



# **OLIVE OIL PRODUCTION IN A SEMI-ARID AREA: EVIDENCE FROM ROMAN TELL ES-SUKHNAH, JORDAN**

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## **ABSTRACT**

Olive cultivation and oil pressing can be considered as cultural phenomenon characterizing the Mediterranean area. With special reference to the southern Levant, the culture – history of olive cultivation can be traced back as far as to the Late Neolithic \ Chalcolithic Period. Meanwhile, oil pressing began later on, especially during the Bronze Ages and has lasted until the present time. During the Roman period, olive pressing flourished as indicated by the uncovering of several oil pressing installations. However, the newly complete discovered olive press at the archaeological site of Tell Es-Sukhnah, Jordan shed more light on both the technique of olive pressing and the economic significance of olive beyond the core area of olive cultivation. It helps understanding the economic importance of the north-eastern part of Jordan during the Roman period, an area that can be considered a semi-arid one.

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**KEYWORDS:** Olive oil production, Olive press, Roman period, Tell Es-Sukhnah, Jordan.

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## 1. INTRODUCTION

The archaeobotanical evidence from the Mediterranean area showed that olive cultivation has been attested in different spatio-temporal contexts. Direct evidence of olive cultivation has been uncovered in the archaeological record of the southern Levant at sites such as T. Ghassual and Abu Hamid in the Jordan Valley and dates back to the Chalcolithic period (Zohary, Hopf and Weiss 2011, 20). Evidence of olive production included fragments of crushed stones which usually are considered as a waste product of pressing activity. Other argues that olive production can be traced back to the late Neolithic and early Chalcolithic period as has been found at sites in the Carmel coast (Galili et al. 1997; Liphshitz et al. 1991) While, more clear evidence of olive production came out during the early Bronze Age (Salavert 2008). At around 3200-2700 BC Crete evidence of oil is being produced (Koh and Betancourt 2010). However, at Early Bronze Ages sites both botanical evidence and archaeological installations correlated to olive pressing have been found. These include installations used for the extraction of oil, such as mortars and pits in a ceramic paved floor.

During the Late Bronze Age (ca. 1550-1200 BC) evidence of olive oil production has been found at several sites in the southern Levant (Beeri 2008). The scale of olive oil production has been suggested to have been at village scale or *cottage* scale. It served a family or a group of families. Installations of olive oil production were found either inside residential complexes or outdoors in a courtyard. These installations can be simply described as consisting of an open, round conical vat, either built below floor surface or ca. 10 cm below surface, and including a basin as means of collecting the pressed oil. The basin is either as pot or a stone bowl or a basin hewn into the stone bottom (Beeri 2008, 159-160). The changing scale of olive oil production, mainly during the Bronze Ages, was

correlated with increase demand of the Egyptian (Milevski 2005).

Olive oil production changed remarkably during the Iron Age (1200-539 BCE) (Frankel et al. 1994; Faust 2011). Changes were encountered at both the scale of production and the technique of oil pressing. It has been argued that the intensive olive pressing installations found at the archaeological site of Tell Muqanna' (Ekron) are a hint at the change of scale of olive oil production. That is, a change (in scale) of production from a *cottage* or domestic one to industrial scale. This change has been attributed to an increased demand for olive oil. The Assyrians, has been argued, were not interested in the by-product of olive in Palestine and, hence, did not influence the changing scale of production. On the contrary, it was the Phoenicians who traded olive oil to the west and played a major role in the world trade system (Faust, 2011). At the technical scale, it has been argued that lever and weight press was the type of press used for olive (Frankel et al. 1994). In the southern Levant, remarkable changes with respect to olive oil production have been observed in the archaeological record from the Persian to the Byzantine era (Kaniewski et al. 2012, 893). Analyses of the pollen data, taken from different areas in the Levant, show that the cultivation of olives reached its highest scores since the onset of the Holocene (Kaniewski et al. 2012, 893; Neumann, Schoelzel and Litt 2007, 339-340). The techno-economic context of olive oil production changed during the Roman period. Oil production was specialized and large-scale permanent installations for processing olive were found (Foxhall 2007, 132). At the same time, the hegemony of Romans over the southern Levant might lead to the adoption of a new technology of olive oil extraction. In general, changing technologies could be a means of increasing production to meet increasing demands. It is known, that olives were an important commodity in the Greek and Roman empires, so most probably the

technological change has to be interpreted as an adaption to higher demands.

**2. SITE SETTING AND ENVIRONMENT**

The significance of the archaeological site of Tell Es-Sukhnah is that it is located outside of the heartland of olive cultivation. The site is situated c. 25 km north-east of Amman and about 7 km to the west of Az-Zarqa city (Fig.1). Four seasons of excavations (2009; 2011; 2012; 2013) were carried out at the site. Es-Sukhnah is a Tell measuring about 7.5 acres, and ranging in height about 12 m.

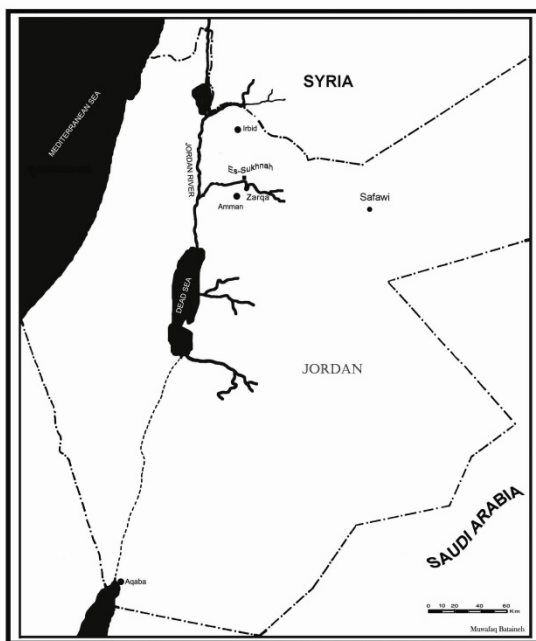


Figure 1 Showing the location of Tell ES-Sukhnah

The site has multi-period settlement history with human occupation having been attested from Bronze Ages to the Ottoman era (Ali in preparation). The location of Es-Sukhnah directly next to the Az-Zarqa River and its drainage might have been a major attraction causing its long occupation. Moreover, environmental resources enabled the inhabitants of the site to practice irrigated cultivation. At the larger scale, the site is located along the trade roads connecting the urbanized centers from west to east. The archaeological site of Tell Es-Sukhnah is locat-

ed in the Irano- Turanian bioclimatic zone. This area is a transition between the Mediterranean zone to the west and the Sahro-Arabian zone to the east. This zone is characterized by altitude ranges from 500 to 700 m, and annual rainfall ranges between 100-300 mm (Al-Eisawi 1985).

Tell Es-Sukhnah is part of the cool, arid Mediterranean climate region (Fig 2). The mean minimum annual temperature is 2-5 °C and mean maximum annual temperature 15-25°C. However, the area surrounding the site is well known for the presence of two main water sources. These are the springs and the Az-Zarqa River (biblical Jabbok River). Both sources are of vital need to practice irrigated agriculture, a technique, which can be noticed till the present nearby the site. Nowadays, however, it can be said that agriculture practice in the environs of the site would not be possible without irrigation.

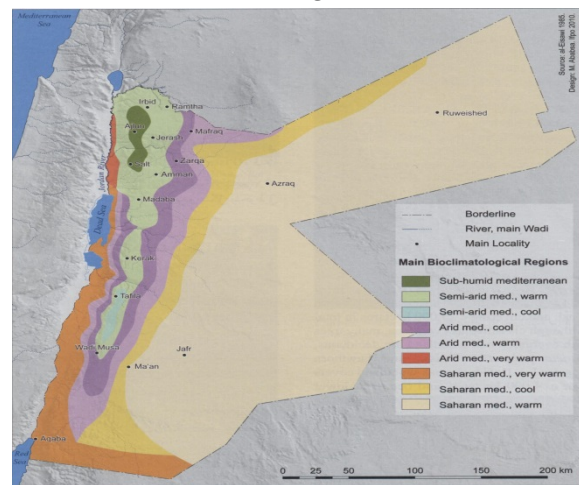


Figure 2 Major bioclimatic zones in Jordan (al-Eisawi 1985, fig. 8, modified by Ababsa 2013, fig.1.19)

**3. THE TELL ES-SUKHNAH OIL PRESSING COMPLEX**

In the southern Levant, olive oil presses have been found to be either built in caves or included within architectural complexes. The olive press at Tell Es-Sukhnah is related to the second type. It has been constructed at the top of the Tell at about 500.00 m a. s. l.

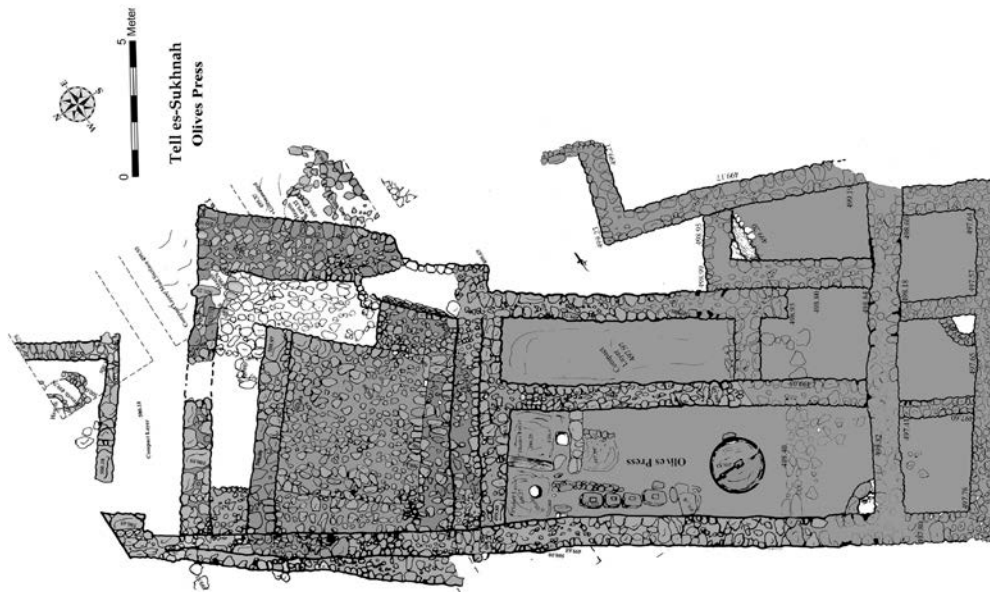


Figure 3 General top plan of the olive press uncovered at Tell Es-Sukhnah

The segmental components of oil extraction have been materialized in the architecture elements of the press. These include olive crushing, pressing and oil separation and collecting. Below is a detailed description of the architectural components of the olive press complex at Tell Es-Sukhnah (Fig.3).

### 3.1 The stone platform

The stone platform is considered part of the olive press complex because it relates to other pressing installations both architecturally and functionally. The lever niche is built inside this platform in its southern face (Fig. 3). From the architectural point of view, the walls of the press are connected with this stone platform. The function of the platform is still unclear. During the Islamic and medieval ages several burials were dug in the stone platform.

### 3.2 The pressing room

The pressing room is a rectangular room built in a NE-SW axis. It measures 4.4 m in width and 14.8 m in length. The NE wall of the room is built adjunct to the stone platform, where the lever niche (the solid win-

dow) has been uncovered. The height of this wall is ca.2.07 m. Its external face is made of dressed stones, while the stones used in the wall construction have undressed shapes, except the ones used in the lever niche. The NW wall is ca. 2.05 m high and built of undressed stones, set in two rows. The inner face of the wall shows semi - dressed surfaces. The SE wall of the room is preserved to a height of 1.48 m, and has two rows, the space in between was filled with smaller stones. The SW wall is built of two rows and is preserved to a height of ca. 0.5 m.

The floor of the room is made of a compacted mud layer and in some parts (esp. in the SW portion of the room) a part of a stone pavement has been found. The entrance of the pressing room is located in the NE wall, which has been blocked in later phase.

The pressing room can functionally be divided into three main parts; the crushing of olives, where the stone bed has been found, the oil pressing part where the stone weights and press installations have been uncovered, and lastly the vats where the oil is flowed after the pressing.

### 3.3 The lever niche

This part of the olive press is located in the NW corner of the pressing room, as a part of its NW wall. It has the shape of solid window, measuring 75x 61 cm (fig. 4). The lever niche was built of dressed lime stone stones slabs. It is located at the same direction of the stone weights to the south and at the same axes. Moreover, its location is in direct functional harmony with the press installation.



Figure 4 The lever niche of the olive oil press

### 3.4 The stone weights

Inside the pressing room, five stone weights have been found and their spatial distribution is from north to south axis and parallel to the western wall of the pressing room. The size of these stones varies (Table 1), which might be a hint of the different weights needed to control the press activities. Each stone weight is characterized by the presence of a bore in a T- shape (Fig. 5).

Table 1 The measurement of stone weights from Tell Es-Sukhnah

Nr.	Length (cm)	Width (cm)	Height (cm)
1	63	45	66
2	61	41	53
3	54	20	42
4	47	30	41
5	55	46	41

### 3.5 The crushing bed

The crushing bed is made of hard limestone, has an almost circular shape and measures 183 cm x 198 cm (fig. 6). The bed is hewn from two parts and has a shallow depression. It is supported from outside by concave rectangular slabs which functioned to prevent the crushed olive from getting outside the bed.

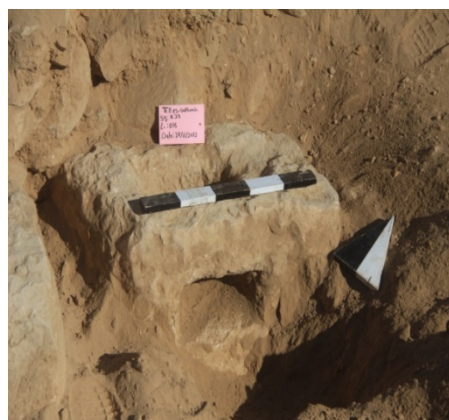


Figure 5 Photo showing the uncovered stone weight from Tell Es-Sukhnah

These slabs raised above the surface of the bed which might have been used to produce a basin form. The bed has a square-shape socket in its centre, measuring 28x30 cm.



Figure 6 Showing the crushing bed of the olive oil press at Es-Sukhnah

It is the place where a wooden beam would have been placed as a vertical axis facilitating the rotation of the crushing bed, which has not been found. It should be mentioned that olive seeds were found to the south east of the crushing bed (Fig.7).



Figure 7 Olive seeds uncovered close to the crushing bed

### 3.6 The vats area

The vats and canals needed for the pressing procedure were located in the northern part of the complex (Fig. 8).



Figure 8 Genral photo of the pressing area at Tell Es-sukhnah

This area was separated from the rest of the pressing room by two building methods. Firstly, its floor level is raised over the area around the crushing bed by about 31 cm. Secondly, a short wall built of undressed stones was constructed to separate the plastered area of the vats and canal from further installations (Fig. 9). The plastered part of the room measures 432 cm in length and 154-170 cm in width. It includes two vats which are separated by a partition wall of 161 cm and 16 cm, running from north to south. This partition wall has been covered with a thick lay-

er of plaster. The first vat is located close to the pressing bed or surface. It measures 107 cm length by 61 cm width and 91cm height. The opening of this vat is 40 cm in diameter. The second vat is located south-east of the first one and measures 50 cm x 63 cm. The inner surfaces of the two vats were plastered. The opening of the second vat is not oriented along the same axis as the first one. The walls surrounded the press area have been coated with plaster.



Figure 9 Collecting oil vat, canal and partition wall

### 3.7 The press features

This refers to the installations that were used to press the olives pulp after the crushing stage. Such installations include two stones facing each other which were positioned vertically at the raised plaster floor near the vats (Fig. 10). One of these stones measures 133 cm in height and 80 cm in width, and has a concave inner surface (Fig. 10). The second stone measures 110 cm in height and 44 cm in width and is located opposite to the first one, leaving a space of ca. 100 cm between the two stones. These standing stones are located at the same axis formed by the lever niche, the canal and the first vat as well as he stone weights. The space between the standing stones is plastered, where a shallow basin was built in. This basin has a rectangular shape with rounded corners, and was ca. 10 cm below the surrounding surface. It functioned as ca-

nal which connected the first vat through a hole dug into the plastered floor.



Figure 10 Showing the pressing stone and the canal leads to collecting vat.

### 3.8 Other features

There are two features that should be described in the press room at Es-Sukhnah. These are a plastered basin and a pit lined-stone.

## 4. ADJOINING ROOM

The pressing room has an entrance from an adjoining room to SE of it. This room has rectangular shape and measures 9.2 m by 2.6 m (Fig. 3). The floor is made of a compacted mud layer. The entrance of this room might have been located in the SW wall, in which three to four steps were found. The functional relation between this room with the pressing room is not fully clear. It has been recorded that almost 32% of the objects uncovered from the deposits of this room were fragments of grinding stones, and one small bowl found on the mud floor. It could be that this room was either a storage one or it might be an accommodation for oversee of the press.

## 5. THE PROPER FUNCTION OF THE OLIVE PRESS

Based on the architectural remains from Tell Es-Sukhnah, one might draw conclusions about the proper function of the olive

press at the site. Moreover, parallel studies with other olive presses and ethnographic studies can fill the gap in some cases when evidence is absent in Es-Sukhnah (e.g. Dalman 1935; Forbes and Foxhall 1978; Nashef 2009; Warnock 2004). Usually the extraction of oil from olives goes through the following main stages: olive collecting, olive drying, olive crushing, olive pressing and oil collecting. Each stage is correlated with specific objects or features. The preservation of these objects in the archaeological record depends on (the state of) their materials characteristics. For example, baskets or woven bags used in olive storing or collecting are difficult to be found in the archaeological record of Es-Sukhnah.

However, one might describe the working of the olive press at Es-Sukhnah as follows.

### 5.1 Olive collecting

Ethnographic studies in the southern Levant showed that olive collecting takes place in the season from October till January (Dalman 1935). Usually the olives are collected in woven bags.

### 5.2 Olive drying

This activity took place at some solid surface, e.g. house roof or paved courtyard. Ethnographic studies showed that olive drying is an important step before the crushing and pressing activities (Dalman 1935), because it reduces the water content before pressing. At Es-Sukhnah, if we assumed that olive oil extraction was a centralized activity, that is, attached specialized activity controlled by the elite of the site, then the stone platform would be a place where olive drying could have taken place. This assumption might be strengthened by the fact that the stone platform is architecturally and functionally connected to other pressing installations such as the lever niche.

### 5.3 Olive crushing

This is an activity which aims at increasing the volume of olives, reducing the volume of water in olive, and to enhancing the release

of the oil. The most recognized type of olive crusher is the rotary mill. It consists of the stone bed and the millstone (Foxhall 2007, 133). At Es-Sukhnah the method of olive crushing can be reconstructed as following: spreading the olives over the bed as a hard surface, then crushing the olives by rolling the millstone over the bed, and pushing this stone in a round motion. It seems that single stone crusher was used in olive crushing. Such inference can be supported by the characterization of the stone bed (see, above). Human force might be the main mechanical power to rotate the mill stone. Then the pulp was placed in baskets or bags to be transported to the press bed.

#### **5.4 Pressing activity**

Olive pressing at Es-Sukhnah is performed by what is called beam press or lever and weights press. The components of this technique include stone counterweights, a wooden beam, a lever niche, and an installation where baskets filled with olive pulp are pressed. These components functioned as following: the baskets containing the olive mash were placed between the high standing stones. A huge flat stone was probably placed above the baskets to function as pressing weight. Then the wooden beam is tightened to the stone weights (being 5 in number) by ropes wound through the T-shaped holes in the stones. During pressing, the weights will be gradually lifted from the ground. The baskets holding the olive mash will be changed as the pressing is completed. Foxhall (2007, 138) mentioned that hot water was poured on the olives on the press bed in order to release more oil. However, At Es-Sukhnah such process was not possible to identify.

#### **5.5 Olive oil separating and collecting**

This stage is discussed separately from the pressing activity for the sake of illustration. The baskets containing the olive mash might have been placed on the plastered area between the standing stones of the press. This

area contains a closed channel, with its shape being rectangular with rounded corners in shape. The channel lies deeper than the surrounding surface and it slopes more toward the hole leading to the nearby collecting vat. The oil after pressing would be left to separate from the water and olive juice in collecting vat. By this process, the oil would flood to the top and ladle out of the vat (Forbes and Foxhall 1978, 47). No ceramic vessels with spout at the base have been found in the press room complex, which might hint at other process of oil separation from the water.

## **6. DISCUSSION**

The southern Levant is characterized by contrasting climates due to different topographic conditions that can be found in this region, with short distances between the Mediterranean, arid and semi-arid areas. This indicates the need of localized studies of the paleoenvironment of the region and raised caution in drawing a generalized and schematic picture of climate conditions in the region (Rambeau 2010, 5232). Due to the fact that localized studies on paleoenvironment during the Hellenistic and Roman period in the Az-Zarqa basin were not carried out, this study bases its reconstruction of past climate in this region on other sources from the southern Levant, e.g. sources from northern part of the southern Levant. Different studies show that the human - environment relationship in terms of agricultural intensification and landscape clearness for agriculture activities can be reconstructed based on pollen analysis (Heim et al 1997; Brauch 1990). Thus, pollen sequences can reflect the expansion of cultivation as well as human control and modification of the landscape. Paleoenvironmental studies in the southern Levant showed that during the Hellenistic period up to the Byzantine a humid climate condition prevailed in this region. As a consequence, an increase in olive cultivation became possible, as is evident from pollen sequences in the Dead Seas Basin and the Sea of Galilee.



A correlation can be hypothesized between the frequencies of olive pollen and archaeological olive press installations in Jordan. Several of these have been identified in northern Jordan, in the area between Az-Zarqa River and Yarmouk River. These include the ones that have been identified during the archaeological survey in the hinterland of Jarash (major Roman city and one of the Decapolis). In this area 3-4 olive presses were identified. The presses were cut into bed rock and consist of large plastered lined vat, external rock cut basins and a niche in the wall, where the lever beam was fixed (Barker and Kennedy 2011, 461,462). The olive presses have been dated to classical periods.

In the vicinity of the multi-period site of Ya'mun, an archaeological survey identified two olive presses, the date of which has not been given. These were hewn into bed-rock as can be seen in the published pictures (el-Najjar and Rose 2003, 491-92).

Besides archaeological surveys, olive presses were excavated at sites such as Kufur Lahaya (Melhem et al 2011), Kahf al-Ma'sara, (Bataineh 2010), Jarash, and Abila (Mare 1999). The previously mentioned olive presses were hewn in caves and isolated from occupation settlements. However, the Es-Sukhnah olive press differs from the above mentioned ones in its construction method and the context in which it was found. It is one of complete built olive presses in the southern Levant that can be dated back to the late Hellenistic and early Roman period.

From a technical point view, technical tradition of constructing olive presses can observe during the Roman period in the southern Levant. For example, the crusher bed at Abila shows similarity with the one at Khirbet Zabadi in western Galilee. Both crusher beds lack the presence of socket, instead they have a central protrusion (Frankel 1992, 46; Mare 1999: 458), but the Abila millstone represented by single crusher meanwhile, at Zabadi probably has two millstones as seen from the deep concave section of the bed. At

Es-Sukhnah, the crusher bed has a central socket, at its external diameter a set of concave slabs were attached around the bed. Such technique aimed at making the lip of the bed higher than the bed surface. Such technique and construction method were not observed elsewhere. It is more proper that single crusher stone was in used at Es-sukhnah. Chronologically speaking, it has been suggested that the use of single crusher stone was earlier than the two millstones (Foxhall 2007).

The press bed or surface shows also difference among sites. At Es-Sukhnah the lever niche was built as solid window, meanwhile at sites such as Zabadi, slotted piers were found. However, in caves, the niche was carved out in one of the sides of the caves. Differences with Es-Sukhnah press installation can be observed with respect to press bed and olive bags supporting feature. At Es-Sukhnah the press bed is not carved out from stone, but it consists of paved stones and covered with thick layer of plaster. Within the pavement, the place where olive bags would have been placed is formed like a shallow basin. This basin is lower than the surrounding surface (ca. 10 cm) and has a groove like-canal. Moreover, the technique of pressing is accompanied by placing the olive pulp bags between standing stones. It was difficult to find out parallel to such standing stones. The juice has been collected in plastered vat. Other sites showed that juice has been collected inside carved out vats either in the case of olive presses found in caves or built within structures.

Another point that should be highlighted with respect to Roman Es-Sukhnah is its rural character within a regional context. The landscape of Jordan during the Roman period was dominated with ca. 80% of rural sites. Most major cities were spatially distributed to the north of Az-Zarqa River such as Gerasa, Pella, and Gadara. However, the nature of rural settlements and their relationship to major urban centers have been not fully developed (Graf

2001; El-Khoury 2008). Furthermore, the economic aspects such as urban markets, and land allotment have been speculated with respect to the Roman period in southern Levant. It has been, for example, argued that the urban aristocratic elite have extension into the countryside. They expanded their wealth by extracting rents and surplus from the rural hinterland (Graf 2001: 225). The rural Roman site of Tell Es-Sukhnah is located ca. 22 km south-east of Jarash city (one of the Decapolis city). It would be difficult to evaluate the economic or socio-politic relationship between Es-Sukhnah and Jarash. However, what can be said is that the site has been played an economic rule during the Early Roman period. Evidence of trade is represented by Terra-Sigillata fine ware, glass vessels and even the burial goods. All previously finds are an indication for the importance economic rule of the site.

## 7. CONCLUSION

Overall, the energy expenditure required for the construction of oil press and its instal-

lations points clearly to its importance within an industrial olive oil production. This scale of olive oil production inside the Az-Zarqa basin highlights the role of this region during the late Hellenistic and Early Roman period.

Moreover, it can be assumed that the constructed olive oil press at Es-Sukhnah might be a hint at the presence of a centralized authority which controlled the production. The presence of central authority might be supported by the presence of graves that contained offering goods and were located very close to the olive pressing complex.

The accumulation of wealth can be measured at the village scale with the presence of wealthy household benefiting from the economic value of Az-Zarqa basin by which olive oil might have been one major commodity, besides other agricultural product.

Agriculture and fruit products can be considered as a means by which wealth accumulation has been achieved. It is hoped that further excavation at the Roman horizon at Es-Sukhnah will shed more light on the characteristic of villages during Roman period.

## REFERENCES

- Ababsa, M. (ed.) (2013) *Atlas of Jordan: History, Territories and society*. Beyrouth: Presses de l'ifpo.
- Baker, F., and Kennedy, D. (2011) Jarash Hinterland Survey -An Overview of the Results. *Annual of the Department of Antiquities of Jordan* 55: 451-466.
- Bataineh, A. (2010) Restoration and Rehabilitation of an Oil Press from Kahf al-Ma'sara in al-Kura. *Annual of the Department of Antiquities of Jordan* 54: 43-49. (In Arabic).
- Beeri, R. (2008) Round Oil Presses of the 13<sup>th</sup>-10<sup>th</sup> Centuries BCE in Palestine and their Implications: Chronology, Function and Geographical Distribution. *Palestine Exploration Quarterly* 140 (3): 159-167.
- Brauch, U. (1990) Palynological Evidence of Human Impact on the Vegetation as Recorded in Late Holocene Lake Sediments in Israel. In *Man's Role in the Shaping of the Eastern Mediterranean Landscape*, edited by S. Bottema, G. Entjes-Nieborg, W. van Zeijl, 283-293. Balkema: Rotterdam.
- Dalman, G. (1935) *Arbeit und Sitte in Palästina. Band IV: Brot, Öl und Wein*. Tübingen: Florian Lippke. Reprint 2013.
- al-Eisawi, D. (1985) Vegetation in Jordan". In *Studies in the History and Archaeology of Jordan*, II, edited by A. Hadidi, 45-57. Amman: Department of antiquity.
- Faust, A. (2011) The Interests of the Assyrian Empire in the West: Olive Oil Production as a Test-Case. *Journal of the Economic and Social History of the Orient* 54: 62-86.

- Forbes, H., and Foxhall, L. (1978) The Queen of All Trees": Preliminary Notes on the Archaeology of the Olive. *Expedition* (Fall): 37- 47.
- Foxhall, L. (2007) *Olive Cultivation in Ancient Greece: Seeking the Ancient Economy*. Oxford: Oxford University Press.
- Frankel, R. (1992) Some Oil Presses from Western Galilee. *Bulletin of American School of Oriental Research* 286: 39-71.
- Frankel, R. (1999) *Wine and Oil Production in Antiquity in Israel and Other Mediterranean Countries*. JSOT/ASOR Monograph 10. Sheffield: Sheffield Academic.
- Frankel, R., Avitsur, S. and Ayalon, E. (1994) *History and Technology of Olive Oil in the Holy Land*. Arlington VA., and Tel Aviv: Olearius Editions and Eretz Israel Museum.
- Frick, F. (1999) "Oil from Flinty Rock" (Deuteronomy 32:13): Olive Cultivation and Olive Oil processing in the Hebrew Bible- A Socio-Materialist Perspective. *Semeia* 86:3-15.
- Galili, E., Stanley, D., Sharvit, J. and Weinstein-Evron, M. (1997) Evidence for Earliest olive-Oil Production in Submerged Settlements off the Carmel Coast, Israel. *Journal of Archaeological Science* 24 (12): 1141-1150.
- Graf, D. (2001) Town and Countryside in Roman Arabia during Late Antiquity. In *Urban centers and Rural Contexts in Late Antiquity*, edited by Th. Burns, and J. Eadie, 219-240 . Michigan: Michigan State University Press.
- Heim, C., Nowaczyk, N., Negendank, J., Leroy, S., and Ben-Avraham, Z.(1997) Near East Desertification: Evidence from the Dead Sea. *Naturwissenschaften* 84: 398-401.
- Kaniewski, D., van Campo, E., Boiy, T., Terral, J-F., Khadari, B .,and Besnard, G., (2012) Primary Domestication and Early Uses of the Emblematic Olive Tree: Palaeobotanical, Historical and Molecular Evidence from the Middle East. *Biological Reviews* 87: 885-899.
- El-Khoury, L. (2008) Roman Countryside in North-Western Jordan. *LEVANT* 40 (1):1-17.
- Koh, A.J and Betancourt, P.P (2010) Wine and Olive Oil from an Early Minoan I Hilltop Fort. *Mediterranean Archaeology & Archaeometry* 10 (2): 15-23
- Liphschitz, N., Gophna, R., Hartman, M. and Bigger, G., (1991) The Beginning of Olive (*olea europaea*) Cultivation in the Old World: A Reassessment. *Journal of Archaeological Science* 18 (4): 441-453.
- Mare, W. (1999) The 1998 Season of Excavation at Abila of the Decapolis. *Annual of the Department of Antiquities of Jordan* 43: 451-458.
- Melhem, I., as-Shalabi, M., Ghnemat, Z., Malkawi, M., Obeidat, E.,and Tebishat, A., (2011) Archaeological Survey Results at Kufur Lahya and it's Surrounded in Saham al-Kfarat. *Annual of the Department of Antiquities of Jordan* 55: 41-56 (in Arabic)
- Milevski, I. (2005) *Local Exchange in Early Bronze Age Canaan*. Ph.D Thesis, Tel Aviv: Tel Aviv University.
- Nashef, Kh. (2009) Oil Press Installations in Palestine. In *Modesty and Patience: archaeological studies and memories in Honour of Nabil Qadi'Abu Salim'*, edited by H.-G. Gebel, Z. Kafafi, and O. alGhul, 24-51. Berlin: ex oriente e.V. (in Arabic).
- el-Najjar, M. and Rose, J. (2003) Preliminary Report of the 2003 Field Season at Ya'mun by the Joint Yarmouk University\University of Arkansas Project. *Annual of the Department of Antiquities of Jordan* 47: 491-92.
- Neumann, F., Scholzel, Ch., and Litt, T. ( 2007) Holocene Vegetation and Climate History of the Northern Golan Heights (Near East). *Vegetation History and Archaeobotany* 16: 329-346.

- Rambeau, C. (2010) Palaeoenvironmental Reconstruction in the Southern Levant: Synthesis, Challenges, Recent Developments and Perspectives. *Philosophical Transactions of the Royal Society* 368: 5225-5248.
- Salavert, A. (2008) Olive Cultivation and Oil Production in Palestine During the Early Bronze Age (3500-2000 B.C.): The Case of Tel Yarmouth, Israel. *Vegetation History and Archaeobotany* 17 (1):S53-S61.
- Warnock, P. (2004) *Identification of Ancient Olive Oil Processing Methods Based on Olive Remains*. BAR International Series 1635. Oxford: Archaeopress.
- Zohary, D., Hopf, M., and Weiss, E. (2011) *Domestication of Plants in the Old World*, 4ed. Oxford: Oxford University Press.