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Mechanical Engineering in Ancient Egypt, Part 53: Farming Tools

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Abstract:

This paper is the 53rd research paper in a series investigating the evolution of mechanical engineering in ancient Egypt. It tries to achieve this purpose through investigating the farming tools during the ancient Egyptian Predynastic and Dynastic times. It outlines the farming techniques used by ancient Egyptians between land ploughing and grain storage. Extensive examples from different eras are presented for each process outlining the tools used and their location and time span.

Keywords — **Mechanical engineering; ancient Egypt; farming tools; ploughing; sowing; irrigation; harvesting; transportation; threshing; winnowing; grain storage.**

I. INTRODUCTION

This is the 53 paper in a series of research papers aiming at exploring the role of ancient Egyptians in the evolution of mechanical engineering. The paper presents the farming tools in ancient Egypt.

Bowman and Rogan (1999) outlined that the Egyptian agriculture has been capable of generating enormous surplus because of the water of the Nile in the annual renewal of topsoil provided by the silt of the flood. They outlined also that the same animals apparent in Pharaonic friezes continued to assist in the labour of farming in the 20th century [1]. Janik (2002) stated that ancient Egypt was shown to be the source of much of the agricultural technology of the Western World. He presented ancient Egyptian scenes showing lotus and papyrus. He announced that the chief crops used for bread and beer were barley and wheat [2]. Kieta (2005) showed that the Badarians were more affiliated with local and an indigenous African population than with Europeans [3].

Bard (2007) presented a number of scenes including a fishing scene from the tomb of Mereruka at Saqqara from the 6th Dynasty , a relief of Akhenaten with Nefertiti on his legs with four types of fruits in front of them [4]. McGovern, Mirzoian and Hall (2009) declared that the chemical analysis of ancient organics from the beginning of advanced ancient Egyptian cultures (3150 BC) revealed that a range of national products – specially herbs and tree resins were disposed by grape wine [5]. El-Ramady, El-Marsafawy and Lewis (2013) declared that the Egyptians were in charge of their own government and able to set their own environmental poliuces from before 3000 BC. They suggested that the stability of Egyptian civilization was the result of the sustainability of Egypt's ecological relationships [6]. Kristensen (2014) examined the illustrations of private gardens in tomb paintings in light of ancient Egyptian literature and archaeological evidence. He outlined that the gardens did in many aspects reflect a reality and illustrated their importance in the ancient Egyptian society [7].

Odler (2016) in his book about Old Kingdom copper tools and model tools presented a section in chapter 8 about agricultural tools. He studied the use of sickles and hoes during the Old Kingdom of ancient Egypt [8]. Mark (2017) declared that agricultural practices in ancient Egypt began in the Delta Region and in Faiyum during the Predynastic Period (6000-3150 BC) and agriculture was the foundation of the ancient Egyptian economy [9]. Some authors (2017) handled the private tombs of some Nobles from ancient Egypt and presented colored scenes from their tombs

including agricultural, fishing and hunting activities [10] – 13].

II. FARMING IN ANCIENT EGYPT

The ancient Egyptians practiced farming from more than 6000 years BC and cultivated a large number of crops using the good agricultural lands provided by the River Nile. They knew the impact of the farming process on establishing a strong economy and building a strong state that can survive among the continents surrounding Here, we present a number of scenes illustrating the application of farming in the ancient Egyptian society and indicating the high calliper of their civilization:

- The first example is an 1.28 m length engraving showing Niankhwadjet from the frame of the false door niche of her husband Mery from the 4th Dynasty (2575-2520 BC) in display in the Metropolitan Museum of Art at New York and shown in Fig.1 [14]. The designer showed the lady inhaling a Lily flower in her left hand. This indicates how the ancient Egyptians were fond of cultivating plants with good smell for there personal use. .

Fig.1 Niankhwadjet from 4th Dynasty [14].

- The second example is a scene for Sennefer, overseer of granaries and fields, gardens, and cattles of Amun, reign of Amenhotep II (1425-1398 BC), the 7th Pharaoh of the 18th Dynasty shown in Fig.2 [15]. The overseer was shown holding a perfumed flower in each hand of different types while he was surrounded by tree branches from all sides. The scene is indicating the nature of the job of the man. It depicts a serious pose for the overseer even though he is smelling the good scent of the lotus flower.

Fig.2 Scene of Sennefer from 18th Dynasty [15].

- The third example is tomb scene for the overseer Sennefer of the 18th Dynasty and his daughter receiving offerings shown in Fig.3 [16]. The art designer used only plant leaves to decorate the roof. Why not and Sennefer is an overseer of fields and gardens of Amun.

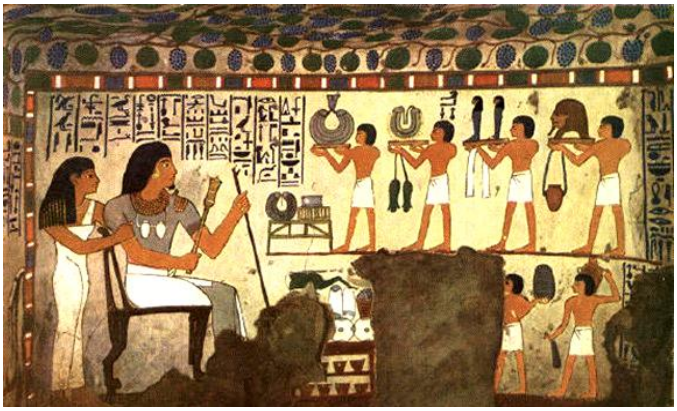

Fig.3 Sennefer and his daughter from 18th Dynasty [16].

- The fourth example is a scene for a lady looking after a tree in the tomb of Menna, scribe of the fields of the Lord f the two lands during the reign of Thutmose IV (1398-1388 BC) the 8th Pharaoh of the 18th Dynasty shown in Fig.4 [17]. The scene depicts how the ancient Egyptian was fond of farming. Even though the lady was a nursing one, she is looking after a tree planted in a pot..

Fig.4 Lady looking after a tree [17].

- The fifth example is a scene from the tomb of Menna from the 18th Dynasty for the daughter of Menna carrying lotus flowers and ducks hunted by her father and shown in Fig.5 [18].

Fig.5 Menna's daughter from 18th Dynasty [18].

The art designer was keen to present the life of the Egyptian nobles in Egypt as an agricultural country showing the interest of its people in very nice drawings.

- The sixth example is a colored scene of ducks and butterflies in a field from the tomb of Nakht, a scribe and priest during the reign of Pharaoh Thutmose IV (1398-1388 BC) shown in Fig.6 [19]. The scene showed one of the ducks flying, one just starting flying and one standing besides its eggs.

Fig.6 Ducks from Nakht tomb [19].

- The seventh example ia a scene of a dates tree between another two different trees in the tomb of Nebamun, scribe and grain accountant near the end of the 18th Dynasty (1350 BC) in display in the British Museum and shown in Fig.7 [20].

Fig.7 Trees from 18th Dynasty [20].

The art designer illustrated how the ancient Egyptians were fond of planting fruit trees to secure their need of food and be able to establish a strong economy.

- The eighth example is a scene of a garden from Nebamun tomb (1350 BC) in display in the British Museum and shown in Fig.8 [21]. This is a wonderful master piece of the ancient Egyptian art and the agriculture technology in the Egyptian society more than 3360 years ago. The designer showed the garden having a central water pool full of birds and fish, flower border just outside the pool, and rows of fruit trees around the border from three sides. This design is so beautiful that it is worth to apply it nowadays in private and public gardens.

Fig.8 Nebamun garden from 18th Dynasty [21].

- The ninth example is farming scene from the tomb of Sennedjem in Dier el-Medina at Luxor, artisan of Pharaohs Seti I and Ramses II (1290-1213 BC) of the 19th Dynasty shown in Fig.9 [22].

Fig.9 Farming scene from 19th Dynasty [22].

The art designer showed two type of fields in this scene: one seeds field served by a farmer and his wife indicating the cooperation of the ancient Egyptian husband and his wife in building a strong economy for their state and a fruit field where a number of fruit-trees are planted. The top field showed two farming activities: ploughing and harvesting.

- The tenth example is a scene a palm in the tomb of Pashedu, servant in the Palace of Truth in Thebes during the early years of Pharaoh Ramses II (starting from 1297 BC) shown in Fig.10 [23]. The background of the scene is full of hieroglyphics and shown the tomb owner prostrated besides the palm. The scene depicts the knowledge of the ancient Egyptians with the prostration as a worshipping operation.

Fig.10 Palm from 19th Dynasty [23].

- The eleventh example a scene for a field from tomb of Sennedjem (1290-1213 BC) of the 19th Dynasty shown in Fig.11 [24].

Fig.11 Sennedjem field from 19th Dynasty [24].

This is another wonderful field consisting of two distinct field areas isolated by irrigation canals. The first are comprises fruit-trees arranged in an interchangeable manner. The second area may be a vegetable field comprising at least three types of vegetables arranged in an interchangeable manner. The scene depicts the greatness of the ancient Egyptians in design, art and life.

III. CATTLE AND POULTRY FARMING

Two of the post-farming processes in any cultivation society are cattle farming and poultry farming. They are important to preserve the people need of protein for the human being health. Those two activities represented two important corners of the ancient Egyptian economy. Here, we will present some examples illustrating the ancient Egyptian concern regarding cattle and poultry farming:

- The first example is a scene of a home servant carrying geese in each hand from the tomb of Menna, a noble of the 18th Dynasty (1398-1388 BC) shown in Fig.12 [25]. The scene depicted a very important meaning which is the self-dependence of the ancient Egyptian family in preserving a complete diet system using available resources.

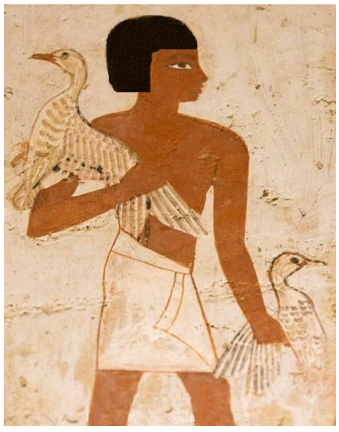

Fig.12 Home servant from 18th Dynasty [25].

- The second example is a scene from the tomb of Nebamun the scribe and grain accountant during the 18th Dynasty (1350 BC) showing Nebamun driving a herd of cattle in display in the British Museum and shown in Fig.13 [26]. The colored scene showed Nebamun doing the job himself assisted by workers one of them carrying a bucket of water in case cattle need to drink.

Fig.13 Nebamun driving cattle from 18th Dynasty [26].

- The third example is scene showing a gaggle of geese from the tomb of Nebamun, the noble of the 18th Dynasty in display in the British Museum and shown in Fig.14 [27]. The scene showed a worker driving the geese gaggle and another having a number of geese in a net-basket ready for offering.

Fig.14 Gaggle of geese from 18th Dynasty [27].

- The fourth example is a scene showing Noble Nebamun of the 18th Dynasty (1350 BC) hunting birds using a boat in the marshes in display in the British Museum and shown in Fig.15 [28]. This scene shows Nebamun as a zippy man hunting birds using a hunting-stick with his family around him. The scene depicts using the ancient Egyptians the marshes in poultry farming.

Fig.15 Hunting scene from 18th Dynasty [28].

IV. PLOUGHING

The ancient Egyptian farmer new that ploughing is required to refresh the land and make it ready to receive the new plant. He devised two ploughing tools: manual ploughing tool (hoe) and animal driven ploughing tool (plougher) as will be illustrated through the following examples from different Pharaonic Dynasties:

- The first example is an engraving for Scorpion, the 1st King of the 1st Dynasty (3100 BC) holding a hoe in display in the Ashmolean Museum at Oxford and shown in Fig.16 [26].

Fig.16 Scorpion holding a hoe from 1st Dynasty [26].

This scene of more than 5030 years old shown the King holding the hoe by both hands which is a great appreciation for this tool and indicating the great concern of the ancient Egyptian Kings with the farming process.

- The second example is a statue for a farmer holding a hoe by both hands in a working position from the 6th Dynasty (2250 BC) in display in the British Museum and shown in Fig.17 [26].

- The third example is a plough model powered by two oxen from the 11th Dynasty (2000 BC) in display in the British Museum and shown in Fig.18 [29]. This may be the first actual model illustrating the mechanical design of the plough in ancient Egypt which continued to be used for thousands of years and helped in establishing a great agriculture and great economy.

Fig.17 Hoe from 6th Dynasty [26].

Fig.18 Plough from 11th Dynasty [29].

- The fourth example is another plough model from the Middle Kingdom (2010-1961 BC) in display in the Museum of Fine Arts at Boston and shown in Fig.19 [30]. This design is completely different than that in Fig.18. The farmer is holding the straight bar ending by the blade of the plough while the connection between this bar and the oxen's necks is not shown. The designer was keen to show a work overseer watching and guiding the ploughing process.

Fig.19 Plough model from Middle Kingdom [30].

- The fifth example is a ploughing model using two oxen from the 12th Dynasty (1991-1783 BC) shown in Fig.20 [31]. It is of the same type shown in Fig.18, except it has two ploughing blades around the central rod. The driving rod is extended towards the farmer such that the farmer can stant on ot giving more vertical force leading to more penetration in the land. This is a generous mechanical engineering idea depicting the creative thinking of the ancient Egyptians.

Fig.20 Plough model from 12th Dynasty [31].

- The sixth example is a 648 mm length wooden hoe for hand-land ploughing from the New Kingdom in display in the British Museum and shown in Fig.21 [32]. The hoe is a mechanism consisting of two links, one of them is the ploughing blade and the second is the manual deriving ling. Both are joined together using a revolute joint. To limit the relative position of the two links with respect to each other a robe is used to adjust the maximum angle between the two links. The rounded end of the driving link allows using this link to break mud-stocks of the land easily while ploughing. There is a recess in both links to secure the robe in position and and prevent any lateral motion during the ploughing process.

Fig.20 Ploughing hoe from New Kingdom [32].

- The seventh example is a 388 mm wooden hoe from the 19th-20th Dynasties (1295-1070 BC) in display in the Carnegie Museum of Natural History at USA and shown in Fig.21 [33]. It is of the same mechanical design shown in Fig.20. The designer here preferred to use a two steps driving link to secure the robe instead of using a recess in the design of Fig.20. In both designs the driving link has an L-shaped end to secure the ling in the hand of the hoe user. Even though the design is simple but it reflects high calliper of machine element design in the ancient Egyptian society.

Fig.21 Ploughing hoe from 19th-20th Dynasties [33].

- The eights example is a 325 mm height Usbabti statue for the Nubian/Kushite King Aspelta (600-580 BC) during the 26th

Dynasty of the Egyptian Late Period in display in the Royal Ontario Museum at Canada and shown in Fig.22 [34]. This is another appreciation for the farming process in ancient Egypt. The ushabti depicts the King holding one hoe in each hand. How great were those Kings and how great was the ancient Egyptian economy.

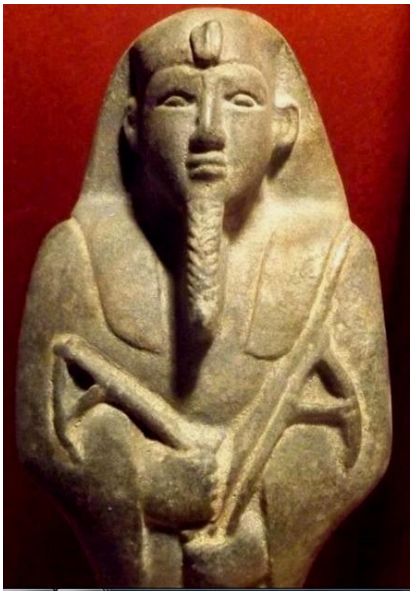

Fig.22 Ploughing hoes from 26th Dynasty [34].

V. SOWING

Now, after ploughing, the land is ready to receive the seeds to start a new cycle of crop farming. The ancient Egyptians registered the sowing process through wonderful scenes in Noble tombs. Here, are some of their authorization of this process:

- The first example is a scene from the tomb of Urarna at Sheikh Said from the Middle Kingdom and shown in Fig.23 [35]. The farmer is sowing the seeds from his basket just behind the plougher. Two labours are driving a cattle hard to follow the sowing farmer to make the seeds disappear inside the soil. This may be the fastest way devised by the ancient Egyptians to complete successfully the sowing process.

Fig.23 Sowing scene from Urarna tomb [35].

- The second example is a scene in the tomb of Khaemhat at Luxor from the 18th Dynasty and shown in Fig.24 [24]. This is a wall engraving in the tomb wall showing both the ploughing and sowing processes.

Fig.24 Sowing scene from Khaemhat tomb [24].

- The third example is a scene from Nakht tomb from the 18th Dynasty (1398-1388 BC) and shown in Fig.25 [36]. One of the labours is sowing the seeds from a basket in his left hand while another labour is using a rake to mix the soil with the seeds forcing the seeds down into the soil.

Fig.25 Sowing scene from Nakht tomb [36].

- The fourth example is a scene from the tomb of Sennedjem from the 19th Dynasty (1300 BC) in display in the Metropolitan Museum of Art !! and shown in Fig.26 [37]. The scene depicts the cooperation between the farmer and his wife in completing the farming process. The farmer is ploughing while his wife is sowing the seeds using a basket in her left hand.

Fig.26 Sowing scene from Sennedjem tomb [37].

- The fifth example is a scene from the tomb KV11 of the 20th Dynasty shown in Fig.27 [24]. One labour is sowing the seeds behind the plougher while another labour is carrying spare seed-baskets to increase the productivity of the sowing process.

Fig.27 Sowing scene from tomb KV11 [24].

VI. IRRIGATION

After the seeds have been sowed into the soil, now comes the irrigation process. From the very old times, the ancient Egyptians devised the positive displacement pumps in a primitive way as will be illustrated by the following examples.

- The first example is a scene for a two-jugs positive displacement pump driven manually through a man carrying a yoke with the two jars at its ends from the tomb of Mereruka at Saqqara from the 6th Dynasty of the Old Kingdom (2330 BC) shown in Fig.28 [38]. The idea depends on using first-class lever mechanics where the pivot is on the porter shoulder. The porter is holding the robes of the jars to prevent water losses due to the jar vibration during walking. The water-flow rate using this technique was increased by increasing the size of each jar and by increasing the number of porters per field.

Fig.28 Irrigation scene from 6th Dynasty [38].

- The second example presents the second technique use by the ancient Egyptians to irrigate their lands. It is a scene from the tomb of Ipuy at Der el-Medina of Thebes from the 19th Dynasty (1279-1213 BC). It is a scene for land irrigation using the 'Shaduf' shown in Fig.29 [39]. The pivot of the lever was set on a tree stem while a counter weight (in white color) was set at the far end of the lever and the load was a conical bucket (in brown color) attached by a robe to the other end of the lever. The operator is simply holding the robe to guide the robe in the vertical motion of the bucket and tilt it to discharge the water into the field. The flow rate of this positive displacement pump depends on the volume of the bucket and the frequency of the operator in repeating each cycle.
- Both irrigation techniques require the availability of water source suitable for both designs. The River Nile was the main source for water in ancient Egypt. They devised two techniques to have water in levels

suitable for their positive displacement pumps:

- The first is digging canals going through the fields as depicted in the scene shown in Fig.30 from the tomb of Sennedjem from the 19th Dynasty [24]. Using such canals supports both irrigation techniques and still in use till now.

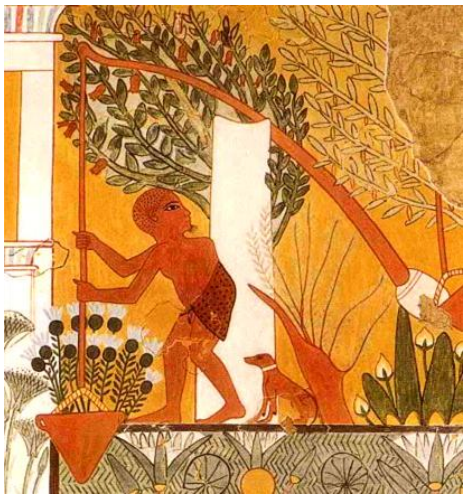

Fig.29 Irrigation scene from 19th Dynasty [39].

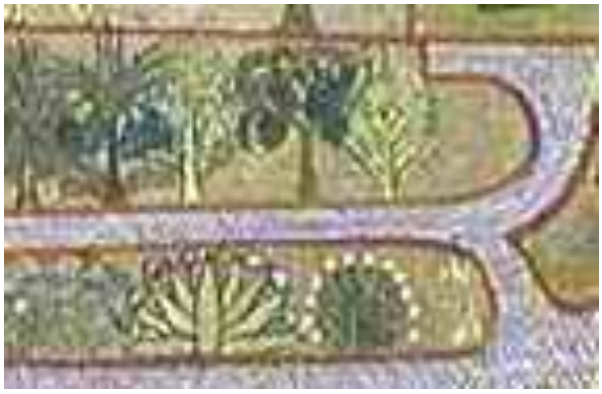

Fig.30 Canals scene from 19th Dynasty [24].

- The second is making an artificial pool to fill with water and use it for multi purposes including fields and gardens irrigation. An example is a scene from the tomb of Nebamun of the 18th Dynasty (1350 BC) shown in Fig.31 [40]. The pool can be used for irrigation and poultry and fish farming.

Fig.31 Pool scene from 18th Dynasty [40].

VII. HARVESTING

Now. The plants had grown and the crops are ready to be harvested. The ancient Egyptians gave vast importance to the harvesting process as one of the agricultural operations. They registered this process through tomb scenes and sample models of the sickles used in the harvesting process. Here are some examples starting from the predynastic to the Late Periods:

- The first example is a 30 mm length sickle blade from the time of Gerza (3900-3200 BC) displayed as a private collection and shown in Fig.32 [41]. This blade was produced from a hard stone such as flint with saw-teeth design and attached in series to the sickle front edge to cut the plant stems by a harvester.

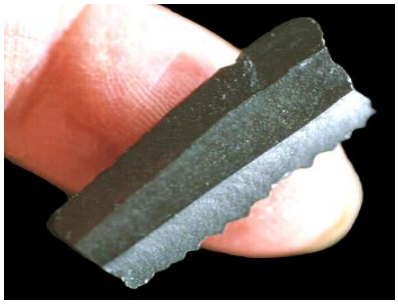

Fig.32 Sickle blade from Gerza [41].

- The second example is a 63 mm length flint sickle blade from the Early Dynastic Period (3100-2650 BC) in display in the Metropolitan Museum of Art and shown in Fig.33 [42]. From more than 4700 years the ancient Egyptian designer could design and

produce a sickle blade in the form of a saw without breaking its teeth during processing. He succeeded to select a proper material that can live for thousands of years without deterioration.

Fig.33 Sickle blade from Early Dynasties [42].

- The third example is 54 mm length flint sickle blade from the Old Kingdom (2686-2181 BC) in display in the Liverpool Museums and shown in Fig.34 [43]. In this design, the teeth are straight compared to that of the Early Dynasties and its body has less thickness and more uniform compared with that in Fig.33.

Fig.34 Sickle blade from Old Kingdom [43].

- The fourth example is a 38.8 mm wooden ceremonial sickle from the 18th Dynasty reign of Thutmose III (1479-1425 BC) in display in the Brooklyn Museum at New York and shown in Fig.35 [44]. It has a C shape with two colors: black color for its hand and tip and a brown color for its body. It has no sickle blades.

Fig.35 Ceremonial sickle from the 18th Dynasty [44].

- The fifth example is a scene of a girl harvesting flowers in the tomb oif Menna of the 18th Dynasty (1398-1388 BC) shown in Fig.36 [45]. Most probably this is one of the daughters of scribe Menna harvesting flowers from the marshes during one of her father's journeys. It depicts the fact of the cooperation of all the family members during their daily life.

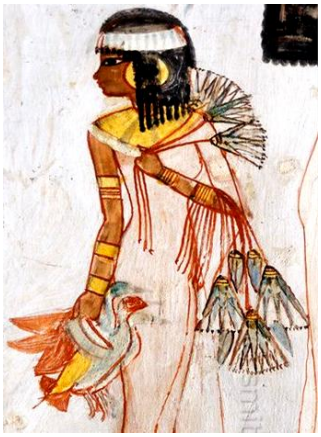

Fig.36 Flowers harvesting from Menna's tomb [45].

- The sixth example is a 400 mm length of gilded wood ceremonial sickle of Pharaoh Tutankhamun of the 18th Dynasty (1332-1323 BC) in display in the Egyptian Museum at Cairo and shown in Fig.37 [46]. The sickle was decorated by the cartouches of the Pharaoh and had blades manufactured from glass. This is a great appreciation from the pharaohs for the farming process that sustained for thousands of years making Egypt a great empire in the Middle East.

Fig.37 Ceremonial sickle of Pharaoh Tut [46].

- The seventh example is a scene of grapes harvesting from the tomb of Userhat, the Royal scribe during the rein of Pharaoh Amenhotep II (1425-1398 BC) shown in

Fig.38 [47]. The scene depicts workers busy in harvesting grapes with great concentration in the harvesting process.

Fig.38 Grapes harvesting from Userhat tomb [47].

- The eighth example is a 285 mm length wooden sickle with flint blade from the 18th Dynasty in display in the British Museum and shown in Fig.39 [48]. It is decorated by a Pharaoh cartouche and had only two flint blades.

Fig.39 Sickle with flint blades from 18th Dynasty [48].

- The ninth example is a scene from the tomb of Sennedjem of the 19th Dynasty (1300 BC) showing a farmer and his wife harvesting flax manually without any sickles shown in Fig.40 [49]. Again the image reflects the cooperation of the Egyptian wife with her husband in a number of activities related to the farming process and hence building the ancient Egypt great civilization.

Fig.40 Flax harvesting from Sennedjem tomb [49].

- The tenth and last example is a wall engraving for a team of ladies harvesting lily for perfume production in a tomb from the 26th Dynasty of the Late Period (664-526 BC) in display in the Louvre Museum at Paris and shown in Fig.41 [50].

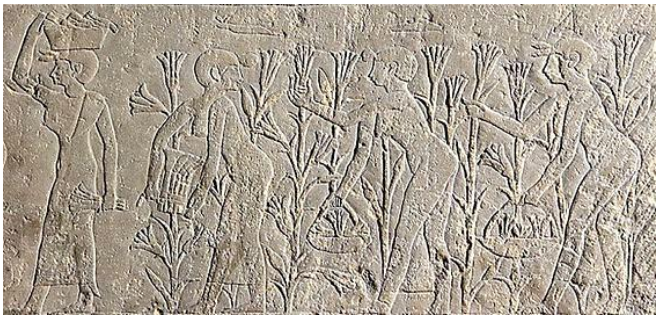

Fig.41 Lily harvesting from a 26th Dynasty tomb [50].

VIII. CROPS TRANSPORTATION

Transportation is needed to transfer the harvested crops to the location where they have to be threshed an then to transfer the seeds to the granaries. Ancient Egyptians using different ways of transportation:

1. Using man-carried baskets as depicted by the following examples:

- The first example is a tomb scene for a net-basket carried by two porters from the tomb of Menna of the 18th Dynasty (1420 BC) shown in Fig.42 [51]. The two porters are carrying the basket through a pole on their shoulders.

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Fig.42 Crop transportation from Menna's tomb [51].

- The second example is a scene from the tomb of Nakht from the 18th Dynasty (1400 BC) and shown in Fig.43 [52]. In this scene the basket was equipped with a pole and a robe. One of the porters is holding the poly using both hands while the other is holding the robe using both hands. It seems that they are loading the basket by the crop.

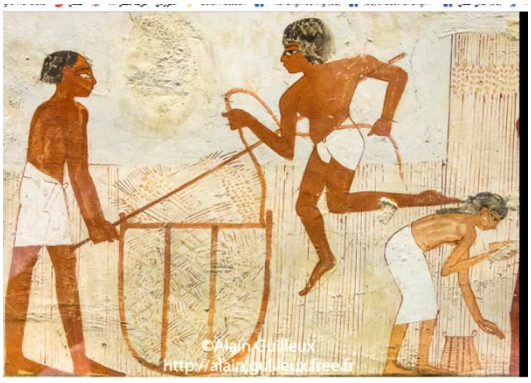

Fig.43 Crop transportation from Nakht's tomb [52].

2. Using man-carried sacks as depicted in the granary model from the tomb of Meketre from the 12th Dynasty of the Middle Kingdom during the reign of King Amenemhat I (1981-1975 BC) shown in Fig.44 [53]. The model depicts transferring the seeds to the storage granary by six porters carrying sacks and another six scribes recording the input-output activities of the granary.

3. Using donkeys as depicted by the following examples:

- The first example is a an engraving in a tomb from the 4th Dynasty (2500 BC) shown in Fig.45 [54]. The scene depicts a hard of five donkeys prepared to carry a stuff of googd or plants on their backs.

Fig.44 Granary model from Meketre tomb [53].

Fig.45 Donkey's transportation from 4th Dynasty [54].

- The second example is a wooden model of transportation donkey from the 11th Dynasty (2000 BC) shown in Fig.46 [55].

Fig.46 Donkeys model from 11th Dynasty [55].

The model depicts the ancient Egyptian thinking and administration more than 4000 years ago. Each donkey is equipped with a specially designed container to suit its back. The contained is labelled with a designation character or symbol may be indicating the owner or the transported stuff. Each donkey has its own worker equipped with a stick in his right hand.

- The third example is a tomb scene of crop transformation on a donkey from the 19th Dynasty (1298-1235 BC) shown in Fig.47 [56]. The transportation is achieved by two –large-net-baskets on the back of the donkey. The donkey is striding uniformly and may be braying indicating its activity. The worker is following the donkey with a stick in his right hand.

Fig.47 Crop transportation in the 19th Dynasty [56].

IX. GRAIN THRESHING

The crops now are transferred in a threshing-floor where the grain are split from the crops. The ancient Egyptians used almost two techniques for grain threshing:

1. Human-threshing: where a number of workers squeeze the crops by their feets as illustrated in Fig.48 [57]. The scene is from the tomb of Menna of the 18th Dynasty (1420 BC). Two men are crushing the crops by their feet while using a fork to bring new crops under their feet without bowing their back. The process was performed under full supervision by an overseer watching the threshing process.
2. Animal-threshing: To increase the productivity of the threshing process they used animals (usually oxen) as they are strong animals with four legs doing the job. Fig.49 shows a threshing scene from the tomb of Menna (1420 BC) [58]. A hard of four oxen were used driven by one operator, while two men using forks to pull more crops in front of the oxen.

Fig.48 Human-threshing from Menna's tomb [57].

Fig.49 Animal-threshing from Menna's tomb [58].

X. WINNOWING

The output of the threshing process is a solid mixture of grain and hay. The ancient Egyptians devised tools helping in separating both from each other as illustrated in the following examples:

- The first example is from the Middle Kingdom (2050-1800 BC) which is a wooden winnowing scoop in display in the World Museum at Liverpool and shown in

Fig.50 [59]. It has a hand little bit longer than the width of a worker's hand and a quarter-ellipse-palm to hold a specific quantity of the grain-hey mixture during winnowing. The winnowing process itself will be illustrated in another tomb-scene.

Fig.50 Winnowing scoop from Middle Kingdom [59].

- The second example is a scene of grain winnowing from tomb of Mena of the 18th Dynasty (1420 BC) shown in Fig.51 [60]. The scene illustrates exactly the mechanism of the winnowing process. The scene shows four workers (two from each side), each holding a scoop in each hand. They throw the mixture vertically as far it goes. The wind takes the hay away while the grain fall down under its gravity. Three labours in the middle are putting the grain aside.

Fig.51 Winnowing scene from Menna's tomb [60].

- The third example is scene from the tomb of Nakht of the 18th Dynasty (1398-1388 BC) presenting a winnowing process shown in Fig.52 [61]. In this scene, six men are winnowing in a complete harmony while other two are using scoops and putting the grain aside. Again, each worker is using two scoops. All the workers in the two scenes of Figs.51 and 52 are wearing headdress to protect their hair against the separated hay.

Fig.52 Winnowing scene from Nakht's tomb [61].

XI. GRAIN STORAGE

This is the final stage in grain production .. storing the grain obtained from the threshing process. Because Egypt was a great empire, they devised several techniques for storing the grain:

1. Using open silos: Here are two actual examples of using this type:

- The first example is a square cross-sectional open silo from the step pyramid complex of King Djoser, the founder of the 3rd Dynasty (2686-2649 BC) shown in Fig.53 [62].

Fig.53 Open silo from the 3rd Dynasty [62].

- The second example is an open silo from the 17th Dynasty (1630-1520 BC) from Tell Edfu at Southern Egypt taking the shape of a half circle build by mud bricks and shown

in Fig.54 [63]. The diameter of the half-circle was up to 6.5 m.

Fig.54 Open silo from the 17th Dynasty [63].

2. Using cylindrical-domed silos: This type has a loading window near its top and a discharging door from the bottom as illustrated in Fig.55 [64]. Each silo is loaded by the help of an external ladder and a permanent worker on each ladder while another workers bring the grain in sacks from the threshing floor as depicted in Fig.55. Unfortunately, I couldn't trace the location of this scene nor its time-period. This silo design continued to be applied in Egypt up to only about 70 years ago when Egypt were still a big agricultural country..

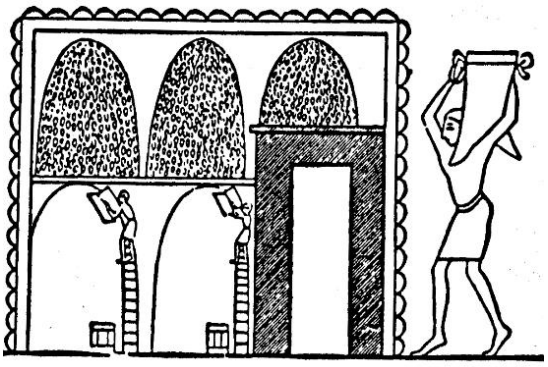

Fig.55 Closed cylindrical silos [64].

3. Using granaries: Granaries were the most efficient grain-storage facility because of their design and possibility of supervising the storage capacity and all the activities regarding the grain demand. Here are some examples:

- The first example is a granary model from the Middle Kingdom (2000-1900 BC) in display in the Louvre Museum at Paris and shown in Fig.56 [65]. The model depicts a granary consisting of a number of adjacent closed compartments for grain storage. The compartments are bounded by a wall with outside door. There is internal stairs to load the compartments from a circular hole in the top of each compartment.

Fig.56 Granary model from the Middle Kingdom [65].

- The second example is a granary model from the early reign of King Amenemhat I (1981-1975 BC) of the 12th Dynasty in display in the Metropolitan Museum of Art and shown in Fig.57 [66]. It depicts an elaborated granary consisting of two compartments. The first facing the main door of the granary structure which is an administration office where a number of scribes record or the activities of the granary. The second compartment comprises the storing closed-compartments with stairs to load the compartments from their top and doors in the bottom to discharge the granary.

Fig.57 Granary model from the 12th Dynasty [66].

XII. CONCLUSIONS

- The paper presented evidences outlining the passion of ancient Egyptians by farming from the 4th, 18th and 19th Dynasties.
- As a direct application of plant farming, the ancient Egyptians could establish cattle and poultry farming supporting their daily life.
- The paper handled all the farming activities in the Egyptian ancient society starting from land-ploughing up to grain storage.
- Ancient Egyptians applied ploughing through using hand-hoes and animal powered ploughs.
- They registered using the hoe during the 1st Dynasty and the plough during the 11th Dynasty.
- They showed great appreciation to the hoe through showing some of their Kings and Pharaohs holding hoe in one or two hands during the 1st and 26th Dynasties.
- They applied manual seeds sowing and registered this process starting from the Middle Kingdom down to the 20th Dynasty of the New Kingdom.
- They used different schemes for soil irrigation using jugs carried by porters as a positive displacement pump during the 6th Dynasty and shaduf as a single-jug positive displacement pump registered during the 19th Dynasty.
- Water supply was provided using the River Nile water through canals and pools registered during the 18th and 19th Dynasties.
- They performed crops harvesting using sickles registered from as early as the time of Gerza (more than 5200 years ago).
- Sickle blades used by ancient Egyptians during the Predynastic, Early Dynastic and Old Kingdom are in display in a number of world museums.
- The Pharaohs showed great appreciation to the farming processes through having ceremonial sickles during the 18th Dynasty.
- The ancient Egyptians transported the harvested crops to threshing floors using men-carried baskets, men-carried sacks and using donkeys.
- They applied a grain-threshing technique using human and animal power.
- They applied a technique for grain winnowing to isolate the grain from the hay.
- They used wood winnowing scoops registered from the Middle Kingdom (more than 3800 years ago).
- They registered the winnowing process using wonderful colored scenes in Noble tombs from the 18th Dynasty.
- They devised several techniques for grain storage for future use. They registered the use of open silos during the 3rd Dynasty and continued to use this type up to the 17th Dynasty through actual excavation of such silos. They used cylindrical-domed silos and various design of granaries appeared during the Middle Kingdom.

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