ABSOLUTE COUNTS OF ARCHAEOBOTANICAL ASSEMBLAGES FROM TOPRAKHİSAR HOYUK

Table 31. Counts of archaeobotanical samples from Toprakhisar Höyük.

TOPRAKHİSAR (51/52.37)									
Square	51.37	51.37	51.37	51.37	51.37	51.37	51.37	51.37	51.37
Sample No	247	435	444	274	411	262	289	293	306
Locus	20	52	53	20	47	22	28	15	32
Lot	23	89	94	33	82	30	40	44	47
Date	3.09.2016	19.09.2016	19.09.2016	6.09.2016	16.09.2016	5.09.2016	8.09.2016	8.09.2016	9.09.2016
Soil Volume									
Local Phase	2	2	2	2	2	3a	3a	3a	3a
CROP PLANT TAXA									
POACEAE									
Avena sativa	-	-	-	1	1	-	-	-	-
Triticum monococcum/dicoccum	3	-	-	-	1	2	-	-	-
Triticum durum/aestivum	4	1	1	1	1	2	-	1	-
Triticum sp.	6	3	-	4	7	6	2	-	-
Hordeum vulgare	5	-	-	2	2	-	-	1	-
Cerealia indet.	11	3	5	8	5	13	3	8	-
T. monococcum spikelet fork	-	-	-	-	-	-	-	-	-
T. dicoccum spikelet fork	-	-	-	-	-	-	-	-	-
T. aestivum rachis segment	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	1	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	1	-	1	1	-	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE									
Indet. Legume	12	-	-	-	-	4	1	1	-
VITACEAE									
Vitis vinifera fragments	1	-	-	3	1	-	-	1	-
Vitis vinifera pedicel	-	-	-	-	-	1	-	-	-
OLEACEAE									
Olea europaea fragments	-	-	-	-	3	-	-	2	-
CROP PLANT TAXA TOTAL	42	7	7	20	22	29	6	14	0
WILD PLANT TAXA									
AMARANTHACEAE									
Amaranthus sp.	-	-	-	-	-	1	-	-	8
Chenopodium sp.	-	-	1	-	-	-	-	-	-
APIACEAE									
Bupleurum sp.	-	-	-	-	-	-	-	-	-
BORAGINACEAE									
Echium sp.	-	-	-	2	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	-	-
BRASSICACEAE									
Brassica sp.	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE									
Silene sp.	-	-	-	-	-	-	-	-	-
CYPERACEAE									
Carex sp.	-	-	-	-	-	-	-	-	-
Scirpus sp.	1	-	-	-	-	-	-	-	3
EUPHORBIACEAE									
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-
FABACEAE									
Coronilla sp.	-	-	-	-	-	-	-	-	-
Scorpiurus sp.	3	1	-	-	-	1	-	-	-
Trifolium sp.	6	-	-	7	-	-	1	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	1	-	-
GRAMINEAE									
Lolium sp.	25	2	3	4	5	16	5	5	-
Phalaris sp.	11	-	1	3	2	9	1	1	-
Indet. Grass	-	1	2	2	7	2	-	-	-
LINECEAE									
Linum sp.	-	-	-	-	-	-	-	-	-
MORACEAE									
Ficus carica	-	-	-	-	-	-	-	-	-
POACEAE									
Aegilop sp.	-	-	-	-	-	-	-	-	-
Avena sp.	-	-	-	1	-	-	-	-	-
Bromus sp.	4	-	-	1	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-
POLYGONACEAE									
Polygonecaea family plant	-	-	-	-	-	-	-	-	-
Persicaira sp.	-	-	-	-	-	-	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-	-
Rumex sp.	-	-	-	-	-	-	1	-	-
RANUNCULACEAE									
Ranunculus sp.	-	-	-	1	-	-	-	-	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-
RUBIACEAE									
Asperula sp.	-	-	-	-	-	-	-	-	-
Galium sp.	-	-	-	-	-	-	-	-	-
Sherardia sp.	-	-	-	-	-	-	-	-	-
THYMELAEACEAE									
Thymelaea sp.	1	-	-	-	-	-	-	-	-
Indet.	1	-	-	3	-	-	-	-	-
WILD PLANT TAXA TOTAL	52	4	7	24	14	29	9	6	11
GRAND TOTAL	94	11	14	44	36	58	15	20	11

TOPRAKHİSAR (51/52.37)									
Square	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**
Sample No	**308**	**313**	**315**	**317**	**323**	**333**	**334**	**360**	**362**
Locus	**29**	**31**	**30**	**31**	**31**	**32**	**31**	**45**	**41**
Lot	**49**	**50**	**51**	**50**	**53**	**55**	**53**	**61**	**63**
Date	**9.09.2016**	**9.09.2016**	**9.09.2016**	**9.09.2016**	**10.09.2016**	**10.09.2016**	**10.09.2016**	**14.09.2016**	**14.09.2016**
Soil Volume									
Local Phase	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**
CROP PLANT TAXA									
POACEAE									
Avena sativa	-	-	-	1	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	1	-	-	1	-	1	-	-	-
***Triticum* sp.**	-	-	-	-	1	-	2	1	-
Hordeum vulgare	-	-	1	-	-	-	2	-	-
***Cerealia* indet.**	-	-	-	-	1	1	5	2	-
***T. monococcum* spikelet fork**	-	-	-	-	-	-	-	-	-
***T. dicoccum* spikelet fork**	1	-	-	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	1	-	-	-	1
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE									
Indet. Legume	-	3	-	-	1	3	-	-	-
VITACEAE									
***Vitis vinifera* fragments**	1	2	2	-	-	-	-	-	-
***Vitis vinifera* pedicel**	-	-	-	1	-	-	-	-	-
OLEACEAE									
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	3	5	3	3	4	5	9	3	1
WILD PLANT TAXA									
AMARANTHACEAE									
***Amaranthus* sp.**	-	-	-	-	-	-	-	6	1
***Chenopodium* sp.**	-	-	-	-	-	-	-	-	-
APIACEAE									
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-
BORAGINACEAE									
Echium sp.	-	-	-	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	-	-
BRASSICACEAE									
***Brassica* sp.**	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE									
***Silene* sp.**	-	-	-	-	-	-	-	-	-
CYPERACEAE									
***Carex* sp.**	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	4	-
EUPHORBIACEAE									
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-
FABACEAE									
***Coronilla* sp.**	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	1	-	-	1	-	-
***Trifolium* sp.**	-	1	-	-	1	-	-	1	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-
GRAMINEAE									
***Lolium* sp.**	1	2	1	1	3	4	1	1	1
***Phalaris* sp.**	-	-	-	1	2	1	-	-	1
Indet. Grass	1	-	-	1	-	-	-	-	-
LINECEAE									
***Linum* sp.**	-	-	-	-	-	-	-	-	-
MORACEAE									
Ficus carica	-	-	-	-	-	-	-	-	-
POACEAE									
***Aegilop* sp.**	-	-	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	1	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-
POLYGONACEAE									
Polygonecaea family plant	-	-	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-
RANUNCULACEAE									
***Ranunculus* sp.**	-	1	-	-	-	-	-	-	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-
RUBIACEAE									
***Asperula* sp.**	-	-	-	-	-	-	-	-	-
***Galium* sp.**	-	-	-	-	-	-	1	-	-
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-
THYMELAEACEAE									
***Thymelaea* sp.**	-	-	-	-	-	-	1	-	-
Indet.	-	-	-	4	-	1	-	1	-
WILD PLANT TAXA TOTAL	**2**	**4**	**1**	**8**	**6**	**7**	**4**	**13**	**3**
GRAND TOTAL	**5**	**9**	**4**	**11**	**10**	**12**	**13**	**16**	**4**

TOPRAKHİSAR (51/52.37)										
Square	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**
Sample No	**366**	**375**	**385**	**387**	**399**	**402**	**426**	**453**	**466**	**485**
Locus	**45**	**34**	**33**	**38**	**45**	**41**	**52**	**16**	**53**	**43**
Lot	**61**	**66**	**69**	**71**	**75**	**79**	**52**	**95**	**99**	**102**
Date	**14.09.2016**	**14.09.2016**	**15.09.2016**	**15.09.2016**	**15.09.2016**	**15.09.2016**	**16.08.2016**	**19.09.2016**	**20.09.2016**	**20.09.2016**
Soil Volume										
Local Phase	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**	**3a**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	1
Triticum monococcum/dicoccum	1	1	1	-	-	-	-	-	1	-
Triticum durum/aestivum	2	-	-	-	-	-	1	-	-	2
***Triticum* sp.**	1	-	5	-	1	-	2	1	1	24
Hordeum vulgare	-	-	2	1	-	-	-	1	-	2
***Cerealia* indet.**	2	-	1	-	-	-	3	-	3	30
***T. monococcum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. dicoccum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	-	-	-	1	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	-	-	-	1	-	-	-	-	-	32
VITACEAE										
***Vitis vinifera* fragments**	-	-	1	1	-	-	1	-	-	4
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	2	-	-	7	-	-	-	-	-
CROP PLANT TAXA TOTAL	6	3	10	3	8	0	7	3	5	95
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	1	-	-	-	-	-	2	1	-	-
***Chenopodium* sp.**	-	-	-	-	-	-	-	-	1	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE										
***Brassica* sp.**	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERACEAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	3
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	2
EUPHORBIACEAE										
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Coronilla* sp.**	-	-	-	-	-	-	-	1	-	-
***Scorpiurus* sp.**	-	-	-	-	-	-	-	-	-	26
***Trifolium* sp.**	-	-	1	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	3	3	2	1	2	1	-	1	-	21
***Phalaris* sp.**	-	1	-	-	-	-	2	2	-	23
Indet. Grass	-	-	1	-	1	-	1	-	-	1
LINECEAE										
***Linum* sp.**	-	-	-	-	-	-	-	-	-	-
MORACEAE										
Ficus carica	-	-	-	-	-	-	-	1	-	-
POACEAE										
***Aegilop* sp.**	-	-	-	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	-	-	-	-	2
Hordeum spontaneum	-	-	1	-	-	-	-	-	-	-
POLYGONACEAE										
Polygonecaea family plant	-	-	-	-	-	-	1	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	12
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Asperula* sp.**	-	-	-	-	-	-	-	-	-	-
***Galium* sp.**	-	-	-	-	-	-	-	-	-	2
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	-	1	-	2	-	-	1	-	-	1
WILD PLANT TAXA TOTAL	**4**	**5**	**5**	**3**	**3**	**1**	**7**	**6**	**1**	**93**
GRAND TOTAL	**10**	**8**	**15**	**6**	**11**	**1**	**14**	**9**	**6**	**188**

TOPRAKHİSAR (51/52.37)										
Square	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**51.37**	**52.37**
Sample No	**499**	**502**	**505**	**514**	**521**	**1098**	**635**	**901**	**478**	**697**
Locus	**57**	**56**	**58**	**16**	**45**	**63**	**70**	**63**	**31**	**14**
Lot	**107**	**105**	**110**	**111**	**144**	**172**	**150**	**165**	**98**	**22**
Date	**21.09.2016**	**21.09.2016**	**21.09.2016**	**21.09.2016**	**21.09.2016**	**30.08.2017**	**11.08.2017**	**22.08.2017**	**20.09.2016**	**15.08.2017**
Soil Volume										
Local Phase	**3a**	**3a**	**3a**	**3a**	**3a**	**3c**	**3c**	**3c**	**3**	**3**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	4	1	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	1	-
Triticum durum/aestivum	-	2	-	-	-	-	-	1	1	-
***Triticum* sp.**	1	1	-	3	2	1	1	-	17	-
Hordeum vulgare	-	-	-	-	-	-	-	-	3	-
***Cerealia* indet.**	1	2	1	6	-	1	-	-	5	-
***T. monococcum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. dicoccum* spikelet fork**	-	-	-	1	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	-	2	-	1	-	-	-	2	9	2
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	3	-	-	-	-	-	-
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	1	-	-	-	8	-	-	-	-	-
CROP PLANT TAXA TOTAL	3	7	1	14	10	2	1	7	37	2
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	2
***Chenopodium* sp.**	-	-	-	-	-	-	1	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	130	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE										
***Brassica* sp.**	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERACEAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	1	-
EUPHORBIACEAE										
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Coronilla* sp.**	-	-	-	-	-	-	-	-	1	-
***Scorpiurus* sp.**	-	-	-	-	-	-	-	-	-	-
***Trifolium* sp.**	-	-	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	-	7	-	3	1	1	8	-	23	1
***Phalaris* sp.**	-	-	-	6	-	-	-	-	5	-
Indet. Grass	-	1	-	1	-	-	1	-	3	-
LINECEAE										
***Linum* sp.**	-	-	-	-	-	-	-	-	-	-
MORACEAE										
Ficus carica	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Aegilop* sp.**	-	-	-	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	1	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
Polygonecaea family plant	-	-	-	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	2	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Asperula* sp.**	-	-	-	-	-	-	-	-	-	-
***Galium* sp.**	-	-	-	1	-	1	-	-	-	-
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	16	-	-	-	1	-	-	-	1	-
WILD PLANT TAXA TOTAL	**16**	**8**	**0**	**142**	**2**	**2**	**10**	**0**	**36**	**3**
GRAND TOTAL		**15**	**1**	**156**	**12**	**4**	**11**	**7**	**73**	**5**

TOPRAKHİSAR (51/52.37)										
Square	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**
Sample No	**1001**	**1012**	**1017**	**1021**	**1044**	**1053**	**1060**	**1074**	**801**	**815**
Locus	**17**	**17**	**17**	**15**	**28**	**39**	**15**	**40**	**15**	**15**
Lot	**84**	**81**	**88**	**89**	**94**	**99**	**100**	**104**	**31**	**36**
Date	**27.08.2017**	**27.08.2017**	**27.08.2017**	**28.08.2017**	**28.08.2017**	**29.08.2017**	**29.08.2017**	**30.08.2017**	**18.08.2017**	**19.08.2017**
Soil Volume										
Local Phase	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	2	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	3	-	-	-	-
Triticum durum/aestivum	-	-	-	-	-	1	-	-	-	-
***Triticum* sp.**	-	-	-	-	-	16	-	1	-	-
Hordeum vulgare	-	-	1	-	-	-	-	-	-	-
***Cerealia* indet.**	-	-	1	1	-	19	2	-	4	-
***T. monococcum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. dicoccum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	-	-	-	-	-	16	1	-	-	-
VITACEAE										
***Vitis vinifera* fragments**	2	-	-	-	-	11	1	-	3	-
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	2	0	2	1	0	68	4	1	7	0
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
***Chenopodium* sp.**	-	-	1	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	1
Lithospermum arvense	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE										
***Brassica* sp.**	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERACEAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	-
EUPHORBIACEAE										
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Coronilla* sp.**	-	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	-	-	4	-	-	-	-
***Trifolium* sp.**	-	-	1	-	-	-	-	-	-	1
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	-	-	1	1	1	89	-	-	1	1
***Phalaris* sp.**	-	-	-	-	-	5	-	-	-	-
Indet. Grass	-	-	-	1	1	57	-	-	-	-
LINECEAE										
***Linum* sp.**	-	-	-	-	-	-	-	-	-	-
MORACEAE										
Ficus carica	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Aegilop* sp.**	-	-	-	-	-	8	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
Polygonecaea family plant	-	-	-	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	4	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	10	-	-	-	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Asperula* sp.**	-	-	-	-	-	6	-	-	-	-
***Galium* sp.**	-	-	1	-	-	-	-	-	-	-
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	-	-	-	1	-	5	-	1	-	-
WILD PLANT TAXA TOTAL	**0**	**0**	**4**	**3**	**2**	**188**	**0**	**1**	**1**	**3**
GRAND TOTAL	**2**	**0**	**6**	**4**	**2**	**256**	**4**	**2**	**8**	**3**

TOPRAKHİSAR (51/52.37)										
Square	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**
Sample No	**834**	**859**	**895**	**921**	**940**	**943**	**957**	**959**	**965**	**970**
Locus	**26**	**17**	**33**	**36**	**17**	**17**	**17**	**17**	**17**	**17**
Lot	**41**	**45**	**55**	**76**	**56**	**58**	**59**	**59**	**64**	**64**
Date	**21.08.2017**	**21.08.2017**	**23.08.2017**	**26.08.2017**	**23.08.2017**	**24.08.2017**	**29.08.2017**	**24.08.2017**	**25.08.2017**	**25.08.2017**
Soil Volume										
Local Phase	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
CROP PLANT TAXA										
POACEAE										
Avena sativa	1	-	-	-	-	-	1	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	1	-	-	-	-	1	-	-	-	-
***Triticum* sp.**	-	1	-	1	2	-	1	-	-	-
Hordeum vulgare	-	-	-	-	-	-	-	-	-	-
***Cerealia* indet.**	4	-	-	-	-	2	-	-	7	-
***T. monococcum* spikelet fork**	-	-	-	-	-	1	-	-	1	-
***T. dicoccum* spikelet fork**	-	-	-	1	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	1	-	-	-	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	1	-	-	-	-	-	-	-	-	-
VITACEAE										
***Vitis vinifera* fragments**	1	-	-	-	-	-	1	1	-	-
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	3	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	11	1	0	2	3	4	3	1	8	0
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	2	-	-	1	-	-	-	1	-	-
***Chenopodium* sp.**	12	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE										
***Brassica* sp.**	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERACEAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	1	-	-	-	1	-	-	1	-	-
EUPHORBIACEAE										
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Coronilla* sp.**	-	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	-	-	1	-	-	-	-
***Trifolium* sp.**	-	-	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	-	4	-	-	-	-	-	1	1	-
***Phalaris* sp.**	4	-	-	-	-	-	2	-	-	-
Indet. Grass	5	2	-	-	-	-	1	-	-	-
LINECEAE										
***Linum* sp.**	-	-	-	-	-	-	-	-	-	-
MORACEAE										
Ficus carica	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Aegilop* sp.**	-	-	-	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
Polygonecaea family plant	-	-	-	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	1	-	-	-	-	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Asperula* sp.**	-	-	-	-	-	-	-	-	-	-
***Galium* sp.**	-	3	-	-	-	-	-	-	-	-
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	1	1	-	-	2	-	-	-	1	-
WILD PLANT TAXA TOTAL	**25**	**10**	**0**	**1**	**4**	**1**	**3**	**3**	**2**	**0**
GRAND TOTAL	**36**	**11**	**0**	**3**	**7**	**5**	**6**	**4**	**10**	**0**

TOPRAKHİSAR (51/52.37)										
Square	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**52.37**	**54.38**
Sample No	**971**	**977**	**986**	**989**	**990**	**994**	**1396**	**1399**	**1586**	**1284**
Locus	**17**	**35**	**17**	**15**	**29**	**17**	**52**	**52**	**56**	**3**
Lot	**64**	**67**	**68**	**70**	**71**	**81**	**167**	**167**	**172**	**11**
Date	**25.08.2017**	**25.08.2017**	**26.08.2017**	**26.08.2017**	**26.08.2017**	**27.08.2017**	**25.09.2018**	**25.09.2018**	**26.09.2018**	**14.09.2018**
Soil Volume							**12.5 L**	**4 L**	**11.4 L**	**16.5 L**
Local Phase	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**4**	**4**	**1**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	1	-	-	-	-	-	-	-	-	4
Triticum durum/aestivum	-	-	-	-	-	1	-	-	-	-
***Triticum* sp.**	-	-	-	-	-	1	-	1	-	5
Hordeum vulgare	-	-	-	-	-	1	-	-	-	2
***Cerealia* indet.**	-	-	1	1	-	1	4	-	5	14
***T. monococcum* spikelet fork**	-	-	-	-	-	-	-	-	1	-
***T. dicoccum* spikelet fork**	-	-	-	-	-	-	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-	-	2	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	-	-	-	-	1	1	6	5	-	2
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	-	-	-	-	-	2
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	1	-	27
CROP PLANT TAXA TOTAL	1	0	1	1	1	5	10	7	8	56
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
***Chenopodium* sp.**	-	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-	1	-	-
BRASSICACEAE										
***Brassica* sp.**	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERACEAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	-
EUPHORBIACEAE										
Euphorbia heioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Coronilla* sp.**	-	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	-	-	-	-	-	-	1
***Trifolium* sp.**	-	1	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	1	-	3	-	1	-	-	6	4	7
***Phalaris* sp.**	-	-	-	-	-	-	-	-	-	-
Indet. Grass	1	-	-	2	-	-	8	-	-	-
LINECEAE										
***Linum* sp.**	-	-	-	-	-	-	-	-	-	-
MORACEAE										
Ficus carica	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Aegilop* sp.**	-	-	-	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
Polygonecaea family plant	-	-	-	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	-
Ranunculaceae family plant	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Asperula* sp.**	-	-	-	-	-	-	-	-	-	-
***Galium* sp.**	-	-	-	-	-	-	-	-	-	1
***Sherardia* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	1	-	-	1	-	2	-	-	-	2
WILD PLANT TAXA TOTAL	**3**	**1**	**3**	**3**	**1**	**2**	**8**	**7**	**4**	**11**
GRAND TOTAL	**4**	**1**	**4**	**4**	**2**	**7**	**18**	**14**	**12**	**67**

TOPRAKHİSAR (51/52.37)							
Square	**54.38**	**54.38**	**54.38**	**54.38**	**54.38**	**54.38**	**54.38**
Sample No	**1481**	**1430**	**1448**	**1532**	**1536**	**1738**	**1840**
Locus	**16**	**11**	**15**	**22**	**8**	**3**	**3**
Lot	**44**	**26**	**32**	**55**	**56**	**70**	**96**
Date	**22.09.2018**	**20.09.2018**	**21.09.2018**	**25.09.2018**	**25.09.2018**	**29.09.2018**	**7.10.2018**
Soil Volume		**8.25 L**	**16 L**	**14 L**	**8.8 L**	**21 L**	**13.2 L**
Local Phase	**1**	**2**	**2**	**2**	**2**	**2**	**2**
CROP PLANT TAXA							
POACEAE							
Avena sativa	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	1	-	-
Triticum durum/aestivum	-	-	1	-	1	1	-
***Triticum* sp.**	2	-	1	-	4	1	1
Hordeum vulgare	1	-	3	-	1	2	1
***Cerealia* indet.**	-	-	3	-	5	4	7
***T. monococcum* spikelet fork**	-	-	1	-	-	1	-
***T. dicoccum* spikelet fork**	-	-	1	-	-	-	-
***T. aestivum* rachis segment**	-	-	-	-	-	1	-
Indet. *Cerealia* rachis node	-	-	-	-	-	-	-
Indet. *Cerealia* rachis internode	-	-	-	-	-	-	-
Indet. *Cerealia* rachis segment	-	-	-	-	-	-	1
Indet. *Cerealia* rachis lemma/palea	-	-	-	-	-	-	1
LEGUMINOSEAE							
Indet. Legume	-	-	4	2	-	6	-
VITACEAE							
***Vitis vinifera* fragments**	-	-	4	-	-	10	-
***Vitis vinifera* pedicel**	-	-	-	-	-	-	-
OLEACEAE							
***Olea europaea* fragments**	-	7	36	4	-	21	32
CROP PLANT TAXA TOTAL	3	7	54	6	12	47	43
WILD PLANT TAXA							
AMARANTHACEAE							
***Amaranthus* sp.**	-	-	-	-	1	-	-
***Chenopodium* sp.**	-	-	-	-	-	-	-
APIACEAE							
***Bupleurum* sp.**	-	-	-	-	-	-	-
BORAGINACEAE							
Echium sp.	-	-	-	-	-	-	-
Lithospermum arvense	-	-	-	-	-	-	-
BRASSICACEAE							
***Brassica* sp.**	-	-	-	-	-	-	-
CARYOPHYLLACEAE							
***Silene* sp.**	-	-	-	-	-	-	-
CYPERACEAE							
***Carex* sp.**	-	-	-	-	6	-	-
***Scirpus* sp.**	-	-	1	-	-	-	1
EUPHORBIACEAE							
Euphorbia heioscopia	-	-	-	-	-	-	-
FABACEAE							
***Coronilla* sp.**	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	-	-	1	-
***Trifolium* sp.**	-	-	1	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-
GRAMINEAE							
***Lolium* sp.**	9	-	16	-	-	7	-
***Phalaris* sp.**	-	-	-	-	-	-	-
Indet. Grass	-	-	1	-	-	-	4
LINECEAE							
***Linum* sp.**	-	-	-	-	2	-	-
MORACEAE							
Ficus carica	-	-	-	-	-	-	-
POACEAE							
***Aegilop* sp.**	-	-	-	-	-	-	-
***Avena* sp.**	-	-	-	-	-	-	-
***Bromus* sp.**	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-
POLYGONACEAE							
Polygonecaea family plant	-	-	-	-	-	-	-
***Persicaira* sp.**	-	-	-	-	-	-	-
***Polygonum* sp.**	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	1
RANUNCULACEAE							
***Ranunculus* sp.**	-	-	-	-	-	1	-
Ranunculaceae family plant	-	-	-	-	1	-	-
RUBIACEAE							
***Asperula* sp.**	-	-	-	-	-	-	-
***Galium* sp.**	-	-	1	-	-	1	1
***Sherardia* sp.**	-	-	-	-	-	1	-
THYMELAEACEAE							
***Thymelaea* sp.**	-	-	-	-	-	-	-
Indet.	-	4	2	-	-	2	-
WILD PLANT TAXA TOTAL	**9**	**4**	**22**	**0**	**10**	**13**	**7**
GRAND TOTAL	**12**	**11**	**76**	**6**	**22**	**60**	**50**

APPENDIX C.2. ABSOLUTE COUNTS OF ARCHAEOBOTANICAL ASSEMBLAGES FROM TELL ATCHANA

Table 32. Counts of archaeobotanical samples from Tell Atchana.

TELL ATCHANA (42.10)										
Sample No	**19554**	**20471**	**20402**	**20426**	**20428**	**20466**	**20472**	**20486**	**21210**	**21220**
Locus	**21**	**23**	**25**	**28**	**26**	**28**	**27**	**25**	**31**	**39**
Lot	**114**	**120**	**147**	**152**	**150**	**158**	**151**	**159**	**165**	**168**
Date	**07.07.14**	**10.07.14**	**29.07.14**	**2014**	**30.07.14**	**03.08.14**	**30.07.14**	**04.08.14**	**05.08.14**	**06.08.14**
Soil Volume	**7,00**	**9,00**	**8,00**	**4,00**	**8,00**	**16,00**	**6,00**	**26,00**	**47,00**	**30,00**
Local Phase	**3b**	**3b**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	1	-	-	-	-	-	-	-
Triticum durum/aestivum	-	-	1	-	-	-	-	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	-	4	10	2	8	6	-	9	5	11
Hordeum vulgare	-	-	-	-	-	-	-	-	-	1
***Cerealia* indet.**	-	1	-	3	1	3	1	4	-	3
LEGUMINOSEAE										
Indet. Legume	24	2	-	1	1	3	-	2	7	8
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	1	-	4	-	1	-	1
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**24**	**7**	**12**	**7**	**10**	**16**	**1**	**16**	**12**	**24**
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	1	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	1	2	-
CYPERECAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	-
EUPHORBIACEAE										
Euphorbia helioscopia	-	-	-	-	-	-	1	-	-	-
FABACEAE										
***Astragalus* sp.**	-	-	-	-	-	-	-	-	-	1
***Scorpiurus* sp.**	-	-	-	-	-	-	-	-	-	-
***Trifolium* sp.**	-	-	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	2	-	8	-	1	1	1	4	4	-
***Phalaris* sp.**	-	-	-	-	-	-	-	-	-	-
Indet. Grass	-	-	-	-	-	-	-	-	-	6
MALVACEAE										
***Malva* sp.**	-	-	-	-	-	-	-	-	-	-
Malvaceae family plant	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
Bromus sp.	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	1	1
Polygonaceae family plant	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Galium* sp.**	-	-	-	-	-	-	-	-	2	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	1	-	-	-	-	-	-	-	1	-
WILD PLANT TAXA TOTAL	**3**	**0**	**8**	**0**	**1**	**1**	**2**	**6**	**10**	**8**
GRAND TOTAL	**27**	**7**	**20**	**7**	**11**	**17**	**3**	**22**	**22**	**32**

TELL ATCHANA (42.10)										
Sample No	**21234**	**21252**	**21269**	**21277**	**26010**	**26139**	**26194**	**22653**	**24482**	**21567**
Locus	**27**	**36**	**39**	**36**	**95**	**67**	**67**	**40**	**40**	**42**
Lot	**170**	**177**	**179**	**181**	**410**	**419**	**436**	**257**	**322**	**214**
Date	**07.08.14**	**11.08.14**	**11.08.14**	**12.08.14**	**27.06.16**	**12.07.17**	**22.06.18**	**28.06.18**	**15.07.15**	**09.07.16**
Soil Volume	**8,00**	**93,50**	**3,50**	**37,00**	**5,00**	**4,00**	**14,00**	**13,00**	**6,00**	**27,80**
Local Phase	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4a**	**4a**	**4b**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	1	6	-	10	-	-	1	-	-	1
Triticum durum/aestivum	-	3	-	-	1	-	-	-	-	1
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	2	25	2	11	-	-	1	-	-	2
Hordeum vulgare	-	9	-	5	-	-	-	-	-	-
***Cerealia* indet.**	-	37	1	18	1	-	1	-	-	2
LEGUMINOSEAE										
Indet. Legume	1	34	-	-	2	-	2	4	-	-
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	-	-	4	-	-	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	1	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**4**	**115**	**3**	**44**	**4**	**0**	**9**	**4**	**0**	**6**
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	1	-	-	-	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	1	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	1	-	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERECAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	-
EUPHORBIACEAE										
Euphorbia helioscopia	-	-	-	-	-	-	-	-	-	1
FABACEAE										
***Astragalus* sp.**	-	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	-	-	-	-	-	1	-	-	-
***Trifolium* sp.**	-	-	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	-	47	-	10	-	-	2	-	-	-
***Phalaris* sp.**	-	1	-	-	-	-	-	-	-	1
Indet. Grass	-	31	-	-	-	-	1	-	-	-
MALVACEAE										
***Malva* sp.**	-	4	-	-	-	-	-	-	-	-
Malvaceae family plant	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
Bromus sp.	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	1	-	-	-	-	-	-
POLYGONACEAE										
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	8	-	7	-	-	1	-	-	1
Polygonaceae family plant	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	3	-	-	-	-	-	-	-	-
RUBIACEAE										
***Galium* sp.**	-	3	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	-	-	-	-	-	-	-	1	-	-
WILD PLANT TAXA TOTAL	**0**	**98**	**0**	**19**	**0**	**0**	**6**	**1**	**0**	**3**
GRAND TOTAL	**4**	**213**	**3**	**63**	**0**	**0**	**15**	**5**	**0**	**9**

TELL ATCHANA (42.10)										
Sample No	**22155**	**22170**	**22666**	**22692**	**23224**	**23206**	**23207**	**23213**	**24169**	**24172**
Locus	**50**	**50**	**54**	**54**	**54**	**68**	**57**	**59**	**55**	**68**
Lot	**237**	**238**	**261**	**269**	**279**	**275**	**276**	**278**	**288**	**290**
Date	**28.06.15**	**2015**	**08.07.15**	**19.07.15**	**21.07.15**	**23.08.15**	**22.07.15**	**22.07.15**	**22.07.15**	**16.06.16**
Soil Volume	**16,20**	**7,80**	**9,00**	**9,50**	**6,30**	**11,30**	**14,75**	**18,45**	**13,25**	**9,80**
Local Phase	**4b/5**	**4b/5**	**4b/5**	**4b/5**	**4b/5**	**5**	**5**	**5**	**5**	**5**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	1	-	-	1	-	1	-	1	-	-
Triticum durum/aestivum	1	-	-	1	-	1	-	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	13	29	-	1	1	-	2	2	-	-
Hordeum vulgare	3	9	-	1	-	-	-	1	-	-
***Cerealia* indet.**	15	11	-	-	2	-	1	2	-	-
LEGUMINOSEAE										
Indet. Legume	8	3	-	-	-	-	1	-	-	2
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	-	-	1	-	-	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**41**	**52**	**0**	**4**	**3**	**2**	**5**	**6**	**0**	**2**
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	1	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERECAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	1	-
EUPHORBIACEAE										
Euphorbia helioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Astragalus* sp.**	-	-	-	-	-	-	-	1	-	-
***Scorpiurus* sp.**	-	1	-	-	-	-	-	-	-	-
***Trifolium* sp.**	2	-	-	-	-	-	1	-	-	-
Trigonella foenum-graecum	1	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	16	5	-	-	2	-	-	-	-	-
***Phalaris* sp.**	1	-	-	2	-	-	2	-	-	1
Indet. Grass	-	18	-	-	2	-	-	1	-	-
MALVACEAE										
***Malva* sp.**	-	-	-	-	-	-	-	-	-	-
Malvaceae family plant	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
Bromus sp.	-	-	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	-
POLYGONACEAE										
***Polygonum* sp.**	-	-	-	-	-	-	-	-	1	-
***Rumex* sp.**	-	-	-	-	-	-	-	-	-	-
Polygonaceae family plant	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Galium* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	1	-	-	-	-	-	-	-	-	-
Indet.	1	-	-	1	-	-	-	-	-	-
WILD PLANT TAXA TOTAL	**22**	**24**	**0**	**3**	**4**	**0**	**3**	**3**	**2**	**1**
GRAND TOTAL	**63**	**76**	**0**	**7**	**7**	**2**	**8**	**9**	**2**	**3**

TELL ATCHANA (42.10)										
Sample No	**24374**	**24495**	**24810**	**26156**	**26161**	**26333**	**24930**	**24944**	**24945**	**25513**
Locus	**67**	**77**	**81**	**99**	**99**	**99**	**66**	**80**	**83**	**66**
Lot	**307**	**327**	**331**	**425**	**425**	**461**	**343**	**347**	**349**	**371**
Date	**16.06.16**	**11.07.16**	**13.07.16**	**25.06.18**	**25.06.18**	**04.07.18**	**14.06.17**	**15.06.17**	**15.06.17**	**23.06.17**
Soil Volume	**7,60**	**9,55**	**12,80**	**10,50**	**16,75**	**13,50**	**7,50**	**23,25**	**6,45**	**20,25**
Local Phase	**5**	**6**	**6**	**6**	**6**	**6**	**6a**	**6a**	**6a**	**6a**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	-	-	-	-	-	-	-	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	-	-	-	3	4	2	-	5	-	-
Hordeum vulgare	-	-	-	-	1	-	-	1	-	-
***Cerealia* indet.**	-	-	1	4	-	-	-	4	4	-
LEGUMINOSEAE										
Indet. Legume	-	-	-	-	-	-	-	-	-	-
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	1	2	-	-	-	1
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**0**	**0**	**1**	**7**	**6**	**4**	**0**	**10**	**4**	**1**
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	-	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERECAE										
***Carex* sp.**	-	1	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	1
EUPHORBIACEAE										
Euphorbia helioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Astragalus* sp.**	-	-	-	-	-	-	-	-	1	-
***Scorpiurus* sp.**	-	-	-	-	-	-	-	2	-	-
***Trifolium* sp.**	-	-	-	-	-	-	-	-	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	-	-	-	5	2	2	1	2	4	-
***Phalaris* sp.**	-	-	-	1	-	-	-	-	-	-
Indet. Grass	-	-	-	-	3	-	-	-	-	1
MALVACEAE										
***Malva* sp.**	-	-	-	-	-	-	-	-	-	-
Malvaceae family plant	-	-	-	-	-	-	-	-	-	-
POACEAE										
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
Bromus sp.	-	-	-	-	1	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	1	-	-
POLYGONACEAE										
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	1	-	-	1	-	-
Polygonaceae family plant	-	1	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Galium* sp.**	-	1	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	-	-	-
Indet.	-	-	-	-	-	1	2	-	-	1
WILD PLANT TAXA TOTAL	**0**	**3**	**0**	**6**	**7**	**3**	**3**	**6**	**5**	**3**
GRAND TOTAL	**0**	**3**	**1**	**13**	**13**	**7**	**3**	**16**	**9**	**4**

TELL ATCHANA (42.10)										
Sample No	**25501**	**25505**	**25506**	**25507**	**25508**	**25512**	**25524**	**25525**	**25526**	**25541**
Locus	**85**	**85**	**85**	**85**	**85**	**85**	**86**	**87**	**88**	**85**
Lot	**369**	**370**	**370**	**370**	**370**	**370**	**378**	**379**	**380**	**384**
Date	**23.06.17**	**23.06.17**	**23.06.17**	**23.06.17**	**23.06.17**	**23.06.17**	**29.06.17**	**29.06.17**	**29.06.17**	**03.07.17**
Soil Volume	**16,50**	**10,00**	**10,75**	**11,05**	**8,25**	**8,25**	**9,00**	**10,50**	**9,75**	**16,25**
Local Phase	**6b**	**6b**	**6b**	**6b**	**6b**	**6b**	**6b**	**6b**	**6b**	**6b**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	2	2	-	-	-	-	-	1	1	1
Triticum durum/aestivum	1	-	6	-	-	-	-	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	8	2	1	-	-	1	1	3	-	7
Hordeum vulgare	-	-	-	-	-	-	-	-	-	-
***Cerealia* indet.**	3	-	1	1	-	-	6	6	-	-
LEGUMINOSEAE										
Indet. Legume	11	2	4	-	-	2	4	4	3	4
VITACEAE										
***Vitis vinifera* fragments**	-	1	-	-	1	-	-	-	1	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	-	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**25**	**7**	**12**	**1**	**1**	**3**	**11**	**14**	**5**	**12**
WILD PLANT TAXA										
AMARANTHACEAE										
***Amaranthus* sp.**	-	-	-	-	-	-	-	-	-	-
APIACEAE										
***Bupleurum* sp.**	-	-	-	-	1	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE										
Echium sp.	-	-	-	-	-	-	-	-	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-	1	-
CARYOPHYLLACEAE										
***Silene* sp.**	-	-	-	-	-	-	-	-	-	-
CYPERECAE										
***Carex* sp.**	-	-	-	-	-	-	-	-	-	-
***Scirpus* sp.**	-	-	-	-	-	-	-	-	-	1
EUPHORBIACEAE										
Euphorbia helioscopia	-	-	-	-	-	-	-	-	-	-
FABACEAE										
***Astragalus* sp.**	-	-	-	-	-	-	-	-	-	-
***Scorpiurus* sp.**	-	1	-	-	-	-	-	-	-	1
***Trifolium* sp.**	-	-	-	-	-	-	-	1	-	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-	-	-
GRAMINEAE										
***Lolium* sp.**	32	4	-	-	2	1	-	12	1	5
***Phalaris* sp.**	-	-	-	-	-	-	1	-	-	-
Indet. Grass	-	-	-	2	-	-	3	-	3	-
MALVACEAE										
***Malva* sp.**	-	-	-	-	-	-	-	-	-	-
Malvaceae family plant	-	-	-	-	-	-	-	-	1	-
POACEAE										
***Avena* sp.**	-	-	-	-	-	-	-	-	-	-
Bromus sp.	1	-	-	-	-	-	-	-	-	1
Hordeum spontaneum	-	-	-	-	-	-	-	-	-	1
POLYGONACEAE										
***Polygonum* sp.**	-	-	-	-	-	-	-	-	-	-
***Rumex* sp.**	-	-	-	-	-	-	-	1	-	2
Polygonaceae family plant	-	-	-	-	-	-	-	-	-	-
RANUNCULACEAE										
***Ranunculus* sp.**	-	-	-	-	-	-	-	-	-	-
RUBIACEAE										
***Galium* sp.**	-	-	-	-	-	-	-	-	-	-
THYMELAEACEAE										
***Thymelaea* sp.**	-	-	-	-	-	-	-	1	-	1
Indet.	-	-	-	-	-	-	-	-	1	2
WILD PLANT TAXA TOTAL	**33**	**5**	**0**	**2**	**3**	**1**	**4**	**15**	**7**	**14**
GRAND TOTAL	**58**	**12**	**0**	**3**	**4**	**4**	**15**	**29**	**12**	**26**

TELL ATCHANA (42.10)								
Sample No	**25546**	**25547**	**25555**	**25559**	**26166**	**26240**	**26348**	**26429**
Locus	**85**	**85**	**85**	**87**	**94**	**102**	**102**	**117**
Lot	**385**	**385**	**386**	**389**	**426**	**442**	**463**	**471**
Date	**03.07.17**	**03.07.17**	**04.07.17**	**04.07.17**	**26.06.18**	**01.07.18**	**08.07.18**	**10.07.18**
Soil Volume	**12,00**	**14,00**	**21,75**	**5,00**	**25,50**	**14,50**	**22,50**	**13,75**
Local Phase	**6b**	**6b**	**6b**	**6b**	**7**	**7a**	**7a**	**7b**
CROP PLANT TAXA								
POACEAE								
Avena sativa	2	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-
Triticum durum/aestivum	6	-	-	-	-	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-
***Triticum* sp.**	6	3	-	-	3	4	2	-
Hordeum vulgare	2	-	-	-	1	1	-	-
***Cerealia* indet.**	-	-	-	-	-	-	-	2
LEGUMINOSEAE								
Indet. Legume	7	3	-	-	-	3	-	-
VITACEAE								
***Vitis vinifera* fragments**	3	-	-	-	-	2	2	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-
OLEACEAE								
***Olea europaea* fragments**	-	-	-	-	-	-	-	-
CROP PLANT TAXA TOTAL	**26**	**6**	**0**	**0**	**4**	**10**	**4**	**2**
WILD PLANT TAXA								
AMARANTHACEAE								
***Amaranthus* sp.**	-	-	-	-	-	-	-	-
APIACEAE								
***Bupleurum* sp.**	-	-	-	-	-	-	-	-
Bupleurum / Carum Sp.	-	-	-	-	-	-	-	-
BORAGINACEAE								
Echium sp.	-	-	-	-	-	-	-	-
Lithospermum sp.	-	-	-	-	-	-	-	-
CARYOPHYLLACEAE								
***Silene* sp.**	-	-	-	-	-	-	-	-
CYPERECAE								
***Carex* sp.**	-	-	-	-	-	-	-	-
***Scirpus* sp.**	1	-	-	-	-	1	1	-
EUPHORBIACEAE								
Euphorbia helioscopia	-	-	-	-	-	-	-	-
FABACEAE								
***Astragalus* sp.**	-	-	-	-	-	-	-	1
***Scorpiurus* sp.**	-	-	-	-	-	-	-	4
***Trifolium* sp.**	1	-	-	-	-	-	1	-
Trigonella foenum-graecum	-	-	-	-	-	-	-	-
GRAMINEAE								
***Lolium* sp.**	19	2	-	-	4	1	2	-
***Phalaris* sp.**	1	-	-	-	-	-	-	1
Indet. Grass	-	1	-	-	-	3	1	-
MALVACEAE								
***Malva* sp.**	-	-	-	-	1	-	-	-
Malvaceae family plant	-	-	-	-	1	-	-	-
POACEAE								
***Avena* sp.**	-	-	-	-	-	-	-	-
Bromus sp.	-	-	-	-	-	-	-	-
Hordeum spontaneum	-	-	-	-	-	-	-	-
POLYGONACEAE								
***Polygonum* sp.**	1	-	-	-	-	1	1	-
***Rumex* sp.**	-	-	-	-	2	1	-	-
Polygonaceae family plant	-	-	-	-	-	-	-	-
RANUNCULACEAE								
***Ranunculus* sp.**	-	-	-	-	-	-	1	-
RUBIACEAE								
***Galium* sp.**	-	-	-	-	-	1	-	-
THYMELAEACEAE								
***Thymelaea* sp.**	1	-	1	-	-	-	-	1
Indet.	2	1	-	-	-	2	-	-
WILD PLANT TAXA TOTAL	**26**	**4**	**1**	**0**	**8**	**10**	**7**	**7**
GRAND TOTAL	**52**	**10**	**1**	**0**	**12**	**20**	**11**	**9**

TELL ATCHANA (42.10)												
Sample No	**26766**	**26768**	**26787**	**27075**	**27085**	**27255**	**27317**	**27318**	**27321**	**27329**	**27352**	**27374**
Locus	**127**	**122**	**130**	**131**	**123**	**156**	**156**	**158**	**156**	**123**	**156**	**156**
Lot	**514**	**513**	**523**	**587**	**592**	**610**	**619**	**618**	**619**	**622**	**627**	**632**
Date	**01.07.19**	**01.07.19**	**03.07.19**	**30.07.19**	**31.07.19**	**21.07.20**	**24.07.20**	**24.07.20**	**24.07.20**	**25.07.20**	**29.07.20**	**30.07.20**
Soil Volume	**5,50**	**22,00**	**19,50**	**6,50**	**22,25**	**22,00**	**23,25**	**22,50**	**13,00**	**29,00**	**21,00**	**17,25**
Local Phase	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**
CROP PLANT TAXA												
POACEAE												
Avena sativa	-	-	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	1	1	-	1	1	9	4	4	-	4	5	-
Indet. *Cerealia* chaff	-	-	-	-	-	4	-	-	-	-	-	-
***Triticum* sp.**	-	-	1	-	-	8	3	6	-	-	8	3
Hordeum vulgare	-	2	-	14	3	5	3	6	7	5	4	-
***Cerealia* indet.**	2	1	-	6	2	-	3	-	4	-	2	1
LEGUMINOSEAE												
Indet. Legume	2	1	5	-	3	6	1	14	4	3	4	-
VITACEAE												
***Vitis vinifera* fragments**	-	7	1	-	1	2	5	2	3	3	3	2
Vitis vinifera pedicel	-	-	-	-	-	-	-	1	-	2	-	-
OLEACEAE												
***Olea europaea* fragments**	-	2	1	-	4	7	11	4	6	2	8	4
CROP PLANT TAXA TOTAL	**5**	**14**	**8**	**21**	**14**	**41**	**30**	**37**	**24**	**19**	**34**	**10**

TELL ATCHANA (42.10)										
Sample No	**27634**	**27655**	**27680**	**27691**	**27700**	**27734**	**27735**	**27739**	**27793**	**27802**
Locus	**158**	**158**	**158**	**158**	**158**	**123**	**123**	**123**	**124**	**158**
Lot	**699**	**699**	**704**	**704**	**711**	**529**	**529**	**533**	**557**	**711**
Date	**15.08.20**	**15.08.20**	**18.08.20**	**18.08.20**	**19.08.20**	**04.07.19**	**04.07.19**	**07.07.19**	**14.07.19**	**19.08.20**
Soil Volume	**18,00**	**21,25**	**21,00**	**18,00**	**29,50**	**20,00**	**6,50**	**12,75**	**18,50**	**6,50**
Local Phase	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**	**7b**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	5	5	1	4	10	2	-	1	-	-
Indet. *Cerealia* chaff	-	-	1	-	-	-	-	-	-	-
***Triticum* sp.**	-	5	-	2	3	2	2	1	-	-
Hordeum vulgare	2	3	-	1	21	3	1	2	-	1
***Cerealia* indet.**	-	-	-	2	7	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	1	1	1	1	7	-	1	-	-	-
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	1	-	4	1	-	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	3	2	3	4	8	-	-	-	-	-
CROP PLANT TAXA TOTAL	**11**	**16**	**6**	**14**	**57**	**7**	**8**	**5**	**0**	**1**

TELL ATCHANA (42.10)										
Sample No	**27755**	**27771**	**27776**	**26725**	**27007**	**27022**	**27023**	**27050**	**27052**	**27062**
Locus	**137**	**137**	**137**	**126**	**136**	**126**	**26? Or 120**	**136**	**126**	**126**
Lot	**540**	**541**	**546**	**496**	**564**	**568**	**568**	**572**	**574**	**577**
Date	**08.07.19**	**09.07.19**	**10.07.19**	**25.06.19**	**10.07.19**	**22.07.19**	**22.07.19**	**24.07.19**	**25.07.19**	**28.07.19**
Soil Volume	**18,50**	**17,00**	**8,50**	**23,25**	**26,50**	**19,75**	**21,50**	**20,50**	**20,50**	**15,50**
Local Phase	**7c/7b**	**7c/7b**	**7c/7b**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	17	9	1	3	1	2	-	-	1	-
Indet. *Cerealia* chaff	-	3	-	-	-	-	1	1	-	-
***Triticum* sp.**	19	11	4	-	-	1	2	-	-	2
Hordeum vulgare	2	1	1	1	3	1	2	1	5	1
***Cerealia* indet.**	3	-	-	-	2	2	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	3	1	-	6	-	-	-	-	2	1
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	2	-	1	1	-	1	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	2	-	4	2	1	4	-	-	1
CROP PLANT TAXA TOTAL	**44**	**27**	**6**	**16**	**8**	**8**	**10**	**2**	**9**	**5**

TELL ATCHANA (42.10)										
Sample No	**27076**	**27087**	**27343**	**27360**	**27373**	**27381**	**27396**	**27398**	**27413**	**27436**
Locus	**148**	**151**	**159**	**136**	**136**	**161**	**162**	**145**	**161**	**163**
Lot	**588**	**594**	**626**	**630**	**635**	**638**	**639**	**640**	**643**	**651**
Date	**30.07.19**	**31.07.19**	**28.07.20**	**29.07.20**	**30.07.20**	**30.07.20**	**31.07.20**	**31.07.20**	**03.08.20**	**04.08.20**
Soil Volume	**18,00**	**18,00**	**19,00**	**19,75**	**22,75**	**23,25**	**24,00**	**16,50**	**21,50**	**10,50**
Local Phase	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	1	-	-	-	1	4	7	-	-	-
Indet. *Cerealia* chaff	-	-	-	-	-	-	-	-	-	-
***Triticum* sp.**	-	-	1	2	-	-	2	1	3	1
Hordeum vulgare	-	1	1	4	3	2	2	2	1	2
***Cerealia* indet.**	-	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	1	-	-	1	1	1	3	3	2	-
VITACEAE										
***Vitis vinifera* fragments**	-	-	-	-	-	-	4	-	-	-
Vitis vinifera pedicel	-	-	-	-	-	-	1	-	-	-
OLEACEAE										
***Olea europaea* fragments**	-	1	-	5	1	-	10	1	-	2
CROP PLANT TAXA TOTAL	**2**	**2**	**2**	**12**	**6**	**7**	**29**	**7**	**6**	**5**

TELL ATCHANA (42.10)										
Sample No	**27437**	**27439**	**27449**	**27458**	**27486**	**27498**	**27499**	**27506**	**27545**	**27552**
Locus	**162**	**164**	**159**	**162**	**167**	**166**	**169**	**167**	**166**	**169**
Lot	**647**	**652**	**648**	**655**	**667**	**670**	**674**	**673**	**679**	**681**
Date	**04.08.20**	**04.08.20**	**04.08.20**	**05.08.20**	**07.08.20**	**08.08.20**	**08.08.20**	**08.08.20**	**11.08.20**	**11.08.20**
Soil Volume	**16,50**	**15,25**	**21,00**	**19,00**	**21,40**	**15,75**	**10,00**	**14,00**	**15,00**	**16,00**
Local Phase	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	1	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	4	6	1	2	1	-	3	-	4	1
Indet. *Cerealia* chaff	-	4	-	-	1	-	-	-	-	-
***Triticum* sp.**	-	-	3	1	3	-	3	-	3	1
Hordeum vulgare	4	-	1	-	3	1	1	-	2	-
***Cerealia* indet.**	-	-	-	1	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	-	-	3	-	1	1	1	-	5	3
VITACEAE										
***Vitis vinifera* fragments**	-	2	4	2	2	2	-	-	1	-
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	5	2	15	20	11	9	2	9	7	-
CROP PLANT TAXA TOTAL	**14**	**14**	**27**	**26**	**22**	**13**	**10**	**9**	**22**	**5**

TELL ATCHANA (42.10)										
Sample No	**27577**	**27599**	**27613**	**27640**	**27679**	**27692**	**27746**	**27756**	**27775**	**27777**
Locus	**167**	**174**	**173**	**173**	**173**	**177**	**133**	**133**	**133**	**140**
Lot	**685**	**690**	**691**	**695**	**705**	**707**	**534**	**537**	**548**	**?**
Date	**12.08.20**	**13.08.20**	**15.08.20**	**18.08.20**	**18.08.20**	**07.07.19**	**08.07.19**	**10.07.19**	**10.07.19**	**14.08.20**
Soil Volume	**23,00**	**18,50**	**21,25**	**16,25**	**23,50**	**15,25**	**41,50**	**21,00**	**22,50**	**18,00**
Local Phase	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**	**7c**
CROP PLANT TAXA										
POACEAE										
Avena sativa	-	-	-	-	-	-	-	-	-	-
Triticum monococcum/dicoccum	-	-	-	-	-	-	-	-	-	-
Triticum durum/aestivum	-	2	-	-	3	6	-	1	2	1
Indet. *Cerealia* chaff	-	-	1	-	2	2	1	2	-	2
***Triticum* sp.**	3	5	4	4	-	2	-	-	4	-
Hordeum vulgare	-	-	3	1	-	2	3	-	-	-
***Cerealia* indet.**	4	-	-	-	-	-	-	-	-	-
LEGUMINOSEAE										
Indet. Legume	1	-	3	4	2	7	2	1	1	1
VITACEAE										
***Vitis vinifera* fragments**	-	1	-	1	1	3	1	-	-	1
Vitis vinifera pedicel	-	-	-	-	-	-	-	-	-	-
OLEACEAE										
***Olea europaea* fragments**	6	-	5	4	1	8	1	3	1	1
CROP PLANT TAXA TOTAL	**14**	**8**	**16**	**14**	**9**	**30**	**8**	**7**	**8**	**6**

APPENDIX D.1. MORPHOMETRIC MEASUREMENT DETAILS OF GRAINS FROM TOPRAKHİSAR HOYUK

Table 33. The measurement details of free-threshing wheat grains from Toprakhisar Höyük.

Site	Photo ID	Plan-Square	Phase	Date	Dorsal		Side		Ventral		Area (mm2)	Volume (mm3)
					Length (mm)	Width (mm)	Length (mm)	Breadth (mm)	Length (mm)	Width (mm)		
TOPRAKHİSAR HÖYÜK	TPH035_wheat_01	51/52.37	3a	2000-1900 BC	4,07	2,66	4,06	2,55	4,04	2,67	40,47	14,43
	TPH044_wheat_01		3a		3,41	2,34	3,38	2,14	3,38	2,35	29,02	8,91
	TPH044_wheat_03		3a		3,79	2,77	3,76	2,24	3,75	2,78	37,05	12,26
	TPH044_wheat_05		3a		3,89	1,92	3,90	1,66	3,95	1,98	33,20	6,63
	TPH006_wheat_01		3a		3,69	2,62	4,09	2,73	4,13	3,12	40,74	16,29
	TPH007_wheat_01		3a		4,42	2,78	4,34	2,87	4,92	2,99	50,19	19,77
	TPH013_wheat_02		3a		4,80	3,10	4,68	2,49	4,26	2,75	50,87	17,47
	TPH017_wheat_02		3a		3,97	2,00	3,96	1,64	3,83	2,00	33,64	6,73
	TPH020_wheat_02		3a		3,54	1,48	3,56	1,30	3,51	1,50	25,41	3,59
	TPH043_wheat_01		3a		4,16	2,70	4,15	2,66	4,17	2,65	42,11	15,50
	TPH037_wheat_02		3		3,29	2,15	3,22	1,82	3,29	2,15	26,27	6,69
	TPH042_wheat_01		3		4,71	3,29	4,08	2,59	4,18	2,86	47,90	18,03
	TPH056_wheat_01		3		4,40	3,05	4,48	2,51	4,39	3,03	49,24	17,67
	TPH054_wheat_01	54.38	2	2100-2000 BC	4,24	3,50	4,21	3,18	4,25	3,53	50,09	24,78
	TPH055_wheat_02		2		5,24	2,74	5,18	2,19	5,10	2,74	59,53	16,25

Tablo 34. The measurement details of hulled wheat grains from Toprakhisar Höyük.

Site	Photo ID	Plan-Square	Phase	Date	Dorsal		Side		Ventral		L	W	Lm	U	Area (mm2)	Volume (mm3)
					Length (mm)	Width (mm)	Length (mm)	Breadth (mm)	Length (mm)	Width (mm)						
TOPRAKHİSAR HÖYÜK	TPH044_wheat_02	51/52.37	3a	2000-1900 BC	3,21	1,44	3,21	1,59	3,19	1,38	3,20	1,41	2,31	0,69	21,19	3,76
	TPH001_wheat_01		3a		4,36	2,54	4,32	2,34	4,37	2,58	4,35	2,56	3,46	0,61	44,12	13,64
	TPH013_wheat_03		3a		4,65	1,72	4,74	1,64	4,76	1,71	4,72	1,72	3,22	0,73	42,97	6,95
	TPH037_wheat_01		3		3,58	1,93	3,60	1,87	3,57	1,92	3,58	1,93	2,75	0,64	28,74	6,75
	TPH037_wheat_03		3		3,86	2,03	3,91	1,61	3,86	2,08	3,88	2,06	2,97	0,64	33,44	6,72
	TPH037_wheat_04		3		3,12	1,74	3,13	1,88	3,11	1,63	3,12	1,69	2,40	0,64	21,84	5,18
	TPH048_wheat_03	54.38	1	2100-2000 BC	4,25	2,25	4,26	2,15	4,29	2,26	4,27	2,26	3,26	0,64	40,45	10,83
	TPH048_wheat_04		1		3,29	2,00	3,34	1,93	3,33	1,98	3,32	1,99	2,66	0,60	25,92	6,68

APPENDIX D.2. MORPHOMETRIC MEASUREMENT DETAILS OF GRAINS FROM TELL ATCHANA

Table 35. The measurement details of free-threshing wheat grains from Tell Atchana.

Site	Photo ID	Plan-Square	Phase	Date	Dorsal		Side		Ventral		Area (mm2)	Volume (mm3)
					Length (mm)	Width (mm)	Length (mm)	Breadth (mm)	Length (mm)	Width (mm)		
TELL ATCHANA	AT002_wheat_01	42.10	Phase 4	1300-1200 BC	4,15	2,35	4,09	2,09	4,13	2,27	38,76	10,42
	AT015_wheat_02		Phase 4		4,45	2,64	4,46	2,22	4,38	2,64	46,03	13,59
	AT015_wheat_07		Phase 4		4,11	2,28	4,13	2,24	4,12	2,26	38,41	10,97
	AT015_wheat_08		Phase 4		3,80	1,98	3,76	1,91	3,80	2,04	31,92	7,61
	AT004_wheat_01		Phase 4/5	1325-1275 BC	4,61	3,18	4,62	2,25	4,58	3,21	53,61	17,33
	AT021_wheat_02		6b	1350-1300 BC	4,42	3,09	4,49	2,35	4,51	3,03	50,24	16,84
	AT022_wheat_01		6b		4,49	2,66	4,45	2,15	4,50	2,63	46,87	13,34
	AT023_wheat_01		6b		4,08	2,21	4,06	1,76	4,06	2,25	37,35	8,36
	AT072_naked_01	32.57	5a/b	1750-1650 BC	3,54	2,11	3,68	2,16	3,66	2,14	30,61	8,72
	AT069_naked_01		5b		4,25	2,56	4,24	2,35	4,31	2,59	42,95	13,52
	AT069_naked_02		5b		2,85	1,86	2,94	1,81	2,99	1,84	20,67	5,13
	AT069_naked_03		5b		4,09	2,88	4,16	2,38	4,06	2,89	42,89	14,75
	AT069_naked_04		5b		4,01	2,55	4,06	2,27	3,98	2,45	38,63	11,94
	AT078_naked_01		5b		4,40	2,63	4,33	2,10	4,31	2,61	44,55	12,52
	AT080_naked_01		5b		3,58	2,27	3,59	1,87	3,55	2,37	31,22	8,12
	AT080_naked_02		5b		4,54	2,55	4,51	2,10	4,51	2,53	46,64	12,62
	AT080_naked_03		5b		3,33	2,31	3,40	1,91	3,39	2,37	28,78	7,89
	AT070_naked_01		5c		4,71	2,63	4,65	2,24	4,73	2,70	50,58	14,68
	AT070_naked_02		5c		4,38	2,71	4,47	2,13	4,41	2,76	46,65	13,48
	AT074_naked_01		5c		3,44	2,03	3,42	1,87	3,44	2,06	27,64	6,87
	AT076_naked_01		5c		4,21	2,94	4,21	2,46	4,22	2,91	44,91	15,87
	AT076_naked_02		5c		3,82	2,74	3,79	2,46	3,79	2,72	37,20	13,36
	AT082_naked_01		5c		4,27	2,40	4,26	2,13	4,28	2,45	41,83	11,55
	AT082_naked_02		5c		4,01	2,75	4,04	2,44	4,05	2,78	40,89	14,25
	AT075_naked_01		5d		5,03	2,95	5,02	2,62	5,09	2,99	59,39	20,56
	AT075_naked_02		5d		4,44	3,23	4,46	2,38	4,45	3,22	51,26	17,88
	AT075_naked_03		5d		4,58	2,86	4,57	2,38	4,54	2,95	50,42	16,52
	AT075_naked_04		5d		3,72	2,44	3,75	2,11	3,68	2,35	33,65	9,83
	AT075_naked_05		5d		5,23	2,93	5,22	2,92	5,23	2,95	62,40	23,49
	AT075_naked_06		5d		4,16	2,47	4,19	2,07	4,11	2,45	40,34	11,07
	AT075_naked_07		5d		4,38	2,86	4,34	2,67	4,11	2,93	45,67	17,31
	AT075_naked_08		5d		3,96	2,36	3,97	2,23	3,92	2,33	36,53	10,82
	AT075_naked_09		5d		3,87	2,51	3,88	2,36	3,86	2,50	36,56	11,98
	AT079_naked_01		5f		3,96	2,48	3,91	2,37	3,91	2,48	37,19	12,08
	AT081_naked_01		5f		4,31	2,93	4,37	2,67	4,34	2,96	47,10	17,87
	AT081_naked_02		5f		4,34	2,69	4,33	2,40	4,25	2,66	44,37	14,48
	AT081_naked_03		5f		3,75	2,57	3,78	2,54	3,80	2,60	35,82	12,98
	AT_MBA_wheat_01	33.32	VII	1750-1650 BC	4,97	2,96	5,02	2,42	4,97	2,97	58,26	18,73
	AT_MBA_wheat_02		VII		4,63	2,86	4,63	2,77	4,70	2,94	51,89	19,57
	AT_MBA_wheat_03		VII		4,64	2,62	4,74	2,37	4,77	2,66	50,70	15,45
	AT_MBA_wheat_04		VII		4,72	2,85	4,65	2,51	4,77	2,72	51,90	17,25
	AT_MBA_wheat_05		VII		4,20	2,75	4,29	2,11	4,27	2,80	44,34	13,04
	AT_MBA_wheat_06		VII		4,64	2,85	4,68	2,08	4,62	2,85	51,34	14,42
	AT_MBA_wheat_07		VII		4,57	2,71	4,55	2,34	4,63	2,73	49,18	15,27
	AT_MBA_wheat_08		VII		4,63	2,99	4,66	2,62	4,63	3,00	52,49	19,06
	AT_MBA_wheat_09		VII		4,71	2,82	4,71	2,58	4,69	2,83	52,08	17,95
	AT_MBA_wheat_10		VII		5,02	2,80	5,16	2,03	5,07	2,80	58,47	15,13
	AT_MBA_wheat_11		VII		5,17	3,39	5,24	2,13	5,05	3,48	65,80	19,74
	AT_MBA_wheat_12		VII		4,31	2,63	4,32	2,46	4,32	2,68	44,37	14,76
	AT_MBA_wheat_13		VII		4,54	3,40	4,49	2,34	4,44	3,31	53,06	18,46
	AT_MBA_wheat_14		VII		4,44	2,54	4,43	2,39	4,39	2,49	44,85	13,91
	AT_MBA_wheat_15		VII		5,16	2,92	5,11	2,37	5,17	2,90	60,64	18,59
	AT_MBA_wheat_16		VII		5,11	2,82	5,11	2,07	5,09	2,82	59,01	15,60
	AT_MBA_wheat_17		VII		3,93	2,31	3,92	2,12	3,90	2,35	35,95	10,13
	AT_MBA_wheat_18		VII		4,85	3,11	4,85	2,12	4,86	3,08	57,08	16,67
	AT_MBA_wheat_19		VII		4,29	2,74	4,27	2,77	4,23	2,85	44,66	17,28
	AT_MBA_wheat_20		VII		4,63	2,58	4,61	2,15	4,63	2,60	48,73	13,48
	AT_MBA_wheat_21		VII		4,43	2,41	4,46	2,18	4,45	2,46	44,62	12,36
	AT_MBA_wheat_22		VII		4,61	2,71	4,69	2,35	4,68	2,80	50,74	15,80

Table 36.The measurement details of hulled wheat grains from Tell Atchana.

Site	Photo ID	Plan-Square	Phase	Date	Dorsal		Side		Ventral		L	W	Lm	U	Area (mm2)	Volume (mm3)
					Length (mm)	Width (mm)	Length (mm)	Breadth (mm)	Length (mm)	Width (mm)						
TELL ATCHANA	AT015_wheat_01	42.10	4	1300-1200 BC	4,32	2,78	4,41	2,63	4,29	2,76	4,34	2,77	3,56	0,57	45,66	16,55
	AT015_wheat_03		4		4,57	1,93	4,46	1,71	4,46	1,92	4,50	1,93	3,21	0,70	41,32	7,75
	AT015_wheat_05		4		4,29	2,50	4,29	2,55	4,30	2,47	4,29	2,49	3,39	0,61	42,65	14,24
	AT015_wheat_06		4		3,64	2,14	3,70	2,05	3,64	2,10	3,66	2,12	2,89	0,61	31,01	8,33
	AT015_wheat_09		4		4,39	2,19	4,39	1,58	4,34	2,12	4,37	2,16	3,26	0,67	41,27	7,80
	AT018_wheat_05		4		4,24	2,36	4,16	2,30	4,24	2,35	4,21	2,36	3,28	0,63	40,43	11,95
	AT018_wheat_08		4		4,22	2,26	4,17	2,40	4,19	2,22	4,19	2,24	3,22	0,64	39,26	11,80
	AT018_wheat_09		4		3,72	2,06	3,73	1,86	3,75	2,08	3,73	2,07	2,90	0,63	31,63	7,53
	AT004_wheat_02		4b/5	1325-1275 BC	4,52	2,21	4,51	1,88	4,42	2,27	4,48	2,24	3,36	0,66	43,62	9,89
	AT022_wheat_02		6b	1350-1300 BC	3,14	1,76	3,09	1,55	3,13	1,77	3,12	1,77	2,44	0,62	22,29	4,47
	AT080_hulled_01	32.57	5b	1750-1650 BC	5,19	2,63	5,22	2,28	5,16	2,63	5,19	2,63	3,91	0,66	58,80	16,30
	AT080_hulled_02		5b		4,88	2,73	4,87	2,36	4,93	2,75	4,89	2,74	3,82	0,63	54,58	16,57
	AT080_hulled_03		5b		3,73	2,01	3,72	1,94	3,73	2,05	3,73	2,03	2,88	0,64	31,27	7,68
	AT071_hulled_01		5f		4,15	2,00	4,14	1,91	4,08	1,91	4,12	1,96	3,04	0,68	36,12	8,06
	AT079_hulled_01		5f		4,12	2,05	4,07	1,88	4,11	2,05	4,10	2,05	3,08	0,66	36,49	8,27
	AT079_hulled_02		5f		5,47	2,34	5,44	2,17	5,42	2,44	5,44	2,39	3,92	0,69	61,12	14,78
	AT081_hulled_01		5f		4,05	2,06	4,05	1,97	4,06	2,05	4,05	2,06	3,05	0,66	35,87	8,59
	AT081_hulled_02		5f		4,00	2,22	4,01	1,94	4,00	2,21	4,00	2,22	3,11	0,63	36,34	9,01

APPENDIX E.1. SUMMARY STATISTICS OF MANN-WHITNEY U TEST ON TOPRAKHİSAR SEEDS

Table 37. The summary statistics of Mann-Whitney U test on free-threshing wheat grains of Toprakhisar.

Variable	Observations	Obs. With missing data	Obs. With missing data	Minimum	Maximum	Mean	Std. deviation
S1	51	0	51	5,131	23,494	14,408	3,725
Var1	15	0	15	3,587	24,776	13,667	5,977

Table 38. The summary statistics of Mann-Whitney U test on hulled wheat grains of Toprakhisar.

Variable	Observations	Obs. With missing data	Obs. With missing data	Minimum	Maximum	Mean	Std. deviation
S1	8	0	8	7,685	16,568	11,158	3,964
Var1	8	0	8	3,760	13,644	7,563	3,170

APPENDIX E.2. SUMMARY STATISTICS OF MANN-WHITNEY U TEST ON ATCHANA SEEDS

Table 39. The summary statistics of Mann-Whitney U test on free-threshing wheat grains of Atchana.

Variable	Observations	Obs. With missing data	Obs. With missing data	Minimum	Maximum	Mean	Std. deviation
S1	8	0	8	7,612	17,327	12,308	3,615
Var1	51	0	51	5,131	23,494	14,408	3,725

Table 40. The summary statistics of Mann-Whitney U test on hulled wheat grains of Atchana.

Variable	Observations	Obs. With missing data	Obs. With missing data	Minimum	Maximum	Mean	Std. deviation
S1	10	0	10	4,469	16,555	10,031	3,613
Var1	8	0	8	7,685	16,568	11,158	3,964

APPENDIX F.1. STABLE CARBON ISOTOPE RESULTS OF FREE-THRESHING WHEAT

Table 41. Stable carbon isotope values of free-threshing wheat.

ISOTOPE VALUES OF FREE-THRESHING WHEAT							
	$\delta^{13}C$ (Gas)	Sample No	Layer	Date (ca. BC)	$\delta^{13}C$ (Air)	D13C	Water Input (mm)
E34	-22,09	AT20466	4	1300-1200	-6,5	15,94	70,27
E39	-22,92	AT21252	4		-6,5	16,81	97,28
E40	-24,11	AT21252	4		-6,5	18,05	155,03
E41	-23,15	AT21252	4		-6,5	17,04	106,08
E42	-23,87	AT21252	4		-6,5	17,80	141,10
E43	-24,95	AT21252	4		-6,5	18,92	215,02
E44	-24,75	AT21252	4		-6,5	18,71	198,75
E37	-22,68	AT22692	4b/5	1325-1275	-6,5	16,55	88,26
E57	-22,66	AT26161	6	1350-1300	-6,5	16,53	87,55
E59	-23,02	AT25525	6b		-6,5	16,91	101,14
E52	-23,92	AT25501	6b		-6,5	17,85	143,66
E54	-24,51	AT26240	7	1450-1400 BC	-6,5	18,46	180,89
E55	-23,73	AT26240	7		-6,5	17,65	133,42
E56	-21,96	AT26240	7		-6,5	15,81	66,81
E1	-22,64	AT12969	5b	1750-1650	-6,5	16,52	87,16
E2	-23,65	AT12969	5b		-6,5	17,57	129,31
E3	-23,10	AT12969	5b		-6,5	16,99	103,99
E4	-23,44	AT12969	5b		-6,5	17,35	119,04
E6	-22,65	AT15836	5f		-6,5	16,53	87,50
E7	-23,74	AT15836	5f		-6,5	17,66	133,69
E8	-23,44	AT15836	5f		-6,5	17,34	118,83
E11	-23,20	AT13765	5c		-6,5	17,10	108,52
E12	-23,51	AT13765	5c		-6,5	17,42	122,25
E13	-23,96	AT13731	5d		-6,5	17,89	146,04
E14	-22,44	AT13731	5d		-6,5	16,30	80,36
E15	-24,12	AT13731	5d		-6,5	18,06	155,57
E16	-23,30	AT13731	5d		-6,5	17,20	112,84
E17	-23,98	AT13731	5d		-6,5	17,90	146,81
E18	-24,56	AT13731	5d		-6,5	18,52	184,95
E19	-22,39	AT12378	5a		-6,5	16,26	78,99
E20	-23,35	AT12378	5a		-6,5	17,25	114,77
E27	-22,52	AT10589	VII	1750-1650	-6,5	16,39	83,10
E28	-21,92	AT10589	VII		-6,5	15,77	65,71
E29	-21,27	AT10589	VII		-6,5	15,09	51,04
E30	-22,06	AT10589	VII		-6,5	15,91	69,40
E31	-21,83	AT10589	VII		-6,5	15,67	63,34
E32	-23,00	AT10589	VII		-6,5	16,89	100,31
E62	-23,41	TPH901	3c	2000-1900	-6,5	17,31	117,48
E64	-23,30	TPH411	3a		-6,5	17,20	112,64
E71	-23,60	TPH317	3a		-6,5	17,52	126,92
E72	-23,99	TPH247	3a		-6,5	17,92	147,79
E73	-22,48	TPH247	3a		-6,5	16,34	81,63
E74	-21,54	TPH247	3a		-6,5	15,37	56,71
E75	-22,09	TPH247	3a		-6,5	15,94	70,16
E82	-21,81	TPH834	3		-6,5	15,65	62,84
E61	-23,50	TPH1738	2	2100-2000	-6,4	17,52	126,81
E68	-22,59	TPH1536	2		-6,4	16,56	88,64
E81	-22,60	TPH1448	2		-6,4	16,57	88,92

APPENDIX F.2. STABLE CARBON ISOTOPE RESULTS OF HULLED WHEAT

Table 42. Stable carbon isotope values of hulled wheat.

ISOTOPE VALUES OF HULLED WHEAT							
	δ¹³C (Gas)	**Sample No**	**Layer**	**Date (ca. BC)**	**δ¹³C (Air)**	D13C	**Water Input (mm)**
E33	-21,83	AT21234	4	1300-1200	-6,5	15,67	63,46
E45	-23,26	AT21252	4		-6,5	17,15	110,75
E46	-23,49	AT21252	4		-6,5	17,40	121,23
E47	-22,64	AT21252	4		-6,5	16,51	86,97
E36	-22,80	AT22155	4b/5	1325-1275	-6,5	16,68	92,65
E38	-21,67	AT22692	4b/5		-6,5	15,51	59,60
E53	-23,29	AT23213	5	1350-1300	-6,5	17,19	112,12
E58	-23,80	AT26161	6	1350-1300	-6,5	17,72	136,96
E60	-22,20	AT25525	6b		-6,5	16,05	73,20
E50	-22,58	AT25501	6b		-6,5	16,46	85,13
E51	-21,50	AT25501	6b		-6,5	15,33	55,67
E9	-23,36	AT15836	5f	1750-1650	-6,5	17,26	115,21
E10	-22,91	AT15836	5f		-6,5	16,79	96,71
E63	-23,45	TPH994	3	2000-1900	-6,5	17,36	119,67
E66	-21,61	TPH385	3a		-6,5	15,44	58,18
E76	-22,72	TPH247	3a		-6,5	16,60	89,80
E77	-23,69	TPH247	3a		-6,5	17,61	131,26
E78	-23,06	TPH247	3a		-6,5	16,95	102,47
E65	-23,35	TPH411	3a		-6,5	17,26	115,02
E69	-24,08	TPH1536	2	2100-2000	-6,4	18,11	158,84

APPENDIX F.3. STABLE CARBON ISOTOPE RESULTS OF BARLEY

Table 43. Stable carbon isotope values of barley.

ISOTOPE VALUES OF BARLEY							
	$\delta^{13}C$ (Gas)	**Sample No**	**Layer**	**Date (ca. BC)**	**$\delta^{13}C$ (Air)**	**D13C**	**Water Input (mm)**
E48	-22,66	AT21252	4	1300-1200	-6,5	16,54	92,59
E49	-22,84	AT21252	4		-6,5	16,72	99,06
E5	-23,14	AT12969	5b	1750-1650	-6,5	17,03	110,91
E21	-24,27	AT11729	VII	1750-1650	-6,5	18,22	170,50
E22	-22,78	AT11729	VII		-6,5	16,66	96,84
E23	-23,52	AT11729	VII		-6,5	17,43	128,15
E24	-24,40	AT11729	VII		-6,5	18,34	178,61
E25	-23,45	AT11729	VII		-6,5	17,36	124,78
E26	-24,23	AT11729	VII		-6,5	18,17	167,54
E67	-24,78	TPH385	3a	2000-1900	-6,5	18,75	206,90
E79	-23,56	TPH247	3a		-6,5	17,47	130,02
E80	-23,90	TPH247	3a		-6,5	17,82	147,80
E70	-23,56	TPH1536	2	2100-2000	-6,4	17,58	135,13

APPENDIX G. TURKISH SUMMARY/TÜRKÇE ÖZET

Son 11500 yıllık döneme jeolojik zaman ölçeğinde Holosen adı verilir. Bu, Dünya tarihindeki en son buzularası dönemdir. Buzularası dönemler, organizmaların gelişmesi için uygun bir iklim sağlasa bile, güneş radyasyonu, okyanus suyu sirkülasyonu ve diğer birçok faktördeki değişiklikler nedeniyle hızlı iklim değişiklikleri meydana gelebilir ve insan toplumlarının biyolojik, kültürel, ekonomik, ideolojik ilerlemesini kesintiye uğratabilir. Holosen döneminin küresel ölçekte altı farklı hızlı iklim değişikliğine tanık olduğu öne sürülmüş olup bunlardan ikisi, literatürde 4.2 ka ve 3.2 ka olayları olarak bilinen iklim değişiklikleridir. Bahsedilen türde iklim değişiklikleri, yıllık sıcaklık ve yağış azalışını beraberinde getirdiğinden, bitkiler üzerinde, buna bağlı olarak tarım ve tarımsal verim üzerinde doğrudan ve hızlı bir etkiye sahiptir. Arkeolojik alanlarda bulunan arkeobotanik kalıntılarda ise bu değişimin izlerini görmek mümkündür. Dolayısıyla, arkeobotanik, paleoklimatoloji çalışmalarına ve iklimin tarımsal sistemler üzerindeki etkilerinin yorumlanmasına katkıda bulunma potansiyeline sahiptir. Arkebotanik, bu etkilerin ortaya çıkarılmasına yardımcı olabileceği gibi, geçmiş toplumlarda iklim değişikliğine verilen sosyal ve ekonomik tepkiler hakkında da ipuçları verebilir ve bu tepkilerin zaman içerisindeki evrimine ışık tutabilir.

Bu tez, jeoloji bilimleri literatüründe MÖ 2200 ve 1200 yıllarında 4.2 ka ve 3.2 ka olayları olarak da bilinen ani iklim değişikliklerine özel olarak odaklanmaktadır. Çalışma alanları, Hatay ilinin Amik Ovası bölgesinde yer alan Tell Atchana ve Toprakhisar Höyük'tür. Bu höyüklerde iklim değişikliğinin neden olduğu tarımsal uygulamalarda, tarım ürünlerinde ve tüketim kalıplarında meydana gelebilecek olası değişimler, MÖ 2200 ile MÖ 1200 arasındaki yaklaşık 1000 yılı kapsayan makrobotanik kalıntılar yardımıyla araştırılacaktır. Bu tezin temel araştırma soruları aşağıdaki verildiği gibidir:

1) 3.2 ka ve 4.2 ka iklim anomalileri Tell Atchana ve Toprakhisar Höyük'teki tarım sistemlerini değiştirdi mi?

2) Eğer değiştirdiyse, bu değişikliğin derecesi neydi?

3) Tell Atchana ve Toprakhisar Höyük'lerinden alınan tahıl tohumlarında, iklim değişikliğine bağlı oluşan su kıtlığının izleri görünüyor mu?

4) Tahıllarda gözlemlenen su kıtlığı, höyük sakinlerinin tüketim tercihlerini etkiledi mi? Başka bir deyişle, insanlar tüketim stratejilerini değiştirdi mi?

Tarım üzerindeki iklimsel etkiler hakkında fikir yürütebilmek için, arkeobotanik buluntularda temel olarak dört noktaya odaklanılmıştır:

a) *Bütün arpa tohumlarının buğday tohumlarına oranı*. Arpa kuraklığa dayanıklı bir tür olduğundan, çiftçiler su sıkıntısı zamanlarında temel ürün olarak arpayı tercih etmiş olabilirler. Sonuç olarak, iklim değişikliklerine denk gelen arkeolojik seviyelerden gelen arkeobotanik örneklerde, arpanın buğdaya göre daha yüksek oranda görülmesi beklenmektedir.

b) *Buğday tohumlarının boyutundaki değişim*. Su stresi ve soğuk iklim, bitkilerin büyüme hızı üzerinde olumsuz bir etkiye sahiptir. İklim değişikliğinin getirdiği, soğuk ve kurak koşullarda yetiştirilen buğday, daha optimal koşullarda üretilenlerden daha küçük olmalıdır. Zaman içindeki buğday boyutu değişimini görmek için, tohumlar üzerinde morfometrik analizler yapılmıştır.

c) *Kararlı karbon izotop bileşimindeki değişiklikler*. Düşük nem ve kurak koşullar, düşük $\Delta^{13}C$ değerleri ile kendini göstermektedir. Aksine yüksek $\Delta^{13}C$ değerleri, kaynağı hakkında bilgi vermese de bitkilerin büyüdüğü ortamda nemin var olduğunu gösterir (örneğin; nemin kaynağı hem yağmur suyu hem de sulama suyu olabilir). Bu nedenle $\Delta^{13}C$ analizi iklim değişikliği dönemlerinden alınan tohum örneklerinde düşük değerler vermesi beklenmektedir.

d) *İnsanların tükettiği yabani bitkilerin tür ve oranındaki değişiklikler*. Gıda kıtlığı insanları alternatif gıda kaynakları bulmaya zorlayabilir.

> Bu alternatif besin kaynakları, geçmiş toplumlar için çevrelerinde doğal olarak yetişen yabani bitkilerdi. Dolayısıyla, 4.2 ka ve 3.2 ka iklim olaylarının gerçekleştiği döneme ait örneklerde daha yüksek oranda yabani bitki görülmesi beklenmektedir. Ek olarak, kurak iklim nedeniyle flora değiştiğinden, örneklerde daha fazla sayıda kuraklığa dayanıklı bitki türü bulunması beklenmektedir.

Yukarıda belirtilen değişimlerin yalnızca iklim değişikliğinden kaynaklı olmayabileceği, sosyo-kültürel, ekonomik ve politik değişimlerin de arkeobotanik veri üzerinde etkili olabileceği unutulmamalıdır. Ayrıca, çevresel bir strese karşı, insan toplulukları tarafından birçok tepki verilebilir. Bunlardan başlıca 4 gruba ayrılabilir: dirençlilik, göç etme, çöküş ve tepkisizlik. Bunların ilki olan dirençlilikte, topluluklar çevresel/iklimsel değişikliklerden kaynaklı oluşan baskıya sosyal, politik, teknolojik ve ekonomik sistemlerini değiştirerek karşı koyabilirler. Tepkilerden "göç etme" de ise insanlar yeni kaynak arayışında olup, yaşadıkları şehirlerden topluluklar halinde ayrılırlar. Çöküş, toplulukların kurduğu bütün sistemlerin işlevini yitirip, çökmesi anlamına gelir ve toplumların çevresel değişikliklere verebileceği en ekstrem tepkidir. Tepkisizlik, değişimin insanların hayatını etkilemediği durumlarda gözlenir. Topluluklar normal yaşamlarına devam edebilir haldedirler.

Bu tezde verilen tepkinin derecesini tarım üzerinden inceleneceği için arkeobotanik veriye odaklanılmıştır. Bu amaca ulaşmak için 4 farklı analiz yapılmıştır. Bunlardan ilki arkeobotanik örneklerdeki tahıllar üzerinde oran analizidir. İkinci olarak buğday tohumları üzerinde morfometrik analizler yapılmıştır. Üçüncü olarak yabani bitki ekolojisi anlaşılmaya çalışılmıştır ve son olarak arpa ve buğday tohumları üzerinde kararlı karbon izotop analizleri yapılmıştır.

Analizlerin detaylarına geçmeden önce Toprakhisar Höyük ve Tell Atchana'nın tarihine bakmak yararlı olacaktır. Hatay'ın Altınözü ilçesinde yer alan Toprakhisar Höyük, 2 hektarlık bir alana yayılmaktadır. Höyüğü çevreleyen Yarseli barajı ve modern Toprakhisar Köyü'ndeki yerleşimin yol açtığı tahribat nedeniyle alanın net genişliği bilinmemektedir. Alanda yapılan yüzey araştırmaları Kalkolitik dönemden Demir Çağı'na uzanan bir yerleşim tarihine işaret etmektedir. Yüzey araştırmasında karşılaşılan en erken çanak çömlek parçaları Amik D dönemine (MÖ 5500-5000) aittir. Ancak bu yüzey araştırmasında ele geçen en bol çanak çömlek parçaları Amuq E evresine (MÖ 5000/4900-4400/4300) aittir. Geç Kalkolitik Dönem'e (Amuq F-MÖ 4. yy başları) tarihlenen seramikler de yerleşmede bulunmuştur. Höyükte yerleşim muhtemelen Amik G evresinde de devam etmiştir. Amuq H-I evresi çanak çömleği, MÖ 2700-2500 yıllarına tarihlenen bir arkeolojik tabaka olabileceğini göstermektedir. Amuq J dönemine tarihlenen seramikler, Erken Tunç Çağı'nda yerleşimin kesintisiz devam ettiğini göstermektedir. Yüzey araştırmasında Orta Tunç Çağı yerleşimine tarihlendirilebilecek çanak çömlek bulunamamasına rağmen, bu dönemin yerleşim yerindeki varlığı sonradan Hatay Arkeoloji Müzesi tarafından başlatılan kurtarma kazılarında ortaya çıkarılmıştır. Alanın üst kısmında, Toprakhisar'ın Demir Çağı I ve Demir Çağı II dönemlerinde devam ettiğini gösteren az miktarda Amik N ve Amuq O seramiğine rastlanmıştır. Toprakhisar Höyük, Toprakhisar'a yaklaşık 15 km uzaklıkta bulunan MÖ 2. binyılda Alalah şehrinin kontrolündeki kırsal çevre yerleşimlerinden biri olarak tanımlanmıştır. Alalah'ın VII. Tabaka Sarayı'ndan gelen iki tablet, Yarim Lim'in (I) kardeşi ile yaptığı anlaşmayla Alalah ve çevresindeki 17 yerleşim yerini daha ele geçirdiğini ortaya koyuyor. Yarim-Lim'in kontrolüne geçilen bu 17 yerden biri de muhtemelen Toprakhisar'dı. Buna ek olarak, Toprakhisar'ın Alalah metinlerinde bahsedilen zeytinyağı üretiminde uzmanlaşmış yerlerden biri olabileceği öne sürülmektedir. Alandaki kazılarda bulunan Orta Tunç Çağı idari binası (Bina 2), başkent kontrolü altında profesyonel zeytin üretiminin yapıldığına dair arkeolojik kanıtlar sunmaktadır. Depolama ve pişirme için kullanılan geniş alanların da zeytin işleme faaliyetleriyle alakalı olabileceği düşünülmektedir. Bina 2'nin yangın tahribatı izi vardır ve bu yangınla binanın kullanımı sona ermiştir.

Atchana, Amik Ovası'ndaki başlıca Orta Tunç Çağı yerleşimlerinden biriydi ve iskanı Geç Tunç Çağı'nda da devam etti. Atchana bunlardan başka hiçbir dönemde iskân edilmemiştir. Tell Atchana ve komşu höyüğü Tell Tayinat arasında değişimli bir yerleşim vardı. Erken Tunç Çağı'nda insanlar Tell Tayinat'ta yerleşmiş, ancak OTÇ ve GTÇ'de Tell Atchana'ya taşınmışlardır. GTÇ'nin sonunda, Atchana yeniden terkedilmiş ve yerleşim Tayinat'a kaymıştır. Asi Nehri'nin değişen nehir yatağının iki bölge arasındaki bu salınımlı işgale neden olduğu öne sürülmektedir. Atchana, OTÇ döneminde 22 hektarlık alanıyla Amik ovasındaki en önemli yerleşim yeridir ve Mukiş Krallığı'nın başkenti olarak hizmet etmiştir. Yerleşim MÖ 2. binyılda Alalah olarak adlandırılmış ve bugün Suriye'nin Halep şehrinde bulunan Yamhad Krallığı'nın vasal devleti olarak hizmet vermiştir. Yaklaşık olarak MÖ 1650-1600 yıllarına tarihlenen ve Kral Niqmepa tarafından inşa edilen VII. Seviye Sarayı, Alalah'ın OTÇ'deki idari karakterinin arkeolojik kanıtlarını verir. Anadolu, Levant, Mezopotamya ve Akdeniz arasında bir kavşak noktası olan kent, bu dönemde ticaret yollarından yararlanabilmiş ve gelişmeye devam etmiştir. Kazılarda bulunan egzotik malzemeler, şehrin yalnızca yakın çevresiyle değil, uzak bölgelerle de dinamik ilişkilere sahip olduğunu göstermektedir. Alalah'ta OTÇ yerleşiminin bitişi, Seviye VII Sarayı'nın yangınla yok edilmesiyle kendini göstermektedir. Sonraki dönemde, GTÇ I, Alalah kısa bir süre için idari gücünü elinde tutmuş ve MÖ 1450 civarında Kral İdrimi tarafından Seviye IV Saray'ı inşa edilmiştir. Ayrıca bu dönemde Alalah'ın vassallığı Mitanni Krallığı'na geçmiştir. Alalah, GTÇ'de, Hititlerin Suriye yayılma politikasında hedeflerden biri haline gelmiştir. Hititler ilk olarak 17. yüzyılda I. Hattuşili komutasında Alalah'a saldırmışlar ve Alalah birlikleri üzerinde silik bir başarı elde etmişlerdir. Bu saldırıdan sonra hızla toparlanan kent, MÖ 15. yüzyılın ilk yarısında Mitanni kralı Paratarna'dan gelen yardımlar sayesinde eski gücüne kavuşmuştur. Ancak 14. yüzyılda Hititlerin bir başka askeri seferi kenti yeniden hedef almıştır. Bu saldırıda Hititler Alalah'ı ele geçirmiş ve hakimiyetleri başlamıştır. Hititlerin Amik Ovası üzerindeki hakimiyeti MÖ 14. yüzyılın son otuz yılından MÖ 13. yüzyılın sonuna kadar yaklaşık 130 yıl sürmüş ve Alalah bu hâkimiyet boyunca idari karakterini korumuştur. Ancak Alalah üzerindeki Hitit hakimiyeti, arkeolojik olarak sadece kerpiçten yapılmış devasa kalelerde görülebilmekte, yazılı metinlerde ise belirgin bir şekilde belirtilmemektedir. Hititlerin son yıllarında Mukiş Krallığı ve muhtemelen Alalah, hububatın Orta Anadolu'daki Hitit anakarasına sevkiyatında rol oynamıştır. İlginçtir ki Ugarit arşivlerinden gelen metinlere göre aynı dönemde Amik ovasının refahı iyi değildi. MÖ 13. yüzyılın son çeyreği ile MÖ 12. yüzyılın başlarında Alalakh ve Mukiş, tarımını canlandırmak için dışarıdan işgücü yardımına ihtiyaç duymuştur.

Hem Aççana hem de Toprakhisar Höyüklerinde örnekler en başta toprak örneği olarak toplanmaktadır. Kazı işlemi yapılan her plan-karede *locus* olarak adlandırılan ve plankarenin ayrı bölümlerine işaret eden sistem kullanılmaktadır. Başka bir deyişle plan-kare içindeki her bir yapı (duvar, ocak, oda, silo vb.) kendi *locus* numarasına sahiptir. Locuslardan sistematik şekilde yaklaşık 30 L toprak örneği flotasyon işlemi için alınmaktadır. Bununla birlikte, eğer bir alanın yanmış bitki kalıntısı içerdiği görülürse bu alandan da toprak örneği alınmaktadır. Dolayısıyla her iki höyükte de "sistematik" ve "yargısal" örnekleme yöntemlerinin kullanıldığı söylenebilir. Araziden kazıevine taşınan toprak örnekleri, burada bulunan Ankara-tipi flotasyon makinesi yardımıyla yüzdürülür. Flotasyon işlemi sırasında üstte kalan yanmış bitki ve kömür örnekleri toplanır ve kurutulur. Ayıklanan örneklere daha sonra laboratuvar ortamında muamele edilir. Elde edilen arkeobotanik örnekler bir elek yardımıyla 4 mm, 2 mm, 1 mm, 500 mikron ve 250 mikronluk parçalara ayrılır. 4-, 2-, ve 1 mm'lik örnekler bir resim fırçası yardımıyla mikroskop altında ayıklanır ve ayrı türlerden ait tohumlar ayrı Eppendorf tüplere konulur. Tür saptama işlemleri çeşitli kılavuz kitaplar ve referans koleksiyonu yardımıyla gerçekleştirilir. Bu çalışma arpa ve buğday tohumlarına odaklandığı için bu tohumların tanımlanması yapıldıktan sonra, iyi korunmuş olan tohumların, Leica S8AP0 model stereo mikroskopa bağlı kamera altında önden (ventral), arkadan (dorsal), ve yandan (side) fotoğrafları çekilmiş ve yine bu kameraya bağlı bir uygulamayla boyut ölçümü yapılmıştır. Çalışmalar boyunca, tohum sayısına en yakın değerlerle çalışabilmek adına yalnızca embriyosu olan tohumlar analize tabi tutulmuş ve sayılmıştır.

Yanma olayı sırasında buğday tohumlarının boylarının kısaldığı, en ve kalınlıklarının ise arttığı yapılan deneysel arkeoloji çalışmaları esnasında kanıtlanmıştır. Dolayısıyla buğday boyutundaki değişimi anlamaya çalışırken yalnızca boy yahut yalnızca en ölçümünü kullanmak ve buna göre değişim olup olmadığı konusunda çıkarım yapmanın doğru sonuçlar vermeyeceği düşünülmüştür. Yanma esnasında meydana gelen boy uzunluğundaki kısalmayı ve en uzunluğundaki artmayı dengelemek adına hacim ve yüzey alanı hesaplamanın ve bunlardaki değişime bakmanın en iyi analiz sonucunu vereceği düşünülmüştür. Modern buğdaylar üzerinde yapılan çalışmalarda buğdaylar üçboyutlu elipsoit (triaxial ellipsoid) olarak değerlendirilmiş, buğday hacmi ve yüzey alanı buna göre hesaplanmıştır. Bu bakış açısından yola çıkılarak bu çalışmada da buğdaylardan alınan ölçümler, üçboyutlu elipsoit hacmi ve yüzey alanı formülleri kullanılarak hesaplanmıştır.

Kararlı karbon izotopu analizleri kabuksuz buğday, kabuklu buğday ve arpa tohumları üzerinde yapılmıştır. Örnekler, değişimi daha net görebilmek için mümkün olduğunca çok çeşitli arkeolojik katmanlardan ve farklı bağlamlardan alınmıştır. Ek olarak, numune içi sapmaları belirlemek için -mümkün olduğunda- analize birden fazla tohum gönderilmiştir.

Örneklerde bulunan yabani bitkiler ekolojik davranışlarına göre gruplandırılmıştır. Bu gruplar eko-gruplar olarak adlandırılır ve dört ana eko-grup vardır: açık bitki örtüsü, kurak alan, sulak alan, tahıl zararlısı otlar. Açık bitki örtüsü, çok çeşitli habitatları içerir. Sulak alan türleri temel olarak nemi seven ve tatlı su veya kıyı ekosistemlerinde yetişen bitkileri ifade eder. Tahıl zararlısı yabani otlar, genellikle ekinlerin yakınında, bozuk/ekilebilir arazilerde yetişen bitkilerdir. Yaşadıkları habitatlar göz önüne alınarak, Atchana çevresinde suyun varlığına/yokluğuna dair kanıtlar bulunması amaçlanmıştır.

Üstte verilen analizlerden sonra çeşitli tahılların farklı tabakalarla ilişkisini görmek için Uygunluk Analizi, tohum boyutundaki değişimin istatistiksel olarak anlamlı olup olmadığını anlamak içinse Mann-Whitney U testi yapılmıştır.

Toprakhisar’dan alınan örnekler toplamda 2 plan kareden gelmekte olup MÖ 2100-1900 tarihlenen toplam 5 tabakayı temsil etmektedir. Bu höyükten alınan örneklerin toplam sayısı 75tir. Atchana’dan alınan örnekler toplamda 3 plan kareyi ve MÖ 1750-1100 arasına tarihlenen toplamda 11 tabakayı temsil etmektedir. Bu höyükten alınan örneklerin toplam sayısı ise 209dur.

Arkeobotanik örnekler üzerinde yapılan analizlerde Toprakhisar ve Atchana’dan gelen örnekler daha iyi anlaşılması için birlikte değerlendirildiğinde, İTÇ'den OTÇ'ye geçişte kabuksuz buğdayın varlığının arttığı görülmüştür. İTÇ'nin en sonuna tarihlenebilecek 54.38 plan karesi 1. Evre'sinde (MÖ 2100-2000), kabuksuz buğdayın örneklerde hiç bulunmaması dikkat çekicidir. Ancak OTÇ'nin başlamasıyla birlikte bu buğday yeniden görülmeye başlanmıştır. Nitekim kabuksuz buğday, OTÇ’ye ait örneklerde, en yüksek oranlara ulaşmaktadır. Genellikle bu örneklerdeki tahılların toplamının %40'ından fazladır. Kabuksuz buğdayın öneminin artmasının nedeni, kuraklığa duyarlı bu tahıl türlerinin yetiştirilmesini sağlayan olumlu çevre koşulları olabilir. İTÇ'nin sonundaki arpa tanesi oranı, OTÇ'ye göre çok yüksektir. İTÇ örneklerinde arpa, burada tartışılan tahılların yarısından fazlasını temsil etmektedir. Ancak, OTÇ sırasında önemi giderek azalmış ve bu dönemde baskın ürün haline gelmemiştir. Kabuklu buğday hem İTÇ hem de OTÇ'de mevcuttur. İTÇ'de 54.38 açmasının 1. Evre'sinde kabuklu buğdayın arpa ile birlikte bulunması ve kabuksuz buğdayın bulunmaması, bu dönemin, çevresel baskının etkilerinin Toprakhisar Höyük yerleşimcileri tarafından en çok hissedildiği dönem olabileceğini düşündürmektedir. Arkeobotanik örnekler, OTÇ döneminde kavuzlu buğdayın önemi giderek azaldığını göstermiştir. Dolayısıyla, OTÇ sırasındaki iyi çevre koşullarının kavuzlu buğday türlerinin yetiştirilmesi gerekliliğini ortadan kaldırması nedeniyle bu buğday türünün öneminin azaldığı öne sürülebilir.

OTÇ'den GTÇ'ye geçişte, kabuksuz buğdayın örneklerdeki varlığı tekrar azalmaya başlamıştır. Evre bazında düşünüldüğünde farklı evrelerde dalgalanmalar olup, kabuksuz buğdayın diğer tahıllara oranı artıp ve azalmaktadır. Ancak genel eğilime bakıldığında, ilerleyen dönemlerde bir azalma trendi olduğu görülmüş ve kabuksuz buğday örneklerde hiçbir zaman OTÇ'de olduğu kadar yüksek oranda görülmemiştir. Kabuksuz buğdayının öneminin azalmasıyla birlikte arpa, GTÇ'de yeniden önemini kazanmaya başlamış görünmektedir. Arpa kabuklu buğday türleri ile GTÇ'nin baskın tahılı haline gelmiştir. Bir önceki paragrafta bahsedildiği gibi kavuzlu buğday türlerinin OTÇ'deki önemi azalmış, ancak OTÇ'de özellikle 42.10 plan karesi 4. Evre'sinde (MÖ 1300-1200) yüksek oranlarda görülmeye başlanmıştır. Kabuklu buğday türlerinin artan önemi, GTÇ'nin sonlarına doğru artan ve Yakın Doğu'da birçok yerde deneyimlenen kuraklıkla ilişkili olabilir. Dolayısıyla artan kuraklık sırasında direnci için gernik buğdayı ekilmiş ve tüketilmiş olabilir.

Uygunluk Analizi, Toprakhisar'da MÖ 3. binyılın sonunun (MÖ 2100-2000, 54.38 plan kare) arpa ve kavuzlu buğday ile yüksek oranda ilişkili olduğunu ancak bu yakın ilişkinin 2. binyılın başına (51/52.37 plan kareleri MÖ 2000-1900) ait örneklerde ya zayıfladığını ya da kaybolduğunu ortaya çıkarmıştır. Atchana'dan elde edilen sonuçlar ise, kuraklığa dayanıklı kabuklu buğday ve arpanın 42.10 plan karesinin GTÇ katmanları ile özellikle MÖ 14. yüzyılın ikinci yarısının başlangıcından GTÇ'nin sonuna kadar güçlü bir şekilde ilişkili olduğu görülmektedir (MÖ 1350-1200) Öte yandan, kuraklığa duyarlı kabuksuz buğday, çoğunlukla 42.10 plan karesi 7. Tabaka (MÖ 1400-1350) ve 32.57 plan karesi OTÇ (Tabakalar 3,4,5) (1750-1400) tabakalarıyla ilintilidir. Ek olarak, kabuklu buğday, kabuksuz buğdayın ilişkili olduğu bu tabakalarla güçlü bir negatif ilişkiye sahiptir. 42.10'un 7. Tabakası, örneklerin zenginliğinden dolayı temsil gücü yüksek bir tabakadır. Tabaka 7'nin bulguları, kabuksuz buğdayın ekilen tahıllar arasında hala önemli bir yer tuttuğunun ancak GTÇ'nin başlamasıyla arpanın öneminin arttığına işaret etmektedir. Atchana'dan elde edilen sonuçlar, OTÇ ve GTÇ'nin başlangıcının kabuksuz buğdayın tüketimi ile karakterize olduğunun, buna karşın GTÇ'nin ilerleyen dönemlerinin arpa ve kabuklu buğday tüketiminin öne çıktığını göstermektedir. Zaten OTÇ olarak ve GTÇ'nin başlangıcının iyi çevre koşullarının hâkim olduğu bir dönem olması gerekmektedir. Dolayısıyla, bu zaman dilimlerinde, çiftçiler muhtemelen ana tahıl olarak kabuksuz buğday üretebiliyor olması beklenmektedir. Ayrıca, yaklaşan 3.2 ka iklim olayının GTÇ'nin sonuna doğru bir etki yaratmaya başlaması da beklenebilir. Sonuçlar, kuraklığa dayanıklı türler daha güçlü mevcudiyet ile daha görünür hale geldiğinden, GTÇ'nin ilerleyen dönemlerinde de bu beklentiyi karşılamaktadır.

Morfometrik ölçümler kabuklu ve kabuksuz buğdaylar üzerinde yapılmıştır. Toprakhisar örneklerine ait ölçülen kabuksuz buğday sayısı 15, kabuklu buğdayların sayısı ise 8dir. Yapılan ölçümler sonucunda hesaplanan hacim ve yüzey alanı hesaplamaları, MÖ 2100-2000 tarihlerine ait kabuklu ve kabuksuz buğday örneklerinin ortalama değerlerinin MÖ 2000-1900 arasına tarihlenen örneklerden daha büyük olduğunu göstermiştir. Atchana'dan gelen örnekler içinden alınıp ölçülen toplam kabuksuz buğday sayısı 59, kabuklu buğday sayısı 18dir. Atchana'dan gelen kabuksuz buğday örnekleri OTÇ ve GTÇ dönemleri için ayrı ayrı değerlendirildiğinde OTÇ'den GTÇ'ye hem ortalama hacim değerinin hem de ortalama yüzey alanının küçük bir düşüş yaşadığı görülmüştür. Bunun aksine kabuklu buğday örnekleri OTÇ'de, GTÇ'ye kıyasla daha düşük ortalama değerlere sahiptir. Morfometrik sonuçlar üzerinde yapılan Mann-Whitney U testi ise tohumlar arasındaki farklı periyotlarda gözlemlenen boyut farkının yalnızca Toprakhisar kabuklu buğdayları ve

Atchana OTÇ kabuklu buğdayları karşılaştırıldığında istatistiksel olarak anlamlı olduğunu göstermiştir. Bu karşılaştırmada, Toprakhisar kabuklu buğdaylarının, Atchana OTÇ kabuklu buğdaylarından istatistiksel olarak anlamlı şekilde küçük olduğu bulunmuştur.

Kararlı karbon izotopu analizi sonuçları hiçbir kabuksuz buğdayın ciddi su stresiyle büyümediğini, yalnızca bazı tohumların hafif su stresi altında yetiştiğini göstermiştir. Kabuklu buğdaylar içinde durum aynı olmakla birlikte, hafif su stresi altında yetiştirilen kabuklu buğday sayısının, kabuksuz buğday sayısına oranla daha fazla olduğu gözlemlenmiştir. Arpada da durum aynı olup hiçbir tohumun ciddi su stresiyle büyümediği sonucuna ulaşılmıştır. Ancak özellikle arpa sonuçları MÖ 1300-1200 arasında artan su stresine işaret etmektedir.

Örnekler içinde bulunan yabani bitki taksonları ve onların ekolojisi, Toprakhisar'da MÖ 2100-2000 (54.38 plan karesi evreleri) tarihlerine ait evrelerin daha yüksek miktarlarda sulak alan türleri ile karakterize olduğunu, MÖ 2000-1900 (51/52.37 plan karesi evreleri) dönemine tarihlenen evrelerin ise kurak alan bitkileri ile temsil edildiğini göstermektedir. Yine yabani bitkiler, Atchana'daki GTÇ iskanının farklı aşamalarında sulak alanda yetişen taksonların baskın olduğunu göstermiştir. Kurak alan bitkileri de mevcut olmakla birlikte, hiçbir zaman örneklerde sulak alan bitkileri kadar baskın olmamışlardır. Bu durum, değişen dönemler boyunca, Atchana çevresinde sulak alanların var olduğu ihtimali ile ilişkilendirilmiştir.

Bu çalışmada, Tunç Çağı iklim değişikliklerinin olası etkilerini ve bu değişikliklerin Atchana ve Toprakhisar tarımındaki derecesini anlamak için arkeobotanik verilerin çeşitli yönlerine odaklanılmıştır. İlk olarak, mahsul bitki taksonlarındaki tahılların örneklerinin içeriğini ve nispi oranlarını görmek için arkeobotanik analizler yapılmıştır. İkinci olarak, kabuksuz ve kabuklu buğday türlerinde iklim değişikliğine denk gelen dönemlerde boyut değişimlerini tespit etmek için morfometrik ölçümler yapılmıştır. Üçüncü olarak, kabuksuz buğday, kabuklu buğday ve arpa taneleri, su kıtlığı/kuraklığından kaynaklanmış olabilecek, izotop içeriklerindeki değişiklikleri görmek için kararlı karbon izotop analizine gönderilmiştir. Son olarak, yabani bitki taksonları, yabani ot ekolojisi ve yabani:bitki oranı dahil olmak üzere çeşitli yönlerden incelenmiştir.

Arkeobotanik sonuçlar, kabuklu buğday ve arpanın özellikle MÖ 1350'den MÖ 1200'e kadar Atchana'da ve 3. binyılın sonlarında Toprakhisar'da (MÖ 2100-2000) kullanımına yönelik artan bir eğilim olduğunu göstermektedir. Her iki höyükte de kuraklığa dayanıklı türlerdeki artışın zamanlaması teorik olarak bitki tüketim modellerindeki değişikliklerin tartışılan iklim değişiklikleriyle ilgili olabileceğini düşündürmektedir. Yaklaşan 3.2 ka iklim değişikliği ve devam eden 4.2 ka iklim değişikliğinin bölgedeki kuraklığı artırmış ve dönem çiftçilerinde daha dayanıklı türlerin yetiştirilmesine yönelik bir eğilime neden olmuş olması çok muhtemeldir. Ancak GTÇ Atchana'da arpa ve kabuklu buğdayın tercih edilmesi, değişen siyasi güç ve tarım politikası ile de ilişkilendirilebilir. Alalah'ta kabuklu buğday ve arpadaki artış Hitit hegemonyası dönemine de denk geldiği için, Hititlerin bu türleri tercih etmesinin Alalah çiftçilerini bu türlerin tarımına zorlamış olabileceği de iddia edilebilir. Az sayıda örneğin analiz edilmiş olması, morfometrik ölçümlerin ve izotop analizinin güvenilirliğini zayıflatsa da bir ön bilgi verme açısından önemlidir. Bu analizlerin sonuçları, zaman içerisinde küçülme veya artan kuraklığı gösteren özel bir eğilim göstermemiştir. Atchana kabuklu buğday taneleri ile karşılaştırıldığında, sadece Toprakhisar'a ait kabuklu buğdaylarda boyut küçülmesi gözlemlenmiştir. Bu, 4.2 ka olayı sırasında Toprakhisar bitkilerinin yaşadığı kuraklıkla ilgili olabilir. Toprakhisar örnekleri, Atchana'nın iyi çevre koşullarının yaşandığı bir döneme tarihlenen OTÇ örnekleri ile karşılaştırıldığında, Toprakhisar tanelerinin Atchana tanelerinden daha küçük olması beklenmektedir ve sonuçlar bu beklentiyi karşılamıştır. Bu iki höyüğün kabuksuz buğday taneleri arasında, istatistiksel olarak önemli bir tane boyutu farkının olmamasının nedeni, kabuksuz buğdayın sulanması ile ilgili olabilir. Toprakhisar çiftçileri, yağışların azaldığı zamanlarda kuraklığa duyarlı serbest harman buğdayını bir şekilde suladıysa, Toprakhisar'dan gelen serbest harman tanelerinin daha büyük boyutlara ulaşması ve Atchana örnekleriyle bir boyut farkının olmaması beklenebilir. Son olarak, yabancı bitki ekolojisi, Toprakhisar'da MÖ 2. binyılın başında kuru habitatlarda yetişen cinslerdeki artışa işaret etmektedir. Teorik olarak, iklim değişikliğinin neden olduğu su kıtlığı dönemlerinde örneklerde kurak alan bitkilerinin daha bol görülmesi beklenmekteydi. Dolayısıyla, kurak alanlarda yetişen yabani bitki cinslerinin oranındaki artış, o dönemde daha kurak çevresel koşulların mevcut olduğunu göstermektedir. Bu dönem 4.2 ka olayına denk geldiği için bu argüman oldukça olasıdır.

Genel olarak, bu tezin sonuçları Toprakhisar'da MÖ 3. binyıldan 2. binyıla geçişte daha kurak koşullarda yetişebilen domestik ve yabani bitkilerin tüketimine doğru bir kayma olduğunu göstermektedir. Atchana'dan gelen ekin bitkisi taksonları da GTÇ'nin sonuna doğru kuraklığa dayanıklı tahılların artan oranlarda kullanıldığını göstermektedir. Morfometrik ve kararlı karbon izotop analizlerinde, özellikle kabuklu buğday tohumları, daha küçük boyutlara ve artan su stresine işaret eden sonuçlar vermektedir. Bitkilerin bu iki karakteri kuraklık ile ilişkilendirildiği için, bu değişimler söz konusu dönemlerde iklim değişikliğinin artan etkileri olduğu ihtimalini de desteklemektedir. Arkeobotanik veriler, her iki bölgede de büyük bir çöküş olmadan tarımsal uygulamaların devam ettiğini gösterse de tüketilen bitki türlerindeki değişiklik ve bu bitkilerin izotopik içeriği, 4.2 ka BP ve 3.2 ka BP olaylarına denk gelen zamanlarda biraz daha kurak koşullara işaret etmektedir.

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TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English): Tracing the Impact of 4.2 ka and 3.2 ka BP Climatic Events on the Agriculture of Tell Atchana and Toprakhisar Sites in the Hatay Region through Multidisciplinary Examination of Archaeobotanical Assemblages

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans** / Master ☒ **Doktora** / PhD ☐

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