Roman Agriculture and Gardening in Egypt as seen from Kellis

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The Dakhleh Oasis is an isolated region in the Western Desert of Egypt. It lies some 800 km south-south-west of Cairo, and 300 km west of the Nile, and is centred in Mut, its capital, on 25°30´N at 29°07´E. In antiquity travelling time to the Nile Valley was about eight days. The oasis is an undulating plain sitting beneath a 300 m limestone escarpment and rises slightly towards the south. It covers an area of about 2,000 sq km. The climate today is hyperarid with a mean annual precipitation of 0.7 mm, which occurs as occasional local downpours. Relative humidity rarely exceeds 50% and average maximum temperatures vary from 21.5°C in January to 39.5°C in July, but extreme maxima of 50°C are recorded as well. Under such extreme conditions, all needs for water have to be met by underground aquifers that feed to the surface through natural vents, springs and bores. All available evidence indicates, that the climate was not markedly different in Roman times.

Environment and Modern Flora

(Johannes Walter)

Dakhleh Oasis is located in the very dry rainless part of the Great Sahara. The soils are of coarse to medium texture, have a low level of organic matter, are slightly acidic to alkaline in reaction at the surface and sometimes show an accumulation of calcium carbonate within the topmost 1.5 m. The large particle size and the lack of organic matter result in a low water-holding capacity, with also relatively low levels of micro-organisms. In some areas the soil is covered with a thin layer of stones, pebbles and gravel that constitutes a desert pavement from which the fine particles have been lost. In some soils soluble salts are present in sufficient quantity to influence the growth of plants considerably. Water, provided through irrigation, dissolves the salts (mainly carbonates and sulphates, but also chlorides) and, through capillary forces, they are concentrated in the topsoil. In many formerly-cultivated areas and on the banks of swamps the uppermost layer of the soil consists of white crystallized compounds. Salinity and alkaline reactivity are toxic for most plants except the specialised halophytes. Consequently, the natural vegetation of the south-western oases (Dakhleh and Kharga Oasis) is essentially halophytic. The natural vegetation in Dakhleh, however, has been largely replaced by cultivation. Natural vegetation is only possible in areas with (very) high ground water level, where plants can reach water. In some areas, such as around spring mounds and vents, the soil has probably always been waterlogged which allowed reed swamp (helophytic) vegetation to develop. But today reed swamp vegetation is mostly caused by human interference, that is irrigation. The aperiodic rainfall does not trigger off a 'blooming of the desert' as there is no appreciable seed bank in the desert soils. Furthermore, the rainfall is usually too scant and short to cause the remaining seeds to germinate.

Dakhleh Oasis does not match the conception of an oasis that we usually have in our minds: an area of lush, extensive plant growth within a desert. It is rather a stretch of land under cultivation, intersected by areas of barren land. Suitable soils are farmed until the water source fails or soil salinity has become too high, both forcing the farmer to move to another area. Therefore the possession of land is meaningless in Dakhleh, only the access to sufficient water supply is important.

The flora and vegetation of the oasis, as generally of Egypt, belongs predominantly to the Saharo-Arabian Region but also shows some influence from the Irano-Turanian Region and the Mediterranean Region; species belonging to the Sudanesian Region are rather rare (Zohary 1973, 80–244). The investigated flora, including introduced and cultivated plants, consists of about 200 species belonging to 52 families (see also Ritchie 1999). Today seven vegetation types can be recognized: hydrophytic (aquatic), helophytic (reed swamp), halophytic (salt marshes), xerophytic (on dry places of arid regions), psammophytic (vegetation on sand plains), segetal and ruderal (vegetation of cultivated and wastelands) (Zahran and Willis 1992, 86–103). The last two types comprise the largest part of the plant-covered area of the oasis (fields, gardens, orchards, fallows, waste land) and are dependent on irrigation. As many of the wells are continuously overflowing and the irrigation canals are often leaking, this permanent water supply leads to the formation of reed swamps with the diagnostic and often dominant species *Typha domingensis* and *Phragmites australis* or, in areas with high soil salinity, to wet salt marshes with *Juncus rigidus, Suaeda aegyptiaca (= Schanginia a.), S. monoica* and *Tamarix nilotica* and less frequently with *Salicornia fruticosa (Sarcocornia f.),* and *Cyperus laevigatus.*

Dry salt marsh vegetation originates on sandy, saline deposits with moist subsurface layers or on formerly wet salt marshes that are no longer supplied with water. The outstanding feature of dry salt marshes is the high salt content of the soil and special plants living in this habitat (halophytes, salt-tolerant plants) have evolved physiologic strategies to overcome this difficulty. Some of the halophytes are succulent with high concentrations of ions in the cells and enlarged tissue-volume caused by their incomplete capacity to filter these ions: especially *Chenopodiaceae* (*Suadea spp., Salicornia spp*.) and *Zygophyllaceae* (*Zygophyllum spp*.). Others excrete the toxic ions through special vesicular hairs or salt glands and these plants are often encrusted with a thin layer of salt (for example *Aeluropus lagopoides, Frankenia pulverulenta, Tamarix nilotica*). A third group of plants regulates the intake of ions by selective absorption, that is root filtration of grasses. Many halophytes produce compatible solutes for osmotic regulation, protection of enzymes, and stabilisation of membranes. Dry salt marshes, often overlaid with sand, are dominated by *Cressa cretica, Aeluropus lagopoides, Alhagi maurorum, Imperata cylindrica* and *Tamarix nilotica.*

There are no living plants in the open parts of the plains where wind action is continuous and causes instability and variable thickness of the soil. Plants, such as *Alhagi maurorum, Lagonychium farctum, Desmostachya bipinnata*, can only be found on the clay substratum. These plants sometimes become covered with sand and, after being exposed again, they represent the remnants of a previous plant cover. Plants are also instrumental in stabilising dunes. *Lagonychium farctum* and *Alhagi maurorum* can grow abundantly but, above all, tamarisks play an important role and can reach considerable size. They are capable of forming mounds and hillocks that form suitable microhabitats for certain plants. The salt-crusts covering their twigs and branches are highly hygroscopic and in the early morning hours water drips down providing enough humidity for other salt-tolerant plants like *Scirpus maritimus* and annuals to establish themselves. The sand-binding grass *Imperata cylindrica* can be useful for the fixation of dunes.

Xerophytic vegetation is characteristic of arid areas and consists of several (very) common and often dominant plants like *Tamarix nilotica, Acacia nilotica, Zygophyllum coccineum, Salsola baryosma, Chrozophora tinctoria (= C. obliqua), Lagonychium farctum*; other taxa are less common or rare: *Citrullus colocynthis, Hyoscyamus muticus, Calotropis procera, Balanites aegyptiaca, Salvadora persica*. Many plants in arid regions are characterized by their drought avoidance or evasion, with the former being the only strategy of the plants in Dakhleh Oasis. Desert annuals and geophytes (perennial plants surviving the dry period by accumulating water in their bulbs, tubers, rhizomes or thick roots) are absent in this region. Desert plants are able to reduce transpiration to 20–40% and up to 100% (CAM plants) by minimizing leaf surface or by physiological adaptations. Plants with reduced leaf surface are, for example, *Saccharum spontaneum* compared with *S. officinarum* and *Alhagi maurorum*; scaly foliated species are *Salsola spp., Tamarix spp*.; in *Capparis decidua* essentially the green leafless branches are assimilating. Other plants produce fleshy-leathery leaves (*Hyoscyamus muticus, Balanites aegyptiaca, Calotropis procera*) or are covered with hairs reflecting the intensive sunlight and reducing transpiration (*Abutilon pannosum, Bassia muricata, Crozophora tinctoria* [*C. obliqua*]). Additional morphologic adaptations are thickened epidermis and cuticle and reduced stomata often embedded more deeply in the epidermis. The investment into densely branched and deep roots is essential, ensuring a permanent water supply by reaching the ground water level or by absorbing the moisture in the soil. Therefore the biomass of roots can be 80% of the entire plant. Of course physiologic adaptations have been realized as well (C4 plants: such as *Atriplex leucoclada, Bassia spp*., *Portulaca oleracea, Sorghum spp., Saccharum spp., Pennisetum spp*., *Echinochloa spp., Cyperus spp*. or CAM plants of, for example, *Crassulaceae*).[1]

The vegetation of cultivated lands consists of several annuals or geophytes. Many segetal species (plants occurring in fields) are characterized by their short flowering and fruiting season (winter annuals)[2] telling us that they originate in arid areas with a (very) short humid period (ephemerophyts). Several of these belong to the Mediterranean Region. Characteristic segetals and ruderals are: *Echinochloa colona, Avena fatua, Digitaria sanguinalis, Phalaris spp., Setaria spp., Cyperus rotundus, C. tuberosus, C. conglomeratus, Fimbristylis ferruginea, Bassia muricata, Convolvulus althaeoides, Brassica nigra, B. tournefortii, Malva parviflora, Anagallis arvensis, A. foemina, Melilotus spp., Plantago lagopus, Erodium spp., Vicia spp., Lathyrus spp., Medicago spp., Kickxia spp., Chenopodium murale, Polygonum equisetiforme, Emex spinosa*. Some of them occur in temperate regions as well: *Sonchus oleraceus, Convolvulus arvensis, Echinochloa crus-galli*, whereas *Cynodon dactylon* is of tropic origin. Wastelands are often covered with *Zygophyllum coccineum* (especially

[1] C4 and CAM: specialised photosynthetic pathways.

[2] e.g., *Medicago spp., Erodium spp., Brassica nigra, B. tournefortii, Plantago lagopus, Asphodelus fistulosus* var. *tenuifolius*.

in western and central parts of the oasis), *Crozophora tinctoria, Suaeda aegyptiaca, Bassia indica (= Kochia i., ad B. scoparia)* which indicate a high ground water level or high degree of moisture in the soil. Dryer areas are occupied by *Alhagi maurorum, Lagonychium farctum, Tamarix nilotica, Salsola baryosma.* In places where the soil is damp for a long period (swamps, canal banks and wells) grasses occur frequently (*Polypogon monspeliensis, Dichanthium annulatum*, *Sorghum virgatum, Imperata cylindrica, Phragmites australis*) but there is also *Ammania baccifera, Centaurium spicatum, Senecio desfontainii, Sonchus oleraceus***,** in addition to the common plants of the reed swamps (*Scirpus maritimus, Juncus rigidus, Typha domingensis, Eleocharis palustris*).

Kellis

(Colin A. Hope)

The site of Ismant el-Kharab is situated in central Dakhleh Oasis on a low terrace of Nubian clay with dry watercourses on the south-east and the north-west. There is a settlement, which occupies an area of 1050 x 650 m, and beyond to the north and north-west are two cemeteries. The settlement has been under excavation since 1986 and has yielded evidence for occupation from the first to fourth centuries CE. Some of the tombs in the north cemetery (Kellis 1) contain burials from the Ptolemaic Period (Schweitzer this volume), indicating that the settlement must have been in use also at that time.[3]

The settlement preserves considerable architectural remains (Hope this volume, Figure 1). These include a temple complex in use from the first to fourth centuries CE, where the obscure deity Tutu was venerated. Contemporary with the development of the temple complex is a large mud-brick building in the north central part of the site (Area B/1). Whilst its function has not been determined with certainty, it may have been administrative in part; several of its rooms preserve traces of elaborate classical paintings and one such room is a large colonnaded hall. To the north and east of this building lie residential areas (Areas B/2 and C/1–2); those in the east were occupied in the second and third centuries CE. Several of the domestic units on the north resemble villas and also have painted classical decoration. On the extreme north of the site are several pigeon lofts. Other early structures on the site are a bathhouse due south-east of the Temple of Tutu, and two rows of monumental mud-brick tombs on the south and north-west of the village.

In the late third century and during the fourth century there was substantial activity at the site coinciding with the arrival and expansion of Christianity. The central part of the site (Area A) seems to be a development of that time and contains well-preserved domestic units in mud brick. Five of these have been examined to date. Three form a contiguous block in the north of the area (Houses 1–3: A/1–2 and 5), along with a fourth structure of uncertain function (North Building: A/3). These have yielded a wealth of domestic objects and one, House 3 (A/5), a magnitude of inscribed material (Worp 1995) and numerous small bronze coins. These enable the date of occupation within the house to be set within the range of *circa* 273/4–389. The inscribed material is written mainly in Greek but there is a sizeable amount in Coptic; very little occurs in Latin and Syriac. Administrative, economic and domestic matters are documented amongst this material, and there are important documents enabling some of the residents to be identified as Manichaean (Gardner 1996; Gardner *et. al*. 1999). The most informative of the economic texts comes from House 2 (A/2); in the kitchen of that structure were found two intact wooden books, one of which is a record of accounts kept mainly over a three year period from 361/2–363/4 or 376/7–378/9 (Bagnall 1997). Other important inscribed material has been found in a two-storey house in the west of the central area (House 4: A/6); the fifth house (A/9) yielded little inscribed material but, like all others, much domestic material.

Area A also contains a complex of great importance for the study of the last century of activity at the village: it is ecclesiastical and contains the Large and Small East Churches (Bowen this volume). The former is an imposing basilica that appears to have been built early in the fourth century and to have been in use until the last quarter of the century. The smaller church preserves interesting painted decoration in its apse and predates the larger church. A third church is located on the western extremity of the village and was built probably in the mid-fourth century.

Dating evidence at this site comes from a large number of coins, mainly found in the houses, and from texts, written on papyrus, wood or pottery in ancient Greek or Coptic. Preservation of many buildings at the site is exceptional, with many standing intact to roof height. It is probable that the sand began to overwhelm the village before 400 CE; this combined with the very minimal humidity has meant that the organic remains at the site have been well preserved and wood, basketry, textiles,

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[3] The Dakhleh Oasis Project directed by A. J. Mills, is sponsored by the Society for the Study of Egyptian Antiquities and the Royal Ontario Museum; the excavations at Ismant el-Kharab have been funded through the Project, the Australian Research Council and Monash University since 1991. Reports on the excavations by C. A. Hope *et al.* have been published in *Journal of the Society for the Study of Egyptian Antiquities* XV–XVII (1985–87) and XIX (1989), *The Bulletin of the Australian Centre for Egyptology* 1–6 (1990–95), 8 (1997) and 10 (1999), and *Mediterranean Archaeology* 1 (1988) and 8 (1995). See also comments by Hope in *Zeitschrift für Papyrologie und Epigraphik* 117 (1997); additional discussions appear in R. S. Bagnall, ed., *The Kellis Agricultural Account Book,* Oxford 1997, and C. A. Marlow and A. J. Mills, eds, *The Oasis Papers* I, Oxford 2000. A general discussion of the architecture of the site by J. E. Knudstad and R. A. Frey appeared in C. S. Churcher and A. J. Mills, eds, *Reports from the Survey of the Dakhleh Oasis, Western Desert of Egypt, 1977–1987*, Oxford 1999, 189–214.

leather, papyri and food remains are found in abundance. Although completely dependent on fossil water from wells and (possibly) springs, agriculture and horticulture were diversified and the foodstuff grown comprises a large variety of staple crops, vegetables, condiments, fruits and nuts; noteworthy is the near absence of ruderals and weeds.

It seems that the village of Kellis was occupied for some 400 years at least. It flourished as both a pagan and as a Christian centre, deriving its livelihood from agriculture. Traces of ancient field systems lie to the west and the south and ancient wells are located on the south of the village as well as within its confines.

Sampling at Kellis

For the recovery of plant macro remains standard soil samples of two litre volume have been taken from all deposits in habitation areas, as well as from selected areas in the temple complex and the Large East Church and sieved through a 0.5 mm mesh. As rare items would not be represented adequately in such a small sample, all significant matrices from the excavation were screened. In this way macro remains down to grape-pip size were recovered. In addition, the plants from approximately 50 floral bouquets from graves were identified. To date, about 700 samples with some 100,000 plant remains have been analyzed.

Agriculture

In the Nile Valley agriculture was controlled by the annual flooding of the River Nile caused by monsoonal rains in the headwater areas of its main tributaries. Ideally, the river was at its 'bank-full stage' in Upper Egypt by mid-August and the floodwater would then spread, eventually filling the succession of natural flood basins to an average depth of 1.5 m, depositing a layer of fertile silt (Butzer 1976, 17–18). Both, too low and short or too high Nile floods had adverse effects on crop production, either leaving higher flood basins unflooded or causing destruction and at least from the Middle Kingdom onwards attempts were made to control the flood waters. The inhabitants of the Egyptian oases, however, depended on fossil water encapsulated in cavities of the Nubian Sandstone Series, a tertiary formation, which fed to the surface under natural pressure and through man-made bores. As in the Nile Valley, irrigation was gravity fed. The water table was simply raised by building a cofferdam around the source (Mills 1999, 175). The *shadouf* or well-sweep was already known in the 18th Dynasty but effective water-lifting devices such as the *saqiya* or ox-driven water wheel and the *tanbur* or Archimedean Screw were Ptolemaic innovations (Bowman 1986, 19). Independent from the vagaries of the Nile floods, the Egyptian oases have been noted for their fertility and already during pharaonic times agricultural production was geared to self-reliance and production of trade commodities for the Nile Valley. The year-round availability of water might also have facilitated a second crop per year. As today, cereals and pulses would have been sown in late autumn and harvested in early spring, while pearl millet and cotton could have been grown as summer crops.

Grain Crops

One of the most important crops since the Predynastic Period has been wheat. Present in large quantities on site are bread wheat (*Triticum aestivum*) and hard wheat (*T. durum*), both naked wheats originating in the Near East, which made their way into Egypt during the Neolithic and Predynastic Period respectively, but which, according to scarce archaeological finds, only played a minor role throughout the Pharaonic Period. From the Ptolemaic Period onwards they gradually replaced emmer wheat (*T. dicoccum*), once a staple crop in Egypt. There are several mentions of wheat in the Kellis Agricultural Account Book (P.Kell. IV Gr. 96) and it appears that wheat was the largest single crop produced by the tenants of the estate (Bagnall 1997, 36). Several papyri from Kellis also mention transactions of wheat (Worp 1995, P.Kell. I Gr. 6.14, 19, 30, 42, 50; 32.14; 47.16). A sufficient wheat supply for the cities was of major concern. Wheat was used for soup and porridge and ground into flour to make bread. The most esteemed bread was *katharos*, clean or white bread, which was most probably eaten by the more privileged members of the society or in the context of festivities. The poorer individuals probably ate less refined bread, that may have been made of lower quality wheat or wheat of the previous year's crop (Bagnall 1993, 23–24). Rachis fragments, glumes as well as grains of both bread and hard wheat are abundant at Kellis. Emmer wheat is still present in small quantities.

Another important cereal was barley (*Hordeum vulgare*) and both, the two- and the six-rowed forms are present at Kellis. Some of the barley crop was most likely used for the production of bread and beer, while the remainder may have been used as animal feed (Bagnall 1993, 25). Barley is listed in the Kellis Agricultural Account Book on several occasions (Bagnall 1997, 38) and also mentioned in other documentary texts (Worp 1995, P.Kell. I Gr. 10.6; 11.5; 55.2; 61.11; 78.4; 79.4); however it does not appear to be as prevalent as wheat. Barley is much more drought resistant than wheat and less vulnerable to high soil salinity and therefore well adapted to be grown in the marginal areas of the oasis.

Pearl millet (*Pennisetum americanum*, syn. *P. glaucum*), native to the Sahel, is a rare occurrence in Egypt and today is only grown on a small scale in the oases. Except for Kellis, *Pennisetum sp.* has only been found in Qasr Ibrim (Alexander and Driskell 1985, 15). In Kellis we found an abundance of parts of the panicle (the inflorescence), some still containing the fruit (grain). The finds appear to be concentrated in the domestic areas C1 and C2; in unit C/2/4 a bin filled with 39 kg of pure pearl millet was recovered. Unknown to the pharaonic Egyptians, it is not clear when this millet made its first appearance in Egypt. Although not substantiated by archaeological finds, Wagner (1987, 288) claims that millet was grown in the Great Oasis and quotes Olympiodorus of Thebes, who visited the area in 421 CE, saying that millet was sown three times a year. It is not clear which millet was meant.

Pearl millet is the most drought resistant of all millets and wild races still occur in the Sahara. It is nowadays a major crop of the Sahel and dry savannah. Interaction between wild, weed and cultivated races is conspicuous and massive stands of hybrids are built up in West Africa and again in the Jebel Marra part of Sudan (Harlan 1995, 124). In wild and weedy forms the sessile spikelets shatter at maturity, leaving the naked axis, whereas in domesticated forms the pedicelled spikelets remain connected with the axis at maturity and thus rendering the harvest of the whole inflorescence possible. The wild form has a wide distribution along the southern fringes of the Sahara (de Wet 1992, 182) where it is still collected by the local population. When and where pearl millet was domesticated is not yet clear due to lack of systematic archaeobotanical investigation. However, it seems to be clear that the people of Kursakata, north-eastern Nigeria, had domesticated *Pennisetum* shortly after 2800 bp (Neumann *et al*. 1996, 443). In Kellis, pearl millet seems to have played an important nutritional role, either as animal fodder or for human consumption. Nevertheless it is neither mentioned in the Kellis Agricultural Account Book nor in other Greek documentary texts. Contemporary human and animal bones analysed for their stable carbon isotope values reveal signals that indicate the consumption of C4 plants in the 1st–4th centuries CE (Dupras 1999, 267–68).

A variety of pulses was available to the inhabitants of Kellis. These include lentil (*Lens culinaris*), garden pea (*Pisum sativum ssp. sativum*), fava bean (*Vicia faba*), chick pea (*Cicer arietinum*), and termis bean (*Lupinus termis*); bitter vetch (*Vicia ervilia*), common vetch (*V. sativa*) and grass pea (*Lathyrus sativus*) might have been grown as fodder. Most of the pulses have been present in Egypt since the Predynastic Period. Pulses add protein to the diet. This is particularly important for the poorer population who could not afford to eat fish or meat regularly and indeed, the fava bean was one of the staples in the Roman Empire. The seeds were sold whole, crushed or ground into a flour called *lumentum*, which could be used for baking bread, but usually it was eaten as a mash (André 1998, 31). Pulses are attractive because, in contrast to most other flowering plants, they are able to fix atmospheric nitrogen through symbiosis with the root bacterium *Rhizobium*. Therefore, pulses add nitrogen to the soil rather than using it up. By field rotation or by mixing pulse crops with cereals the farmer is able to maintain a higher level of soil fertility, which might be of particular importance in the oasis where it is necessary to compensate for the lack of the fertilizing Nile floods. In contrast to other Roman sites, pulses are a rare occurrence at Kellis and only two species are present: lentil and fava bean, the latter presumably in its small seeded form (*V. faba ssp. paucijuga*).[4] While lentils are very rare, the testas of the fava bean occur regularly in domestic areas and one sample[5] contained nothing else but 150 ml of such fragments. In the Kellis Agricultural Account Book, *arakia* is mentioned (Bagnall 1997, 39). The species of legume referred to is unknown.

Oil and Fibre Plants

Originating in the Near East (Franke 1985, 443; Germer 1985, 174) safflower (*Carthamus tinctorius*) has been cultivated in Egypt at least since the New Kingdom. Several wreaths and other funerary offerings date to that period (Germer 1985, 174). From the petals dyes can be extracted which have been used to colour fabric, ointments and food. The seeds are rich in oil that contains a high proportion of unsaturated fatty acids and written evidence as well as archaeological finds attest the importance of this oil in Egypt (Körber-Grohne 1988, 426). As a seasoning with bitter taste safflower was known in the Greek cuisine in the Classical Period (Dalby and Grainger 1996, 51 and 86), but presumably was not used this way in Egypt (Pliny, *Naturalis Historia* 21, 90). At Kellis, the fruits occur regularly in domestic areas and safflower is also mentioned in the Kellis Agricultural Account Book as a commodity delivered in place of barley (Bagnall 1997, 39).

Flax (*Linum usitatissimum*) one of the founder crops of Neolithic agriculture in the Near East is not native in Egypt but presumably arrived there together with emmer wheat and barley. The earliest finds here, date back to the Neolithic (Barakat 1989, 112) and until the arrival of cotton (*Gossypium sp.*) flax was the only fibre plant grown in Egypt. Its importance is attested by numerous representations of its harvest in tombs from the Old Kingdom onwards. When the use of the oil-rich seed commenced in Egypt is unknown. For Columella (2, 7, 1) it was one of the most pleasant *legumina*. In domestic areas in Kellis whole flax capsules were found regularly. Flax or linseed is neither mentioned in the Kellis Agricultural Account Book nor in any other published text from Kellis, but was commonly used in textiles.

Cotton (*Gossypium sp.*), nowadays a prominent feature of the Egyptian summer landscape, has an ambiguous history. The genus has a wide distribution that covers the tropical and subtropical zones of both the Old and the New World, but in the Old World there is only one wild growing variety (*G. herbaceum* var.

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[4] Identified by A. Butler, Institute of Archaeology, University College London, by an SEM study of the testa.

[5] Sample 32/420-D6-1/A/5, S91.340.

africanum) producing lint-bearing seeds. It is this lint that is used for the production of all kinds of cotton fabric. *G. herbaceum* var. *africanum* has its centre of distribution in south-west Africa (Phillips 1976, 197–8) but to date no archaeological remains of either the plant itself or of tools associated with the processing of its fibres have been found in this area. The earliest indications of cotton cultivation are only available from the Harappan culture in the Indus Valley, dated to the 2nd millennium BCE (Hutchinson 1976; Vishnu-Mittre 1977). In the 1st millennium BCE, tree cotton (*G. arboreum*) seems to have moved from the Indian subcontinent to the Near East and the subsequent establishment of cotton in the Near East and the east Mediterranean region during Hellenistic and Roman times is well documented by Greek, Roman and Jewish authors (Zohary and Hopf 1994, 127). Cotton was introduced in Egypt during the Ptolemaic Period. Today by far the most important crop plant is *G. hirsutum*, a New World species. The traditional Old World cultivars contribute less than one percent to the annual production of cotton. In Kellis we have found fabric as well as whole cotton bolls, seeds and lint, and thus assume that cotton was grown locally at the time. This assumption is reinforced by the fact that Greek texts from the site mention dues in cotton (Bagnall 1997, 39–40; Worp 1995, P.Kell. I Gr. 61.6).

Horticulture

Horticulture or gardening has a long tradition in Egypt and gardens are often represented in tombs. These gardens are plots of land where fruits and ornamentals were grown. They usually have a geometric layout with a pond in the middle and trees and flowers arranged around it. The watering and tending of these gardens demanded a major labour input and therefore the possession of a formal garden seems to have been restricted to the privileged part of the society, the temples and the royalty. In addition to formal gardens undoubtedly market gardens for the growing of vegetables, herbs and spices existed as well (Hugonot 1989; Eigner 1995; Wilkinson 1998). The Roman Period inhabitants of Egypt shared with their pharaonic ancestors their love for nature and growing plants. The Latin term for garden, *hortus*, is all embracing and therefore the actual appearance of an individual garden is difficult to establish. The term could be used in a domestic sense but could equally refer to a market garden, a rustic vegetable plot, an orchard or an urban plot. A garden could serve many purposes, providing not only fresh fruit, greenery and ornamentals, but also space for keeping bees, birds and fish; and last but not least, it was a source of enjoyment and an area for relaxation and contemplation (Farrar 1996).

The botanical assemblage of Kellis contains evidence for thirteen vegetables, herbs, spices and ornamentals, five more are mentioned in the Kellis Agricultural Account Book (Bagnall 1997, 39–40) and various other Greek documentary texts (Worp 1995, P.Kell. I Gr. 89.2; 89.4). Some of these, onion (*Allium cepa*) and garlic (*A. sativum*), have a long tradition of cultivation in Egypt dating back to the 13th Dynasty (Lucas and Harris 1962, 316) and the 18th Dynasty (Lucas 1942, 145) respectively. The finds from Kellis consist of onion skins and of base plates of the bulbs, as well as whole garlic cloves. Onion played an important role in Roman cuisine and was consumed fresh or dried (Diocletian*, Edictum de Maximis Pretiis* 6, 20–1) and Roman horticulturists put great effort into developing plants with large bulbs. Garlic was more expensive than onion (Diocletian*, Edictum de Maximis Pretiis* 6, 20 and 23) and like onion it was considered to be very nourishing.

Archaeobotanical evidence suggests that celery (*Apium graveolens*) has been used in Egypt since the 18th Dynasty (Newberry 1927, 192). The cultivars used today (var. *rapaceum* and var. *dulce*) were unknown at that time, but there is wild celery (var. *graveolens*) growing on slightly saline, damp soil on the Mediterranean coast, in the Nile Valley and the oases. In antiquity, celery was used for medicinal purposes and as a seasoning (Dioscorides, *De Materia Medica* III, 67 and 68; Germer 1985, 137).

The history of the artichoke is not well understood. Originating in the Mediterranean Region, it was known to Greeks and Romans. According to André, the Romans only knew the cardoon (*Cynara cardunculus*), which is grown for its fleshy leaf stalks, while the globe artichoke (*C. scolymus*), grown for its edible bracts and fleshy receptacle of the flower heads was not cultivated before the 15th century (André 1998, 24–5). Zohary and Hopf (1994, 181), however, assume that the globe artichoke was already cultivated by the end of the first millennium BCE. The remains of *Cynara* found at Kellis, consist of a whole flower head with fleshy bracts and several fragments of the receptacle, thus indicating that *C. scolymus* was present in Kellis.[6]

The bottle gourd (*Lagenaria siceraria*) is native to Africa south of the equator, and is now widely cultivated in Egyptian gardens. The first, somewhat equivocal, evidence in Egypt dates back to the second millennium BCE (Germer 1985, 133). The young fruits can be eaten as a vegetable, while the mature fruits are used as containers after the dried-out flesh has been removed. By bandaging the unripe fruit that would otherwise attain the form of a bottle, the fruit can be shaped into various forms. In Kellis, many fragments of the pericarp, as well as whole containers, some of them decorated, were found. Native in tropical Africa, the sponge gourd (*Luffa aegyptiaca*) might have been known in Egypt since the pharaonic period (Germer 1985, 131). The hard durable vascular bundles of its fruit are used as a sponge, hence its name. In domestic areas in Kellis

[6] Further finds of *Cynara* cf. *scolymus* have been reported from Mons Claudianus (van der Veen 1996,139 and 2001, 201).

several of its characteristic seeds were found. There are no finds of cucumber (*Cucumis sativus*) or watermelon (*Citrullus lanatus*) in Kellis, which, according to other published Greek documentary texts and archaeological finds, were of some importance in contemporary Egypt (Konen 1995; van der Veen 1996, 139).

Not very much is known about the history of cultivation of turnip (*Brassica rapa ssp. rapa*) in Egypt. It might have been cultivated there since the Ptolemaic Period but archaeological finds are rather rare (Germer 1985, 50–1; de Vartavan and Asensi Amorós 1997, 52). In the Kellis Agricultural Account Book, turnips appear several times as a rent crop (Bagnall 1997, 40).

Spices have always played an important role in the Egyptian cuisine. They were used to flavour food and render it more palatable. Some of them have antibiotic properties and thus curtail bacterial growth and decomposition of food. In addition, spices and herbs were used for medical purposes in a variety of preparations and were mixed with ointments and oil for hygienic purposes. Accordingly, the list of spices and herbs mentioned in various texts is quite long. The scarce archaeological finds throughout the Egyptian history are in strong contrast with that but it has to be borne in mind that often the leaf is the part used for seasoning. In archaeological contexts with only charred plant remains, leaves usually would not survive.

Most of the spices and herbs recovered in Kellis or mentioned in texts from there are not native in Egypt but originate in the Near East or in Africa and appear in Egypt in the 18th Dynasty: coriander, *Coriandrum sativum* (Renfrew 1985, 176); cumin, *Cuminum cyminum* (Mattirolo 1926, 549 and 556); fenugreek, *Trigonella foenum-graecum* (Germer 1989, 151); sesame, *Sesamum indicum* (Germer 1985, 172). From the Late Period onwards, a variety of new spices arrived in Egypt; laurel, *Laurus nobilis* (Newberry 1889, 51); marjoram, *Majorana hortensis* and rosemary, *Rosmarinus officinalis* (Barakat and Baume 1992, 54); fennel, *Foeniculum vulgare* (van der Veen 1996, 139); probably anis, (cf. *Pimpinella anisum*) and black mustard (*Brassica nigra*). Only fenugreek, cumin and sesame are mentioned in the Kellis Agricultural Account Book and it appears that spices and herbs were not grown for trade but for personal consumption. The favourite spice of the inhabitants of Kellis seems to have been coriander and the hard durable fruits occur regularly in moderate numbers in habitation areas.

Two valuable commodities that were not found in Kellis, but which are mentioned in medical prescriptions from the site, are myrrh, *Commiphora sp.* (Worp 1995, P.Kell. I Gr. 89.4) and pepper, *Piper sp.*, (Worp 1995, P.Kell. I Gr. 89.2). Since the 5th Dynasty, myrrh was imported from the land of Punt and was used in the mummification process, as incense, as component of ointments and for medical purposes (Germer 1979, 68). The demand for myrrh was that high that during the reign of Hatshepsut attempts were made to cultivate the tree in Egypt. These attempts failed (Germer 1985, 107).

Pepper (*Piper sp.*) is not native in Egypt but was imported. The Kellis text does not specify the type and, therefore, it is unknown whether it meant the black pepper (*P. nigrum*), which was imported from India, or an African pepper (*P. capense* and *P. guinense*). As black pepper was the most important spice in Roman cuisine (Thüry and Walter 1997, 36) it is likely that the text refers to this species. At the Egyptian Red Sea Port of Berenike, more than 1,000 peppercorns were found attesting the trade in these items with India at the time (Cappers 1998, 311–12).

Plants that appear to have been grown almost exclusively for funerary purposes are myrtle (*Myrtus communis*) and rosemary (*Rosmarinus officinalis*). Bouquets consisting of myrtle twigs are the most common floral grave offerings and rosemary leaves are frequently sprinkled in the graves. Everywhere else on site, myrtle is extremely rare and rosemary is completely missing.

Fruits and Nuts

Fruits and nuts were an important element of Egyptian food production throughout history. The most commonly found species in Kellis are date (*Phoenix dactylifera*), grape (*Vitis vinifera ssp. vinifera*) and olive (*Olea europaea*). Only the smaller part of the recovered taxa, among them, albeit, the ones with the most numerous finds, are native in Egypt and have a long history of utilization there.

Together with olive, grape and fig, the date palm (*Phoenix dactylifera*) was among the earliest cultivated fruit trees in the Old World (Zohary and Spiegel-Roy 1975). The wild stock from which the cultivated form could have derived is distributed over the southern, warm and dry Near East as well as the north-eastern Saharan and north Arabian deserts. For optimal fruit production the date palm requires a sustained water supply and moderately hot temperatures of *circa* 35ºC (Wrigley 1995, 400). The Egyptian oases, therefore, offer optimal conditions for their cultivation. Although wind pollinated trees set fruit, these usually are not as large nor is fruit production as prolific as from artificially pollinated trees and, based on etymological reasoning, Wallert (1962, 15–7) argues, that dates were artificially pollinated in Egypt from at least the Early Dynastic Period onwards, a view which is not supported by archaeological finds. The date palm not only offers fruit rich in sugar which can be easily dried for storage, but virtually every part of the tree has been utilized until today. This stands in strong contrast to the rather scarce archaeological finds of date stones from pharaonic Egypt and the fact that date palms feature prominently in representations of Egyptian gardens. They never appear to be planted alone, but always grew in combination with other trees, a practice not only present in Roman times (Wagner 1987, 293), but still followed today. In Kellis date stones (whole and crushed ones) are ubiquitous and the number of finds figures in the 10,000s. Other parts of the fruit (stalk, pulp) and of the tree, mainly the mid-rib of the frond, leaflets, fibre and parts of the inflorescence occur regularly. In the Kellis Agricultural Account Book and various papyri from Kellis dates are mentioned several times, both as crushed dates as well as date stones. Crushed dates are most probably pitted dates moulded into a block just the way it is still done today. They are valuable and their implied price is 2.5 times that of ordinary dates. Date stones can be crushed or milled into flour for animal feed. In the Kellis Agricultural Account Book date stones are not a rent crop, but payments of stones against obligations of dates are found several times (Bagnall 1997, 42–3).

Native to Egypt and the Sudan, the dom palm (*Hyphaene thebaica*) has been utilized in Egypt at least since the Late Palaeolithic (Hillman *et al*. 1989, 198–202). The fibrous pulp is rich in sugar, iron and niacin and can be eaten raw or ground into flour for cakes or made into a syrup. Other parts of the tree can be eaten as well. Archaeological finds of whole fruits as well as of the hard seeds are common in Kellis. In the Kellis Agricultural Account Book and other Greek documentary texts, dom nuts are only mentioned twice (Bagnall 1997, 43; Worp 1995, P.Kell. I Gr. 52.5). There are no archaeological finds of the third indigenous Egyptian palm, *Medemia argun*.

Seeds and pods of carob (*Ceratonia siliqua*), stones of sugar date (*Balanites aegyptiaca*) and Christ's thorn (*Zizyphus spina-christi*), all native in Egypt, are found regularly in Kellis and are mentioned in documents from there.

Among the first introductions to Egypt are the grapevine (*Vitis vinifera ssp. vinifera*) and the common fig (*Ficus carica*). Originating in the Near East they presumably made their way into Egypt together with other early domesticates such as emmer wheat, barley, flax and pulses and remains are already found in Predynastic contexts (Thanheiser 1997, 245–6). Both fruit in summer or early autumn, and the fruits can be eaten fresh, or dried for consumption over an extended period. They are an important source for sugar, and the grape would have been the source for the well-known wine of the oasis. In Kellis grape pips belong to the most common finds, but there are also some whole grapes. Rare but present throughout the site are vegetative parts of the vine, leaves, wood and tendril, thus indicating that grapes were grown locally and indeed, since pharaonic times the oases were renown for their high quality grapes (Germer 1985, 117). Although fresh grapes are not specifically mentioned in either papyri or the Kellis Agricultural Account Book from Kellis, there are several mentions of dried grapes and wine, for which both must (new wine) and ordinary wine are documented (Bagnall 1997, 45; Worp 1995, P.Kell. I Gr. 51.5).

Figs are recorded in both papyri from Kellis and the Kellis Agricultural Account Book, and they appear to be a rent crop (Bagnall 1997, 41; Worp 1995, P.Kell. I Gr. 51.5). Sycamore figs (*Ficus sycamoros*) have been part of the Egyptian diet since times immemorial, while the earliest finds of the common fig (*F. carica*) date to the Predynastic Period (van Zeist and de Roller 1993, Tab. 1; Thanheiser 1997, 245–6). Sycamore figs are generally smaller than the common fig, up to 3 cm in diameter, and less sweet (Hepper 1990, 58). The desiccated figs recovered in Kellis are more than 5 cm in diameter, which is in the size range of the common fig.

The persea (*Mimusops laurifolia*) was a popular fruit tree in pharaonic Egypt. It was not only valued for its fruits, leaves and wood, but also for its religious associations (Hepper 1990, 50). Native to the Yemen and Ethiopia, it must have been introduced into Egypt during the Old Kingdom. The earliest persea fruits derive from the Third Dynasty tomb of Djoser, followed by numerous finds into the late Roman Period (de Vartavan and Asensi Amorós 1997, 173–6). By this time it may already have been endangered as the cutting down of persea trees was prohibited by law and by the seventeenth century CE it was completely extinct (Manniche 1989, 21). In Kellis its characteristic seeds occur in small numbers throughout the site.

Following the intensification of contacts with Palestine, starting in the Middle Kingdom and culminating in the Ramesside Period, a whole array of fruit trees were introduced in Egypt. Economically the most important was undoubtedly olive (*Olea europaea*). Native to the maquis and garrigue formations of the Mediterranean basin (Zohary and Hopf 1994, 138), olives make their first appearance in Egypt in the Second Intermediate Period (Thanheiser, in press). The earliest remains are fruit stones which might have reached Egypt as contamination of imported olive oil. From the New Kingdom onwards, olive trees were grown in Egypt and numerous representations in tomb reliefs, as well as finds of all parts of the tree attest to their increasing importance. By the Ptolemaic and Roman Periods the olive tree was grown extensively in Egypt, and particularly in the oases. Several documents report an oil called *l'Oasitique* (*το Αυασιτικον ελαιον*; Wagner 1987, 297). Of the more valuable food commodities listed in the Kellis Agricultural Account Book, olives and olive oil represent more than four-fifths of the total and the manufacture of olive oil for export to the Nile Valley may have been a source of local wealth (Bagnall 1997, 80). Archaeological evidence of olive stones, leaves and wood is abundant in Kellis.

Other newcomers of that period are almond (*Prunus amygdalus*), pomegranate (*Punica granatum*) and pistachio (*Pistacia vera*). While the cultivation of almond and pistachio has never played an important role in Egypt, the pomegranate soon became a valued fruit tree and numerous representations in tombs show the characteristic fruit. Almond and pistachio are rare occurrences at Kellis and it is unknown whether they grew locally or were imported, whereas whole pomegranates are found frequently.

With the onset of the Hellenistic Period in Egypt a variety of exotic fruits were introduced, among them apple, citron, peach and apricot. Walnut (*Juglans regia*), hazelnut (*Corylus avellana*) and pine kernels (*Pinus pinea*) have never been fruit crops in Egypt, but were imported; their hard durable shells as well as whole pinecones occur regularly on site.

The precise botanical origins of the domestic apple (*Malus domestica*) are uncertain. It is a complex hybrid that has developed over thousands of years, but its main ancestor is probably the central Asian species, *M. sieversii*, which is found growing wild from Tien Shan to the Caspian Sea. The wild species of the Caucasus, *M. orientalis*, has also contributed to the genetic make-up of the domestic apple, as has the European crab apple (*M. sylvestris*) and probably a few other species from eastern Asia (Morgan and Richard 1993, 9–10). Cultivated apples segregate widely when grown from seeds and as in many other fruit trees, cultivation depends on vegetative propagation of clones. Since the majority of apples cannot be reproduced from cuttings and suckers, their cultivation depends totally on grafting. Unlike other fruit trees the apple did not evolve into a major fruit crop in the Bronze Age but seems to have obtained its significant role in Old World horticulture in classical times. Apparently, this development is linked to the development of grafting, a sophisticated method of vegetative propagation with which the Greeks were already familiar (Zohary and Hopf 1994, 163). Several desiccated whole apples were found in Kellis and we assume that they were grown locally, as they are today.

The citron (*Citrus medica*) had its origin in south-east Asia and India. It is the only member of the citrus group that was already grown in the Near East in classical times (Zohary and Hopf 1994, 173). The fruit with its characteristic thick rind and astringent taste was initially used for medical and cosmetic purposes only (André 1998, 67). The earliest finds in Egypt date to the Ptolemaic Period (Germer 1985, 106).

Apricot (*Prunus armeniaca*) and peach (*P. persica*) had their origin in central and south-east Asia and reached the Mediterranean basin in Greek and Roman times where they quickly became valuable fruit crops (Zohary and Hopf 1994, 172). Several fruit stones have been recovered in Kellis and it is likely that at least apricots were grown locally, as they are today.

Summary

Initially we expected at Kellis a reduced floral complex from that known from the Nile Valley. In fact, virtually all species are found in both locations. Even the exotics, such as apricot, peach, apple and citron, found their way to the oasis and were regularly grown there in the Roman Period. Other exotics, such as pine kernels, pistachio, hazelnut and walnut, were probably imported into Egypt and distributed throughout the country. Otherwise, all of the staples, vegetables, fruits, herbs and spices would have been cultivated as in the Nile Valley and it is possible that the community was self-sufficient. Even a surplus was produced in such products as olive oil, wine and wheat (Worp 1995, P.Kell. I Gr. 51, 52). The plant remains from Kellis demonstrate both a highly sophisticated resource management and a well-developed international trading system.

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Table 1 Economic Plants from Kellis

HP plant remains from screening
SS plant remains in soil samples
B floral bouquets from graves
T plants mentioned in Greek documentary texts from Kellis (Worp 1995)
KA plants mentioned in the Kellis Agricultural Account Book (Bagnall 1997)
P present
? translation uncertain

F I E L D C R O P S

	HP	SS	B	T	KA	English vernacular names	Greek names[7]
Triticum dicoccum	P	P				emmer wheat	
Triticum durum		P				hard wheat	
Triticum aestivum	P	P				bread wheat	
Triticum sp.				P	P	wheat	*σῖτος* / *πυρός*
Hordeum vulgare ssp. distichum	P	P				2-rowed barley	
Hordeum vulgare ssp. vulgare	P	P				4- and 6-rowed barley	
Hordeum vulgare				P	P	barley	*κριθή*
Panicum miliaceum		P				broomcorn millet	
Pennisetum americanum		P				pearl millet	
				P	P	chaff	*ἄχυρον*
Lens culinaris		P				lentil	
Vicia faba	P				?	broad bean	*ἀράκια* / *κύαμος*
Vicia faba ssp. paucijuga	P	P			?	small seeded broad bean	*ὀρόβιον* ?
Vicia sp.					?	vetch	
Carthamus tinctorius	P				P	safflower	*κνῆκος*
Linum usitatissimum	P	P		P		linseed, flax	*λίνον* / *λινοκαλάμη*
Gossypium sp.	P	P		P	P	cotton	*ἐρεόξυλον*

VEGETABLES, HERBS, SPICES and ORNAMENTALS

Piper sp.				P		pepper	*πέπερι* / *πίπερι*
Trigonella foenum-graecum					P	fenugreek	*τῆλις*
Myrtus communis		P	P			myrtle	
Commiphora sp.				P		myrrh	*σμύρνη* / *ζμύρνη*
Apium cf. *graveolens*		P				probably celery	
Coriandrum sativum		P				coriander	
Foeniculum vulgare		P				fennel	
cf. *Pimpinella anisum*		P				probably anis	
Brassica nigra		P				black mustard	
Brassica rapa ssp. rapa					P	turnip	*γογγυλίδιον*
Cuminum cyminum					P	cumin	*κύμινον*
Lagenaria siceraria	P					bottle gourd	
Luffa aegyptiaca		P				sponge gourd	
Sesamum indicum		P			P	sesame	*σήσαμον*
Rosmarinus officinalis			P			rosemary	
Cynara cf. *scolymus*	P					probably globe artichoke	
Allium cepa	P					onion	*κρεμύσιον* / *κρόμμυον*
Allium sativum	P					garlic	

FRUITS and NUTS

	HP	SS	B	T	KA	English vernacular names	Greek names
Pinus pinea	P	P				pine kernel	
Corylus avellana	P	P				hazelnut	
Juglans regia	P					walnut	
Ficus carica	P			P	P	common fig	*ἰσχάς* / *ἰσχάδιον*
Malus sp.	P					apple	
Prunus amygdalus	P					almond	
Prunus armeniaca	P					apricot	
Prunus persica	P	P				peach	
Ceratonia siliqua	P					carob	
Punica granatum	P	P				pomegranate	
Citrus cf. *medica*	P					probably citron	
Balanites aegyptiaca	P					sugar date	
Zizyphus spina-christi	P	P		P	P	Christ's thorn	*δίζυφον* / *ζίζυφον*
Vitis vinifera ssp.vinifera	P	P		P	P	grape	*βότρυς, σταφίς, σταφυλή*
Mimusops laurifolia	P	P				persea	
Olea europaea	P	P		P	P	olive	*ἐλαία*
Pistacia vera	P					pistachio	
Hyphaene thebaica	P				P	dom palm	*κοῦκι*
Phoenix dactylifera	P	P		P	P	date	*φοῖνιξ*

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[7] Greek names are given for those plants that appear in the Kellis Agricultural Account Book or Greek documentary texts from Kellis. Greek names from the texts were generously provided by K. A. Worp who also checked the spelling.

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