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FRUIT TREE CULTIVATION IN THE NORTHWESTERN COASTAL ZONE OF EGYPT

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PREFACE

This report has been prepared in the framework of the Mariut project. That project, officially designated "Study of production levels and land use planning of the Western Mediterranean region of Egypt (Mariut)", has been a joint activity of the Centre for Agrobiological Research (CABO), the Department of Theoretical Production Ecology of the Agricultural University (TPE), both in Wageningen, the Netherlands and the Ecology group of the Botany Department, Faculty of Science, University of Alexandria, Egypt. It was sponsored by the Directorate-General for International Cooperation (DGIS) of the Dutch Ministry of Foreign Affairs.

The aim of the project was to assess the potentials of different agricultural systems for the purpose of land evaluation and regional planning in the northwestern coastal zone of Egypt. Alternative land use systems were defined and their economic feasibility and impact on the natural resources were investigated. The results of such an investigation should lead to formulation of an optimum development plan for the region, based on sustained productivity of the area.

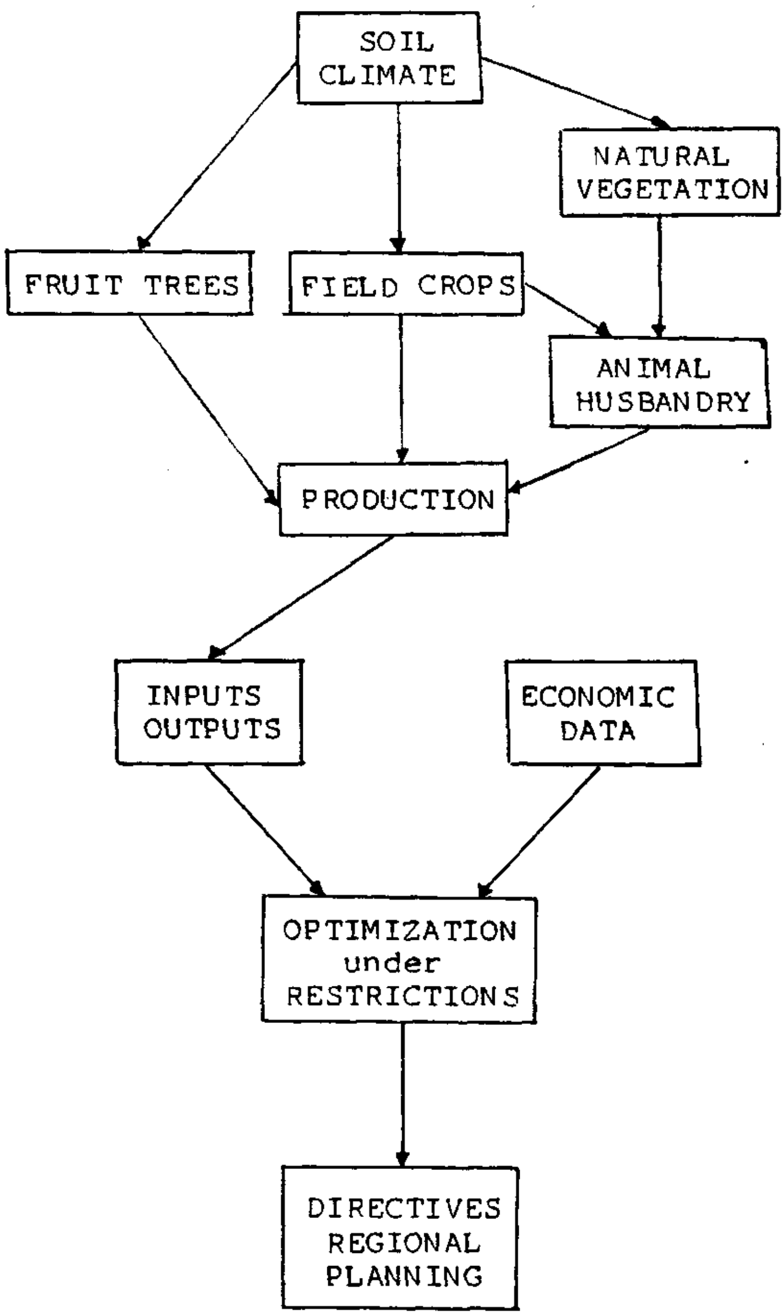
An overall scheme of the method of analysis used in the project is presented below. The potentials for agriculture production are governed by the physical environment, i.e. the soil physical and chemical properties and the climatic conditions.

Three main agricultural activities are distinguished in the region: fruit production, barley production and animal husbandry. Fruit production comprises cultivation of olives and figs. Olive and fig trees are relatively well-suited for the prevailing dryland conditions. Barley is by far the most prevalent field crop in the region, due to its relatively high drought tolerance. Animal husbandry comprises sheep and goat meat production. Additionally, donkeys are kept for transport and for animal traction, required for agricultural activities. Cattle are kept on a limited scale only in the irrigated areas. The sheep and goats graze the natural vegetation and the aftermath of the barley fields. In summer they need supplementary food to cover their maintenance requirements.

For all three brances of agriculture several production techniques have been defined. These include different yield levels and methods of cultivation and various intensification levels for animal husbandry. Barley, for instance, can be grown with or without the use of chemical fertilizers, but the choice between the use of animal traction and mechanical traction also exists. For each production technique, inputs and outputs are quantified and summarized in an input/output table. Inputs consist of chemical fertilizers, human labour etc. Outputs comprise olives, figs, meat etc. Alle relevant constraints in the region are also quantified and in combination with the economic environment form the basis for the multiple goal linear programme.

When all constraints are defined, different goals can be pursued, depending on the interest of the 'user'. Different groups in the region may have different interests and therefore different goals. In an interactive way an acceptable compromise can be searched for. On the basis of that result directives for regional planning can be formulated.

In this report the background material for the formulation of fruit tree systems is presented. Animal husbandry will be the subject of a subsequent report, whereas barley cultivation is discussed in a Simulation Report CABO-TT.



Scheme of the method of analysis used in the Mariut project

1. INTRODUCTION

In addition to barley cultivation and animal husbandry, fruit trees occupy part of the agricultural land in the northwestern coastal zone of Egypt. The Bedouin inhabiting the region, traditionally followed a nomadic way of life. In the early sixties the government adopted a policy of sedentarization and attempted to settle the Bedouin among others by promulgation of the Land Act in 1964. Officially, all the land in the coastal zone belonged to the government. The Land Act entitled farmers to ownership rights, if the land was cultivated with perennial crops. That measure stimulated sedentarization of the Bedouin and fruit tree cultivation has gained considerable importance since 1964. Prices for fruits have also gone up. The main species in the area are olive and fig, as others can not survive under the prevailing rainfed conditions in this harsh climate.

In this first chapter a general introduction on olive and fig cultivation is given. The second chapter describes the suitability of the environment of the northwestern coastal zone for these fruit trees and their distribution in the region. The cultural techniques, the yield and the cultivation systems are discussed in detail in Chapters 3 and 4 for olives and figs, respectively.

1.1. Olives

In general, olive cultivation is not considered an economically attractive activity. Olive trees are often planted in marginal areas, where no other crops can be grown. They recover easily from droughts and have a long productive life span of more than 50 years. They produce olives, though irregularly, without needing much care. However, by applying the available cultural techniques properly and by carefully selecting the site and the plant material, olive trees can produce a good crop and are no less profitable than any other fruit tree culture (Caballero, 1984).

Egypt has good potentials for olive cultivation, but until now the production has been rather low. The Ministry of Agriculture wanting to promote the Egyptian olive production, imported 774 000 young olive trees from Spain in 1979-1981 and distributed these over the various olive producing areas.

Three international projects dealing with the olive sector were implemented after 1981: a World Food Programme Project (ARE 2 270 Expansion), a Dutch Olive and Mango Multiplication Project, both dealing with propagation only, and the University of California Olive Project, that had a wider scope (Caballero, 1984). To improve cooperation and coordination between these projects and the governmental organizations, a Master Plan on the Development of the Olive Sector was formulated in 1984 by FAO, with Caballero as the chief technical advisor (project TCP/EGY/0105).

Olive orchards in Egypt can be divided into two groups according to ownership. Some orchards belong to state-owned agricultural companies. These are generally not run properly due to lack of interest and lack of training of the workers. In the northwestern coastal zone most orchards are privately owned. Lack of rainfall and also lack of skill, but usually not lack of interest, are the main problems here.

The northwestern coastal zone is one of the main olive producing regions of Egypt: 51% of the total area planted to olives is situated in this region. Other regions are Siwa Oasis, North Sinai, Fayoum Oasis, Wadi Natrun and the New Lands west of the Delta (Caballero, 1984). The total olive production in the northwestern coastal zone in 1984 was 6 000 ton, of which 4 000 ton was used for pickling and 2 000 ton for oil production (Caballero, 1984).

1.2. Figs

Fig culture in Egypt has been far less studied than olive culture. Fig is a traditional crop in the northwestern coastal zone, Fayoum and some other places, but the first region is by far the most important area (FAO-3, 1970; Abdel-Razik et al., 1986).

There are numerous fig species, but Ficus carica is the only one grown as a commercial crop (Bolin and King, 1980). The life span of an individual tree is about 100 years, but orchards start declining after 50 to 60 years. In general, the trees start producing figs when they are 3 to 4 years old and they are in full production at about 7 years of age. When compared to olives, figs have a short productive lifespan (Condit, 1947; Rebour, 1968; Bolin and King, 1980).

The fig tree is a deciduous tree, the length of the dormant season depending on local climatic conditions (Condit, 1947). Along the northwestern coastal zone leaves develop in March/April and are shed in October/November. The rooting depth can be up to 7 m (Condit, 1947). The fruit is a hollow cup-like receptacle with a small opening at the top, the ostiolum, and numerous unisexal flowers inside. The fig is thus a false fruit and the collective fleshy receptacle, the syconium, is eaten (Figure 1).

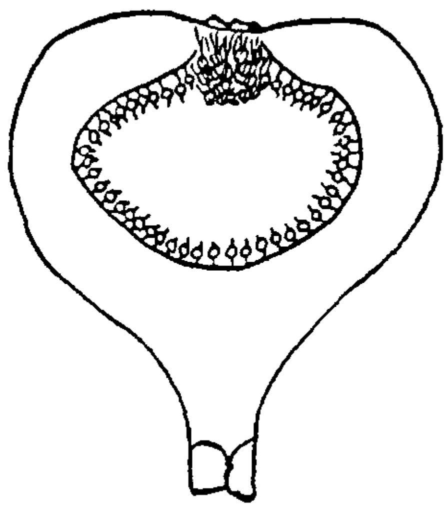


Figure 1. Diagrammatic section af a syconium, showing short-styled pistillate flowers, immature staminate flowers, and scales lining the ostiolum. (Source: Condit, 1947)

2. ENVIRONMENTAL CONDITIONS AND DISTRIBUTION OF FRUIT TREES IN THE REGION

2.1. Environmental conditions

2.1.1. Climate

Olives and figs are two of the most drought resistant crops and they are well suited to dry-farming (Blondel, 1964; Rebour, 1968; Samson, 1980). Both have similar climatic requirements (Rebour, 1968) and thrive well in a mediterranean-type climate. They can stand high temperatures and the minimum temperature to which they can be exposed without frost damage, is -8 °C. The average temperature in the northwestern coastal zone varies from 13 °C in January to 26.5 °C in August (Van de Ven, 1986).There is no danger of frosts, but cool nights, characterized by temperatures below 10 °C, prevail from the middle of December till the middle of March (FAO-2, 1970).

Olives can grow up to an alitude of 800 m and figs to about 1 200 m. Optimum rainfall for figs is 500 to 700 mm annually. Figs can survive and produce reasonably well with 300 to 400 mm, but below this, supplementary irrigation is necessary (Blondel, 1964; Rebour, 1968). The average annual rainfall in the northwestern coastal zone ranges between 100 and 150 mm (FAO-2, 1970), hence fig trees can only be cultivated on areas receiving additional water from surface run-off or wadi flow.

Winds are never very strong, but have a constant direction and make the trees curved and therefore unsuitable for mechanical harvesting. Strong winds also increase evapotranspiration, which is an undesirable water loss in this arid environment. The high temperatures accompanying the Khamasin, the strong sand storms in late spring, also have negative effects. Olives can not stand these constant and strong winds very well and the planting of wind breaks is essential in some areas. Fig trees don't need protection. They resist strong winds fairly well.

2.1.2. Soils suitable for fruit tree cultivation

Olive trees in the Mariut region are grown in the non-saline depressions and on the run-off receiving lands at the foot of the limestone ridges (Abdel-Razik et al., 1986). Most soils are sandy to sandy loam and calcareous. This type of soils is well suited for olive cultivation. (Caballero, 1984). The olive is a deep rooting tree, but the minimum soil depth required is only 1 meter (Caballero, 1984). Soil types suitable for olive cultivation are B1, B2, B4d, F3, Wb and P1 (FAO-2,1970). A short characterization of these soil types is given in Table 1.

Table 1. A short description of the soil types suitable for fruit tree cultivation.

code	potentiality class	texture	origin
B1	I	sandy loam to loam	former beach plains and dune depressions
B2	II	loamy medium fine sand	former beach plains and dune depressions
B4d	I	loamy sand	former beach plains and dune depressions
F3	I	sandy loam to loam	alluvial fans and outwash plains
Wb	I	sandy loam to loam	wadi bottom soils
P1	I	loam	elongated depressions in the plateau
Dol	VI	sand	Coastal dunes, wind blown

For a more detailed description is referred to Van de Ven (1986; 1987). At some locations the high lime content of soil type B2 makes them unsuitable for fruit tree cultivation (FAO-2, 1970). As this is not quantified, B2 is assumed to be fully suitable. Therefore, it should be noted that the area suitable for fruit tree cultivation may be slightly over-estimated. The complex soil types are not considered to be suitable, even when they have locally deep soils.

Figs have only moderate requirements with regard to soil physical conditions and soil fertility. They grow best on light deep soils, well-drained and containing some free calcium. The latter condition improves the quality of the figs, especially of the dried ones (Blondel, 1964; Rebour, 1968; Samson, 1980).

In Egypt the majority of figs is grown in the northwestern coastal zone, in the sandy dunes along the coast and on deep sandy and sandy loam soils (FAO-1, 1970). The soil types in the region suitable for fig trees are the same as the ones for olive trees, with the addition of Dol, the sandy dunes.

The distribution of the soil types over the northwestern coastal zone specified by region and the total area suitable for olives and figs are given in Table 2 (after FAO-2, 1970).

Table 2. Soil types suitable for olive and fig cultivation and their surface area in the various regions of the northwestern coastal zone of Egypt (area in ha).

region	soil type	total area
Burg El Arab	B1, B4d	13 950
Dabaa	B1, F3, Wb	30 020
	Dol	330
Matruh	B1, B2, F3, Wb, P1	11 400
	Dol	1 600
Barrani	B1, B2	2 150
total		59 490

2.1.3. Water resources

For each soil type the water available through wadi flow and surface run-off is calculated identical to that for barley cultivation (Van de Ven, 1986). For irrigated agriculture additional water is required.

The soil types B2 and B4d are situated in the interdunal plain behind the coastal dunes. The water table there is generally less than 5 m below the soil surface (FAO-2, 1970). This implies that olive and fig trees planted on these soil types, can use ground water. It is assumed that on soil types B2 and B4d enough water is available from rain and groundwater and that additional supply from run-off is not needed for fruit trees.

Soil type Dol comprises the coastal dunes with a groundwater table between 5 and 10 m below the soil surface, depending on the height of the dunes (FAO-2, 1970). Figs are grown in the lower half of these dunes, so they can exploit the groundwater. It is therefore assumed that 50% of the area of Dol can be planted to figs.

Irrigated olive and fig culture is only possible around Burg El Arab and in the El Qasr area, east of Mersa Matruh. In the first region water is available from irrigation canals. The irrigation efficiency is estimated at 60% (FAO-2, 1970). In the El Qasr area the use of water collected in galleries is possible. In that region ten galleries exist, with a total length of 11.5 km. The annual extraction of water from the galleries is estimated at 360 000 m^3, of which 125 000 m^3 is used for the urban water supply of Mersa Matruh. The other 235 000 m^3 is used for irrigation of 150 feddan (1 feddan = 0.42 ha) resulting in a water supply of 3 750 m^3 ha^{-1} (FAO-2, 1970).

Other water resources are the water collected in cisterns and the water pumped from wells. At the end of the FAO-project, 486 out of 2 500 cisterns had been cleaned and were in use. The total capacity of the cleaned cisterns was 215 000 m^3 yr^{-1}. FAO (Report 2, 1970) estimated the potential of all 2 500 cisterns at about 1 million m^3 yr^{-1}. The total amount of water used from wells is 325 000 m^3 yr^{-1}. The water available from cisterns and wells is not enough for fully irrigated agriculture. It is mainly used to establish fruit tree orchards, to irrigate small vegetable fields and for human and animal consumption. New cisterns are under construction in the Matruh region.

In the Burg El Arab region about 26 000 ha will be under irrigation, when all the irrigation works are completed. With respect to soil type all this land is suitable for fruit tree cultivation, but in large areas proper drainage is lacking. As waterlogging is disastrous, especially for olive trees, several olive orchards have deteriorated or have been uprooted. Irrigated land is mostly used for field crops, like maize, broad beans, berseem and vegetables, or fruit trees that need more water, like guava, almonds or grapes (Sultan, head of the agricultural sector of the Matruh Governorate, pers. comm.).

2.1.4. Cultivable area

In the northwestern coastal zone water requirements for olives in addition to rain are about 1 m^3 per tree per year. To achieve that amount a water reservoir should be constructed, receiving run-off water. The basins around the trees are about 10 m^2 (Caballero, 1984), hence 100 mm additional water is required. If the planting density is 240 trees ha^{-1}, only 0.24 ha has to be flooded instead of the whole area. In that case only 25 mm water is required. If that is supplied by run-off, a run-off efficiency of 25% should be taken into account. Based on these data, the required water regime in rainfed areas is estimated at 250 mm. This is a very rough estimate, but it indicates the possibilities for olive cultivation in rainfed areas. The cultivable area under a water regime of 250 mm available water annually is given in Table 3.

Table 3. Total area, cultivable area for olives under a 250 mm water regime and cultivable area for figs under a 300 mm water regime in the various regions of the northwestern coastal zone of Egypt.

region	total area	cultivable area			
		olives		figs	
	ha	ha	%	ha	%
Burg El Arab*	13 950	6 460	46	5 720	41
Dabaa	30 020	6 190	21	4 495	15
Dol	330	-	-	165	50
Matruh	11 400	3 250	28	2 380	21
Dol	1 600	-	-	800	50
Barrani	2 150	930	43	690	32
total olives	57 560	16 830	28	-	-
total figs	59 490	-	-	14 250	24

* excluding the irrigated area

For the calculation of the cultivable area under the various water regimes reference is made to Van de Ven (1986).

Fig trees require a minimum amount of 300 mm water annually (Blondel, 1964; Rebour,1968), so the cultivable area is less than for olives (Table 3).

2.2. Distribution of fruit trees in the northwestern coastal zone

2.2.1. Distribution of olive trees

Table 4 shows the area planted to olive trees and the number of trees in the four regions of the northwestern coastal zone in 1968 (FAO-3, 1970).

Table 4. Area under olive trees in the various regions of the northwestern coastal zone, in feddan, and the total number of olive trees.

region	productive	unproductive	total	no. of trees
Burg el Arab	855	1 729	2 584	103 270
Dabaa	161	1 017	1 178	47 130
Matruh	1 239	1 785	3 024	120 970
Barrani	162	472	634	25 360
Total	2 417	5 003	7 420	296 830

Source: FAO-3, 1970.

The main cultivation areas are Burg El Arab and Matruh, where the olive presses are. On average one third of the area under olives was productive, i.e. two thirds consisted of neglected and unproductive orchards. In 1983 the total area under olives was estimated at 21 500 feddan (Sultan, quoted by Ghabbour, 1983). If it is assumed, that all newly planted olive trees are productive, that leads to 16 500 feddan of productive olive orchards in 1983. Caballero (1984) estimates the productive area at 12 800 feddan for the same year. Traditional cultivars occupy 8 700 feddan and the Spanish cultivar Picual occupies the other 4 100 feddan. The author also qoutes another estimate by the Ministry of Agriculture of 25 324 feddan under traditional cultivars, but following careful investigation and confrontation, he decided on 8 700 feddan as the most realistic estimate. In the present study the estimate of Caballero is accepted as reliable, so the total area under olive trees in the northwestern coastal zone was 12 800 feddan or 5 380 ha in 1983. It is assumed that the distribution of newly planted olive trees and traditional ones is identical for all regions. Table 5 gives the distribution of the area under olives over the four regions, based on the distribution in 1968 and on information about the development of the region.

Table 5. Distribution of the productive olive area over the various regions of the northwestern coastal zone in 1968 and 1985, the area in 1985 and the total cultivable area for the 250 mm water regime.

region	1968 %	1985 %	1985 ha	cultivable area ha
Burg El Arab	35.4	25.0	1 430	6 460
Dabaa	6.7	17.1	980	6 190
Matruh	51.2	51.2	2 940	3 250
Barrani	6.7	6.7	380	930
Total	100.0	100.0	5 730	16 830

The annual expansion of the area under traditional olive cultivation was 420 feddan between 1968 and 1983, if for 1968 only the productive area is taken into account. If this trend is extrapolated for the next 2 years, 9 540 feddan were under traditional olive cultivation in 1985 and 4 100 feddan under Picual. Hence, in 1985 a total area of 13 640 feddan or 5 730 ha was covered by productive olive orchards. The share of the regions Matruh and Barrani in olive production for 1985 is estimated identical to that for 1968. For Burg El Arab it is assumed that the share has decreased over these 15 years. The land under irrigation has increased, so less land was available for the expansion of olive culture. For Dabaa the rate of expansion is assumed to have been higher, since a large area is suitable for olive cultivation (Table 3) and transport possibilities have improved due to an increase in the number of cars and an improved road system.

2.2.2. Distribution of fig trees

FAO (Report 3, 1970) estimated the total area cultivated with fig in the northwestern coastal zone at 5 552 feddan in 1968. According to Abdel-Razik et al. (1986) the area under fig trees was 2 000 feddan in 1964 and 7 266 feddan in 1972. Sultan (quoted by Ghabbour, 1983) estimated the area in 1983 at 13 000 feddan. These data are presented graphically in Figure 2. The estimates of Abdel-Razik et al. (op.cit.) apply to the whole of Egypt, while the others refer to the northwestern coastal zone only. Comparing these data it may be concluded that fig cultivation in other parts of Egypt is of very little importance.

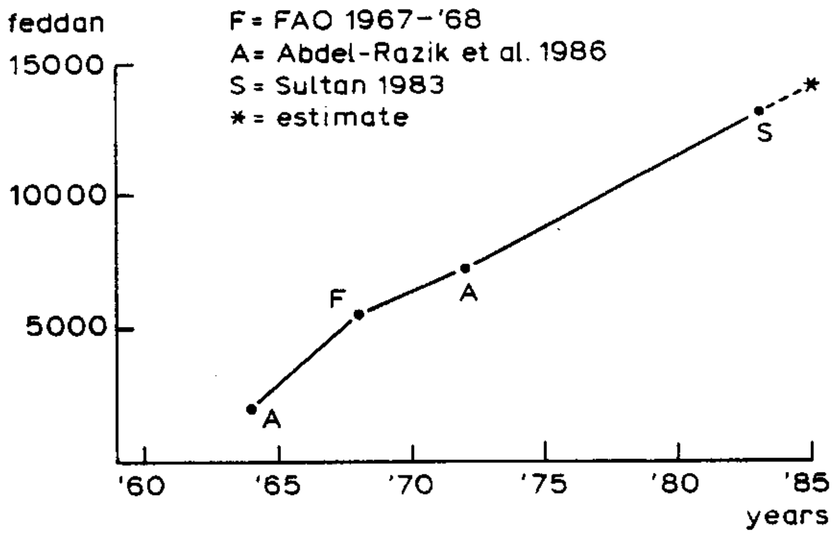


Figure 2. Estimates for the area under fig trees according to various sources.

The mean annual expansion rate of the area under fig trees between 1972 and 1983, based on the data cited, was 521 feddan, i.e. 220 ha. This expansion rate is also applied to the next two years, so for 1985 the total area under fig trees is estimated at 14 040 feddan or 5 900 ha.

The distribution of fig trees over the various regions in 1968 according to FAO is presented in Table 6.

Table 6. Area under fig trees in the various regions of the northwestern coastal zone, in feddan, and the total number of fig trees.

region	produc-tive	young trees	total	no. of trees
Burg el Arab	2 405	1 836	4 241	339 250
Dabaa	299	150	449	35 950
Matruh	578	130	708	56 640
Barrani	124	30	154	12 350
Total	3 406	2 146	5 552	444 190

Source: FAO-3, 1970.

A distinction is made between young trees and old trees. As the annual increase is about 220 ha and fig trees are in full production after 7 years, there are 1 540 ha of young trees in 1985 and 4 360 ha are in full production. Table 7 gives the distribution of the area under fig trees over the four regions in 1985, based on the data of 1968.

Table 7. The distribution of the area under figs in 1968 and the area in 1985, distributed over old and young trees, the total area and the cultivable area for the various regions of the northwestern coastal zone.

region	1968	1985			cultivable area
		old	young	total	
	%	ha	ha	ha	ha
Burg El Arab	76.4	3 330	1 180	4 510	5 720
Dabaa	8.1	350	120	470	4 660
Matruh	12.7	560	200	760	3 180
Barrani	2.8	120	40	160	690
Total	100.0	4 360	1 540	5 900	14 250

The highest concentration of fig trees is on both sides of the road Alexandria - Mersa Matruh, starting just east of Burg El Arab up to Omayed (FAO-3, 1970). Fig plantations are also present in Dabaa, Fuka, Baqqush, Mersa Matruh, Negeila and Sidi Barrani. This uneven distribution is due to the fact that figs are mainly produced for fresh consumption. The plantations in the eastern part of the northwestern coastal zone can produce for tourists in that region and in Alexandria, while the other plantations are producing for the local market only. According to FAO (Report 3, 1970) any expansion beyond the demand of the local market is possible only when figs for drying are introduced, because of transport problems. The last 20 years the relative rate of increase in area under figs has been about twice as high as that in population, so it may be assumed that the local market is satiated. The distance to other markets is too long to transport fresh figs.

2.2.3. Possibilities for expansion of the area under fruit trees

There are several reasons for continued expansion of the area under fruit trees. In 1964 the Land Act was implemented, which recpgnizes land ownership, if fruit trees are cultivated. Barley cultivation or animal husbandry does not entitle land users to this right. Another reason is the closure of the Lybian border in 1978, that forced the Bedouin to direct their attention to the utilization of the biological resources in their own area (Ghabbour, 1983). Ayyad and Le Floc'h (1983) give three additional reasons: sedentarization of the population, a government policy, increased the need for a stable basic income, the price of fruits has increased considerably (for figs by a factor 10 in 14 years) and the speculative trade in land provided the initial capital for tree cultivation.

To achieve a water regime of 250 mm for olive trees and 300 mm for fig trees, water in addition to rainfall has to be supplied from wadis and from surface run-off from the surrounding areas. The gross area required to obtain these water regimes is given in Table 8 for each of the four regions distinguished.

Table 8. Net area under olive and fig trees in 1985, the total gross area and the suitable area, all in ha, for the various regions of the northwestern coastal zone.

region	potentiality class	nett area olives	nett area figs	total gross area	suitable area
Burg El Arab	I	1 430	510	8 720	9 950
	II	--	4 000	4 000	4 000
	total	1 430	4 510	12 720	13 950
Dabaa	I	980	305	6 700	30 020
	IV	--	165	330	330
	total	980	470	7 030	30 350
Matruh	I	2 680	--	9 930	11 140
	II	260	--	260	260
	IV	--	760	1 520	1 600
	total	2 940	760	11 710	13 000
Barrani	I	380	10	1 010	2 000
	II	--	150	150	150
	total	380	160	1 160	2 150

For all regions it is assumed that fig trees are planted in potentiality class II first, as they need more water than olives and are planted close to the coast. For the Burg el Arab region that implies 4 000 ha of figs in potentiality class II and another 510 ha in potentiality class I. All olive trees in that region are planted in potentiality class I. The total gross area needed is 12 720 ha (for olives 25% cultivable and for figs 17% cultivable in potentiality class I, 100% cultivable in potentiality class II). The gross area suitable is 13 950 ha, so the expansion of orchards is limited to a gross area of 1 230 ha. It is assumed that all olive and fig orchards are situated in the rainfed part of the Burg el Arab region. That may not be completely realistic, but in the irrigated areas usually other crops or fruit trees are grown. It is well possible to establish irrigated orchards, if proper drainage is provided.

That is not practised at present, however. Not al irrigation works have been finished yet, so the actual area suitable in 1985 is probably underestimated. That is not taken into account here as considerable effort is made to finish the irrigation works within several years.

In the Dabaa region potentiality class IV is cultivated with figs to the limit, i.e. 165 ha (50%). The remainder of the fig trees is planted in potentiality class I, i.e. 305 ha. All olive orchards are situated in potentiality class I, i.e. 980 ha. The total gross area required for the present fruit tree orchards is 7 030 ha. This leaves a gross area of 23 320 ha available for expansion. Barley can also be cultivated there.

In the Matruh region the 760 ha of fig trees are all situated in potentiality class IV. The gross area needed is 1 520 ha. As the most suitable soil types will be cultivated first and some irrigated olive orchards have been observed in the Matruh region, it is assumed that soil type B2 is used to its limit. The remaining 2 680 ha under olive trees is then situated in potentiality class I. The gross area needed is 9 930 ha. In the Matruh region the expansion of fruit trees is therefore limited to a gross area of 80 ha in potentiality class IV for figs and of 1 090 ha in potentiality class I for either olives or figs. Barley cultivation is a third option.

In the Barrani area 150 ha of figs are cultivated in potentiality class II and 10 ha in potentiality class I. All olive trees are cultivated in potentiality class I. The total gross area used for fruit trees at present is 1 160 ha. This leaves a gross area of 990 ha available for either expansion of fruit trees or barley cultivation.

For olive trees the maximum expansion rate is 300 ha yr^{-1} (Subsection 3.1.5) and the trees are in full production after about 8 years. The maximum expansion rate of fig orchards is 220 ha yr^{-1}. For fresh fig production the expansion rate is set equal to the population growth. For dried fig production the maximum expansion rate is the difference between 220 ha yr^{-1} and the rate of area expansion for fresh fig production. For dried figs production has yet to start. The region has a reasonable potential for production of dried figs from the point of view of climate and soil.

It should be realized that in these orchards barley cultivation is only possible as an intercrop. Due to the limited water availability this is only possible in young and in irrigated orchards. The area under fruit trees must thus be subtracted from the area available for barley cultivation.

3. OLIVE CULTIVATION

3.1. General information on olive cultivation

Most of the information on olive cultivation in this report is based on the report of Caballero (1984). If his name appears in the heading of a paragraph, the information in that paragraph is from his report. If this is not the case, the sources used are given.

3.1.1. Growth cycle of olive trees

The rooting depth of olive trees is several meters and lateral roots may be 4 to 7 m long. The highest root density is found between 0.5 and 1.0 m depth (Enikeff, 1953; El-Shourbagy, 1967).

Vegetative growth occurs in late winter/early spring and is followed by growth of the fruits in late spring and summer. Vegetative growth still continues after reproductive growth has started. In Figure 3 the time course of dry weight of the components of an olive tree is presented (after El-Darier, 1984). The data are obtained from averaging the measurements on five trees in 1980. When harvesting the fruits, part of the leaves and branches came down, as the fruits were knocked from the tree using poles.

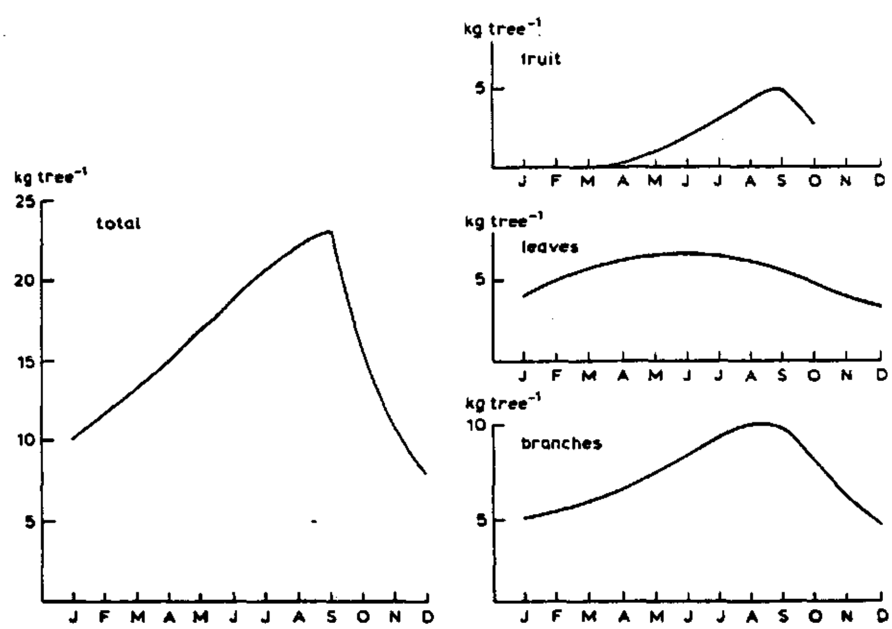


Figure 3. Time course of the weight of the components of an olive tree (after El-Darier, 1984).

Olive trees flower in April and May (El-Desouki, 1979; El-Darier, 1984). The cultivar Chemlali ripens about 195 days after flowering, so the fruits can be harvested in October and November (Essat, 1963).

In Figure 4 the annual growth cycle according to Pansiot and Rebour (1961) is given, presenting a clear visual presentation of the growth cycle of the olive tree. When comparing Figure 4 with the Egyptian data, the timing of all events is shifted by about one month. The time scale at the bottom of the scheme has been adapted to the Egyptian data.

In dry zones the profitable fruit-bearing period is at least 50 years, but it may be longer under more favourable environmental conditions (Pansiot and Rebour, 1961).

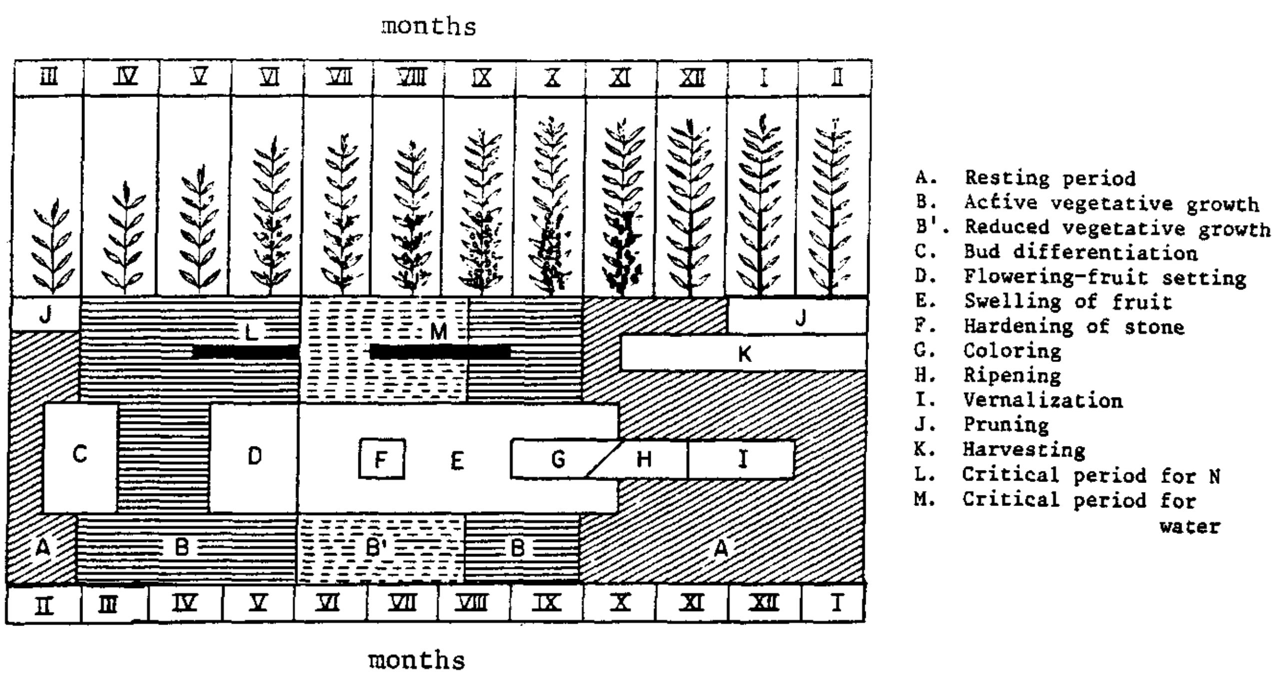


Figure 4. Annual growth cycle of olive in the Mediterranean basin. (Source: Pansiot and Rebour, 1961)

3.1.2. Alternate bearing

Young olive trees grow and produce in dependence of the environmental conditions, also without training and pruning. The leaf/wood ratio is very high during those early stages, which is probably the reason that the tree produces an olive crop each year. However, sooner or later biennial bearing will begin. Lack of pruning accelerates ageing, leading to an earlier occurrence of alternate bearing. This is associated with low leaf/wood ratios and mutual shading.

Other causes for alternate bearing may be lack of water and/or nutrients. In that case the olive tree cannot produce shoots and olives in the same year. One heavy crop exhausts the nutrient reserve in the tree to such an extent, that it does not produce flowers the following year. Cultivars suitable for oil production exhibit the phenomenon of alternate bearing more frequently than cultivars suitable for producing pickled olives. That is partly caused by the later harvesting of olives for oil production. The fruits on the tree use reserves that otherwise are stored for flower differentiation and at the same time the hormonal balance is influenced in such a way that flower formation is inhibited. Such effects are particularly evident after heavy-bearing years.

3.1.3. Cultivars

Various cultivars are grown in the region. Mission, Kalamata and Hamed are cultivars used for production of olives for pickling (FAO-3, 1970; Pansiot and Rebour, 1961). Chemlali is a traditional cultivar, used for oil production. However, not all of the traditional cultivars have yet been identified. After 1981 the Spanish cultivar Picual has also become an important cultivar for oil production. Chemlali is an alternate bearing cultivar, that is very well adapted to an arid environment. It is the most widely grown cultivar (FAO-3, 1970; El-Darier, 1984; Caballero,1984). The oil is not very fruity and congeals easily (Pansiot and Rebour, 1961). Picual has a tendency to alternate heavy and light crops and has a good oil content (24 - 28%) (Pansiot and Rebour, 1961). So far it is growing vigorously in Egypt, but no definite conclusion can be drawn yet.

According to Caballero (1984) one third of the total olive production in the northwestern coastal zone is used for oil production and two thirds are used for pickling.

3.1.4. Planting density

Planting density in the traditional olive cultivation system is 120 to 285 trees per ha, i.e. a planting density of 9x9 m - 6x6 m (Caballero, 1984). The average planting density is 156 to 200 per ha (8x8 m - 7x7 m) according to FAO (Report 3, 1970) and Abdel-Razik et al. (1986). However, 10x10 m is advised under the traditional management system, especially in rainfed areas, where water is limiting growth (FAO-3, 1970). In Table 4 a planting density of 95 trees per ha is used (40 trees per feddan). The planting distance is then about 10x10 m, which is not in accordance with the actual planting distance of 7x7 m - 8x8 m quoted above. Both FAO (Report 3, 1970) and Caballero (1984), however, state that the average planting density is too high and results in low yields.

The cultivar Picual has been planted at a density of about 200 trees per ha, considered an optimum density under rainfed conditions in Spain. As in that country more water is available (about 600 mm), it is possible that in Egypt with less water the trees remain smaller and that it would be advisable to use higher plant densities. The planting density advised under an improved management system is about 200 trees ha^{-1} for irrigated orchards and 240 trees ha^{-1} for rainfed orchards (Caballero, 1984). Under the latter conditions trees remain smaller and at higher plant densities a better use is made of the water resources. The question is still under study and a well based answer can only be given after several years, when Picual is in full production. Most likely, alternate bearing cannot be prevented in this arid environment.

3.1.5. Young orchards

The method traditionally used to propagate olive trees is approach-grafting, a process which may take as long as two to three years. The greatest disadvantages of this method are that the young trees are very weak and that it takes a long time before they produce good crops (Caballero, 1984).

Using this method, one feddan of mother plants, i.e. 80 trees, can produce 8 000 nursery trees per year. Using soft wood cuttings, the same area can produce 120 000 nursery trees per year. The Californian project and the Dutch project both established a modern olive nursery, one in Cairo and one in Fayoum. The nurseries each have a capacity of 60 000 young trees per year and they have to serve all olive growing areas in Egypt. The northwestern coastal zone comprises 51% of the olive growing area, so theoretically about 61 200 young trees will be available each year, if the nurseries work at full capacity. Using improved techniques, the traditional olive nurseries can also provide young trees, but their capacity is unknown. Assuming that 61 200 young trees are available annually, the maximum rate of expansion of the olive culture is 306 ha yr^{-1}, at a planting density of 200 trees ha^{-1}.

During the period of establishment, two to three years, the young olive trees need supplementary irrigation. FAO (Report 3, 1970) quotes an amount of 150 to 200 liters per tree per year for normal rainfed olive culture.

Traditionally, olives are planted and then left to grow without any training. Training systems are different, according to the propagation method used, but they should always produce one-trunk trees, bifurcating at 80 to 100 cm height and having three to four scaffold branches.

FAO (Report 4, 1970) gives an estimate of the labour requirements for establishing one feddan of olive trees (Table 9). The data refer to a supplementary irrigated system and establishment takes five years. The details are not further discussed here.

Table 9. Labour requirement for establishing one feddan olive trees. Data based on survey of 16 farmers. P-d = person -days.

Operation	1st year		2nd + 3rd year		4th year		5th year	
	time	P-d	time	P-d	time	P-d	time	P-d
ploughing (2)	Nov/Dec	4	Dec/Feb	4	Dec/Feb	4	Dec/Feb	4
marking and pegging (40)	Jan	2	-	-	-	-	-	-
marking holes (40)	Jan	1.5	-	-	-	-	-	-
transport seedlings	Feb	0.5	-	-	-	-	-	-
transplant seedlings (a)	Feb	2	-	-	-	-	-	-
collecting and fixing supports	Feb	2	-	-	-	-	-	-
making irrigation beds	Feb	1						
maintenance irrigation beds	-	-	May	1	May	1	May	1
irrigation	(b)	17	(c)	3	(c)	3	(c)	3
weeding	Nov	1	Dec/Feb	2	Dec/Feb	2	Dec/Feb	2
spraying	Apr	1	Apr	1	Apr	1	Apr	1
pruning	-	-	-	-	Nov	2	Nov	3
Total		32		2 x 11		13		14

total person-days in 5 years = 81

(a) Includes filling holes, manuring, transplanting seedlings and irrigation.
(b) Every third day for one month after planting and then every tenth day for four months. Labour for 10 irrigations during February and March: 5 P-d. labour for 12 subsequent irrigations from April to July: 12 P-d.
(c) Three irrigations in summer months of JUne, July and August with 3 P-d for each irrigation by windmill.

3.2. Cultural techniques for olive production

3.2.1. Training and pruning (Caballero, 1984)

Pruning hardly ever takes place and if it is carried out, it usually consists of the removal of dead branches only (Abdel-Razik et al., 1986). Pruning of well-trained trees aims at encouraging new growth by means of removing branches before they become too old (6 - 8 years) and fruitless. Pruning of untrained trees will improve their structure. Pruning is essential to take better advantage of the light and to balance the leaf/wood ratio. An excessive amount of wood leads to increased alternate bearing.

FAO (Report 4, 1970) estimated the labour requirements for the various operations, if carried out properly. Pruning should be carried out in November and requires 7 person-days per feddan, i.e. about 117 hours per ha, assuming a workday of 7 hours (Table 10).

Table 10. Labour requirements in person-days per feddan during the full fruiting stage of olive trees.

operation	Nov	Dec	Feb	Apr	May	Jun	Jul	Aug	Sep	Oct
pruning	7.0									
ploughing (2)		4.0	4.0							
weeding		1.0	1.0							
spraying				2.0						
upkeeping of irrigation beds					1.0					
Irrigation						3.0	3.0	3.0		
picking and drying									5.0	5.0
total	7.0	5.0	5.0	2.0	1.0	3.0	3.0	3.0	5.0	5.0

Total person-days = 39

Source: FAO-4, 1970

3.2.2. Soil and water management (Caballero, 1984)

Three different systems for soil and water management are distinguished, one for rainfed orchards, one for irrigated orchards and an intermediate system for supplementary irrigated orchards. In rainfed areas soil management is an important aspect of the water management system. In irrigated areas water management itself is more important, as an adequate drainage system is essential.

a. Rainfed olive cultivation

In rainfed areas the major effort is directed towards full utilization of run-off water by constructing dykes, basins, terraces and reservoirs. Proper soil management techniques and construction of wind breaks prevent unnecessary water losses.

In general, soil management in the region is adequate. Farmers usually keep the orchards weed free to save all available water for the trees. The main objective of winter ploughing is to increase the infiltration rate and the water holding capacity of the soil. In view of the low organic matter content of the sandy soils, however, ploughing should be limited. The best practice is to plough once a year after harvest, to a depth of 25 to 30 cm. At that time the roots of the trees are less active or resting and some root pruning will do no lasting damage. After the first winter rainfall, shallow tillage of the soil is advisable to improve infiltration capacity and water retention in the soil and to remove weeds. Superficial tillage in spring and summer is also beneficial to the olive trees, as a loose surface layer suppresses evaporation from the soil surface.

b. Supplementary irrigated olive cultivation

In some olive orchards limited irrigation possibilities exist. Abdel-Razik et al. (1986) report that in their 1980 field trial irrigation was applied two to three times a year, during flowering and ripening. The amount of water supplied was not reported. If irrigation is possible, the first application should be in the second half of March, about one month before full bloom. If environmental conditions permit growth of the trees during summer without supplementary water, the second irrigation should be applied one month before harvest in orchards producing olives for pickling and about one month before colour change in orchards producing olives for oil. If the trees cannot survive summer without supplementary irrigation, water should be applied at the end of May and during the period of pit-hardening.

The recommended amount of water per irrigation event is 50 mm. The total seasonal irrigation is 50 to 200 mm, depending on the number of irrigation events. In this system basins, dykes and terraces should be maintained before winter watering takes place.

c. Irrigated olive cultivation

Failure or poor performance of olive groves in irrigated areas is usually due to excessive amounts of water, caused by poor management of the irrigation system, which can also cause secondary salinization. The traditional irrigation technique in the region is flooding. The field efficiency is reported to be 25%. This can be improved to 40 - 63%, by shortening the length of the irrigation runs and postponing the subsequent irrigation until the soil moisture content is below field capacity. FAO (Report 2, 1970) reports an irrigation efficiency of 60%. For sandy soils the recommended irrigation intervals are 15 to 20 days starting in January. In these fully irrigated systems one should be carefull not to damage the roots by tillage, as the roots are closer to the soil surface than in rainfed systems. However, winter ploughing is needed here too. Maintenance of an adequate drainage system is essential. The water requirements are 1 680 m^3 $feddan^{-1}$, i.e. 4 000 m^3 ha^{-1}. Assuming an irrigation efficiency of 60%, 6 700 m^3 ha^{-1} is required. Rain supplies about 1 500 m^3, hence 5 200 m^3 ha^{-1} has to come from additional irrigation.

d. Labour requirements

According to FAO (Report 4, 1970) one irrigation event by windmill requires about 3 person-days per feddan, i.e. about 50 hours per ha (Table 10). That time requirement applies to the supplementary irrigated systems. In rainfed areas where exploitation of cisterns or groundwater is possible, and in the irrigated area around Burg El Arab, full irrigation can be applied. The impression is that full irrigation can only be applied, if mechanical pumps are available. The labour input will be similar to that for irrigation of barley, i.e. 5 h ha^{-1} per irrigation event. It is a flood irrigation system, so pumps and flood gates have to be operated only.

The maintenance of irrigation beds takes one person-day per feddan, i.e. 17 h ha^{-1} (FAO-3, 1970)(Table 10). The work should be carried out before the winter rains in November in the supplementary irrigated systems and before the first irrigation in January in the fully irrigated systems.

According to Table 10 animal traction is used for ploughing, but it may just as well be done by using mechanized equipment. Ploughing is carried out twice a year, once in December and once in February. For barley, shallow ploughing requires 2.5 person-days per feddan and for olives 4.0 person-days per feddan, or 1.6 times as much (FAO-4, 1970). The 2.5 days for barley seemed too high compared to data from other sources and 18 h ha^{-1} or 1.1 day $feddan^{-1}$ appeared more appropriate (Van de Ven, 1987). The shallow ploughing of olive land in February is assumed to require 1.6 times 18 h ha^{-1}, i.e. 29 h ha^{-1}. For the deeper ploughing in December it is assumed to be 1.6 times the requirement for deep ploughing of barley fields, i.e. 45 h ha^{-1}. When using power equipment, it is estimated at 5 h ha^{-1} for shallow and 18 h ha^{-1} for deep ploughing. The fuel requirements are 27 l ha^{-1} for shallow and 95 l ha^{-1} for deep mechanical ploughing.

Each weeding requires 1 person-day per feddan, i.e. 17 h ha^{-1} (Table 10). It cannot be judged how weeding is done, but probably by hand, as no animal traction is used according to FAO. In the improved systems mechanical equipment is used for weeding, probably similar to that for harrowing. The labour requirements are estimated at 1.6 times the labour requirements for harrowing of barley fields, i.e. 3 h ha^{-1}. The fuel requirements are 9 l ha^{-1}.

3.2.3. Fertilizer application (Caballero, 1984)

Application of manure has a favourable effect, as in addition to supplying nutrients, it improves the soil structure and the water holding capacity. In the northwestern coastal zone olives usually receive 10 to 12 m^3 per acre, i.e. 25 to 30 m^3 ha^{-1} (Abdel-Razik et al., 1986). According to Caballero (1984) and Pansiot and Rebour (1961) 5 to 10 ton ha^{-1} are recommended in irrigated areas and less in rainfed areas. Application of the manure should take place before the winter rainfall and it must be mixed with the soil during the first ploughing.

In general nitrogen application increases fruit yield. P and K fertilization have little direct influence (Ferreira Llamas, quoted by Caballero, 1984).

In the Californian Olive Project a survey of the nutrient status of olive trees was made and it was concluded that the levels of all nutrients in the leaves were satisfactory, except those of N, B and Ca. The level of both N and B was too low and that of Ca was too high.

Application of chemical fertilizer N is a regular practice in many olive growing countries. An amount of 1 kg per tree annually has become a rule of thumb. A more accurate rate is 200 - 400 g N per tree plus 20 - 25 kg N per ton of fruit. The N requirements of olive trees are highest at the moment that competition for nutrients takes place among different organs, e.g. at blooming, fruit set, pit hardening, etc. Splitting the fertilizer application between the critical periods would be the best system, but that is only possible under drip irrigation.

FAO does not specify the labour requirements for fertilizer application. Most probably animals or tractors are used to pull a cart loaded with manure, which is spread over the land by hand as reported by Abdel-Razik et al. (1986). As no quantitative data are available on this operation the labour requirement is estimated at 35 h ha^{-1} in accordance with the average data given by Van Heemst et al. (1981). For the mechanized systems, it is assumed to take about half the time, i.e. 18 h ha^{-1}. The fuel requirements are estimated at 10 l ha^{-1}. To estimate the labour requirements for application of chemical N fertilizer the data for barley are again multiplied by 1.6, i.e. 8 h ha^{-1}, to account for the special care that has to be taken of the trees in the field.

3.2.4. Plant protection (Caballero, 1984)

Pest and disease control is hardly ever practiced in Egypt, even though the occurence of several pests and diseases, that can cause a considerable reduction in fruit yield, has been observed. Hegazi et al. (1981), working on two Chemlali trees in 1980, found that 18% of the olive yield was not marketable due to pests. The two main pests were the olive fruit fly (Dacus oleae), which caused 56% of the loss and the olive tree scale (Leucaspis riccae), which caused 30% of the loss. The remainder of the non-marketable yield, 14%, was caused by various other pests. The total yield was rather low, 11 kg of fresh olives per tree. Caballero (1984) also observed the stem miner (Zeuzera pyrina L. or Euzophera pinguis Hw.), Glyphodes, Olive bark beetle (Pholoetribus scarabeoides Bern) and sooty mould (Capnodium elaeophilum Prill).

Infection by scales and sooty mould is widespread in old orchards. Lack of pruning is part of the reason, as the interior of the crown receives less light and has a higher relative humidity, which favours development of pests and diseases. More detailed information on crop losses is not available, but they must be considerable, because no control measures are taken. Due to pest and disease incidence the crops are often of poor quality.

Spraying probably is the most effective way to reduce pest and disease damage, but that should be studied first in more detail. As long as olives are considered a marginal crop, it will not be remunerative to invest in spraying equipment. Such a practice should be part of an improved cultivation system.

FAO (Report 4, 1970) estimates the labour required for spraying at 2 days per feddan (Table 10), i.e. 33 h ha^{-1}, to be effectuated in April.

3.2.5. Harvesting (Caballero, 1984) and transport

Harvesting consists of beating the branches with long poles or of picking the olives. A major disadvantage of the first method is that it increases the frequency of alternate bearing, because many shoots that would otherwise have been able to carry fruits the following year, are also damaged or removed from the tree. Because the fruits are often harvested too early much force must be exerted to loosen the olives and that increases the negative effect. For cultivars grown for oil, damage due to hitting the ground is not important, because the olives will be processed anyway. Table olives, however, should be handled with care. Nets are normally placed under the trees and the load is cleaned from leaves, mud etc. The second harvesting method, on the other hand, takes much more time.

Olives can be harvested mechanically by using shakers. This method is mainly developed to reduce harvesting costs, because in general these costs comprise 50% of the price the grower obtains. In Egypt, however, it is only 20 to 30% of the fruit price. The low yields would make the use of shakers too expensive, hence first the productivity should be increased. The use of mechanical shakers requires a sufficiently large distance between the trees and trees that are properly trained and pruned.

Table olives must be harvested when they are yellowish-light green and olives for oil production just before natural fruit drop.

According to FAO (Report 4, 1970) harvesting (picking) and drying take 5 days per feddan in September and 5 days per feddan in October, i.e. 85 hours per ha each month (Table 10). These data apply to table olives. For oil cultivars harvesting may probably be delayed by one month. Buchmann and Keller (quoted by Pansiot and Rebour, 1961) show the relation between the quantity picked per hour and the average load per tree (Figure 5). The time spent includes bagging, transport to the collection point, weighing and loading into lorries.

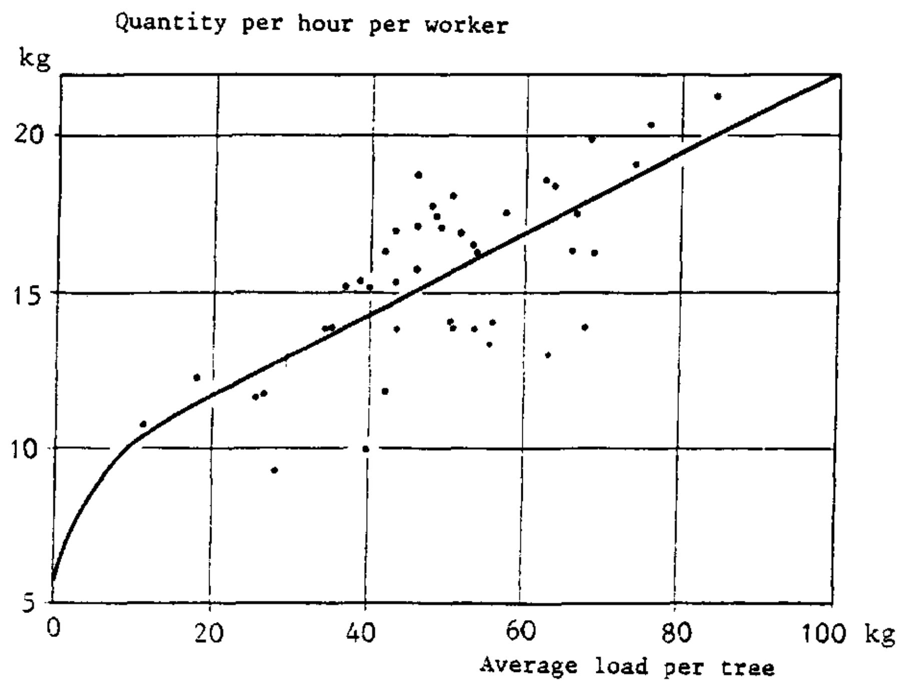


Figure 5. The quantity of olives picked per hour in relation to fruit load per tree. (Source: Pansiot and Rebour, 1961)

It probably is the effective working time. In the northwestern coastal zone the average load per tree is about 15 kg, so about 11 kg per hour per worker can be picked. About one third of the working time is non-operative according to Haswell (quoted by Van Heemst et al., 1981). This means that the total time required for harvesting and the associated operations is 1.5 hours for 11 kg, i.e. 1 person-day for 50 kg. If the yield is 640 kg per feddan, harvesting requires 12.8 person-days per feddan or 210 h ha^{-1}. If the total harvest is spread over 2 months the labour requirement is 105 h ha^{-1} $month^{-1}$. Considering that this time includes bagging, weighing, transport to the collection point and loading onto lorries, the value is comparable to the FAO estimate. To estimate the required animal traction hours a calculation similar to that for barley is applied. The average distance from the field to the busstand is assumed to be 2.5 km, half the distance estimated for the barley fields. The animal walks at a speed of 2.8 km h^{-1}, drawing a cart loaded with 500 kg of olives, at a speed of 4.0 km h^{-1}, drawing an empty cart. The transport thus takes 3 h ton^{-1}.

Mechanical transport takes less time. If the speed of the tractor is 16 km h^{-1}, the distance to be covered 5 km and the capacity of the cart 5 ton, it takes 0.3 h to transport 5 ton. As all labour requirements are expressed in whole h ha^{-1}, the value is set to 1 h ha^{-1}. The fuel requirements are 1 l ton^{-1}.

When beating branches with poles the time for harvesting is reduced, but the time to separate the olives from the dirt is substantial. According to Pansiot and Rebour (1961) harvesting by beating branches takes about 60% of the time needed for picking, but yield losses are higher.

3.2.6. Processing and marketing (Caballero, 1984)

Two olive mills for processing olives to produce oil are located in Mersa Matruh and one in Burg El Arab. Management and organization in the olive mills are not optimal and skilled manpower is very scarce. The mills process about 2 000 ton of fresh olives annually, while their capacity is 120 ton per 24 hours.

In the whole of Egypt only two pickling plants exist, of which one is located in Mersa Matruh. The two plants together process only 400 ton per year out of the 10 200 ton of table olives produced annually in Egypt. The remainder or 9 800 ton, is processed in unofficial small factories or at home. Structural constraints for improvement in this sector are the low quality of the machinery and facilities used and lack of trained staff.

Marketing is an important problem according to the olive growers. The two main problems are that the olives are sold in the market by many small enterprises and that the production fluctuates strongly. The olive sector should be better organized, but that is only feasible, if the productivity is increased and olive cultivation is no longer considered a marginal activity.

3.3. Olive yield

3.3.1. Actual yield of fresh olives

The mean olive yield over bearing and non-bearing years is about 15 kg per tree per year in rainfed areas (Nour, 1967; FAO-3, 1970; El-Gazzar et al., 1974; Bacha et al., 1975; El-Darier, 1984). This estimate may be too high, because most of the data were derived from experimental fields, although the yield itself is not very high. FAO (Report 3, 1970) quotes an average yield of 56 kg per tree, when 110 to 230 mm of water was supplied, showing that irrigation can increase the yield considerably.

In Tunesia the average yield over bearing and non-bearing years of Chemlali trees is about 50 kg per tree yr^{-1}. The planting density is about 25 trees per ha, so this would yield 1 250 kg of fresh olives per ha. The average rainfall in the main cultivation area is about 200 mm. The trees are normally grown on run-off receiving lands. The average yield per ha in Egypt is 1 520 kg fresh fruit according to FAO (Report 3, 1970). This yield has already been corrected for harvest losses, which are about 10%. If harvest losses are disregarded the production is 1 690 kg ha^{-1} (Table 11).

Table 11. The yield of fresh olives in kg ha^{-1} according to various sources, the planting density (number of trees ha^{-1}) and the yield in kg tree-1.

source	yield per ha	planting density	yield per tree
FAO 1970	1 690	95	18
Caballero, Chemlali	1 640	200	8
El-Darier, 1984	1 700	156	11
Caballero, Picual	1 850	190	10

Caballero estimates the annual production at 6 000 ton fresh fruit from 8 700 feddan, i.e. 1 640 kg ha^{-1} (Table 11). From the data of El-Darier (1984) a yield of 1 700 kg ha^{-1} is calculated, when the data are converted to fresh fruit weight (Table 11). For Picual the estimated yield in another few years is 7 000 ton from the 9 000 feddan planted throughout Egypt, i.e. 1 850 kg ha^{-1} (Table 11). This figure is based on the traditional management system applied at present (Caballero, 1984). As mentioned before, the planting density of 95 trees per ha is probably too low. The average yield under traditional management systems is assumed to be 1 700 kg of fresh olives ha^{-1}. Harvest losses are about 10%, so the marketable olive production is 1 530 kg ha^{-1}.

3.3.2. Actual oil yield

No distinction has been made in average yield between oil cultivars and table olive cultivars. The average flesh to fruit ratio, based on fruit fresh weight, is 86% (Nour, 1967; Bacha, 1970). The average oil content for Chemlali is 23% of the fruit fresh weight or 67% of the flesh dry weight (Kamal and Essat, 1957; Essat, 1963; Nour, 1967; Bacha, 1970; FAO-3, 1970).

The olive oil yield for Chemlali is estimated at 18.75% of the fruit fresh weight (Caballero, 1984), hence the oil production is 290 kg ha^{-1}. That does not represent the total oil content in the fruits, but the industrially extracted oil, so it is influenced by the processing method and efficiency. FAO

(Report 4, 1970) estimates the oil yield at 13.5% of the fruit fresh weight or 200 kg ha^{-1}. It may be assumed that the processing methods and hence the efficiency , have been improved since 1968, so the estimate of 290 kg oil ha^{-1} seems more realistic than that of 200 kg oil ha^{-1}. An industrial oil extraction of 23%, i.e. an efficiency of 100%, seems too optimistic.

In Tunesia an industrial oil extraction efficiency of 23% is reached, though. The oil content of the Chemlali fruits there is somewhat higher: 25 - 28% (Trigui, pers. comm.). The low oil yield per unit of olive yield in Egypt is to a large extent due to harvesting too early (FAO-3, 1970; Caballero, 1984). The maximum oil content is reached 6 to 8 months after flowering, when the colour of the fruits changes from yellowish-light green to purpled-violet (Caballero, 1984; Abdel-Razik et al., 1986).

3.3.3. Improved production (Caballero, 1984)

The yield of olive orchards planted to traditional cultivars, could be increased by 50%, if they were intensively managed, i.e. good pruning, proper pest and disease control etc. Under such a management regime the production in the northwestern coastal zone could reach about 2 550 kg ha^{-1}. The planting density is set to 240 trees ha^{-1}. Subtracting harvest losses of 10% results in a yield of 2 300 kg ha^{-1}. The oil yield using improved cultivation and extraction methods can be increased to 23% of the harvested olives, i.e. 530 kg ha^{-1}.

Under full irrigation, yields of about 5 000 kg ha^{-1} could be obtained. Subtracting harvest losses of 10% results in a yield of 4 500 kg ha^{-1}. The planting density is then 190 trees ha^{-1}. For irrigated areas the Chemlali cultivar is not suitable, as it is very sensitive to excess water. More suitable cultivars are available for that situation. FAO (Report 3, 1970) estimated that about 7 200 feddan could be planted to olives under various water management systems, of which 1 200 feddan under full irrigation and 6 000 feddan under supplementary irrigation. The oil yield under irrigation is estimated at 1 045 kg ha^{-1} (23% of 4500 kg).

3.4. <u>Olive cultivation systems</u>

Based on the data presented in the previous chapters six olive cultivation systems have been defined as described below.

3.4.1. Table olives, traditional (Table 12)

The first system describes traditional olive cultivation, producing table olives. In December the soil is ploughed shallow using animal traction. Fertilizer, preferably manure, is applied before ploughing to mix it with the soil. The N-requirement is 80 kg ha^{-1}, i.e. 0.3 kg tree-1 * 150 trees ha^{-1} + 22.5 kg ton^{-1} fruit * 1 530 ton fruit ha^{-1} (Subsection 3.2.3). After the first winter rains, also in December, a first weeding operation is carried out, in February often followed by a second weeding. Olives are harvested in August and September, which is about one month too early. It is assumed that most of the harvesting is done by hand picking, as it concerns table olives here. The yield is 1 530 kg ha^{-1}, distributed over two months. The bags have a capacity of 12 kg each, so 130 bags are needed.

Table 12. Inputs and outputs for traditional table olive cultivation. A '-' indicates an output.

	Dec	Feb	Aug	Sep	unit
ploughing	29	29			h ha^{-1}
fertilizer application	35				h ha^{-1}
weeding	17	17			h ha^{-1}
harvesting, bagging, transport			105	105	h ha^{-1}
animal traction	64	29	2	3	h ha^{-1}
N-fertilizer	80				kg ha^{-1}
bags			130		no ha^{-1}
yield			-765	-765	kg ha^{-1}

3.4.2. Olives for oil production, traditional (Table 13)

The second system describes traditional olive cultivation, producing olive oil. The labour requirements are similar to those for table olives, with the exception that the olives are harvested in September and October instead of in August and September and that harvesting consists of beating the branches with poles. Harvesting is also one month too early. The oil yield is 290 kg ha^{-1}. It is assumed that larger bags with a capacity of about 50 kg are available for transport of olives for oil production, hence the number of bags required is 30 ha^{-1}.

Table 13. Inputs and outputs for traditional olive cultivation for oil production. A '-' indicates an output.

	Dec	Feb	Sep	Oct	unit
ploughing	29	29			h ha^{-1}
fertilizer application	35				h ha^{-1}
weeding	17	17			h ha^{-1}
harvesting, bagging, transport			63	63	h ha^{-1}
animal traction	64	29	2	3	h ha^{-1}
N-fertilizer	80				kg ha^{-1}
bags			30		no ha^{-1}
yield			-145	-145	kg ha^{-1}

3.4.3. Table olives, improved (Table 14)

The third system refers to improved and intensified cultivation of table olives. The season starts in November with pruning. The irrigation beds have to be tended in November before the winter rainfall starts, so the trees can make optimal use of the run-off water. In December the same amount of fertilizer as in the two previous systems, preferably in the form of manure, is applied before ploughing. Deep ploughing (25 - 30 cm) is done by tractor in December only.

Table 14. Inputs and outputs for improved table olive cultivation.
A '-' indicates an output.

	Nov	Dec	Feb	Mar	Apr	May	Jul	Sep	Oct	unit
pruning	117									h ha^{-1}
maintenance irrigation beds	26									h ha^{-1}
fertilizer application		18				8				h ha^{-1}
ploughing		18								h ha^{-1}
weed control		3	3			3				h ha^{-1}
irrigation				50		50	50			h ha^{-1}
pest control					33					h ha^{-1}
harvesting, bagging, transport								105	105	h ha^{-1}
mechanical traction		39	3			3		1	1	h ha^{-1}
fuel		114	9			9		1	1	l ha^{-1}
N-fertilizer		80				20				kg ha^{-1}
pesticide					2					l ha^{-1}
sprayer					33					h ha^{-1}
bags								190		no ha^{-1}
yield								-1150	-1150	kg ha^{-1}

Weeding takes place three times a year, in December, February and May in the form of shallow ploughing or harrowing. Irrigation water is applied three times a year, in March, May and July. In April the olive orchards are sprayed to control pests and diseases. Chemical fertilizers are applied once in May at a rate of 20 kg ha^{-1}, the total N-requirement being 100 kg ha^{-1}. (190 trees ha^{-1} x 0.3 kg tree-1 + 2.3 ton ha^{-1} x 22.5 kg ton^{-1}). The olives are harvested in September and October and transported by tractor to the collection point. The yield is 2 300 kg ha^{-1}, distributed over 2 months.

The total labour requirements for this system, as estimated in this study, are 571 h ha^{-1}. FAO estimated for almost the same system 39 days feddan^{-1}, i.e. 650 h ha^{-1} assuming a 7 hour working day. This difference is due to the difference in degree of mechanization between 1965 and 1985.

3.4.4. Olives for oil production, improved (Table 15)

The fourth system is improved and intensified cultivation of oil cultivars. The table of inputs and outputs is rather similar to that for the preceding activity, only harvesting is delayed by one month. If labour availability is a constraint pruning can also be delayed till December. Harvesting consists of picking the olives, as beating damages the trees. The oil yield is 530 kg ha^{-1} and harvesting, bagging and transport is spread over a period of two months. The number of bags required is 50 ha^{-1}.

Table 15. Inputs and outputs for improved olive cultivation for oil production. A '-' indicates an output.

	Nov	Dec	Feb	Mar	Apr	May	Jul	Oct	unit
pruning	117								h ha^{-1}
maintenance irrigation beds	26								h ha^{-1}
fertilizer application		18				8			h ha^{-1}
ploughing		18							h ha^{-1}
weed control		3	3			3			h ha^{-1}
irrigation				50		50	50		h ha^{-1}
pest control					33				h ha^{-1}
harvesting, bagging, transport	105							105	h ha^{-1}
mechanical traction	1	39	3			3		1	h ha^{-1}
fuel	1	114	9			9		1	l ha^{-1}
N-fertilizer		80				20			kg ha^{-1}
pesticide					2				l ha^{-1}
sprayer					33				h ha^{-1}
bags								50	no ha^{-1}
yield	-265							-265	kg ha^{-1}

3.4.5. Table olives, irrigated (Table 16)

The fifth system refers to irrigated table olive cultivation. Pruning is done in November. Maintenance of the irrigation beds is required before the first irrigation in January, i.e. either in November or December. Fertilizer, preferably in the form of manure, is applied at the same rate as in the preceding systems in December before ploughing. For deep ploughing in December mechanical equipment is used. In December, February and May weeds are controlled and in April pests and diseases are controlled by spraying. Irrigation starts in January with a frequency of once every 20 days and lasts until September. Hence in some months the olive trees are irrigated once, in other months twice. Chemical fertilizers are applied only once in May at a rate of 50 kg ha^{-1}. The olives are harvested in September and October and the yield is 4 500 kg ha^{-1}.

Table 16. Inputs and outputs for irrigated table olive cultivation. The units are the same as in Tables 13 and 14. A '-' indicates an output.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
pruning	117											
maintenance irrigation beds	26											
fertilizer application		18					8					
ploughing		18										
weed control		3		3			3					
pest control						33						
irrigation			5	5	10	5	10	5	10	5	5	
harvesting, bagging, transport											105	105
mechanical tracion		39		3			3				1	1
fuel		114		9			9				2	2
pesticide						2						
sprayer						33						
N-fertilizer		80					70					
bags											375	
yield											-2250	-2250

3.4.6. Olives for oil production, irrigated (Table 17)

The sixth system refers to irrigated olive cultivation for oil production. The input/output table is similar to that for the fifth system, except that harvesting is delayed by one month and one more irrigation is applied in September. Pruning can again be delayed till December, if labour availability becomes a constraint. The oil yield is 1 040 kg ha^{-1}.

Table 17. Inputs and outputs for irrigated olive cultivation for oil production. The units are the same as in Tables 13 and 14. A '-' indicates an output.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
pruning	117											
maintenance irrigation beds	26											
fertilizer application		18					8					
ploughing		18										
weed control		3		3			3					
pest control						33						
irrigation			5	5	10	5	10	5	10	5	10	
harvesting, bagging, transport	105											105
mechanical tracion	1	39		3			3					1
fuel	2	114		9			9					2
pesticide						2						
sprayer						33						
N-fertilizer		80					70					
bags												95
yield	-520											-520

4. FIG CULTIVATION

4.1. General information on fig cultivation

4.1.1. Fig types

Three types of figs are distinguished: the common fig, the smyrna fig and the caprifig.

The common fig is mainly cultivated for fresh consumption as the fruits are not well suited for drying. The fruits are formed by vegetative parthenocarpy. This means that the carpels of the flowers develop without any known stimulus, i.e. pollination is not required for fruit setting (Wiebes, 1980; Storey, 1975; Condit, 1947).

The common fig produces two crops a year, one in June, the breba crop, and one between August and November, the autumn crop. The breba crop develops on the wood of the previous year. The fruits are initiated before winter and survive the low winter temperatures as small resting buds. In spring growth starts again and the fruits ripen in June. Usually the breba crop is not very heavy, but, because of the limited supply during that time of the year, prices are relatively high. The autumn crop develops on the present years wood and is the main crop.

The smyrna fig is cultivated to produce figs for drying. The syconium contains only female flowers. The smyrna fig is non-parthenocarp and must be pollinated with pollen of a caprifig to prevent premature abortion. This process of fertilization is called caprification. The smyrna fig produces only an autumn crop.

The caprifig is only cultivated for pollination of the smyrna fig and not for consumption. The syconium contains both male and female flowers. The fig wasp, Blastophages psenes, lives in the caprifig. The female wasp deposits her eggs in the syconium, the fig wasp develops inside and the females fly out through the ostiolum, and are thereby covered with pollen. If they deposit their eggs in another fig, they simultaneously pollinate the flowers of that fig. The female fig wasp thus pollinates both the smyrna fig and the caprifig. The male wasp never leaves the syconium. The flowers of the smyrna fig are long-styled, so the eggs cannot be deposited properly and no wasps develop in the smyrna fig (Wiebes 1980, 1983).

4.1.2. Fig cultivars

In Egypt figs are grown mainly for fresh consumption and sometimes for preservation. Sultani and Adsi are the most widely grown cultivars, Sultani occupying 95% of the area under figs. Both cultivars belong to the common fig and produce two crops a year. In 1970 some other cultivars have been introduced in the region by FAO, including cultivars for drying (Abdel-Razik et al., 1986; FAO-3, 1970). These cultivars most probably belong to the smyrna fig. It is unknown whether these cultivars have spread over the region since then.

4.1.3. Planting density in fig orchards

From Table 6 it can be derived that the planting density is 80 trees per feddan, i.e. 190 trees ha^{-1}. Other planting densities reported are 204 trees ha^{-1} (Robka et al., 1981; Mohamed, 1971)and 400 trees ha^{-1} (Mohamed, 1971). Blondel (1964) and Rebour (1968) both advise a planting density of 125 trees ha^{-1}, if annual rainfall exceeds 600 mm, 100 trees ha^{-1} under irrigation and 55 trees ha^{-1} when rainfall is below 500 mm. This would mean that in Egypt the figs are planted too close. That is in agreement with Condits observations (1947) that the area under figs had decreased since 1925, due to pests and diseases, poor cultural techniques and too close planting.

4.1.4. Young fig orchards

Fig trees are easily propagated by cuttings (Blondel, 1964; Rebour, 1968; Samson, 1980). After one or two years in a nursery the cuttings can be planted in orchards in November, on the condition that the soil is well drained. If the soil is clayey or the climate rather wet and cold, it is better to wait until February. No fig nurseries are known to exist in the northwestern coastal zone and farmers probably propagate the fig trees themselves, using either cuttings from their own orchards or from orchards in the neighbourhood.

The cuttings are usually put in hand-dug planting holes. The hole is only partially filed with soil again, so irrigation water can be applied easily. The young trees need regular irrigation during the first few years, to ensure proper establishment. The trunks of the trees should be protected against sunburn, e.g. by white-washing.

If figs are produced for drying (the smyrna fig) 5% of the orchard should be planted to caprifigs to ensure fruit setting. As fruitsetting and ripening of the smyrna fig covers a extended period of time it is advisable to plant various cultivars of the caprifig, that produce pollen over a longer time period. That will reduce the occurence of abortions due to lack of caprification.

FAO (1970) has estimated the labour requirements for establishing 1 feddan of fig trees (Table 18).

Table 18. Labour requirements for establishing one feddan of fig trees (pd = person-day).

Operation	1st year		2nd+3rd year		4th year	
	time	pd	time	pd	time	pd
ploughing (a)	Nov/Dec	6	Nov/Dec/Jan	9	Nov/Dec/Jan	9
marking and pegging (80)	Jan	3				
making holes (80)	Jan	3				
transporting cuttings	Feb	1				
planting (b)	Feb	1				
irrigation	(c)	2	(c)	18		
weeding and mulching		21	Nov/Dec/Jan	3	Nov/Dec/Jan	3
total		36				

total person-days in 4 years = 108

(a) two ploughings in the planting year and three during rains in subsequent years

(b) cuttings are obtained from neighbourers free of cost, planting operation comprises carrying cuttings to the holes, filling the holes and planting cuttings

(c) one irrigation 10 days after planting and six irrigations at 15 days intervals in June, July and August for the first three years, with 3 person-days for each irrigation to carry water in buckets

Source: FAO-4, 1970

4.2. Cultural techniques for fig production

4.2.1. Soil cultivation and mulching

According to FAO (Report 4, 1970) ploughing is carried out three times a year in the rainy season in November, December and January, combined with weeding and mulching. According to Krezdorn (1967) and Blondel (1964) only shallow soil cultivation is advisable to control weeds and facilitate infiltration of water, because part of the roots is close to the soil surface.

Mulching is reported to increase fig yields, but that effect depends on the cultivar (Condit, 1947). FAO advises mulching as a regular practise.

FAO (Report 4, 1970) estimates the labour requirements for shallow ploughing, using animal traction at 3 person-days per feddan (Table 19), or 20% higher than for barley.

Table 19. Labour requirements in person-days per feddan during full fruiting stage of figs.

Operations	Nov	Dec	Jan	Jul	Aug	Sep
ploughing	3	3	3			
weeding and mulching	1	1	1			
pruning			2			
picking, packing and transport to busstand				5	10	10
total						

Source: FAO-4, 1970

Here a correction factor is used in a similar way as for olive cultivation, so the labour requirements are 1.2 times those for barley, i.e. 22 h ha^{-1} for ploughing. It is also possible to use mechanical traction and then ploughing requires 4 h ha^{-1}.

Mulching and weeding require 1 person-day per feddan (Table 19), i.e. 17 h ha^{-1} and is carried out three times a year, in November, December and January. Weeds are already controlled by ploughing. No data on mulching are available. Since the 17 h ha^{-1} includes weeding, the labour requirements for mulching are estimated at 10 h ha^{-1} $month^{-1}$.

4.2.2. Pruning

Figs are pruned after leaf fall in autumn. Two common methods of pruning are applied, heavy pruning and light pruning, the choice depending on the type of fig production.

When the common fig is pruned only lightly, it will generally bear a heavy June crop and a light autumn crop. When it is pruned heavily, it will bear a heavy autumn crop, the figs of that crop growing on current year's wood. In that case ripening of the figs is extended over a longer period. That is an advantage for fresh fig production and for figs for preservation, but a disadvantage for figs for drying.

The smyrna fig yields only once, in autumn. When it is pruned lightly, flowering is concentrated in a short period which facilitates caprification, picking and drying. Heavy pruning prolongs the picking period and is better suited for fresh fig production (Blondel, 1964; Rebour, 1968).

According to FAO (Report 3, 1970) the quality of pruning is generally low: only the dead and infected branches are removed.

The labour requirements for pruning are estimated at 2 person-days per feddan (Table 19), i.e. 4.8 person-days or 33 h ha^{-1} and it is carried out in January. With regard to labour requirements no distinction is made between heavy and light pruning.

4.2.3. Irrigation

In dry areas, like the Mariut region, irrigation is necessary to obtain high yields (FAO-3, 1970; Rebour, 1968). Two or three irrigations would be sufficient and they should be applied before July. Excess water leads to root-rot, so the soil should be well drained. During ripening of the fruit some water stress is desired, especially for figs produced for drying (Rebour, 1968; Samson, 1980). In Egypt additional water is only applied during the establishment period. On soils with a high ground water table the water supply should not be a problem. Irrigated fig cultivation is not considered, as no data on fig yields under irrigation are available.

4.2.4. Fertilizer application

Application of manure has a favourable effect, especially on the sandy soils where fig trees are grown. The quantity advised is about 5 ton ha^{-1} yr^{-1} (Blondel, 1964; Rebour, 1968). Fertilization with superphosphate sometimes has a beneficial effect (Blondel, 1964). When cultivating figs for drying, one should beware of over-fertilization, as excess vigour may extend the ripening period, which is a disadvantage during harvesting.

The labour requirement is estimated at 35 h ha^{-1} when using animal traction (Van Heemst et al., 1981). For mechanized systems, it is assumed to take about half the time, i.e. 18 h ha^{-1} (Subsection 3.2.2). Manure is applied in December.

4.2.5. Pest and disease control

Several pests ands diseases occur in figs: scale insects, of which Ceraplastes rusci is the most common in North Africa, the mediterranean fruit fly (Ceratitis capitata), the mosaic virus, rust, the carob moth (Myelois ceratonie) in dried figs and a root rot nematode in wet soils. These pests and diseases directly or indirectly reduce fig yields.

It is unknown which pests and diseaeses occur in Egypt and to what extent they are damaging to the crop. According to FAO (Report 3, 1970) the only pest and disease control carried out is pruning of infected branches. It is assumed that for a good yield pest and disease control by means of spraying with an insecticide is necessary and that such practice increases the yield by 20%.

The labour requirements are assumed to be identical to those for spraying olives, i.e. 33 h ha^{-1} to be supplied in April.

4.2.6. Caprification

The fig wasp cannot cover long distances, so to ensure caprification, syconia of the caprifig with mature pollen are placed in the smyrna type fig trees. First one should examine the smyrna fig for receptive stigmas and the caprifig for the number of blastophaga. Then five male figs are strung on a piece of raffia and three to five strings are placed in each smyrna fig tree (Condit, 1947; Blondel, 1964; Storey, 1975). These activities should be completed before 8 a.m., that is before the insect starts to fly. It must be repeated twice with an 8 day interval in the second half of June (Condit, 1947; Blondel, 1964).

No estimates for the labour requirements are available. It is assumed that caprification-stimulating measures require 9 person-days or 63 h ha^{-1}, based on 2 times 10 minutes per tree.

4.2.7. Harvesting, packing and transport

Fresh figs are picked by hand when sufficiently ripe, sorted and packed in small boxes. They should be handled with care, as they are easily bruised and then start rotting. The figs usually ripen over an extended period, so that harvesting takes some time. The figs should be picked when ripe, but they should not have dried yet.

Figs for drying are left to dry partly on the tree. Then canvas is put under the tree and the tree is shaken lightly. The figs drop on the canvas and are collected (Bolin and King, 1980), after which the drying process starts.

FAO (Table 19) estimates the labour requirements for picking, packing and transporting fresh figs to the busstand at 25 person-days per feddan, i.e. 417 h ha^{-1}, partitioned over July, August and September. The requirements for these three operations are not defined separately. For that purpose, for transport of figs the same calculation is applied as for the transport of olives (Subsection 3.2.5) and thus it takes 3 h ha^{-1}. The total labour requirement for loading, unloading and transport is 9 h ton^{-1}. For a yield of 6 500 kg fresh figs ha^{-1} (Subsection 4.3.1) that implies 59 h ha^{-1}, leaving 358 h ha^{-1} for picking and packing the 6 500 kg. Assuming picking and packing to have about identical labour requirements, each operation takes 179 h for 6 500 ton, i.e. 27.5 h ton^{-1}.

When the figs are transported mechanically it takes 0.3 h to transport 5 ton (Subsection 3.2.5). Loading and unloading requires the same time as described above, so the total labour requirements are 6.1 h ton^{-1}. The fuel requirements are the same as calculated for barley transport, i.e. 1 l ton^{-1}, the distance being half that of barley transport.

Harvesting and packing figs for drying is less labour-intensive, as the figs are collected in canvas after lightly shaking the tree instead of hand picking. Moreover, packing can be done less carefully. The labour requirements for both operations are set to one third of those for harvesting of fresh figs, i.e. 60 h ha^{-1} in September. Transport requires the same time per ton as for fresh figs.

4.2.8. Drying

Drying figs properly is very labour-intensive. For that reason fig cultivation in Algeria is concentrated in densely populated areas (Condit, 1947). The figs are first dipped in a salt solution (4 kg NaCl in 100 l water) for about 40 seconds. Then they are placed on trays and sulphured for 2 hours, using 2 kg of sulphur for 1 ton of fresh figs. Subsequently, the trays are carried outside into the sun and the figs are dried during a period varying from some hours to some days. Drying is completed in the shade and the whole drying process lasts about 8 days. After drying, the moisture content is about 20% on a dry weight basis and the weight is reduced to about one third. The figs are then packed into big boxes. In several countries forced drying in ovens is practised. Often drying is not done properly, so that the quality of the dried figs is inferior (Blondel, 1964; Storey, 1975).

The work involved in drying is often done by women, children and old people, as it requires little physical power. No estimates on the labour requirements are available. It is assumed to take 5 person-days per ton figs, i.e. 35 h ton^{-1}. Drying takes place in September, immediately after harvesting.

4.2.9. Marketing

Fresh figs cannot be transported over long distances, except when refrigerated (Bolin and King, 1980). Therefore, areas at a considerable distance from an export market (Alexandria) can only produce fresh figs for the local market. Part of the fresh figs is preserved in factories. That is an industrial process and is not treated here. Dried figs can easily be transported to areas where a demand exists.

4.3. Fig yield

4.3.1. Fresh fig yield

According to FAO (Report 3, 1970) the average yield of young trees in the Mariut region is 3 kg and of mature trees 20 kg of fresh figs. FAO estimates the planting density at 190 trees ha^{-1}, hence the yield of an established orchard is 3 800 kg of fresh figs ha^{-1}. Elsewhere FAO reports a production of 7 240 kg of fresh figs ha^{-1}, i.e. twice as high. It is possible that the latter value refers to a situation where improved cultural techniques were applied, but that is not quite clear. El-Darier (pers. comm., 1985) reports an average yield of 37 kg of fresh figs per tree. At a planting density of 190 trees ha^{-1} that would result in a yield of 7 030 kg ha^{-1}, which is very close to the high FAO-estimate. According to Abdel-Razik et al. (1986) in 1972 13 764 ton of fresh figs were produced on 7 266 feddan. This area includes both the orchards in full production and the young orchards. On the basis of that estimate, of the expansion rate of fig orchards given in Figure 2 and of an average production of 3 kg tree-1 for young trees, the production of established orchards in 1972 was 6 370 kg ha^{-1}. Taking into account all these estimates, an average yield of 6 000 kg of fresh figs ha^{-1} seems realistic. That can be increased by about 20% to 7 500 kg ha^{-1}, if pests and diseases are efectively controlled.

Samson (1980) reports a value of 12 ton ha^{-1} for a good yield. Blondel (1964) and Rebour (1968) report average yields of 15 to 20 ton ha^{-1} for fresh fig production. Derived from various data quoted by Condit (1947), 13 ton ha^{-1} is an average yield. The scarce Egyptian data would thus suggest that the yield in Egypt is about half the average yield elsewhere. That could partly be due to the lack of proper irrigation in a region with such a low rainfall as the northwestern coastal zone.

4.3.2. Dried fig yield

Storey (1975) reports an average yield of 21 kg of dried figs per tree or 1 829 kg ha^{-1} at a planting density of 89 trees ha^{-1}. In Turkey in the Meander Valley, one of the best fig producing areas, the average yield is 20.5 kg dried figs per tree. Blondel (1964) and Rebour (1968), however, report average yields of 4 000 to 5 000 kg of dried figs ha^{-1}, which is considerably higher. In Turkey the planting density would have to be 200 to 250 trees ha^{-1} to reach that production. At a planting density of 190 trees ha^{-1} and a yield of 20.5 kg per tree, the yield would be 3 900 kg of dried figs ha^{-1}.

No data for Egypt are available, as only fresh figs are produced. However, if the area under figs is extended any further in the region west of El Alamein, part of the production must be processed to dried figs to ensure marketing possibilities. The dried fig yield for Egypt is also estimated at about half the yield in other areas, i.e. 2 000 to 2 500 kg ha^{-1}. Cultivars from abroad have been tested at Kingi Mariut station in the seventies together with some olive cultivars. The results are unknown, but should be available in Egypt.

4.4. Fig cultivation systems

Based on the data described in the previous sections three fig cultivation systems have been defined as described briefly in this paragraph.

4.4.1. Fresh fig production, not mechanized (Table 20)

The first system described refers to non-mechanized fresh fig production. Shallow ploughing is required in November, December and January using animal traction. Immediately after ploughing mulching is carried out. In December, shortly before the second ploughing, fertilizer, preferably in the form of manure, is applied using an animal-drawn cart. In January the trees are pruned. In July, August and September the figs are harvested, sorted, packed and transported to the busstand by donkey carts. Fig yield is 6 000 kg ha^{-1}. The packing boxes used, contain 18 kg of figs each (FAO-4, 1970), so 335 boxes ha^{-1} are required.

Table 20. Inputs and outputs for non-mechanized fresh fig production. A '-' indicates an output.

	Nov	Dec	Jan	Jul	Aug	Sep	unit
ploughing	22	22	22				h ha^{-1}
mulching	10	10	10				h ha^{-1}
fertilizer application		35					h ha^{-1}
pruning			33				h ha^{-1}
harvesting, packing loading, transport				83	166	166	h ha^{-1}
animal traction	22	57	22	4	8	8	h ha^{-1}
n-fertilizer		100					kg ha^{-1}
packing boxes					335		no ha^{-1}
yield					-6000		kg ha^{-1}

4.4.2. Fresh fig production, mechanized (Table 21)

The second system described is very similar to the first one, except for the use of mechanical traction instead of animal traction and application of pest and disease control. The use of mechanical traction reduces the labour requirements. Pests and diseases are controlled in April by chemical means and this operation increases the yield to 7 500 kg ha^{-1} and the number of boxes required to 420 ha^{-1}.

Table 21. Inputs and outputs for mechanized fresh fig production. A '-' indicates an output.

	Nov	Dec	Jan	Apr	Jul	Aug	Sep	unit
ploughing	4	4	4					h ha^{-1}
mulching	10	10	10					h ha^{-1}
fertilizer application		18						h ha^{-1}
pruning			33					h ha^{-1}
pest control				33				h ha^{-1}
harvesting, packing loading, transport					92	184	184	h ha^{-1}
mechanical traction	4	22	4				1	h ha^{-1}
fuel	27	37	27				18	l ha^{-1}
N-fertilizer		100						kg ha^{-1}
pesticide				2				l ha^{-1}
sprayer				33				h ha^{-1}
packing boxes						420		no ha^{-1}
yield						-7500		kg ha^{-1}

4.4.3. Dried fig production (Table 22)

For dried fig production the smyrna fig has to be introduced. The cultural techniques used for dried fig production are partly identical to those for fresh fig production. For this system it is assumed that it will only be introduced if the operations can be executed mechanically.

In June the syconia of the caprifigs have to be placed in the smyrna fig trees to ensure caprification. Harvesting starts later and is completed within one month (September), as the fruits ripen within a short period of time. Harvesting is immediately followed by drying. In October the figs are packed and transported. The yield of the dried figs is 2 500 kg ha^{-1} and 140 boxes ha^{-1} are required.

Table 22. Inputs and outputs for dried fig production.
A '-' indicates an output.

	Nov	Dec	Jan	Apr	Jun	Sep	Oct	unit
ploughing	4	4	4					h ha^{-1}
mulching	10	10	10					h ha^{-1}
fertilizer application		18						h ha^{-1}
pruning			33					h ha^{-1}
pest control				33				h ha^{-1}
caprification					63			h ha^{-1}
harvesting						60		h ha^{-1}
drying						263		h ha^{-1}
packing, transport							76	h ha^{-1}
mechanical traction	4	22	4				1	h ha^{-1}
fuel	27	37	27				3	l ha -1
N-fertilizer		100						kg ha^{-1}
pesticide				2				l ha^{-1}
sprayer				33				h ha^{-1}
packing boxes							140	no ha^{-1}
yield							-2500	kg ha^{-1}

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