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THE OLIVE IN NORTHERN TRIPOLITANIA:
SOME ASPECTS OF AGRARIAN GEOGRAPHY.

By

A. R. Taylor

Thesis presented for the degree of M.Litt
in the University of Durham.

June 1961

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Introduction

The United Kingdom of Libya is a constitutional monarchy situated along the North Central coast of Africa. It is bordered to the north by the Mediterranean Sea and to the south by French and West Equatorial Africa. To the east and west it is bordered by Egypt, Tunisia and Southern Algeria respectively. The three territories comprising Libya - Tripolitania, Cyrenaica and the Fezzan - cover an area of about 1,750,000 km^2,[1] they are separated by large desert areas which constitute a part of the Sahara desert; extending eastwards to the Nile valley and west to the Atlas mountains.

Economically, Libya is an undeveloped country in the widest sense of the word. Large numbers of the population live outside a modern economy. In fact, according to the 1954 census estimate, over 37% of the population were classified as leading nomadic or semi-nomadic modes of existence.[2] Moreover the average annual per capita income is estimated at $35 which is only slightly higher than in India and markedly lower than in the rest of the Middle East countries.[3]

The low standard of living derives in the first instance from the poverty of natural resources, an undiversified economy, and an overwhelming dependence on agriculture which is mainly of a subsistence nature and subject to violemt and often serious fluctuations in production.

Climatically, Libya is a land of extremes. Much of the surface area of the country is formed by the ancient gneissic and granitic plateau of Africa which is slightly deformed on the northern edge. Otherwise the country is monotonously level over large areas and thus it is open to the penetration of air masses of sharply differing origin. In winter European air can bring snow to the northern mountains - the Jebel - of Tripolitania. On the other hand the inflow of Saharan is marked by rapidly rising temperatures and extremely low humidity. The hot, dry Ghibli wind blowing from the southern desert is probably the most devastating feature of Libyan weather as the author often had occasion to remember. Just as serious to agriculture is the low and capricious rainfall distribution which is only mitigated by the existence of underground water supplies. With such natural conditions agricultural development is severely limited.

It would appear from the writings of classical authors and more recent archaeological research that the agricultural wealth of the country was greater in the past. Under Roman occupation, it is recorded that Libya was a major exporter of cereals and to a lesser extent of olive oil and wine. But Roman colonisation was superceded by the invasion of the Vandals and pastoral Arab peoples whose culture was alien to sedentary agriculture and therefore to the conservation of soil and water resources.

Not until the present century, during Italian occupation, has any attempt been made to restore and expand the possibilities for static farming which Roman ingenuity had shown to exist.

Developments undertaken by Fascist Italy without much regard to rapid financial return, and by the Libyan government since 1945 have been significant in raising standards and yields. Moreover it is now clear that the discovery of high quality petroleum in commercially workable quantities over several parts of Libya will change radically the financial situation over the next few years.

It is significant that these somewhat analogous periods of development (Roman and 20th) were accompanied by immense expenditure of economic and human resources on the part of the external administrations. At the same time the development by the Italians aimed at coordinating the Libyan economy with the Metropolitan economy. Unfortunately the indigenous agrarian economy was neglected. Thus when Libya achieved independence in 1952 the government was faced with the problem of maintaining Italian capital developments and expanding the productive capacity of Libyan agriculture.

In terms of population and agricultural resources Tripolitania is the foremost territory in Libya. It contains about 69% of the total population of Libya and in normal years contributes approximately two thirds of the total national income. Agriculture and grazing are the chief features of the economy; these employ at least 27% of the total working population. Other occupations are confined to commerce, services, consumer industries, military forces and handicrafts. The main crops produced are barley, olives, citrus, almonds, grapes, groundnuts and vegetables; livestock products constitute the most valuable asset.

Tripolitania is administratively divided into four provinces, (fig. 33); Tripoli, Western, Central and Northern. Each province is governed by a provincial commissioner. The provinces are further divided into districts run respectively by a District Commissioner (Ar. Mutasarree) and Mudiria under a Mudir. Sheiks or chiefs of tribes are under direct supervision of the Mudirs in the discharge of their duties in the cabila or tribal area.

The economic and social ties of Tripolitania in contrast to those of the Fezzan and Cyrenaica have been closely related to North West Africa and the northern Mediterranean lands. Commercially, Cyrenaica has traditional ties with Egypt.

Topographically Tripolitania consists of narrow littoral which forms part of a vast sedimentary plain, the Jefara. This triangular lowland is replaced inland by a line of hills, the Jebel, whose northern boundary coincides with a scarp that runs from Homs westwards to the Tunisian border. South of the Jebel is a stony plateau, the Hamada, partly of red sandstone and frequently overran by basaltic overflows, some of which form imposing highland ridges.

The southern boundary of the region, Northern Tripolitania, is defined by the morphological limits of the Jebel. Where the Jebel hills descend into the large south east and west flowing wadis Mediterranean climate and vegetational features are replaced by those which are definitely Saharan. This boundary, which is transitional, also coincides with the junction between the young sedimentary rocks and the much older rocks forming the Saharan platform.

Essentially it is the geographical position of Tripolitania and its low latitude relative to the 'Maghreb which lends interest to the geographical study of the potentialities for the olive and the attendant problems of expanding and improving its production in this region.

Because of the border situation of the country and its relative morphological uniformity Tripolitania has formed a region open to both environmental and cultural forces of diverse origin; it is a zone of transition. Mediterranean influences, climate and European colonisation, have been dominant im the northern part of the country. From the east came the peculiar socio-economic phenomenon of the 'tribe', the Moslem religion and a pastoral economy. The southern regions have contributed an arid climatic regime and certain ethnic minority groups.

The olive, a classical plant of the Mediterranean and of the characteristic climatic regime, has played a fundamental part in the sedenterisation and economic development schemes of the European colonists in Tripolitania. Opposing this development have been the constant forces of the desert climatic elements and the more temporary alien pastoral economy of the nomad. It is significant that the extension of olive cultivation and sedentary agriculture has been achieved by external powers who transferred their technical and human resources from north Mediterranean lands.

But these historical circumstances which favoured the spread of the olive have been altered by the fact that Libya was granted political independence in 1952; the indigenous population was given the right to determine their future for perhaps the first time in the history of their country.

Although the greater part of olive oil production at present comes from Italian plantations and oil factories the political climate does not appear to be favourable to their continued expansion. Therefore the main problem facing the government is one of expanding and improving indigenous olive production.

The problem of expanding and improving olive oil production presupposes a need for such developments in the light of the present economic and social conditions. Although the territory derives benefits from its historical associations and more amenable climate, it is an undeveloped region in the sense that capital equipment is scanty, standards of living are low, and the techniques of production are backward. Tables abc illustrates the salient features of the economy. They may be summarised as follows:

(a) The economy of the country is deficitory and relies for its viability on grants-in-aid from countries utilising Tripolitania's strategic position.

(b) Over 27% of the population are engaged in agriculture. Since the country is poorly endowed with other material resources, Table a

Distribution of population 1950*

Category	Tripolitania	Cyrenaica	Fezzan	Total	%
Town (Urban)	150,000	60,000)	37,000	717,000	62.4
Settled (Rural)	450,000	20,000)			
Semi nomads	150,000	60,000	11,000	221,000	19.2
Nomads	50,000	160,000	2,000	212,000	18.4
Total	800,000	300,000	50,000	1,150,000	100
%	69.6	26.1	4.3	100	

* Source. Dr. M. Shawany - Un. Tech. ass. mission in Libya. For Fezzan 4 power Commission for former Italian Colonies, Vol. III.

Table b

Occupation Structure (Citizen population) 1954 Census.

Services 238, 291
Agric., forestry
Hunting, fishing 160, 046
Manufacturing - 26, 995
Commerce - 10, 484
Transportation - --4, 304
Storage communications
Construction -3, 929
Electricity, Gas - 377
Water, sanitary
Unclassified -145, 119

Total 579,905

Table c

Budget Deficits % 1943/4 - 1950/1.

1943/4	-56%	1947/8	-35%
1944/5	20%	1948/9	-25%
1945/6	-1.7%	1949/50	24%
1946/7	11%	1950/51 (9 months)	-8.5%
		1951/52	-15%

Note: National income varies from year to year. In 1950 a normal year, national income was estimated at about £10 million.

with the exception of oil, which could affect and stabilise the fluctuations in agricultural production, standards of living are continually being depressed. Whilst the possibilities of commercial oil development become increasingly likely and may reduce the role of external capital assistance it seems likely that agriculture and its allied consumer industries will remain the mainstay of the economy.

It is evident therefore that there is a need for the stabilisation and expansion of agricultural production in order that standards of living may be improved and the present gap in the balance of payments, only reduced by foreign aid, diminished. This need has been experienced throughout the Arab world and it has been precipitated by the transformation of Arab conservatism accelerated by independence.

The fact that Tripolitania lies between Tunisia and Egypt, more prosperous neighbours, is also a constant spur to progress.

The problem of agricultural development in the region is two-fold. In the first place there are certain technical and economic difficulties for agricultural production in a semi-arid environment which is distinctly marginal for many crops. Secondly, there is the problem of the adaptation of rural society, for long governed by custom, to modern agricultural practices. These two are inevitably interrelated and only the solution of both can bring an advanced social and economic status to the country alongside its Arab neighbours.

It is necessary to stress the favourable atmosphere at the present time for agricultural development. This is a result of several factors, political independence, the changing economic position due to aid from external powers and the discovery of oil.

The wealthier industrial nations, especially U.S.A. are devoting much of their energy and resources either directly or through United Nations agencies, to meeting the capital and technical needs of such undeveloped countries. Moreover government policy is heavily weighted in favour of agricultural development.

In general the fields of agriculture offering good opportunities are there which are already significant in foreign and domestic trade.

The olive is one of the basic subsistence and cash crops of both the Italian and Libyan rural communities; olive products control to a large extent the volume of exports and are staple in the diet of Libyan, Italian and Jewish segments of the population. Consequently much of the land, water and capital resources of the country are tied up in the cultivation of the olive and the production of oil.

The rural population, excluding the more capitalised commercial developments of the Italians, remains to a large extent in a self contained economy. They are on the whole independent of the market and their standard of living fluctuates rather with the outcome of the crops than the development of prices. These short term fluctuations in production are determined by environmental factors, in particular climate which is the least controllable.

Another problem facing agricultural development in this region is the accelerated pace of urbanisation. This is in part due to the development of Tripoli as the commercial and administrative capital of Libya, but also to rural depopulation which is swelled in drought years. Rural migration has been stimulated by urban developments on the coast, and the breakdown of the tribe. The abandonment of land and the shortage of labour are becoming acute problems in many parts of the region.

The problems of expanding and improving olive oil production are related to the many problems posed by the environment, the segmentation of Libyan and Italian agriculture and the raising of living standards.

Where so many factors are involved both environmental and cultural, in a fundamentally agrarian problem the author believes that the most rational approach to a study of them is geographical.

The bases of assessment for the improvement of olive cultivation and increased oil production are therefore several, environmental, historical, social, economic and political. The chapters in the thesis correspond broadly to these criteria. Many problems, other than those concerned solely with the olive, have been briefly discussed and provide scope for further research. The following topics would bear fuller investigation; rural depopulation, land use and water supply, role of outside assistance in an undeveloped country, problems of agriculture in a marginal area, and finally the impact on agriculture of a stable and expanded economy.

The author found research in Libya a challenge; the size of the country, difficulties of travel in the interior, a trying climate and the Arabic language appeared at first insuperable obstacles but after several months acclimatisation to the environment and pace of life some progress was made and the foregoing chapters are a synthesis of all information gathered. Chapters 1-6 have been compiled from a variety of sources, documentary, personal interview and observation in the field. The discussion and conclusion in Chapters 7 and 8 arise mainly from fieldwork carried out by the author. Because of the vastness of the region much emphasis has been placed upon the technique of sampling in the field or by questionnaire.

A brief summary of the chapters appears below:-

<u>Chapters 1-3</u>, Geology, Morphology, Soils.

In the first two chapters a reasoned account is given of the distribution of rock types and morphological features. These are closely correlated and the distribution and accessibility of water resources which are of fundamental importance to agriculture and land settlement. Existing and potential sites for aboriculture are examined.

An attempt has been made in chapter three to classify Tripolitanian soils since these have hitherto received only incidental treatment. The significance of the physical and chemical nature of these soils is analysed in relation to their efficiency of water use and crop suitability.

Chapter 4, Climate, Land Use and Water Resources

A single chapter scarcely serves to emphasise the importance of considering the olive with regard to climatic exigencies and the availability of moisture. The nature and control of precipitation, temperature variations and other climatic elements over land use, crop distribution and agricultural development is carefully examined in order to determine the most rational use of land. A land use map based on previous surveys and fieldwork, graphically illustrates the effect of the interaction of these phenomena on the landscape.

The causes and effects of soil erosion and the necessity for water conservation are briefly discussed. It is argued that the tree crop and the olive in particular has a major role to play in the rejuvenation or conservation of areas afflicted by loss of soil cover and moisture depletion.

Chapter 5, Ecology of the Olive.

The main object in chapter five is to determine how for local conditions - climatic, edaphic, topographic and biotic - affect the productivity of the olive.

Therefore the distribution, density, productive phases and yields of differing varieties were studied and compared with other leading oil producers and competitors in the Mediterranean.

How far modes of land use influence yields, and the productive phases of the tree, provides an important corollary to the previous discussion. Finally, on the basis of varying ecological and cultural factors several olive growing regions are defined. In each the possibilities of intensifying or expanding the cultivation of the olive is assessed.

Chapter 6, Evolution of Olive Cultivation.

In order to explain the apparent decadence of aboriculture in the present century compared with the zenithal period during Roman times it was necessary to retrace the development of the culture since its inception by the Phoenicians. Accordingly the sequence of occupation and changing land systems are examined so that the evolution of existing methods of arboriculture can be appreciated. Whether the decline in olive cultivation and sedentary agriculture should be attributed to climatic change or nomadic pastoralism poses an interesting problem.

Italian and Libyan systems of arboriculture are compared in the light of the environmental, economic, social and political factors affecting their evolution. The superimposition of different cultures, Roman, Arab, Turkish and Italian is reflected in the modes of land use and techniques of arboriculture but the landscape mosaic is incomplete since the arid erosion elements have been quick to exploit any slight irrationality in man's approach to land use and resource conservation.

Finally the changing nature of Libyan and Italian agrarian societies is discussed. Major transformations and slight adjustments in agrarian practises and attitudes to the land are a result of broader cultural contacts which have developed since Libya achieved political independence.

Chapter 7, Systems and Techniques of Olive Cultivation.

Chapter seven is primarily devoted to a geographic and economic analysis of prevailing systems of olive cultivation. Farm samples, field observations and questionnaires have yielded valuable up-to-date information on the use, economy and viability of present farming systems. Libyan and Italian methods of growing olives are compared in relation to environment, society and wealth. In this way, amongst other things, it is hoped to determine the most rational systems of arboriculture and at the same time assess the effect of varying techniques of cultivation on the quality, quantity and regularity of oil production. In such an arid environment the value of irrigation is emphatically demonstrated. Finally the role of the olive is investigated in consideration of soil and water conservation and cropping systems.

Chapter 8, Olive Oil Industry and Commerce.

The concluding chapter is concerned with the status of the oil industry. Many of the ailments of olive growing in Tripolitania - low grade of oil, poor yields and irregular production - are thought by the author to be partially a result of the backward and uncoordinated nature of the industry. Sample studies provide a good cross section of existing olive processing industries and their degree of specialisation. A comparison of these industries on a purely economic and technological basis is unsatisfactory since such factors as the density of population and trees ultimately effect the value of each type of process. The marketing systems and trade in olive products provide a final topic.

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CHAPTER I

Geology, Structure and Groundwater

An examination of the geology and structure of Northern Tripolitania is relevant to this study of arboriculture since they exercise a marked influence directly on the soil, water resources and morphological evolution, indirectly on the climate and botanical response. They are therefore basic to the distribution of rural settlement and sedentary agriculture.

The examination will inevitably suffer from generalisations owing to the vast size of the area, the incomplete exploration, and the fact that much of the strata is masked by a varying thickness of loose Quaternary deposits.

However, following closely Christie's work in the Jebel[4] it is possible to outline the salient features of the stratigraphy and structure. The general theory of evolution of Northern Tripolitania, which is commonly accepted by most authors, can be outlined as follows: it is dependent on the view that the disposition of the Jebel mountain range is intimately related to the surrounding lowland areas and in part has determined their extent and orientation.

The Jebel, as a whole, is regarded as the remnant southern limb of a vast domed anticline aligned north-west - south-east which was uplifted by a late Cretaceous orogenesis. The anticline tilts to the south-east where it is replaced by a complementary synclinal trough; it was probably centred in the vicinity of Azizia in the Jefara. A Post-Cretaceous epeirogenesis resulted in the downfaulting of the northern limb to form the Jefara; this was later covered by Miocene and Quaternary deposition. Post-Miocene uplift determined the creation of a large spur in the extreme north-east of the Jebel around Sciogran. Subsequent Quaternary erosion and deposition has been responsible for the formation of an extensive mantle of loose terrain over the Jebel dorsal.

Essentially, therefore, the region is constituted by a solid substratum overlain by a mantle of loose terrain of varying thickness and derived in part from the erosion of the former.

<u>Solid Geology</u>.

The stratigraphy is reasonably well known and appears to be simple although there are one or two controversies regarding non-sequences which have been detected in certain localities. The majority of rocks exposed are sedimentary and predominantly marine limestones.

The total thickness of the strata as revealed by well borings in the Jebel at Garian is about 684 metres and consist for the most part of limestones, sandstones, and clays with a generally uniform horizontal bedding which dips gently to the south and south-east in conformity with the main structural trends. Fig. (2a) shows the distribution, (2b) is a cross section of the Jefara and Table (I) the stratigraphical succession.

The oldest formations, the Triassic, are exposed at the base of the Jebel and in isolated parts of the Jefara near Azizia from which much of the Cretaceous strata has been eroded.

Stratigraphy

I. Triassic

The Triassic strata is the lowest stratigraphically and therefore the oldest formation exposed in Northern Tripolitania. It has been found to underlie the whole of the Jefara up to the Jebel front and is best exposed in the vicinity of Azizia where it reaches a maximum thickness of about 144m's. The lowest 34m's forming the Boutoniere formation (Werfrenian of Christie) is mainly composed of dark red micaceous sandstones, silty clays and lesser beds of narrow carbonate bands.

Above these beds lies the Azizia formation (Muschelkalk) which attains a thickness of 110m's constituted by resistant grey and pink limestones or dolomitic limestones which contain narrow bands of chert nodules. They are reponsible for the residual hills which outcrop in this part of the plain and disrupt its relative uniformity. (Plate).

II. Jurassic

The Jurassic strata appear to lie directly on the calcareous beds of the Middle Triassic at the Jebel foot. They appear again in the Jefara adjacent to the Triassic near Azizia. They are the oldest exposed formations in the Jebel and have a total thickness of about 320m's in the Jebel front area to the north of Garian. The Jurassic beds, together with the overlying Lower Cretaceous, show much lateral variation in composition and thickness. In general they thin towards the east of Garian and thicken westwards. There are 3 series in the Jurassic:-

i. <u>Bir el Ghnem Group</u>

More than 100m's of the Bir el Ghnem group is exposed at the foot of the Jebel north of Garian. These beds are characterised by a predominance of white to grey gypsum, lesser interbeds of grey limestone and minor sandstone and clay. Where the terrain is underlain by gypsum it forms distinctive small rounded hills of almost uniform shape and size. Christie op. cit. determined that the gypsum beds graded eastward into the Bu Gheilan limestone and Bu Sceba groups.

ii. <u>Bu Sceba Group</u>

The Bu Sceba group is composed mainly of cross bedded red to brownish sandstone and small pebble conglomerate, white sandstone and a considerable thickness of red and green clays in part bentonitic, and a minor amount of gypsum. It is only moderately variable in composition and thickness. The best exposure of this group is found in a wadi to the north of Garian where it attains a maximum thickness of 165m's outcropping above the Triassic. Here it forms the lower part of the scarp. To the west it grades, in part, into the gypsum.

iii. Bu Gheilan Limestone

The Bu Gheilan limestone is about 55m's thick at the base of the scarp directly north of Garian and is composed of light grey to light brown limestone and dolomitic limestone. The lower 20m's of the section is much fractured and recemented to form a breccia. Christie relates this phenomena to the occurrence of earth movements during the deposition of the limestone. In the upper part of the formation a notable amount of chert forms a resistant band.

The gradual thinning eastwards of the limestone may be attributed to a depositional rather than an erosional action. In the scarp zone north of Tarhuna several small outcrops occur but further east this formation is masked by the thick Miocene and Quaternary deposits. To the west of Garian the Bu Gheilan limestone passes into the Bir el Ghnem formation and is probably represented further to the west by thinner separate limestone beds and in the thicker gypsum series.

The stratigraphical correlation of the Jurassic series in the Garian area with the Jebel areas to the east and west is difficult owing to the sparse outcrops to the east, and by the almost total lack of information for the western Jebel. However, a well boring examined by Christie to the north of Jefren, which is on the margin of the western Jebel, revealed that the contact between the Triassic and Jurassic occurred at a depth of 131m's. In the above 88m's the strata was composed of gypsum, red sandstone and red and green shale and mudstone, similar lithologically to the Bir el Ghnem group and Bu Sceba groups that outcrop in the vicinity.

When the total thickness of the Bir el Ghnem series, which succeeds it is added, the Jurassics in this part of the western Jebel appear rather thick, at least 200 metres.

Cretaceous

The Cretaceous system is flat lying and reaches its maximum thickness in the Jebel thinning towards the south and south south east. This area according to Lipparini[5] marked a circum-Mediterranean trough and was consequently the region of maximum marine sedimentation. A later orogenesis formed the anticline. The lower Cretaceous lying unconformably on the Jurassic beds and represented by Wealden and Albian was a continental phase prior to the extensive Cenomanian marine ingression of the Middle Cretaceous.

Wealden (Chicla formation).

At Chicla, a village, which lies on the scarp to the north-west of Garian, the exposure of Wealden beds was verified by the collection of fossils from a lignitiferous shale band of about 1m thick. Above this is exposed 21m's of sand sandstone, clays and marl. This shale band has subsequently been traced at Cussabat in the eastern Jebel and by Bernet[6] at Fassato in the western Jebel. North of Garian an exposure of about 65m. consists of small pebble conglomerate, sandstone and clay. There are no great exposures east of Garian as the strata is soft and easily eroded. West of Jefren however the formation increases in thickness though this may be because of the addition of continental formations of Albian age. Wealden and Albian beds underlie the Jefara south of Suk es Sebt.

Cenomanian

The great Cenomanian marine transgression has been traced as far south as the 29th parallel in Tripolitania. In lower Orfella, however, which lies to the south east of the Jebel, the Cenomanian gives way to later Cretaceous sediments of the Campanian and Maestrichtian[(ibid5)]. This junction also marks the southern culmination of the Jebel anticline and the limits of the regions.

These marine formations lie unconformably on the Wealden but are overlain in the extreme eastern Jebel by the Miocene. In the vicinity of Garian they reach a maximum exposed thickness of about 224 metres and appear of relatively constant thickness and composition to the east and west.

According to the lithological variations Christie recognises three formations in the Jebel at Garian which seem to recur throughout much of the Jebel.

I. Ain Tobi Limestone.

The Ain Tobi limestone forms the base of the series and is one of the most widespread and constant formations in the Central Jebel where it has a maximum exposed thickness of 79m"s. It extends with little change west of Jefren and is similarly conspicuous near Tarhuna but is only exposed in the scarp area which lacks the overlying marl and detrital cover of the plain areas to the south.

An important constituent of this limestone series is the Ichthyosarcolites band which is composed of 5m's of hard massive limestone and owes its durability to its siliceous limestone or chert content and also to its massive structure. This band is responsible for the sharp angle of the escarpment to the north of Garian and Tarhuna.

Below this band, in the type section north of Garian, is the base of the series formed by grey white to buff marly limestone commonly porous with a minor amount of interbedded more argillaceous material. A similar 16m's section of limestone occurs above but with a greater percentage of argillaceous limestone beds. The upper part overlying the 5m band is mainly composed of marly limestone.

II. Jefren Marl.

The Jefren marls overlie the Ain Tobi limestone in the Garian area with apparent conformity and comprise about 80 metres of soft,, easily eroded, marls, clays silts limestones and commonly contain a 2m band of almost pure gypsum. Over the rest of the Jebel exposures are poor except in northern Tarhuna where the marls sometimes form residual corniches on top of the Ain Tobi limestone.

III. Garian Limestone

The Garian limestone is one of the most resistant and therefore conspicuous formations in the area and underlies most of the dorsal plateau of the Jebel. It commonly forms a resistant capping over the Jefren marls which result in subsidiary scarp features. The limestone is a massive looking, crystalline dolomitic limestone, that is generally siliceous. Christie's type section occurs south-west of Garian where the measured thickness is 55m's. Bernet[ibid.3] has found this limestone capping the summits of the western Jebel in the area of Cabao with a thickness of 50m's; in Fassato however, although it remains a constant thickness the Garian Limestone is overlain, by what Bernet calls a gypsum layer, having a thickness of about 25 metres.

The Garian limestone is characterised in the lowest 28m's by massive white limestone in which veins of calcite are common. The upper 27m's forms a well bedded white limestone which contains bands of white chert.

Together with the Icthyosarcolites band of the Ain Tobi Limestone the Garian limestone is responsible for the abruptness of the Jebel scarp in the Garian area (Plate I).

Cenomanian - Turonian.

In the Garian area Christie determined the exposure of the Gasr Tigrinna formation corresponding to the highest and youngest of the Pre-Quaternary sedimentary rocks, but this formation is absent towards Tarhuna. West of Jefren it is constituted by a gypsum layer which is liable to erosion, and thins westwards being 25m's at Fassato and only 10m's at Cabao and in several places it is absent altogether.

South-east of Garian at Gasr Tigrinna the formation is composed of at least 87m's of soft marl, lesser, narrow red and yellow limestone bands, and at the top a considerable thickness of white, porous, chalky-looking limestone. It underlies the fertile land of the Assaba plain and in part the farming settlement of Tigrinna. In the western Jebel it underlies, likewise, the cultivated landscape. (Plate II).

The Senonian according to Lipparini (ibid 5) represents oscillating phases of the regression of the Cenomanian sea during and after the formation of the Jebel anticline. These sedimentaries are only exposed in the great wadi region to the south-east of the Jebel (The Ghibla) and form an arc (the remnants of a pericline) around what is believed to be the culmination of the anticline.

Essentially, the Senonian is formed by a phosphate bearing bed (Campanian) overlying the crystalline limestone of the Cenomanian unconformably. Above this bed is a thick formation of chalky calcareous marl (Maestrichtian).

<u>Tertiary</u>.

The Eocene and Oligocene of the Tertiary are not represented in Northern Tripolitania but cover much of the Sirte area to the south-east where they present a marine facies. At this time the continental and fluvial erosion of the Mesozoic sediments was in operation. Thus, during these two periods of the Tertiary, the deposition of the important 'Gefarico' beds were in formation.

'Gefarico'

These Pre-Miocene sediments are petrographically related to the later fluvial and aeolian deposits of the Quaternary being derived in part from the erosion of the Jebel. They occupy much of the piedmont zone of the Jebel scarp together with the Quaternary sediments. To the north, the 'Gefarico' descends to a depth of 162m's at Suk es Sebt, to underlie the Miocene. Here these beds attain a thickness of 78m's and comprise an upper layer of fine argillaceous sand with a zone of cementation and below some 15m's of pebble conglomerate. These beds of varying permeability have a marked influence on the circulation of groundwater in the Jefara, since they act as catchment zones for run off water from the Jebel. Nearer the piedmont zone of the Jebel the Miocene beds are lacking and it is more difficult to differentiate the 'Gefarico' beds from the superficial Quaternary sediments which overly them. At Bir es Sbea in the Jefara the total thickness of 'Gefarico' and Quaternary sediments amounts to about 99m's outcropping at the surface. The 'Gefarico' is probably represented in the lowest 57m's where the presence of calcareous gravels and pebble conglomerates is indicative of the more intensive fluvial erosion in the Pre-Miocene period when the Mesozoic sediments were denuded from the Jefara. The masking of the Jebel scarp north of Cussabat must also be, in part, a function of the formation of the 'Gefarico' sediments.

The depth and thickness of the Gefarico varies over large areas, generally thinning from north to south over the Jefara with a maximum thickness near Suk es Sebt.

<u>Miocene</u>

The distribution of the Miocene sedimentaries in Northern Tripolitania is only partly known. Deep borings have proved their existence under the Quaternary cover of the Jefara but the only exposures occur from Gasr Chiar eastwards along the Jebel front; in the more incised valleys and on spurs and slopes of the Jebel flank surrounding Homs. Most of the Italian maps represent the Miocene as ending just to the south of Homs where it is replaced by continental Pliocene deposits. However C.O.T.H.A. geologists[7] have traced the Miocene in the valley of the Wadi Caam well to the east of Homs. Its southern extension still remains unknown.

The Miocene deposits represent a phase of marine transgression over Northern Tripolitania, more particularly the northern Jefara and the eastern flank of the Jebel which Lipparini believes to have been much lower than today, being uplifted by Post-Miocene movements. In the Jefara the southern boundary has been traced beneath the Quaternary cover. It runs from Gasr Chiar, where it is 2-3km's from the Jebel scarp westwards to Azizia some 28km's north of the scarp. Thereafter the boundary becomes less certain but passes to the north of Bir el Ghnem.

From well borings it has been deduced that the Miocene increases in depth west and south west of Gasr Chiar. At Garabulli it lies 28m's from the surface. Further west at Hascian the Miocene is found 71.5m's below the surface. Thus, it appears that this formation lies assymetrically under the Quaternary cover.

The total thickness of these sediments is approximately 560m's which grades north to south from argillaceous and sandy to conglomerate, identified in the well at Suk es Sebt. Archambault[8] and Desio[9] have subdivided the Miocene in the Jefara into 3 age groups. From the top the series is:-

I. Yellowish-white, porous limestones containing Alveolines which identify this formation as Tortonian. It has a maximum thickness of 80m's.

II. Very fossiliferous clays and green marls with intercalation of greenish sandy limestone - maximum thickness 400m's - Helvetian.

III. Sandstones or whitish quicksands sometimes containing gravel and shingle - maximum thickness 80m's - Langhian of Italian geologists corresponding to a phase between the

Burdigalian and Helvetian.

By using Florida's results in the Homs area(10) it is possible to correlate the Miocene beds of the Jebel with those of the Jefara. The total thickness of the Tortonian amounts to 89m's and is well exposed at slopes of En Nab where it outcrops as a white limestone. The Helvetian, comprising an upper 70m's of sandy marls and below 50m's of crystalline limestones and sandstones, is visible on the slopes of the Mergheb (Plate 111) and in the wadi Ghenima. (II [illegible]

The composition and distribution of the Miocene formations have been of great economic significance in the evolution of agriculture and rural settlement.

The Miocene clays, in the Jebel have been almost exclusively excavated for the construction of cisterns, storage silos troglodyte dwellings and subterranean olive presses (Plate III). Some of the best soils are found where the clays have modified the essentially sandy Quaternary formations. South of Misurata and in the Jefara the existence of porous strata alternating with impermeable clays has determined the distribution of deep seated Artesian acquifers which have been exploited by Italian farmers.

Pliocene.

The Pliocene is largely represented by a continental facies; sandstones, aeolian siliceous elements and cemented limestones; and fluvial conglomerates cemented in conoids and terraces. East of Homs it is readily identified as it overlies the Miocene and constitutes an eastern prolongation of the Tarhuna Jebel scarp. Thereafter it swings to the south-east at Misurata and forms the south-western margin of the Sebka of Tauorga where it is found as a cemented conglomerate in the Wadi Soffegin. South from Homs and Zliten the Pliocene covers in part the Cretaceous beds of the northern Ghibla syncline, in the region of Bir Dufan. Here the beds are composed of silts and sandstones.

In the Jefara the Pliocene ('Gefarico'-Post Miocene) is petrographically similar to the overlying Quaternary deposits and therefore not easily distinguishable. However the presence of a Tyrennhian marine facies in the lower beds of the Quaternary is a useful indicator of the chronology. Lipparini (ibid 5) subsequently describes the beds below the Tyrrhenian as Pre-Wurmian and Pliocene which at Suk es Sebt reach a total thickness of 69m's overlying the Miocene.

Volcanic Rocks

The Igneous rocks include extensive flows of basalt, small cross-cutting intrusions of basalt and larger intrusions of phonolite; they are distributed over the Jebel and the Ghibla roughly in a line from Garian to Beni Ulid.

The extrusive basalts constitute a massive hill area between Tarhuna and Uesctata in the east, Tarhuna - Garian in North and Garian - Tigrinna in the west. Here the maximum altitude in the Jebel of 925m's is reached. This mass is profoundly incised and appears to thin rapidly at its outward edges where it is commonly 5-10m's thick. Since these basalts flow down several wadis in the area overlying a calcareous crust their age is assumed to be early Quaternary or late Pliocene. These basalts and Phonolites are aligned along the axis of the tectonic folding, north-west - south-east.

The phonolite is a much more acidic rock than the basalt and less dense but whereas the basalt is liable to fracturing and less exposed these intrusives are well exposed resistant masses, in the Garian area. They produce dome like structures in the area of intrusion around which the sedimentary formations dip more steeply.

Structure

The solid strata in the area of greatest exposure has a maximum thickness of 634 metres but is about 350m's in the eastern Jebel and less than 500m's in the west. All the beds are nearly horizontally disposed but there is considerable variation in their lateral and vertical lithology. In the Western Jebel the beds are almost horizontal with a scarcely perceptible dip of 1° to the south. In the eastern Jebel however there is a dip of about 5° to the south near Tarhuna and stronger inclination of about 12° in Msellata more to the south-east. The strata on the Jefara is practically horizontal dipping gently south at first but changing to the north near Azizia. The Miocene beds as we have noted increase in depth from east to west over the Jefara and this can be attributed to the depositional impediment offered by the eastern flank of the Jebel.

The limited exposure of the Jurassic series in the Eastern Jebel corresponds to the plunging of the anticline from its culmination in Garian.

There is considerable evidence that front faulting and the advanced fluvial erosion of the Jebel have produced many discordances and discontinuities especially in the Jefara and Jebel east of Garian. Two predominant fault directions have been verified by several authorities: east-west faults running parallel to the Jebel scarp: these are prominent in the vicinity of Azizia and bring the lower Cretaceous beds and Jurassic into lateral contact with the Triassic. North-west - south-east faults: these are the major faults in the Jebel and influence not only the hydrographic pattern but are responsible for the exposure of several spring lines in the eastern Jebel.

The volcanic rocks are roughly aligned in a north westerly direction to the north of Garian along the same axial direction as the north-west faults. Several small dome structures occurring in the central Jebel appear to be related to the injection of small igneous bodies. The fact that the Garian limestone descends from high in the Jebel to the Jefara suggests further the north-west trending flexure.

Quaternary and Recent

Quaternary and Recent sediments are in evidence over most of the region but they display significant local variations in lithology, thickness and disposition: they mask large areas of the Cretaceous strata of the Jebel and the hinterland, and the Triassic and Cretaceous substratum of the Jefara. (Plate IV). This mantle serves to soften the highly accidented relief of the Jebel and provides the base from which the soils have been developed. In the piedmont zone of the Jebel and the plateau itself and similarly in the northern plain areas, the generally permeable nature of the Quaternary permits the percolation of rainfall and run-off so as to enhance groundwater reserves, on the one hand, and on the other to create an accessible zone of moisture for deep-rooting plants. The distribution of the Quaternary in the Jebel where broken terrain and rock overcrop are limiting factors is of special significance in the siting of Italian plantations and Libyan tree culture.

Chronology

The origin of the Quaternary deposits is only partly known but their occurrence is intimately related to alternations of pluvial and arid climatic cycles consequent to the oscillations of the middle and upper Pleistocene in Europe to the north. Nothing has been traced of the lower Pleistocene from which Lipparini[ibid 5] concludes that the continental filling up of the northern plains must have been active enough to impede the first eustatic movements of the Quaternary. Post-Miocene uplift must have aided this impediment. A later eustasy (Tyrrenhian) did however penetrate inland following the direction of the Miocene as far as Suk es Sebt in the Jefara.

The chronology of events during the Quaternary have been clarified in a recent publication by Butzer(11) as a result of the investigation of Quaternary cave deposits in Central and eastern Libya (See Table 2 below). These are correlated with similar information in the Middle East.

TABLE 2. Climatic Chronology of the Quaternary

Recent	(Holocene	150mm's	Arid
	(Early Holocene	300mm's	Pluvial
Quaternary	(Late & Main Wurm	200mm's	Arid
	(Interstadial		
	(Early Wurm	300mm's	Pluvial
	(Riss/Wurm	200mm's	Arid
	(Riss	400mm's	Pluvial
	(Mindel/Riss	200mm's	Arid

A striking feature of the Quaternary is the relatively higher rainfall than at the present in the southern desert regions such as the Jebel Soda from which in part the table was compiled. However the arid and pluvial cycles are well marked by wide deviations.

In general the pluvial periods were characterised by intense fluvial activity responsible for the dissection and denudation of the cretaceous strata of the Jebel anticline and its subsided limb with both the formation, in situ, of eroded material and the transport to base levels in the surrounding lowlands of the Jefara and Ghibla. On the other hand, during the arid periods, aeolian erosion and deposition of the unconsolidated fluvial material was dominant. Strong southerly winds carried fine loess-like material from the Ghibla and the desert to the more humid north where deposition took place extensively over the Jefara and to a lesser extent the Jebel.

Essentially therefore the Quaternary comprises two elements, wadi alluvium and aeolian sands which are found in combination or in their extreme forms. Differences in relief, exposure and even the effects of man have influenced their present lithology and distribution.

Brief mention may be made here of one of the most characteristic and general phenomena found in hot arid countries where rainfall is no more than 150-200mm's and limited to a brief period of year. This is the formation of a calcareous crust or hand pan which is found at variable depths throughout the Quaternary deposits of the Jebel and the lowland areas. It comprises a rich calcareous concretion of sesqui-oxides and quartzose grains of aeolian origin and is generally about 20cm's thick. The formation of the crust is intimately connected to the thick red loess-like sands which were laid down when continental conditions of the Riss were prevalent. According to Lipparini the Riss was followed by a period of competition between the aeolian loess and torrential rainfall with the advantage to the former. The Wurmian saw a stabilisation of steppe conditions and the formation of the crust. Rainwater penetrated the fine permeable loess but rose by capillarity after the cessation of the rains and calcareous salts held in solution were precipitated at varying depths.

Morphologically, the crust acts as a conserving agent on landforms exposed to wind erosion but at the same time if it occurs near the surface it can impede drainage and hinder cultivation. Run off can also be aggravated where the hardpan is found on slopes.

The perforation of this crust for the extension of Libyan tree planting is often found in the Jebel.

The Post-Glacial period of the Holocene and Recent has witnessed from all accounts a return to more arid conditions generally in Northern Tripolitania. Intervening pluvial periods have not been absent entirely as the Neolithic rock paintings of Giraffe, elephants and ostrich in the Libyan desert could only presuppose a more luxuriant vegetation and a higher precipitation. In the most recent past one can speak of a general decrease in the rainfall in the Middle East where levels in the Caspian and Dead seas have fallen markedly[(ibid 5)]. Wind deflation and deposition has in consequence been continued whilst the action of the wadis is pronounced more especially in the better rainfall zones.

From the preceding discussion it is possible to classify the Quaternary and Recent accumulations according to site:

7 types may be recognised.

I. Quaternary of the low plains - Jefara and Eastern lowlands.
II. Quaternary of the High level surfaces.
III. Quaternary of the Dahar.
IV. Quaternary of the Upper Wadis Basins.
V. Quaternary Terraces.
VI. Scree and Alluvial fans.
VII. Wadi Alluvium.

I. <u>Quaternary of the Low Plains</u>

The Quaternary of the northern low plains is composed predominantly of very fine and uniform loess-like red sands. These sands, which are more or less stratified and compact, contain an irregular intercalation of calcareous crust and north of Azizia the impervious Tyrrenhian clay layer which helps to consolidate the sands. In places, the red sands are covered by littoral marine dunes and in the interior by extensive areas of continental dunes, partly mobile.(Plate V).

II. <u>Quaternary of the High Level Surfaces</u>

This formation is restricted to heights of over 400m's and is typically developed on the humid northern edge of the Jebel. It consists of 20-30 metres of fine sand and is rarely stratified.

III. <u>Quaternary of the Dahar</u>.

On the southern slopes of the Jebel there is a fairly continuous deposition of fine sandy material. South and south east of Msellata it takes the form of several accumulations at the foot of the south facing slopes. Whilst in the central and western parts of the Jebel it occurs in large stretches of thin sand with a monotonous aspect. These sands produce dunes which are transported northwards to invade the southern farms of the Italian estates.

IV. Quaternary of the Upper Wadi Basins.

These Pre-Quaternary basins are covered by loose sandy terrains. Subsequent fluvial erosion has stripped much of this cover and mixed it with wadi gravels, pebbles and fine sand. Large stretches remain uncultivated, but form in places a zone of Libyan tree culture(Plate VI).

V. Wadi Terraces

The Quaternary terraces are developed in almost all of the main wadi channels along the scarp zone of the Jebel. In Tarhuna and Msellata they are generally 3-8m's high with a series of stratification that represent different periods of fluvial and aeolian deposition. Little use is made of them for tree cropping. By contrast in the more arid western Jebel these terraces form significant micro-regions for indigenous tree cropping.

VI. Scree and Alluvial fans.

At the foot of the main ridges and spurs along the wadis in the Jebel front there is an accumulation of scree derived from fluvial and aeolian erosion. It can be classed with the alluvial cones along the Jebel front which extend far north into the Jefara and mark a distinct break in slope. These cones are deltaic in appearance.(Plate VII). In the eastern Jebel they form outwash ridges composed mainly of fluvial gravels and are utilised as supplementary cereal areas by the Libyans. The Italians established a farming settlement on similar outwash fans north-west of Msellata.

VII. Wadi Alluvium

These recent deposits consist of fine alluvial gravels and small pebbles and are limited to the present wadi channels.(Plate VIII). Generally they are used for cereal cultivation especially where the alluvium is mixed with sandy deposits.

Although the Quaternary is apparently uniform in all its types the essential difference lies in the particular mixture of locally eroded material with the sandy material which is found at all levels in the Jebel and almost continuous over the northern lowlands.

Lithologically the Quaternary corresponds to four types:-

I. Pure Sand - Loose fine grained sand forming the Quaternary of the Dahar and the Dunes of the Jefara.

II. Terra Rossa - More compact than the above and characterised by the presence of calcareous grains and fragments. The calcareous crust is developed in this type.

III. Wadi Terra Rossa - Found in the main north flowing wadis and some of the southern thalwegs. It is composed of sandy elements with a considerable amount of gravels. It is much more calcareous than the others.

IV. Mixed Quaternary of the slopes.
This is derived mainly from local elements with sand elements having little importance.

Groundwater.

A striking feature of the groundwater is the discontinuous lateral and vertical distribution of aquifers. The Jefara and the coastal lowland from Zuara to Misurata appear as areas of relative abundance in contrast to the scarcity of supplies in the Jebel by reason of the following facts:-

(a) The Aquifers of the Miocene and Quaternary are continuous over most of the northern Jefara and in the similar hydrological zone around Misurata.

(b) The plains act as areas of discharge for the run-off water of the Jebel. Moreover the almost continuous permeable Quaternary cover over the plains greatly assists the percolation and recharge by rainfall.

The Jefara and Coastal Lowlands.

Two distinct water levels occur in this area: one is superficial and the second deep seated and artesian (Fig. 3).

I. The essentially sandy and permeable nature of the superficial Quaternary sediments explains the existence of a regular and abundant Phreatic water table found at a maximum depth throughout the coastal lowlands. It is extensively exploited by Libyan farmers but because of poor techniques yields from many of the wells are no more than 2-3m^3 per hour. The cordons of littoral dunes serve as admirable areas of recharge for this aquifer whose level tends to oscillate seasonally.

Below this water table and separated from it by a clay layer water is encountered in siliceous sand beds of 15-40m's thickness. At the base of these beds is a marl bed which separates it from the first clay layers of the Miocene. This aquifer is semi-artesian but requires pumping and its rate of flow varies from 25-300m^3 per hour. It is more abundant in the northern Jefara between Azizia and Tripoli than in the eastern coastal lowlands in which the area of recharge is much smaller. The great extent of the aquifer from the Jebel foot, the more numerous wadis and the extent of continental dunes, all contribute to the greater abundance of groundwater at this level in the Jefara. Archambault(ibid.8) believes that this aquifer is the same as that in the permeable layers of the Upper Miocene (Tortonian) trapped in sands which surmount the tortonian limestone sands of Quaternary, Pliocene or even Miocene. The presence of this aquifer has facilitated the expansion of several hundred Italian farms in the Jefara.

II. Since Desio distinguished an Artesian acquifer in the lower Miocene (Langhien) Viali's contribution(ibid.9) has led to a more detailed knowledge of the distribution of the Miocene aquifers. He distinguishes two Artesian zones in the Jefara.

I. West of Tripoli between Sorman and Zanzur Viali found 2 water tables. The first was at a depth of 250m's below the Quaternary in the Upper Miocene (Tortonian of Desio) which yields 20-50m^3 per hour but which can be augmented to 200-300m^3 per hour by pumping. A second table was located at 650m's corresponding to the lower Miocene (Langhien-Desio) yielding 60-250m^3 per hour.

II. A single Miocene acquifer was discovered in the vicinity of Tripoli contained in a complex of sands and limestones between 250-450m's which yields 300-350m^3 per hour.

The origin of these Miocene acquifers is still uncertain and apart from the recharge through the permeable Quaternary cover there are two factors which would seem to be relevant in augmenting supplies. It is possible that the water is in part a fossil formation of Cretaceous age. Infiltration through the dejection cones at the foot of the Jebel is more likely since many of the wadis discharge into these deposits.

Jebel.

The Jebel acquifers are marked by a low rate of flow. This feature is related to:-

(a) The general inclination to the south and south east of the strata. Thus the flow of groundwater is away from the climatically favoured areas of the northern Jebel.

(b) The more pronounced effects of faulting and erosion which have interrupted the water bearing strata.

(c) The less uniform distribution of the Quaternary formations.

The great majority of the Libyan and Italian wells are based on shallow sources of groundwater preserved in the basins of the Cretaceous surfaces. Other wells are fed from acquifers lying high in the Jefren Marls or at the base of the Ain Tobi limestones. Deeper acquifers are largely unknown except for the Jurassic acquifers at Cussabat. Italian wells rarely exceed 40m's in depth and are based on an acquifer at the junction of the permeable Garian Limestones and the impervious Jefren Marls. The yield from these wells rarely exceeds 30-60m^3 per hour.

Of some importance are the springs which effuse at several levels in the Jebel but are most common on the Jebel front where the greatest exposure of the strata occurs. The lowest is at the foot of the scarp and corresponds to the base of the Wealden. Above Spring lines are found at the base of the Jefren Marls and the yellow tufaceous limestones (Cenomanian - Turonian) in the Central and Western Jebel. Less frequent are springs in the northern lowlands, but several occur in the major wadis.

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TABLE OF GEOLOGICAL HISTORY.

SYSTEM	STAGE	DEPOSITS	NOTES
Holocene	Flandrian	Alluvial & Aeolian	Slight marine ingression but continental conditions prevalent.
	Riss	Argillaceous and reddish sand	Continental
	Tyrrenhian	Almost continuous thin clay layer	Marine
	Mindel	?	?
Pliocene	--	'Gefarico'	Continental - Marine regression
Miocene	Tortonian	Sands and clays - white and yellow limestones	Marine
	Helvetian	Green & very fossiliferous clays and marls	"
	Langhien	Sands, sandstones, gravels and shingles.	"
Oligocene	--	'Gefarico'	Continental
Eocene	--	"	"
Middle Cretaceous	Danian	-	Retreating sea.
	Senonian	Maestrichtian - marly limestone Campanian-phosphate beds	Transgressive oscillations. Regressive oscillations Jebel orogenesis-NW-SE faulting in Tarhuna. Syncline of Ghibla.
	Turonian	Massiwes limestones of Nalut-Gasr Tigrinna formation in the east.	Marine
Lower Cretaceous	Albian	Sandstones, quartz, conglomerate and cemented sands.	Continental deposits thin and disappear to the east.
	Wealden	Marls and Clays	Continental deposits in the east more of sandstone and conglomerate nature. Albian and Wealden rocks form small Cotes in the west
Jurassic	Bajocian	Bu Gheilan dolomitic limestones	Marine & Lagoon conditions
Triassic	Muschelkalk	Grey to dark grey, buff compact limestones	Marine Outcrops at Azizia.
Senonian	Danian Maestrichtian Campanian	Marine	Jebel orogenesis NW-SE anticline - eruptive rocks, NW-SE faults. Syncline of Ghibla.

After Archambault
Lipparini
Christie
Desio

CHAPTER II

Morphology

Geology and structure, difference in surface and slope, in addition to the diversity of the wadi pattern and the great accumulations of wind blown sand and the saline expanses fundamentally affect the agricultural value of the region for arboriculture. These resources up to now have been incompletely developed and often in a rather 'extensive' way. In order to illustrate the potentialities of the region and the background to physical problems of land use in relation to arboriculture it is necessary to consider in some detail the influences of orogenesis, epeirogenesis, structure and the processes of the erosion cycle.

Tectonic evolution combined with the remodelling effects of aeolian and fluvial erosion has created the present morphology of Northern Tripolitania. This may be illustrated by an analysis of surface, hydrology and slope from the point of view of the types of landscapes which they determine.

The region is one of comparatively modest relief being for the most part below 700m's with significant areas below 200m's. Gently sloping plateaux and plains often intensively dissected and sometimes sharply differentiated by scarps are the dominant elements of the relief. Fig. (4a). Two factors would seem to explain the gently sloping tabular nature of the terrain. Unlike the 'Maghreb' to the north west, the region did not participate to anything like the same degree in the intense folding of the Alpine orogenesis, and secondly the Mesozoic strata of the base forms structurally the northern edge of the older resistant Saharan plateau on which it was deposited almost horizontally. In consequence, marine ingression has been less obstructed. Minor discordances and non-sequences do occur but these are related in the main to the alternation of marine and continental conditions together with faulting.

The most striking feature of the morphology which is readily apparent in the profiles is the distinction between the low flat Jefara and the higher Jebel plateau which extends in an arc from Southern Tunisia to meet the sea at Homs.(Plate IX). The former is unbroken except for a few small hills in the west and south. East of Homs the Jefara is replaced by a narrow coastal plain which widens towards the Sirtic Gulf where it forms a large arid plain. The Jebel along its entire length consists of a broken northern edge defined by a scarp, associated with north flowing wadis, and a gently sloping plateau which is inclined towards the south-west near its western confines, but gradually swings to the south-east in the east. At the base of this slope there is a sharp break in slope bounded by the Senonian scarp of the Hamada el Homra; a vast featureless gravel surface.

Of primary importance in the evolution of the structural morphology has been the formation of the Jebel.

Tectonic Evolution

All authorities agree that the Jebel was formed by an anticline which was uplifted during the late Cretaceous. The fold movements were essentially centred towards the Alpine - Atlas complex. Owing to the lower latitude of this part of North Africa and to the existence of the resistant block of the Cretaceous plateau, which formed the northern edge of the Saharan platform, the orogenetic forces were only powerful enough to cause the uplift of a weak but extensive fold roughly aligned north west - south east so that the southern slope faced the centre of the orogenetic activity. The formation is confirmed by the gentle but perceptible dip of the Cretaceous, Jurassic and Triassic strata to the south. The existence of the scarp which sharply terminates the main strata together with its arc shape indicates some form of dome or anticline, the northern limb of which has been destroyed. Recent deep borings in the Jefara have revealed, below the Miocene, strata, believed to be Lower Cretaceous, which Lipparini op. cit., and Archambault op. cit. contend is part of the remnant northern limb. Because of the absence of the Miocene south of Azizia and since the Triassic is the oldest exposed rock in the region, occurring at an unknown depth below the Cretaceous in the Jefara, the alignment of the Triassic would correspond to the alignment of the Jebel anticline. The parallel alignment of the igneous outcrops, and the arc-shaped scarp around the Triassic belt indicate that the main tectonic axis of the anticline was north west - south east. This tectonic axis reaches its culminating point near Garian which is also the area of orographic culmination in the Jebel. Here the Jebel is for the most part over 700m's compared with average heights of 600m's to the west and 4-500m's in the vicinity of Tarhuna. Corresponding laterally to the anticline is the synclinal depression of the Ghibla which is compressed between the anticline and the Hamada el Hamra. The restriction of the beds of the Maestrichtian and Upper Campanian to the south western extremities of this area, indicates that they were deposited either during or after the orogenesis of the Jebel. These beds probably represent the extension of an arm of the Sirtic gulf during its maximum ingression during the Eocene[12].

Accompanying this uplift was magmatic activity and faulting which has affected most commonly the area of the tectonic axis since it was the area of greatest tangential pressure. These faults havebeen traced in the Jebel to the east of Garian and in the Jefara at Azizia and since they affect only the lower beds of the Cretaceous their age is presumed to be synomymous to that of the formation of the anticline.

Whilst there has been a common acceptance as to the mode of formation of the Jebel anticline there has been much conflicting discussion regarding the formation of the Jebel scarp which decisively demarcates the high plateaux from the low plain of the Jefara. Theories of marine abrasion and continental erosion have both had their exponents. More recently, because of deep borings in the Jefara, the theory of faulting which was promulgated nearly 40 years ago, has come to be accepted. Marine abrasion must be discounted because it does not explain the Pro-Jebellian hills nor the marine miocene deposits, which at Homs reach a height of 200m's but are only traced below the Quaternary in the Jefara. Despois[13] recognised the dome structure and regarded the present scarp as being a result of fluvial erosion in a more humid period and achieved by the successive retreat of the water divide. Although this may account in part for the Pre-Jebel hills and the present surface configuration of the Jebel such erosion must surely have degraded the whole of the northern limb of the anticline. The theory of faulting, which in the author's opinion is the most convincing, was put forward by Lipparini[ibid 5] after he discovered from deep borings in the Jefara that the Triassic nucleus at Azizia was broken to the north by a series of faults running east north east - west south west which have been subsequently traced in the Jebel and which correspond to the direction taken by the escarpment. The existence of lower Cretaceous beds below the Miocene, which seems to be terminated by these faults in the Jefara, would appear to substantiate his theory that faulting, as a result of radial pressure, originally caused the formation of the scarp. He associates these faults with an epeirogenic movement during Eocene affecting all strata from Triassic to Senonian. Subsequent fluvial erosion has removed the former Cretaceous strata of the Jefara and resulted in the recession of the scarp which must have marked the southern extension of the Miocene.

Prior to the Miocene ingression, during the Eocene and Oligocene, the Cretaceous strata was exposed for the most part to sub-aerial denudation especially in the Jebel. Only to the south and south-east of the anticline in the region of Sirte, according to Desio[ibid.12] is there any evidence of marine transgression.

The miocene may be traced however, from southern Tunisia through to Misuratino and from the coastal areas of Sirte to as far east as the Egyptian frontier. In Northern Tripolitania the Miocene is found, with great variations in thickness and depth, 2-3 kilometres north of the present scarp at Tarhuna and at Azizia and probably marks the position of the original scarp. In general the Miocene increases in thickness and depth westward from Homs; at Homs it is about 200m's thick and outcrops to a height of at least 161m's. But south of Tripoli, in the Jefara, its thickness exceeds 500m's and it is buried under the marine and continental Quaternary.

This assymetry and thinning eastwards of the Miocene is attributed by both Desio and Lipparini to an epeirogenic uplift which occurred either in late Miocene or early Quaternary. This is based on the fact that first eustasy of the Quaternary (Calabrian) cannot be traced in the Jefara nor even on the eastern flank of the Jebel. It is presumed also that continental infilling of the base levels to the north and south east of the Jebel was sufficient to impede invasion.

However, of the last phase of eustasy (Tyrrenhian) there are notable traces in the Jefara and the coastal plain to the east of Homs. Although no post Tyrrenhian tectonic movements of any importance have affected the coast of the Jefara between Zuara and Homs there is evidence for a notable negative Quaternary and post Quaternary movement in the zone of Misuratino. From Homs, where the Tyrrenhian is found at about sea level, it falls progressively towards the east: at Zliten it is 30m's thick with the base 21m's below sea level and near Misurata it lies 42m's below sea level. This lowering of the land determined an increase in fluvial sedimentation from the Jebel and consequent formation of thick continental deposits. Lipparini concludes from the direction of stratification, which is parallel to the northern flank of the Jebel anticline, that it is clearly the posthumous direction of Quaternary and Holocene epeirogenic movements which were independant of the eustatic movements of the same periods. To this phenomena is attributed the formation of the vast triangular plain of Misuratino with its apex on the coast and its widest side resting on the Mesozoic of the Jebel. These movements were also responsible for the origin of the Sebka of Tauorga which Lipparini deems as an area of tectonic depression.

In profile the general features resulting from the tectonic evolution may be clearly seen. Figs. 4a and 4b.

These reveal the close correspondence between the supposed line of the tectonic axis and the area of orographic culmination which is formed by a large detached domed mass to the south east of Garian and coincides with the exposure of the basaltic lavas which outcrop at about 1000m's. From this highland section the general slope falls gradually to the west and south but perceptibly to the east and north east. These lower levels represent the synclinal slopes of the ancient anticline which plunged to the south east to give a marked decrease in height. The decrease in altitude towards the north is the result of erosion consequent to the formation of the scarp and its later erosion back which resulted in the transformation of the sub-Jebellian wadi regime. This erosion has been differential and higher surfaces have been preserved especially by the resistant Garian Limestone and also by the phonolite intrusives.

The essential difference in level and morphology between the eastern Jebel and the Jebel area west of Garian is explained by its position to the east of the main axis of tectonic activity. It was therefore less affected by uplift. Also it participates in the general synclinal slope to the south as well as in a distinct slope east and north east to the sea. In the extreme east - Msellata - the lower altitude and essentially different morphology has resulted from more intense wadi erosion in a humid zone from three sets of consequents; from the Jefara, and from the synclinal southern slope and the eastern slope to the sea, rendered more effective by the Miocene uplift.

The Jebel scarp which abruptly terminates this northern slope of the Jebel is a continuous feature and has normally been developed by the erosion of clays and sandstones, overlain by resistant limestone bands. West of Garian the scarp assumes a cliff-like form rising to heights of over 500m's from the piedmont detritus at its base. There are numerous small changes in slope and extensive gullying by large wadis which has caused the complete separation of large outliers from the main strata, particularly at Nalut and Jefren. These give rise to secondary scarps parallel to the main scarp. Towards the east as the scarp swings round to the sea it becomes lower and its nature changes from an imposing cliff feature to a series of indistinct step-like ridges and outwash spurs along the front of western Msellata. South east of Home the scarp is barely 80m's high and it declines eastwards to Misurata to form the northern edge of the synclinal southern slope.

The Jefara rises gently southwards from the sea with only slight undulations to take the form of a piedmont zone at the foot of the scarp at varying heights - 300m's in the west declining to 200m's north of Tarhuna.

Surfaces

Relief constrasts and differences in surface level are greatest in the Jebel which extends south and south east from the scarp at a variable distance depending on the criterion adopted to delimit it. Morphologically the Jebel is that area contained between the scarp and the main watershed of the north and south flowing wadis and would thus extend from 10-15 km's south of the scarp near Garian. The Jebel is succeeded by the Dahar which constitutes its southern slopes. This is transitional between the Jebel and the trough of the Ghibla sycline.

The Jefara and the lowlands of Misuratino on the other hand are distinguished by their relatively normal gradient which descends gradually from the scarp and the southern slopes.

The Jebel

Considering the fact that the Jebel has been exposed to sub-aerial denudation since the late Cretaceous - a process operating differentially and regionally - and also that the structural formation has produced fundamental differences, it is still possible to trace the main surfaces in profile (Figs. 4a - 4b). These clearly reveal that the highest surface levels are found in the zone of tectonic culmination at Garian with a decline to the west and north east in response to the dip slopes of the anticline: the general decrease in height to the south being a function of the syncline of the Ghibla and the south east tilt of the anticline. The relatively lower altitude of the area to the north east towards Tarhuna and Cussabat must also be attributed to a stratigraphical thinning - with the absence of the Gasr Tigrinna formation - and to the greater intensity of fluvial erosion. The continuous fluvial erosion of the front means that only the highest surfaces represent the original surface of the anticline, but these may be extensive where the top-most beds have been preserved by Quaternary deposition or else where the resistant Garian Limestone outcrops at the surface.

It is therefore possible to classify the surfaces according to height. (Incorporated in Fig. 5).

I. <u>Highest Surfaces</u>

i. 750-900m's embracing the Basalt Dome area, the plains of Assaba and el Baten (and the high plateaux of Jefren and Chicla).

ii. 600-750m's Forming the backbone of the Jebel west of wadi Zaret and the interfluve areas of the upper tracts of the south flowing wadis.

II. <u>Intermediate Surfaces</u>

i. 600-700m's - constituting the wedge area between the basalt plateau and the plains to the west and in part the Tigrinna plain.

ii. 500-600m's - Large area of this surface is known as the plain of Guassem.

III. Lowest surfaces

i. 350-500m's. The central Tarhuna plateau.

ii. 250-350m's. The northern slope of Tarhuna.

iii. 200-300m's. Cussabat Plain.

iv. 100-200m's. Sciogran.

750-900 metres.

The highest surface level in the Jebel occupies an area corresponding roughly to the zone of tectonic culmination. East of the wadi Zaret it embraces an extensive area to the north and south of the main watershed. This surface is constituted by the plains of Assaba and el Baten, which abut onto the scarp, and by the dome shaped plateau of the basalt extrusive zone. West of the wadi Zaret the surface is discontinuous and smaller and forms the cuesta-like plateau interfluves between Jefren and Chicla. The boundary of the surface coincides approximately with the 750m's contour and on its northern edge, the scarp pf the Jebel.

The variation in altitude over large areas is mainly structural in origin. But complications have been introduced by the basalt extrusion in the west. There is a perceptible slope to the south-east of the Assaba and el Baten plains (Plate X) and west from an indented northern edge. The surface is underlain by the flat lying Gasr Tigrinna formation which has been preserved from intense fluvial erosion by the Quaternary cover. Thus the plains exhibit undulations only over large areas.

However the basalt dome to the east, with altitudes of over 900m's, has been subjected to greater erosion on all sides from wadis which radiate from it. There is in consequence a slope in all directions from the highest elevations which are aligned along the main watershed.

600-750m's.

The main surface of the Jebel west of the wadi Zaret is developed on the south western slope of the ancient anticline and lies roughly between the 600 and 750m's (photo) contour but in the extreme west it declines to below 500 metres. The relatively flat disposition of the bedrocks and the absence of pronounced tectonic activity, notable in the Garian area, means that over large areas there is little differential in altitude. North of the watershed in scarp area because of the fluvial erosion by north flowing wadis the surface is accidented. Whilst there is a structural decline in altitude from east to west vertical variations are produced by the differential erosion of the uppermost beds. Where the soft Gypsum strata remains it forms usually the highest knolls.

The general uniformity of level between the interfluves and the main watershed is partially a result of the Quaternary cover into which the upper wadi beds are only vertically incised.

600-700m's

This surface forms a wedge between the basalt plateau and the plains of Assaba and el Baten. The general slope to the east and south east from a minor scarp at Garian is related to the structural dip. The whole area is underlain by Garian limestone from which the softer beds of the Gasr Tigrinna formation have been weathered by the upper wadi tributaries of the Gan and the Megenin. These wadis radiating from the basalt plateau are deeply incised into the surface and are responsible for its aspect of broken relief. The largest unbroken surface is formed by the Tigrinna plain which has been less subjected to erosion and is covered by extensive Quaternary deposits.

500-600m's

The lower surface of the plain of Guassem extends on the interfluves of the north flowing wadis between the scarp and faulted basin in the north and the minor scarp of Garian to the south. The Garian limestone cover has been eroded almost entirely from the surface except for small residual hills which together with isolated cappings of basalt stand out from the general level. Recent alluvium and Quaternary deposits mask much of the underlying Jefren marls and Ain Tobi limestones. The surface slopes from north west - south east from areas of highest relief which coorespond to the zones of phonolite intrusion, some of which remain unexposed under the plain of Guassem. In contrast to the undulating moulded relief of the actual Plain of Guassem, the greater intensity of erosion and the effects of faulting have broken up the surface towards the south east, and it is only traceable in small summit levels.

350-500m's

This surface forms the large central Tarhuna plateau (Plate XI): it is a rectangular area widening towards the west as far as the wadi Gherraia. It is split into two distinct sections by the Abanat fault, the more easterly of which has been subject to greater erosion. The plateau represents the eroded northern edge of the synclinal slope to the south and its northern boundary therefore coincides with the main watershed and the Abanat fault. The southern confines are more arbitrary and are roughly marked by the 350m's contour.

The surface extends northwards on the interfluve spurs as far as the ancient watershed. Though there is a visible variation in altitude this is mainly the result of the general slope of the Jebel eastwards from the zone of tectonic culmination at Garian. Most of the area is underlain by the resistant Garian Limestone except in the extreme north. This essentially structural surface is also the zone of maximum aeolian deposition so that the underlying bedrock is covered up to depths of 30m's by sand and Ard Hamra.

250-350m's

North of the Tarhuna plateau there is a distinct break in slope and an erosional surface at 250-350m's which north to the scarp. The surface runs parallel to the arc shape of the plateau edge from the wadi Gherraia in the west round to the wadi Ueni in the east. The intensive erosion of the north flowing wadis and the progressive eating back has largely removed the Garian limestone cover and laid bare the softer Jefren marls and Ain Tobi limestone. In consequence the surface is extremely dissected and is only apparent as narrow ridges and knolls on the interfluves.

200-300m's.

West of the wadi Ueni this surface is best seen in the Cussabat plain which forms a relatively uniform area orientated in the axial direction north west - south east (Plate XII). The plain is underlain by Ain Tobi limestone which is mainly covered by Quaternary and fluvial deposits. These have mitigated the intense erosion of the wadis responsible for the serration of the northern edge. Here the surface is only found in the small summit levels of the ridges and spurs of the scarp and is less easily detected towards the west. The main slope to the east and south is in relation to the anticline slope and to the synclinal slope of the Ghibla.

100-200m's.

The Sciogran surface lies on the extreme north eastern flank of the Jebel; the area of Miocene deposition and subsequent uplift. The surface slopes east to the sea and south east to the lowlands of Misuratino and is roughly defined by the 100-200m's contours. The area is underlain by both Miocene and Cenomanian strata which has been intensively eroded by wadis flowing north and north east to the sea. It thus appears as an area of small dissected surfaces (Plate XIII).

Ghibla

There is a general decline in altitude from the surfaces of the Jebel and Dahar to the synclinal zone of the Ghibla but it is not easy to define because of the lack of adequate topographical maps. However the surfaces differ according to position in relation to the tectonic axis and wadi systems. South of Nalut the surface declines from 600 metres and is mamillated. It is higher south of Jefren, and extends in broad wadi interfluves. From Garian its surface declines from 750 metres where the relief is broken by numerous wadi tributaries. South of Tarhuna the surface declines gradually from 350m's but the surface is varied due to aeolian deposition and greater wadi action. The basalt mass of Uesctata, to the north east of Beni Ulid, stands above the general level. From Sciogran there is a gentle dip eastwards to the piedmont of Misuratino.

The Jefara

The Jefara and the lowlands of Misuratino, tectonic and erosional in origin, correspond to ancient plains of erosion which since the Tertiary have been filled up by the detritus transported from the interior by wind and water. Eustatic movements of the sea have also contributed to this embellishment. The surface morphology therefore reflects the passage of these various forces which have reacted according to period, and to the oscillation of climatic and hydrographic conditions. Unlike the Jebel these areas exhibit no great relief contrasts over small areas.

The Jefara forms a vast triangular plain and is actually a geographic prolongation of the Tunisian Jefara; it covers an area of 18,000 km^2. From sea level, at about 1 m. near the coast at Tripoli, the plain rises gradually south with a slope of about 3:1000. It is terminated by the foothills of the Jebel at altitudes varying between 300m's in the west and 80m's in the extreme east where it is smaller and forms the apex of the triangle. Its configuration is dependent on the arc shape of the Jebel scarp.

The lowlands of Misuratino are separated from the Jefara by the eastern spur of the Jebel at Homs. From Homs the plain widens and is defined to the south by a minor scarp (Plate XIV) corresponding to the 100m contour. Towards Misurata the plain trends south-west to follow the coast line of the Sirte Gulf.

The surface of these plains is not absolutely monotonous;

where the Jebel wadis meet the plains large alluvial cones have been formed, especially in the Eastern Jefara and southern Misuratino.

The elements which introduce variety into the morphelogy of plains may be enumerated as follows:-

I Dunes - Continental and Marine.

II Sebkas (Salt Marshes).

III Calcareous crust.

IV Pro-Jebel Hills.

V Trough of 'Bernet'

VI Alluvial cones of the Piedmont.

VII Erosion by Wadis.

Dunes

(a) Marine Fringing the coast line is a broken cordon of littoral marine dunes composed of white calcareous material. On the flat beaches which are exposed to maritime winds the sand is brought inland especially in dry periods to form these dunes.

(b) Continental Although the northern part of the Jefara is constituted prevalently by a Quaternary deposit of fine quartzose red sand, mostly consolidated, of aeolian origin, which is the soil immediately used for cultivation, in places, it is covered by great extensions of continental dunes. These dunes consist of mobile elements of fine red quartzose sand derived from the alluvial material of the southern Jefara and the Ghibla by strong winds. A large area of these dunes stretches from Zuara in the west to Garabulli in the east; an area 70kms. long and 10kms. wide with an average height of 70 metres. These dunes are developed also in the Misuratino lowlands especially in the region of Zliten where they are mixed with marine accumulation. Although these dunes afford excellent infiltration areas for rainfall, their mobility is a constant threat to cultivated zones. Their rate of movement varies and has been interrupted to some extent by the efforts made by the Italians to stabilise them. East of Misurata they have been found to move north at the rate of 1 metre per annum.

The formation of these dunes was observed by Lipparini in the vicinity of Garabulli, where the alluvial sands in the depressions were undergoing a process of 'Eolism' which involved the removal by winds of the finer argillaceous particles, from the heavier sand particles which without the argillaceous parts became loose and formed dunes around the depressions. This process is distinct from that responsible for the formation of dunes on the southern slopes of Jebel. Sands here are constituted by finer materials blown from southern desert and are in consequence more argillaceous.

<u>Sebkas</u>

Sebkas correspond to areas of salt concentration which may become marshy in the wet season. The areas of salinity are found mainly in zones of depression in the plains and can have a dual origin according to Principi. In those sebkas formed in depressions along the coast, separated generally from the sea by a low cordon of cemented marine dunes, the salt comes from marine seepage or else from continental superficial or subterranean water with the nearness of the sea impeding or helping the flow.

In this category are the sebkas of Zuara and Tauorga. The latter covers the greatest area, being 100km's long by, about, 3km's wide. It is separated from the sea by marine dunes partially cemented and defined to the west by the alluvial cones at the mouths of the wadis which flow into it from the Ghibla. The water which occupies the basin comes from marine infiltration in the north east but from an artesian spring in the south west which in the summer evaporate to give salt formations. The Salt deposits are more potent in the north west but tend to be leached out by winter rain in the south east. This area is at or below sea level but at Zuara general level is about 12m's.

Another restricted area of saline soil occurs near Tagiura and is related to the capillary movement during summer of a salty superficial acquifer which leaves salt incrustations on the surface. But the degree of saltiness is not comparable to that of the sebkas.

In the interior of the Jefara areas of salinity correspond to depressions in the Quaternary. Several small basins are distributed in the south west. The salts are derived from washing out from surrounding solid strata concentrated by the presence at depth of an impermeable layer so as to impede drainage and favour evaporation. This impermeable layer in many cases corresponds to the calcareous crust.

Calcareous crust

Petrographically the crust is a rich calcareous concretion of sesqui-oxides and quartzose grains of aeolian origin. The formation of this crust takes place under a given climatic regime where rainfall is no more than 200mm's. Normally it is formed by the capillary movement towards the surface during summer of moisture containing calcium carbonate in solution which has percolated down during the rainy winter period. This movement takes place especially in the receptive Quaternary cover or in the beds of wadis. It can also be associated with the drop in the general water table during summer. The level at which the crust forms varies with the slope of the surface and the depth of the Quaternary cover and also with the rate of capillary movement. Where however there is persistent aridity and a strong capillary movement then the crust is formed at the surface as a fairly thick deposit. Such an area of continuous crust is formed in the western Jefara. Here mean rainfall is less than 200mm's and there is a strong surface movement of moisture towards the surface. Since humidity increases eastwards, the crust is found about

In the western Jefara the crust is responsible for the uniformity of the terrain.

Pro-Jebel Hills

These Triassic hills, which rise from the general level of the plain to heights of at least 300m's, are aligned parallel to the Jebel scarp. They are found especially in the area of Azizia. Morphologically they are testimony to the intensive erosion which stripped the Jurassic and Cretaceous cover from the original anticline and laid bare the Triassic.

Trough of Bernet

In general the Jefara rises southwards but at the foot of the central and western Jebels an anomolous trough aligned east-west occurs. The existence of this trough was first discovered by Bernet(6). This trough is not a continuous feature but a series of troughs separated by detrital cones and is thought by Bernet and Lipparini to represent the original direction of consequent wadis flowing south west down the flank of the original anticline to southern Tunisia; a system destroyed by the Miocene ingression.

Alluvial cones

Important indicators of the evolution of the Jefara morphology are the accumulations at the foot of the scarp which have been traced in depth as far north as Azizia from which it is inferred that they represent the gradual withdrawal of the scarp. Their existence is partly responsible for the change in slope from the Jefara to the Jebel scarp. Marly and argillaceous in the north they graduate to conglomerates in the piedmont towards the south. They were formed in the last pluvial phase of the Quaternary and have subsequently been overlain by more recent fluvio-aeolian accumulations. They are characteristic also of the Misuratino piedmont area.

<u>Erosion by Wadis</u>

Wadi erosion in the Jefara and lowlands of Misuratino has scarcely affected the general uniformity of the Quaternary cover. In the western Jefara a host of youthful wadis descend from the scarp in ill defined courses. These rapidly infiltrate into the sandy cover and the trough zone. Further east however where the Jefara narrows in a more humid zone many of the wadis reach the sea where they have often eroded ravine-like valleys. This feature is repeated in the north flowing wadis of the lowlands to the east of Homs. Essentially it is a result of negative eustatic movements causing the wadis to seek new base levels .

<u>Importance of relief forms.</u>

The variety of relief forms have a human and ecological interest since not only do they contribute to the regional diversity in climate but they have influenced the evolution and character of agriculture in Tripolitania. Historically the accessibility of the plains has played an important part in the direction and movement of nomadic peoples. On the other hand, the Jebel has acted as an area of refuge for sedentary peoples and as a reservoir of water. The mountains act also as a climatic divide and especially in the west have restricted the activities of pastoralists.

The forces that produced the base give to the region its particular character in which the main distinctions may be made into:-

(1) Jefara
(2) Lowlands of Misurata
(3) The Jebel
(4) Rigid mass to the south and south west of the Tectonic axis (Hammada el Hamra)
(5) Synclinal slopes to the west, east and north east of the Tectonic axis.
(6) Sycline of the Ghibla.

Erosion which has subsequently remodelled these tectonic regions emphasising their differences, has acted according to period. In the evolution of the drainage pattern three periods can be recognised:-

(1) Post Cretaceous.
(2) Miocene.
(3) Quaternary and recent.

The primary interest in the study of the wadis lies in their differing systems, and varying morphology between individual wadis and their sections. Ecologically the wadi as an element of relief and as a humid zone is a significant factor in land use. Although the utility of these wadis, which flow only intermittently during the wet season, varies according to profile and size of catchment area, they contain certain common features of importance to agriculture:-

(1) Generally contain some of the better soil areas - Alluvium sand.

(2) Areas of ground water availability during the dry summer.

(3) Favourable climatic entities.

(4) Often contain large flat basins.

(5) Sporadic surface flow can be utilised for irrigation.

Fig. (5) incorporates the hydrographic reticule of the region with the main watershed running east north east - west south west parallel to the scarp along the highest surfaces of the Jebel. It separates a relatively dense system of wadis flowing in a northerly direction to base levels in the Jefara and at sea levelfrom a more dispersed tenuous system flowing southwards to gently sloping more distant base levels in the Ghibla syncline. In contrast to the simple pattern of wadis in the west where both north and south thalwegs discharge into the sands and sebkas of the Jefara and the Ghibla the system shows increasing complexity eastwards with confused and abrupt changes in direction. This is a function not only of increased humidity but also of the greater influence of tectonic phenomena. In order to illustrate this diversity it will be necessary to examine briefly the evolutionary processes which have determined this distinction.

description can be made).

Evolution.

There is no established chronology of pre-Quaternary erosion other than that of Butzers. Desio(ibid.9) saw successive periods of humidity in the Eocene associated with the extension of arms of the Sirtic embayment in land south of the Jebel. The retreat of the Gulf during Oligocene brought continental conditions but Miocene transgression resulted in a partial reversal to more humid conditions. A consequent drainage pattern seems to have been established on the original surfaces whose direction and emanation was determined by the faulting north-west - south-east, by the zone of orographic culmination and volcanic masses. Thus consequent wadi systems operated to the north and south of the tectonic axis. However after the formation of the Jebel and its subsequent retreat the northern system was destroyed, and the original surfaces of the anticline are only preserved to the south and south-east of the Jebel by the resistant Garian limestone. Consequents of these slopes include the wadis from the Zuzam in the west round to the wadis feeding the Lebda and the Taraglat. The fossil trough of Bernet visible in profile and orientated in an east-north-east - west-south-west direction at the foot of the Jebel in the west presumably marks the original valley of a consequent flowing down the stratigraphic dip of the anticline towards the south-west which has been destroyed by the creation of the scarp and Miocene transgressions. The normal southern consequents have only been altered by Quaternary infilling.

After the formation of the scarp, consequent upon east-west faulting, the creation of new base levels in the Jefara resulted in a period of intense fluvial erosion. Actual outcrop and surface determined the course of the new north flowing 'subsequents', which hollowed out valleys starting from small run off gullies on the edge of the scarp. By processes of normal regressive erosion facilitated by the clay and marl composition of the Albian Wealden and lower Cretaceous, the upper basins were extended to their present dimensions with the formation downstream of a vast piedmont plain. In the Jebel, the valleys are formed by small basins, arranged in tiers, in which the profile is controlled by the lithological diversity of the underlying formations. As the bed is hollowed out the sill is weathered, and lateral terraces are vigorously attacked by run off. In this way the wadis, engendered by the creation of a new base level, were able to eat back and capture the headwaters of the more gently flowing southern thalwegs for which phenomena there is abundant evidence in the eastern Jebel in the sharp deviation of many of the wadis. Subsequent fluvial erosion dominated by the process of continual capture is manifest in all the wadis.

The creation of the Jebel front, in late Tertiary, destroyed the old consequent pattern. East-west dislocation and north-west - south-east faulting in addition to the modifications caused by the subsequent retreat of the scarp and by the transformation of the sub-Jebellian regime both consequent and subsequent contributed to this.

All writers believe that Tertiary uplift sponsoring the flow of wadis draining Sciogran and fracture was complete by the Pleistocene with, however, traces of posthumous movements in the area of Misuratino. In the Jebel the high rainfall of the early Pleistocene led to the establishment of the main systems and their characteristics of capture and multilinear development either along the earlier pattern or through the development in relation to the late Tertiary earth movements.

Belonging to the category of wadis of latest imposition are:-

i. Wadis flowing and furrowing the Jefara - established on Pleistocene and Holocene cover - Megenin.

ii. Brief torrents which cut into the coastal slope and Pleistocene outcrop at the sea.

iii. Torrents of Jebel incising the scarp - Western Jebel.

iv. Brief autonomous wadis established on the Neogene formations Miocene and Pliocene.

The basic pattern of the wadis is therefore essentially guided by tectonics, i.e. north across the scarp to the Jefara but in the Msellata in response to the slope of the anticline; south to synclinal ditch of the Ghibla; south-west to synclinal slope, and south-east to dip slope of Amamra and Zliten.

This basic pattern has been altered by faulting and deposition of aeolian loess during the Pleistocene.

Faulting - Often large sections of the wadis are guided by faulting particularly by north-west - south-east, eg. W. Gan, Gsea and Turgut.

Aeolian loess - affects only small sections in the Jebel but is responsible in many parts of the Jefara and Ghibla for the truncation and infiltration of the wadis.

The modelling of the original surfaces by erosion and river capture together with the effects of aeolian deposition and faulting means that although the above directions are clearly seen they are often found in combination in many of the wadi systems.

The influence of these features whilst governing the direction of the wadis is also manifest in the shape, slopes and nature of the wadi floor.

It is possible to classify the wadis on the basis of certain common characteristics obtaining in their profiles and direction of flow, even though there are marked differences in direction and individual morphology as a result of tectonic and erosional evolution (Figs. 6a & 6b)

1. Synclinal slope.
2. Northern slope consequents.
3. Scarp consequents.

1. Included in this section are all wadis flowing from the main watershed down the several dip slopes of the anticline and the corresponding slopes of the Ghibla syncline. Owing to the lack of adequate topographical maps detailed study

of these wadis in their entirety is impossible. However, a few remarks may be made concerning the upper sections. The significant factors are the sharp break in slope in the upper section related to the normal regressive erosion and to the fact that this tract is incised in the aeolian loess whilst lower sections are encased in Garian limestone. The upper sections are narrow but well incised with a tributary complex giving rise to rounded undulating relief. Lower down, the wadis are well incised but between steep sloped banks the valleys are broad and generally covered with gravels and pebbles in which the wadi course is marked by minor incisions.

These southern wadis with their heads in the humid north receive considerable flow of water in the winter months but owing to the permeable nature of the beds and the irregularity of rainfall much of this flow is subsurface. The tributaries of the Tareglat run south-east then deviate to the north-east in response to the southern slopes and eastern slopes from the anticline.

Between the Tmasla and the Soffegin a similar but more extensive deviation is seen. The size of these wadis in relation to the present fine grained sand wadi beds and the occurrence in fossil terraces of the Soffegin and Merdum of coarse gravels and boulders suggests that they were initiated in a past pluvial period. This is also borne out by the gradients of these wadis near their mouths which appears well below the present sea level at Tauorga.

The course of the Soffegin illustrates well the influence of tectonic and structural phenomena. From its head in the Jebel the wadis runs in a normal consequent course down the dip slope of the anticline to Mizda after which in response to the syncline of the Ghibla and the proximity of the Hammada it follows a meandering east - west track. Then it describes three arcs before discharging in the Sebka of Tauorga. The first is an accessory arc of the Jebel axis corresponding to the pericline, whilst the second is the result of the pericline entering a phase of depression which aligns the thalweg south-west - north-east. The last arc is consequent to the Jebel slope.

2. Northern slope consequents.

These wadis are only found in the zone of tectonic culmination and to the east; they include those wadis from the Gan to the wadi Turgut. The form and direction of many of these wadis has been modified by faulting lithological variations and complicated, particularly near Garian, by vulcanicity. Normally their direction corresponds to the slope of the ancient structural surface, i.e. north and north-east. They constitute the longest flowing wadis in the Jebel proper. In the east the upper basins of the north flowing wadis Ramle, Msabaa and Sarai are wide and well developed, falling steeply from the Garian limestone which marks the watershed. They lie at about 3-400m's. Downstream, where they incise the less resistant Jefren marl and Ain Tobi limestone, the beds are deeply incised with, however, wide channels and well developed Quaternary terraces. Towards the scarp they are more deeply incised. Sharp deviations in the course of the Msabaa and Turgut are a result of the large biaclatase which may be traced along the whole of the Gsea wadi to the Msabaa where its passage is marked by a sudden turn northwards of both wadis. It is a wide, low surface lying at about 2-300m's.

The evolution of the erosive processes in the Tertiary has notably altered and degraded the old wadi system. The relative youthfulness of the actual relief is due to the Post-Miocene uplift and the deep erosion in the Quaternary. After the last pluvial phase the effects of aeolian deposition were dominant and resulted in the blocking and limitation of thalwegs, the lateral movement of courses and occlusion of areas of capture.

Rather different are the valleys belonging to the zone of tectonic culmination in the vicinity of Garian which run in correspondence to the area of eruptives, sedimentary strata, and phonolite intrusives between Garian and Tarhuna. In correspondence to the anticline direction of the sedimentaries exists a vast zone of basalt effusives which partly cover the Cenomanian-Turonian, and numerous intrusive masses, covered by the sediment areas, but exposed by erosion.

The valleys of the effusive zone often pass into the surrounding zone of Garian limestone and G. Tigrinna formations and owe their form and direction to the slope north of the old structural surface of the basalt but also to the structural composition. Although the beds are more or less resistant, alternating beds of thick basalts with tuffs crossed vertically and obliquely by faults and veins cause the generally north flowing wadis to exhibit brusque changes and meanders. The wadis are more deeply incised in the less resistant Gasr Tigrinna formations.

The wadis passing into the sedimentaries and rising from the same formation have been deepened as far as the intrusives and thus show changes in course as a result of lateral deviation which is caused by the outcrop of the intrusives and by the running of the tributary wadis along the sedimentary beds; these dip from the intrusives. Thus, the combination of north consequents in the Gan and the tributaries controlled by intrusive masses which rise near the scarp and flow south-east - Guassem - has produced a form of crater in the softer Jefren Marls and Ain Tobi limestones; it is known as the plain of Guassem. Although the main wadi beds are deeply incised into the Quaternary deposits the valley sides are gently sloping. To the east of the eruptive zone are wadis forming the tributaries of the Megenin and these are modified particularly by the north-west - south-east faulting which forms a trough area near the scarp.

Only a few of the wadis have large catchment areas on the Jebel. Their courses traverse the Pleistocene and Holocene cover of the Jefara into which they are often deeply incised as a result of Quaternary

3. <u>Scarp Consequents</u>.

Distinct from the wadis of ancient imposition crossing the scarp which are aligned by tectonics and have a long deep profile, are those wadis which rise from the top of the scarp often from springs and which fall in brief torrents to the piedmont zone, in narrow furrows. Here their courses are indeterminate. They are more commonly a feature of the scarp area west of Jefren than the lower more mature wadi regime in the eastern parts of the Jebel. To their attack of the soft clays and marls overlain by resistant limestones and sandstones owes the continual regression of the scarp.

The wadis established on the Miocene (eg. Chabbaza) run in brief courses down the slope north east to the sea. They have small basins at the head, but give way to a narrow tract then become gorge like in lowest tract. These wadis display small Quaternary terraces.

Within the whole wadi system certain types of common morphological characteristics may be recognised. These correspond to the tectonic and structural features that are indicative of direction.

i. Upper basins of north flowing wadis.
ii. Middle basins.
iii. Scarp zone basins.
iv. Faulted basins.
v. Upper parts of southern and eastern thalwegs.

vi. Lower Dahar wadis.
vii. Wadis in the plain tracts of Jefara and Misuratino.

i. The Upper Basins.

The Upper Basins of the north flowing wadis are generally well incised to depths of 200m's in the west. Courses are for the most part straight with a series of Quaternary terraces and narrow wadi beds with rock face development. At the sources there is often an amphitheatre development resulting from run off on all the slopes. (Plate XV). Narrow gullies are found above the basin to considerable depths in the Quaternary cover.

ii. Middle Basins.

The Middle Basins are more a feature of the wadis in central and eastern Jebel where they have been influenced, in the past, by extensive wadi capture, faulting, and especially Pleistocene deposition. The basins are often of great extent, being almost completely covered with Pleistocene loess above which the low denuded Cretaceous emerges to form small broken ridges along the main interfluves or where fluvial action has stripped the wind blown sand. The wadis meander through the basins with wide courses incised to depths of 5-10 metres on the Pleistocene loess or calcareous crust. The wadis have only in a few places excavated to the Cretaceous basement. There are frequent examples of truncated valleys and in some places it is possible to observe the phenomenum of occlusion where accumulations of aeolian deposits have caused the wadi to alter course. These basins are characterised by an aspect of low rounded relief, broken by the denuded slopes of minor interfluves with deeply encased wadi beds, which are cut into the Pleistocene loess. The main interbasin interfluve are characterised by their denuded, garrigue covered slopes, which are generally gentle. However important breaks in slope result from lithological variation in underlying formations.

iii. Scarp Zone Basins.

These include the lower Jebel sections of the main Jebel wadis which are characterised by deep incision in the Pleistocene as well as the Cretaceous. There is often extensive development of terraces in the latter, lying between the wadi channel and the slope foot. The course tends to follow the anticline slope but in these sections the effects of faulting, particularly east of scarp at Garian, are pronounced. The main wadi channels are wide, meandering in the Pleistocene in narrow valleys. The minor wadis are deeply encased being extended run off gullies with little lateral terracing and with considerable rock face development.

iv. Faulted Basins - Wadi Gsea, Wadi Turgut - Megenin.

Effects of faulting may be seen in the narrow and heavily incised valleys with markedly straight courses. These are common in Northern Msellata (Wadi Turgut).

v. Upper Parts of Southern and Eastern Thalwegs.

The more gentle slope to a distant base level means that the morphological characteristics of the southern thalwegs are distinct from those flowing northwards. The upper courses generally originate in the Quaternary in which run-off channels and gullies are deeply incised. However in these upper courses incision is often prevented from reaching the Cretaceous base by the calcareous crust development. Lateral erosion is of greater importance and the whole area is one of rounded relief. The larger valleys are of great lateral extent with an even slope and gently rounded unterfluves - Wadi beds often 10 metres wide being covered by sand, gravel and angular rock fragments.

vi. Lower Basins.

As rainfall sharply decreases southwards the wadis are characterised by broad massive valleys encased between mesa-like formations of aeolian covered Garian limestone.

vii. Jefara & Misuratino Wadis

The almost total lack of wadis crossing the lowlands of Misuratino between the Sebka of Tauorga and the Caam, contrasts with the frequency of Wadis traversing the Jefara east of Azizia. These wadis - Megenin Ramla Turgut - exhibit mature profiles and are incised into the Quaternary cover in narrow valleys. Nearer the sea however these wadis are gorge like and cut through the Miocene and ancient alluvial fans.

Slope

In general, slope development is controlled by the action of wadis working towards the two base levels in the Jefara and Ghibla with the degradation of the Jebel and the gradual augmentation by deposition of the plains. This action is particularly pronounced in the northern edge of the Jebel where the greater humidity, and the rapid descent of the wadis from the scarp and the high level surfaces determines a strong vertical erosion on the less resistant beds exposed beneath the Garian limestone. This process is relatively mature in the Jebel to the east of Wadi Zaret and especially in Msellata. By contrast the wadis of later imposition located in the more arid west without the same regressive powers of erosion only incise the Jebel a comparatively short distance from the scarp.

On the other hand the fall to the Ghibla of the south flowing wadis is gradual and the capture of their heads by the north flowing wadis has inevitably reduced their powers of vertical erosion. Thus the absolute and continuous dissection of the southern slopes is less intense than that of the Jebel front.

South of the scarp occurs the most rugged terrain in the Jebel. Wadi incision is profound with narrow almost I shaped valleys. The plateau dissected by the wadis consists of twisting narrow ridges which are swollen towards the front to form peninsular spurs. In the more humid zones of Cussabat and Sciogran the advanced fluvial erosion has given rise to more rounded interfluves with gentler slopes and wider V shaped wadis channels.

The whole of the northern edge ofthe Jebel is an area of broken terrain and soil erosion is advanced especially in the denuded areas where run off is high and leads to gullying. This process is augmented by the agricultural practises of close grazing pulling of Esparto grass and the cutting of numerous channels to feed trees and cisterns.

The utility of these wadis and their sections as regards accessibility, water supply and soil fertility varies considerably.

The Upper Basins, for example Gasr Doga, have the advantage of being located in the humid northern edge of the Jebel. In addition they are easily accessible from main concordant routes along the back of the Jebel. The areas are small but water is assured from shallow wells. In order to be successfully cultivated terracing and conservation techniques would be necessary.

The middle basins appear eminently suitable for sedentary agriculture because they are situated in areas where the amplitude of relief is great.

There is considerable scope for agricultural development in the scarp zone basins provided that run off water from the Jebel can be controlled and utilised efficiently. Otherwise the large flat or gently undulating areas covered with deep Quaternary deposits form attractive sites for cultivation and settlement.

Some of the largest areas of flat land in the Jebel are found in the faulted basins. They are well sheltered by steep walls and soils are deep but settlement depends on a fluctuating water supply found in shallow wells in the wadi beds.

Areas of the Dahar most susceptible to cultivation are the upper parts of the southern and eastern thalwegs which are surrounded by denuded interfluves. They form regions of humidity and deep soils.

The lower basins of these wadis are broad but their agricultural value is limited by the aridity and low rainfall of adjacent areas.

The wadis of the northern plains contain fertile alluvial soils but their use depends on the means employed to control their flash floods and to disperse the water either by draining in the lower reaches or by spreading in the Piedmont zone.

The area of flat land lies in restricted zones to the south of the Jebel front but is discontinuous. Being incised by wadis the slope from the main level surfaces is generally steep more especially in the area surrounding Garian. The large accessible flat wadi bottoms therefore assume greater importance. In the proper utilisation of these northern slopes lies the solution to the continuous degradation of soil resources.

The elements that determine slope are primarily the wadis and mountain forms which are dependent on the structure and stage of erosion.

In the light of the preceding discussion it is possible to identify several physiographic regions. These are defined as:-

(I) <u>Jefara</u>

The Jefara represents a plain of erosion and subsequent infilling. It is defined by the sea to the north and by the Jebel Scarp in the south. The plain is relatively uniform and little dissected by wadis. There are three significant divisions:-

(i) A narrow coastal plain no more than 50 metres in height and backed by a cordon of marine and continental dunes.

(ii) The Undulating Jefara constitutes an area of continental dunes. Proceeding from the coastal belt the southern boundary is defined by the approximate line of the furthest Miocene ingression running East North East - West South West, through Azizia.

(iii) The Plain Jefara was formerly the sub plain of the Jebel. In this region the calcareous crust is predominant and partially accounts for the nearly unbroken level surface. It merges gradually into the Piedmont Plain of the Jebel. The Pre-Jebel Hills stand out above the general level. (Plate XVI).

II. <u>Misuratino Lowlands</u>.

This area resembles the Jefara as regards the general uniformity of relief but it is much smaller. Unlike the Jefara the Jebel forms the hinterland only in the east to the south of Homs. Elsewhere

dissected hill land which allows maximum penetration of southern climatic influences. However, the dunes, calcareous crust and sebkas are features common to both plain areas.

III. Jebel

Within the Jebel there are five distinct morphological zones:-

(i) Piedmont Zone.

This zone is regarded as an extension of wadi conditions in the scarp zone. The slope is roughly 1.5% in this area and it has been colonised by the indigenous Jebel tribes.

(ii) Scarp Zone.

The scarp zone is composed of steep slopes and deeply incised wadi channels of the Jebel front as well as the area immediately to the south. Settlement in this extremely rugged zone is confined to the larger spurs and Quaternary terraces.

(iii) Inner Basins.

With a thick cover of Quaternary loess and more undulating relief these areas are some of the most fertile in the Jebel but as yet they have only been partially utilised since they formed in the past traditional grazing grounds for nomad herds.

(iv) Plateaux.

The plateau surfaces of the Jebel are composed of gentle slopes and stretches of flat or undulating terrain. They are covered with aeolian sands. Wadi incision is low since this zone lies on a dip slope. It is defined roughly by the 200mm isohyet.

(v) Dahar.

The greater aridity combined with the thin and mainly discontinuous cover of aeolian sand have led to the formation of large, flat mesa-like plateaux broken by the wide and deep wadi depressions. Whilst the interfluve areas are largely devoid of soil the wadis form regions of fertility and humidity.

As well as these divisions of the Jebel there are three larger lateral divisions:-

(I) Western Jebel

The Western Jebel extends from the Tunisian border to the Wadi Zaret. The region lies on the dip slope to the south west of the zone of tectonic culmination. Horizontally bedded strata has been little altered by North West - South East faulting. The simple hydrographic pattern of north and south flowing wadis has given the mountains a tabular aspect.

(2) Central Jebel

Eastwards the Central Jebel is defined by the incision of the Wadi Gherraia. This region coincides with the area of orographic culmination and the zone of eruption.

(3) Eastern Jebel

The Eastern Jebel is distinguished from the other two regions by the following features:-

(a) Alignment - it lies to the north east of the main tectonic axis.

(b) Composition - The Turonian and Jurassic beds are hardly represented in this region.

(c) Surfaces are much lower.

(d) Fluvial erosion is more advanced.

From the point of view of land settlement and cultivation, the Jefara plain represents the most important physiographic unit in Northern Tripolitania. Topographically the plain allows freedom of movement and access to maritime climatic conditions. The largest acquifers with the best quality waters are located in this region. It is also the natural focus for the Jebel and interior plateaux. Settlement is more difficult in the Jebel where topographic units are smaller, the amplitude of relief greater, and where water supplies are inferior to those of the Jefara or east coastal plain.

Although the Jebel scarp appears to divide sharply the uplands from the plains the wadis tend to unite the different physical units. If they are to be fully utilised it is essential that the problems of soil and water conservation be considered throughout the entire watershed areas. This means the prevention of run off in the catchment areas of the Jebel so that the danger of flooding and destruction can be reduced on the plains.

CHAPTER III

Soils

No comprehensive empirical study of the principal soils of Tripolitania appears to have been published and a soil map still awaits compilation. The greater part of the Italian results of soil and groundwater investigation which appeared between 1912 and 1942 remain unpublished in Italy.

Fortunately the suitability of soils for the olive, in terms of yields, has been investigated in other Mediterranean countries, in particular Tunisia and Italy.

Derivation.

Since Northern Tripolitania lies with an arid and semi-arid climatic zone the soils of Northern Tripolitania have been derived primarily from the physical and to a lesser extent chemical weathering of parent material arising from two sources: the Mesozoic formations of the Jebel and the aeolian deposits from the desert regions south of the Dahar.

The soil types belong to two distinct regions. In contrast to the Jefara and Misuratino lowlands where the soils have been derived mainly from the alluvial erosion of the Jebel and marine sedimentation the soils of the Jebel are not independant from the underlying Cretaceous strata (limestones, marls sandstones and shales).

SOIL TYPES.

(1) Coastal Belt.

Brown Pedocalic Regosols.

There is no clear distinction between soil of coastal belt and succeeding Steppe areas except that induced by greater humidity and more continuous cultivation.

A great proportion of the soils of the coastal belt, including most of those under cultivation, fall within this category[14]. On the whole these soils are deep, but in the Misurata area they become increasingly shallow and more compact. They are loose, friable and permeable. They are immature soils and show little or no profile development. Typically they have a PH greater than 8 and contain free calcium carbonate both as fragments and small nodules. Usually they do not contain stone or gravel, and are largely confined to sandy areas. Unless the surface is protected by vegetation these soils are susceptible to wind erosion; the effects of wind are evident everywhere and exemplified by ripple markings on soil surface of olive and almond groves in this region (Plate XVII). Although with sound irrigation techniques, the availability of plant nutrients soon becomes limiting, in general, moisture is the controlling factor for crop production.

In order to study this soil type in more detail a soil pit was dug within the precincts of the experimental agricultural station of Sidi Mesri, situated a few kilometres to the east of Tripoli City.

<u>Profile I</u> (Deep ploughed land in close proximity to the Wadi Megenin.)

Here the surface was covered by large clods to a depth of

2 feet. The surface horizon appeared to be a result of an overflow from the neighbouring Wadi Megenin. In years of high flooding the area affected may be considerably increased. The alluvial deposits accumulating on the surface can be considerable.

A 1. 0-35 cms.

The surface soil was grey buff in colour in contrast to the orange brown of the succeeding horizon. The soil was dry, friable and free draining and clods were found to break down to single grains with little pressure. Grey buff fragments of indurated clays about 2 cms. in diameter, together with occasional fragments of calcium carbonate, were observed throughout this horizon. The horizon was sharp and even somewhat compacted towards the base. Rootlets were seen to be present throughout.

B 1. 35-105 cms.

Orange brown fine sandy soil, mostly single grain structure, with a few small fragments of calcium carbonate. No roots were found to be present.

B 2. 105 cms. to depth

Light brown coloured sand with numerous particles of calcium carbonate.

The physical and chemical analysis of this soil (Sample 1, Table 3.I) reveals that:-

(a) The sample is classified as sand or loamy sand reflecting its aeolian origin. The content of organic matter was low and this was associated with low carbon and nitrogen percentages.

(b) A notable feature is the low total of exchange capacity although this could be expected for extremely sandy soils low in organic status. The distribution of exchangeable cations exphasises the high sodium percentage. The level of available phosphate is low and the absolute amount of exchangeable potassium is also low. Water holding capacities are inevitably low but a compensating factor is the good depth and uniform texture. The extremely light texture makes them highly susceptible to wind erosion.

2. <u>Shifting and Fixed Dunes</u>

The extensive areas of sand occurring parts of the coast, interior steppe and Jebel has been noted and mapped. (p. (Fig. 5). These form Azonal soilsof the genetic classification. Two types of sand are present, marine and continental and different combinations of these give rise to a variety of intermediate soils.

The distribution of the Marine sands is limited to the coastal belt. Robb[15] estimates that moving and barren dunes cover an area of approximately 115,000 hectares in Northern Tripolitania. These sands are known to have engulfed the ancient Roman city of Sabratha which is situated about 15 kilometres to the west of Zavia. The dunes here are associated with a westward spit and lagoon type shoreline. As a result of the presence of fragments of sea shells, molluscs, and foraminifera the colour of the marine sands is a grey white though sometimes with black and orange particles. They contain much more carbonate than the continental dunes. The particle size can vary and although there is an appreciable proportion of coarse sand most of the grains are less than 0.2mm's in diameter. Comel[16] gives a complete chemical analysis of the marine sands close to Homs.

Emen in the coastal belt aeolian sands of continental origin are of greater importance than the marine sands as parent material. Usually the former are very fine grained, the majority of particles being less than 0.2mm's in diameter. The colour of the aeolian sands shades from red to brown depending on the degree of hydration of iron compounds. The content of organic matter is low.

Associated with the dominant quartz fraction are various minerals and felspars together with a little carbonate, but mica is usually absent. Profile development is virtually non-existent and the soil formed is immature, homogeneous and unconsolidated.

The clay fraction is in the order of 6% and there is consequently little cohesion or adhesive properties; the sands are therefore unstable and constantly moved by winds and readily eroded by water.

Sand dune encroachment on cultivable soils has long been a problem in Libya. Sir J. Russell[17] as a result of his visit in 1939, drew attention to the method adopted by the Italians of planting enclosures. These were about 2 metres apart and were made by driving stems of dead speargrass (Imperata cylindrica) into the soil, and then planting a young sapling in this centre. This highly effective though costly method has been developed successfully by the Forestry

Department. With the technique of 'dissing' shifting dunes may be fixed and made to produce Acacia. Eucalyptus and Pine, though in sparse stand. There is sufficient internal water available in the sand dunes to support this degree of rank vegetation.

Most continental dunes exhibit varying degrees of calcification in their lower horizons and when the water table remains constant, over a long period, these sands may become highly cemented by the calcium carbonate or sulphate present, into an almost solid formation. Such a formation, known as Tin, was observed by the author and quoted by Principi, near the Israel cemetary in Tripoli.

Solonchaks.

Forming a distinctive category are the saline soils belonging to the Halomorphic sub-order of the world classification. (Table III, Sample 2). These are well developed along the coast but occur also in the Jefara and southern parts of the Dahar. (Fig 5). Already we have discussed the three main reasons for their occurrence.(p.).

In general the Holomorphic soils are of little significance to agriculture unless they can be drained and the salt concentration lowered. However, when the salt content of the Sebkas is not excessive, as for example at Tagiura, some salt tolerant grasses will flourish and can be useful for grazing purposes. But where the salt content increases

Halophile vegetation will develop and this is of little use.

Soils of the Interior Plain

A variety of soil types occur in this steppe zone of the Jefara and Misuratino with no sharp line of demarcation from those of the coastal belt. Thus sand dunes similar to those described can be found especially in the northern part of the Jefara. In the same way sebkas invade localities where conditions are conducive to their development. The problems presented by these formations are essentially the same as those in the coastal belt. Moreover the greater part of the area is mantled by an extensive cover of sandy soil, the characteristics of which indicate its classification as a Brown Pedocalic Regosol[ibid (15)].

Brown Pedocalic soils of Interior Plain

These soils exhibit most of the characteristics of the regosols of the coastal belt as already described. In particular the profile is undifferentiated. The depth, though variable, is about 30-40 metres according to Comel[ibid (16)] but is often much less in Misuratino.

A more precise description of these Regosols results from investigations by the C.O.T.H.A. organisation, in citrus grove soils at Azizia, which they designate as an intermediate type of soil. It is described as a fine grey brown sandy soil with little clay and silt and occasionally covered by small dunes about 1 metre in height. Here the soil is usually about 10 metres in depth. It is low in organic matter but not so low as in the true sandy soils and exhibits some degree of cohesion. It presents, in the northern part of the plain, a featureless landscape, broken only by the Triassic knolls and by small mounds with a characteristic vegetation of Zizyphus Lotus.

No true profile development can be distinguished but occasionally there is a suggestion of horizons. The grey-brown colour is the result of the presence of alluvial layers of calcium carbonate, occurring at varying depths.

The soils of the Bir el Ghnem area are typical of the Regosols found in the Jefara plain but are slighly more compact than those soils at Azizia or Crispi (Table III, Sample 3). They consist of a red brown sandy loam not markedly different from those already considered. Significant features are the low nitrogen content and the medium available potash status. In most analyses the sample closely resembles those already made.

Cemented Soils and Crustal soils

Attention has already been drawn to the presence of such soils in Northern Tripolitania. The process of calcification may result in the formation of calcareous layers of varying hardness, extent and thickness. These calcareous layers may also be deposited on the surface as a result of climatic and soil conditions, thus forming a hard crust.

According to Caswell[18] a deposit of calcium carbonate or mixed calcium and magnesium carbonates occurs at a depth

TABLE 3a.a

Soil Samples (Lowlands) *

(1) Sidi Benur Brown Pedocalic Regosols of the Coast.
(2) Tagiura Solonchak.
(3) Bir Ghnem
(4) Alluvial Soil (Wadi bed below Nalut)

	PH.	Carbon	Nitrogen	C/N Ratio	Organic Matter
(1)	8.75	0.04	0.005	8	0.07
(2)	8.8	0.45	0.04	10.0	0.78
(3)	8.4	0.17	0.015	11.3	0.29
(4)	7.95	0.16	0.02	8.0	0.23

Soil Mechanical Analysis.

	Coarse Sand	Fine Sand	Silt	Clay	Textural Class
(1)	0.2	91.8	2.0	6.0	Sand
(2)	0.4	87.0	4.2	8.4	Loamy Sand
(3)	7.7	76.6	7.9	7.8	Loamy Sand
(4)	16.3	54.4	11.1	18.2	Loam

Exchangeable Cations.

	Milliequivalents/100 grams Soil.					% of Total			
	Ca	Mg	Na	K	Total Exchange Capacity	Ca	Ma	Na	K
(1)	2.0	0.05	0.71	0.14	2.90	69.0	1.7	24.5	4.8
(2)	3.0	1.04	2.57	0.28	6.89	43.5	15.1	37.3	4.1
(3)	3.4	0.10	1.91	0.54	5.95	57.1	1.7	32.1	9.1
(4)	6.4	2.12	0.83	0.79	10.14	63.1	20.9	8.2	7.8

Available Nutrient Status

(Extracted with N. Acetic Acid).

	K20	P205
(1)	Medium	Trace
(2)	Low	Medium
(3)	Medium	Trace
(4)	High	Low

* After Willimot S.G. Soils of the Jefara.

TABLE 13b.

Sample 1 - Sidi Benur

This sample is classified as sand and reflects its aeolian origin. The organic matter content is low in association with low carbon and nitrogen percentages. The soil is very alkaline. A notable feature is the low total exchange capacity for sandy soils of low organic content. Sodium content is high but that of magnesium is low.

Sample 2 - Tagiura

The sample is representative of a marshy area with a high salinity. It is a loamy sand with a high P.H. The percentages of carbon and nitrogen are again low. Because of the higher clay content the total exchange capacity is double that of Sidi Benur. The high percentage of distribution of sodium and magnesium is clearly related to the saline groundwater.

Sample 3 - Bir-el-Ghnem

A loamy sand not markedly different from Sidi Benur. Nitrogen content is low and the available potash status is only medium even though potassium contributed a high proportion to the total exchange capacity.

Sample 4 - Alluvial Soil - Nalut

A loam soil of P.H.8.0. The organic matter content was low but it had a high phosphate status.

of between 20 and 30 inches, throughout the Jefara. When the layer becomes hard and cemented it is usually termed 'Caliche' and may create adverse drainage conditions. Caswell found caliche deposits to be much more prevalent in the B ir el Ghnem area than at Azizia and states that in the course of drilling operation caliche was encountered at a depth of 7 feet and found to be approximately 60 feet thick. In the western and arid parts of the Jefara the calcareous deposits rise gradually and eventually reach the surface; a considerable area of the western plain is thus covered by a calcareous crust which is characteristically associated with extremely low rainfall (less than 200mm's) in the hottest region of the Jefara. These areas are unsuitable for cultivation and are of little use for grazing.

Alluvial Soils

These soils have a diverse character and distribution (Table III). Numerous wadis flow from the Jebel, north into the interior plain of the Jefara, east and south east to the lowlands of Misuratino. Only a few of these reach the coast when heavy rainfall occurs in the Jebel. These wadis are closely associated with an alluvial soil resulting from the deposition of fine and coarse material, eroded from the hills. Soils thus formed vary in texture from coarse sands and gravels in the Jebel piedmont to heavier soils in the basins and depressions of the Jebel. From year to year the wadis often change course due to variations in flow and thus they give rise to a variety of soil material deposition in different localities. Notable amongst these is the Wadi Megenin. Most of the fertile soils of the Jefara originate from the alluvium of the Wadi Megenin derived from the Cretaceous beds of the Jebel.

The heaviest soils in the northern parts of the lowlands are found at some distance from the Wadi beds where the suspension load has been deposited. These deposits are known locally by Arab farmers as Tin.

Table 4 Mechanical Analysis of Tin

Sand		5 - 10%
Silt		60%
Clay	up to	30%

The heavier texture does not respond well to irrigation since the water tends to lie on the surface. They have a percolation rate of only 5 - 6cms. per hour. These alluvial soils are of some importance in the areas of Azizia, Bir el Ghem and Gasr Chiar. Where they extend northwards from the Jebel scarp. They include the Gattis (floorlands) and the Dafnia (steppe) in Misuratino used for shifting cultivation. In these areas the land is ploughed once every three years depending on rainfall, and then lies fallow. This allows the wind to reconstitute the soil by aeolian deposition.

Piedmont Soils

Colluvial soils occur in the piedmont zone along the whole length of the Jebel scarp in the Jefara and to a lesser extent in Misuratino. In general they become more gravelly and develop into a series of long, narrow, esker-like ridges.

Lithosols

These are Azonal soils and consist of fans of stony material and gravel which is brought down when the wadis are in flood. During the course of time the fusion of these deposits give rise to the formation of a detrital belt. These immature soils are of little consequence to agriculture.

Skeletal Soils

These low value, immature soils are found principally on the eroded hills of the Jefara but also on the interfluves of the Eastern Jebel (Plate XVIII). These areas are so eroded by wind and water as to be almost devoid of soil.

Soils of the Jebel

The soils of the Jebel are derived both from the physical and chemical decomposition, in situ, of the bedrocks - clays, shales sandstones and limestones - and from the aeolian Quaternary deposits. The admixture of these constituents combine with the variations in climate and morphology to produce a variety of soil types, ranging from brown Pedocolic Regosols distributed over the high plains to the skeletal soils of the semi-desert regions.

The soils of the humid northern zone of the Jebel are prevalently aeolian, sandy calcareous and fine grained. Because of a uniform profile it is often difficult to distinguish soil from sub-soil although some local differences are created by the presence of the calcareous hardpan. In general the depth of the soil is only a few metres but reaches a maximum depth of 20 metres at Tarhuna; it is distributed discontinuously in Garian, Msellata and the scarp zone. Where the rocky sub-soil is near the surface it naturally influences the constitution and structure of the overlying soil. Quaternary deposits are often profound on the plains but less uniform in the scarp zone where wadi erosion is most intense. Where the sub-soil notably influences the soil then it becomes more coherent with a high content of calcium carbonate, reflecting the predominantly calcareous nature of underlying strata. On the other hand where the subsoil is deep, under the Quaternary cover, the soil becomes more loose and permeable. Thus the physical nature of the soil tends to vary according to site between the scarp and high plains, wadi and interfluve.

Traditionally, the Libyan farmer recognises three main (cultivable) soil types. These are known as:-

(1) Ard Hamra.
(2) Ard Hammari.
(3) Ard Ten - Tin or Tein.

The mechanical and chemical analysis of these soils is shown in Table 5.

<u>Ard Hamra</u>

This soil is similar to the Brown Pedocolic Regosols of the Jefara and displays no profile development except for the differentiation caused by the calcareous hardpan which readily forms in these soils. Typically, this soil is developed on the Tarhuna Central Plateau, but is also found on the larger plains and wide wadi depressions.

In origin, the soil is predominantly aeolian; it has a sandy texture, reddish colouration with little compactness.

Because of the high calcareous content of the soil it is slightly more cemented than the dune types (Ar Ramle) dispersed over the southern slopes of the Jebel.

The Libyan farmer cultivates these soils in an extensive way. Olives and cereals are the dominant crops. Because of its predominantly sandy texture the soil is highly permeable, with a good rate of infiltration. Rainwater is readily absorbed thereby facilitating the root development of perennial tree crops. In several small spring-irrigated gardens of Tarhuna the roots of Herba Medica were observed to reach the acquifer at a depth of 6.5 metres. At Garian palm roots were seen to extend downwards for about 7.8 metres in this soil.

With respect to fertilizing elements this soil has low absorbtive powers. The organic content is poor whilst the available nutrient status of potassium and phosphates is low (Table 5). Unless measures are taken to stabilize this soil it dessicates rapidly and may become unfavourable for cultivation.

Ard Hammari

The Ard Hammari is less deep than the Hamra and has a more restricted distribution over the Jebel. It is commonly found in the valley orchards of Msellata and together with Ten occupies the great wadi beds and terraces to the south - Soffegin etc. Being more shallow rainfall can penetrate throughout the soil and thus the formation of the calcareous crust is not so constant as in the Hamra. The soil is light red in colour and slightly more coherent than the Hamra. It is regarded by the Libyan farmer as the same value as the Hamra.

The Ard Hammari is a transitional soil between the Hamra and Ten. It differs from the Hamra in having a higher calcium carbonate content and lower proportion of fine sand. Being less deep, the underlying parent rocks are readily mixed with the sand. As a result the calcareous crust is less well developed. In general the clay fraction is higher in this soil especially where the parent rock is formed by Jefren Marls. In consequence it is more compact and less permeable. The low available nutrient status and organic content is similar to that of the Hamra.

Ard Ten

The Ard Ten contains a greater proportion of local material as opposed to transported aeolian material and large quantities of marly limestone are mixed with the sand.

In general the Ten is less red than the Hamra or Hammari and is found in dissected rocky areas, as soils that have been slightly displaced or mixed. Their high lime and clay content is responsible for their greater compactness. Often the soil is shallow where it occupies the slopes of higher elevation.

It is found also as an alluvial soil in the scarp zone and the great wadi area to the south.

The Ten is well suited to cultivation although local farmers claim that it is difficult to work. The soil of the sedimentaries derived from volcanic parent rocks are also called Ten but they are less easily erodible. Ard Ten is rarely found in the Western Jebel.

A good Ten is much more compact, more calcareous, and less sandy than the other two types; it is therefore the least permeable. The organic content is higher and the amount of potassium is considerably greater. The clay fraction in the Ten is the highest for all Tripolitanian soils owing to its lowland distribution and to the marlaceous outcrops in the scarp zone. The Ten appears therefore as the most fertile soil type in the Jebel.

Beyond the Jebel rainfall diminishes and vegetation becomes sparse and stunted. Soil farming processes are therefore limited and slow. The northern part of the Dahar is partially covered by a thin Hamra soil. In the Steppe zone, behind Zliten and Misurata, Ten and Hammari occupy the valleys and slopes but on the highest parts of the interfluves soils are generally thin and skeletal.

South of the Dahar there is a noticeable increase in stony material amounting to 30% and 64%, 50kms. south of Garian and at Mizda respectively. The clay fraction on the whole is higher but because of the high temperatures and aridity, what organic material there is, remains dry on the surface.

Beyond Mizda and Nalut the climate is decisively arid and the growth of natural vegetation is severely limited to the wadi beds. Cultivation is virtually impossible on these immature soils constituted primarily by rock fragments (Hammada), gravel (Serir), and mobile sand dunes (Ramle). Solonchaks occur in small basins south of the Jebel whilst lithosols and skeletal soils are common on most of the interior areas.

From the above analysis several conclusions can be made regarding the soils of northern Tripolitania.

(1) Over large areas of the region soils with negative physical and chemical properties occur, often in the best rainfall zones. These include the solonchaks, crust soils of the Western Jefara, the lithosols and skeletal soils.

(2) Most of the soils are very calcareous, with an alkaline reaction, rather poor in nitrogen, low in phosphates and potassium. However their physical characteristics, predominantly sandy or sandy loam, make them easy to work, with the exception of the Tin lands, and adaptable to dry farming and irrigated agriculture where water is available. However, because of their high infiltration rates they require frequent irrigation.

(3) The most fertile soils are the Tin and alluvial deposits but they are unevenly distributed and often occur in regions

where access is physically difficult or else away from the best rainfall areas. These soils are the most intensively cultivated in the Jebel whereas the seat of cultivation in the northern plains are the brown Pedocolic Regosols which are only transformed steppe soils.

(4) The fine sandy soils - Brown Pedocolic Regosols of the interior plain and Ard Hamra of the Jebel - are the most widely distributed of the cultivable soils. They occupy the plains and uniform plateaux areas. They appear to be least appreciated by the Libyan farmer who utilises them mainly for shifting cultivation of cereals with scattered groves of olives. In contrast the Italians, by adopting successful conservation techniques use these soils intensively and cultivate dry land tree crops in specialised and mixed orchards.

(5) Undoubtedly the low fertility of soils is responsible in part for alternating production of the olive tree.

Soil Requirements of the Olive

It is widely accepted that the olive is adaptable to a great variety of soils but thrives best on deep limestone soils of moderate fertility with a sandy loam texture. Caruso[20] holds that the olive does not prosper on extremely sandy or clay soils. If the winter rainfall is low then fructification is seriously affected on the former. On clay soils depending on the rainfall the olive may suffer from an excess of humidity. Even though rainfall may be excessive if the topography allows free drainage then the tree can grow and produce well on compact soils. Morrettini[21] recalls that the olive can grow well, on the clay soils of the hill zone and even on the chalk and pliocene clays of Serese and Valterano. Therefore in any classification of soils one can say that, depending on the rainfall, the olive is found on most soils. However, in soils homogeneous from the point of view of climate considerable differences arise to influence the planting of the olive on one rather than the other.

In marginal moisture regions such as Northern Tripolitania where rainfall is seasonal and often torrential and where summer aridity is prolonged the soil should be considered as a storage basin for perennial crops such as the olive that utilise the greater part of the year in their cycle of growth. The main problem of water in the soil is in its conservation.

This relation between soil and rainfall is particularly strict where the olive is cultivated as a dryland crop. In Tunisia where rainfall is between 5-600mm's. the olive grows equally well on all types of soil provided they are not too compact. But in the zone 200-400mm's. olive cultivation is subordinated to the physical constitution of the soil.

The availability of soil moisture, especially during the critical periods of early growth and fructification, is essential for the productivity of the tree. In arid regions sandy soils are rated as physiologically moist. They enable tree crops, with low water requirements, to exist in regions of extremely arid conditions.

Although no information exists regarding water holding capacity of soils in Northern Tripolitania general information is available[21].

≡ Table 6

Water holding capacities of differently textured soils inches per foot				
Sand	Sandy Loam	Loam	Light Clay Loam	Clay
1.0	2.0	3.2	3.7	3.9

In general soils in this region, predominantly Brown Pedocalic Regosols, have a sandy or loamy sand texture with low water holding capacities. However these occupy the plains and plateau areas where run off is comparatively slow. Furthermore their depth compensates for this low capacity. Because of the torrential nature of the rainfall the rate of permeability and efficiency of water use are critical factors which must be considered in relation to soil texture.

Tournieroux[22] has shown that a high clay content diminishes the permeability of soils. Water does not penetrate the soil but stays on the surface and is readily evaporated. Water becomes absorbed in greater quantities by silicious soils. Sandy soils also have a lower coefficient of water retention than clay soils (Table 7).

≡ U.S. Dept. Agric. Yearbook 1955 19.20.

Table 7

	Quantity of water that a plant may dispose of. %	% water remaining in soil when plant perishes. Wilting point
Coarse sand	26	2
Sandy earth	44	5
Silico - Mud	43	8
Muddy	38	10

Thus with a deep sandy textured soil and corresponding increase in water storage capacity it becomes possible for one years rainfall to make good any deficit for an earlier year. As surface water affects the regular recharge of water reserves in the soil the alluvial and Tin soils, with a notably high clay content, can be suitable for the olive if provision is made to reduce this run off.

Sandy soils are generally poor in chemical elements and do not support a luxuriant vegetation throughout the year. In consequence the loss of moisture through transpiration is reduced. These also allow a deep root penetration because of their depth and uniform profile. Therefore under semi arid conditions the olive appears to flourish best on siliceous soils rather than those with a high clay fraction, because the former are more efficient users of soil moisture.

Broc(24) emphasises strongly that in the evaluation of the textural quality of a soil everything refers to rainfall. In Tunisia experimental work has enabled certain generalisation to be made.

Average annual rainfall 200mm's best soils contain 8-10% clay
Average annual rainfall 380mm's best soils contain 10% clay
Average annual rainfall 450mm's best soils contain 24% clay

Whilst the clay content is low for most of the coastal plain being generally less than 5% it rises to over 10 in the wadis of the Jefara and Piedmont zone where rainfall in the west is below 200mm's.

The Hamra soils of the Jebel, situated south of the scarp and in the lower rainfall zones and also the Hammari seem well adapted with clay content less than 5% but the Ten soils, notably those in the wadis, have a clay content varying between 2.5 and 31% which in areas of low rainfall would be unsuitable for olive cultivation, without irrigation. Further investigation by Tournieroux (ibid 23) on the proportion of sand and clay in a soil, places in evidence the influence exercised by the size of the sand grains and the quantity of calcareous material (calcium carbonate) in the soil. Coarse grained sands diminish the compactness and impermeability in the soil whilst the calcium carbonate determines the flocculation of clay colloids. He established that the best soil came between a sand and clay according to the rainfall required.

Soil fertility requirements of Olive

The principal elements contained in the dry substance of the tree - the branches, leaves and fruit - and which the olive will utilise during growth and fructification, are potassium, calcium, nitrogen and phosphates in this order. 21). The amount of these nutrients used by the tree will of course vary according to the age of the tree, density of plantings, method of cultivation, pruning and productivity. Olives prosper on soils with Alkaline reaction. Thus arid southern regions of cultivation are more rich in $CaCo_3$ than in the northern humid areas. The tree has also a substantial tolerance to alkali salts (Table 8).

Tolerance of the olive to Alkalis (Hilgard)

Pounds per acre at 4-ft. depth

	Sulphates	Carbonates	Phosphates	Total Alkali 40,160
Olive	30,640	2,880	6,640	26,400
Fig	24,480	1,120	800	25,560
Almond	22,720	1,440	2,400	26,400
Oranges	18,600	3,840	3,306	8,328
Date Palm	5,280	2,800		

These nutrients are required in the early and late stages of the tree's growth, but an excess of nitrogen when the tree is in full production can retard maturation. An excess of phosphates promotes root development and confers upon the tree a greater resistance to parasites.

Potassium is a major nutritive element in branches, leaves and fruit and favours the formation of glucose and protein.

Normally, during the annual cycle of fructification, maximum protein content is observed when the tree is flowering. This declines to the end of October with the fall of the leaf but increases again with the growth of new fruiting branches to the next spring. The phosphate and potassium content display a similar trend.

According to Pantanelli[24] the % content of nutritive elements utilised by the branches, leaves and fruits is the following:-

Calcium	4.815
Phosphates	1.940
Potassium	5.680
Nitrogen	4.029

Only the Tin soils appear rich in Potassium although most of soils are rich in calcium.

In arid and sub-arid regions similar to the one in question, in which water normally constitutes the principal factor limiting cultivation, the use of fertilisers is generally limited, except in the irrigated lands of the coastal plain. With fertilisation of arid soils an excessive concentration of circulating soluble salts can sometimes cause a physiological aridity harmful to the tree crops.

The exact relation between the textural qualities of soil, its inherent fertility to the olive, in terms of yields, periods of bearing is difficult to determine. It depends on the age of the tree and cultural techniques. Nor is the fact that the crop grows well on a certain soil sufficient grounds for regarding it as suitable forthat soil.

On the basis, primarily of the physical nature of the soils in Northern Tripolitania, a tentative classification of the suitability of the soils with regard to olive cultivation can be made. The soils may be divided into 4 groups:-

(1) Well adapted
(2) Intermediate soils
(3) Little adapted
(4) Absolutely negative

Well adapted soils

(1) Brown Pedocalic Regosols of the coastal plain and Jefara and the Ard Hamra of the Jebel where rainfall does not fall below 200mm's are eminently suited to olive cultivation.

Intermediate soils

(2) In low rainfall areas Tin and heavy alluvial soils are too compact but the tree grows well in the higher rainfall zones or where irrigation can be applied, artificially or naturally. Ard Hammari soils have a similar value where they are not too thin.

Little adapted soils

(3) Saline soils - although where rainfall is high enough or irrigation water applied, which can leach the soils then the tree can grow and produce.

Cemented and crustal soils hinder root development where their formation is thick and superficial; but when thin it can be broken through. At depth these soils can act as useful reservoirs for soil moisture.

Negative Soils

(4) These soils comprise those which are immature, superficial, Sebkas and shifting sands or where the land gradient is too steep. Skeletal and Lithosols.

TABLE 5

Analysis of Jebel Soils

Mechanical Analysis

Sample Type	Sample Location	Sand	% Silt	Clay	Class
(1) Hamra	Tarhuna Plain	91.7	3.0	5.3	Sand
(2) Hammari	Assaba "	60.6	27.6	11.7	Sandy Loam
(3) Ten	Wadi Ghelil (Cussabat)	44.9	41.7	13.4	Loamy Clay
(4)	Dahar (25 kms. south of Garian)	87.24	4.6	8.1	Sand
(5)	Dahar (50 kms. south of Garian)	96.1	1.6	2.3	Sand

Chemical Analysis

Sample Type	Sample Location	Moisture Content	% Organic Matter	PH	K_2O	Nitrogen	P_2O_5
(1) Hamra	Tarhuna Plain	0.8	0.6	?	-	0.05	-
(2) Hammari	Assaba Plain	0.7	0.3	?	0.13	0.06	0.06
(3) Ten	Wadi Ghelil (Cussabat)	9.5	11	?	0.3	0.09	0.06
(4)	Dahar	-	1.68	?	-	-	-
(5)	"	-	2.43	?	-	-	-

CHAPTER IV

Climate Land Use and Water Resources

It will be relevant at this stage to examine the significance of the fruit tree (and especially that of the olive) in the agriculture and land use of Northern Tripolitania, with particular regard to the moisture factor which, as will be demonstrated, exerts the main physical control over agricultural practise and production not only in this region but in all arid regions and their margins.

The moisture factor can be considered a function of precipitation, irrigation, evaporation and transpiration.

In terms of a minimum of precipitation and a maximum of heat and aridity the greater part of the region belongs to an arid climatic zone or at least is marginal to one. Nowhere does the mean rainfall approach the 500mms. isohyet used by Tixeront [25] to delimit the arid regions of Tunisia, and it is not without significance that the highest recorded temperature on earth of 136°F was recorded in the Jefara at Azizia in 1932 (25). This figure has since been disputed. Further-more only about 0.2% of the whole province receives a mean rainfall higher than 200mm. considered by Fantoli and others to be the minimum moisture requirements for dryland cereal crops and only then if the rainfall is suitably distributed; it is also the minimum at which tree crops can vegetate rather than produce.[26]

A cursory examination of the synoptic meteorology of the Eastern Mediterranean, and therefore Northern Tripolitania, will serve to illustrate that the prevalent climatic types, as measured by seasonal features, are transitional between a dry Mediterranean type (Sub-tropical mesothermal) and an arid desert Africa type (macrothermal), with the latter becoming increasingly dominant inland from the coast.

Air masses.

Over Northern Tripolitania there is an almost constant discontinuity between the air masses of Mediterranean origin and those of the desert or even Equatorial origin. This discontinuity indicates a front, sometimes known as the Mediterranean front, but which always forms part of the Tropical front and sometimes becomes the main front when the latter is driven to lower latitudes in North Africa by an intense invasion of cold air. When the normal balance prevails, the hotter Tropical air almost always remains above the colder air from the Mediterranean which comes in from the northern sector and is the predominant current for most of the year.

It is the variation in this front and in the size, frequency and intensity of the Tropical air masses which gives to the seasons their particular characteristics.(27)

Winter.

In winter, (October-March), the Mediterranean region appears as an area of low pressure between the semi-permanent Azores anticyclone and the continental high pressure of Eastern Europe and Asia. Air is drawn into the region from widely separated areas: Polar air from Europe and the North Atlantic and Tropical air from the Sahara. Temperature contrasts are marked between the Tropical and Polar air masses and fronts often exist between them. Most of the depressions develop in the Western Mediterranean and subsequently move eastwards. However, Northern Tripolitania lies to the south of the main tracks of the depressions (Fig. C) and, in consequence, is affected mainly by rainfall which is somewhat unreliable in distribution and amount. Between unsettled conditions, associated with the various depressions, spells of fine weather are common.

<u>Summer</u>.

In summer (April-September) the circulation of air masses is less active for the region lies on the eastern margins of the semi-permanent Azores anticyclone. The mean pressure over Central Asia is low at this season and North or North West winds are prevalent over the Mediterranean. But the contrasts between the Polar and Tropical air masses is far less than in winter. Settled conditions and constant wind directions are usual. However, when the relatively high pressure over Cyrenaica is intensified southerly winds countering the sea breezes, produce very high temperatures in the exposed and low lying areas of Northern Tripolitania.

Autumn and spring are periods of transition when weather conditions of either summer or winter may occur.

These weather conditions which recur in a similar pattern each year are responsible for the outstanding seasonal features of the Mediterranean type of climate; mild moist winters and hot dry summers with a relatively uniform annual temperature sequence. In Northern Tripolitania this seasonal rhythm applies in only a very general way because of the following facts:

(a) The position of the country in the southern Mediterranean and its enormous extension southwards means that it is marginal to the main cyclonic activity.

(b) The situation of the region in the lee of Tunisia and the High Atlas shelters much of the area, except for the coastal fringe and the seaward facing edge of the Jebel, from the rain bearing northwesterlies.

(c) Tropical air has a relatively free access from the Sahara to the coast. Therefore summer temperatures tend to be accentuated and the period of summer drought is normally extended from April to September in contrast to areas in the northern Mediterranean where the summer drought period is usually not more than 3 months.

On the basis of the effect of this characteristic air masses on the elements of climate - mean rainfall, temperature range, and relative humidity - which are influenced in turn by the morphology of the region, Fantoli identified five climatic regions which represent transitional stages between Mediterranean and Desert climatic types(26) (Fig. 7). Table (9) shows average climatic data for selected stations. Appendix

I. Coastal Zone
II. Steppe Zone
III. The Jebel
IV. Semi-desert
V. Desert

I. Coastal Zone.

The coastal zone comprises an area 6-8km's wide extending from the Tunisian border in the west to Misurata in the east. It bears all the essential characteristics of the Mediterranean climatic regime. Rainfall, which occurs almost entirely in the period from October to March, reaches a mean maximum of 371mm's in the vicinity of Tripoli, but decreases to the east and west being 250.4mm's and 216.8 at Misurata and Zuara respectively. Along the coast temperature ranges from a mean minimum of 7-8°C in January to 30°C in the hot summer months of July and August. The moderating influence of the sea is particularly welcome in the summer and is manifested in the relatively high humidities which average 55% at midday and mitigate the intense evaporation and extreme dessicating effects of the southerly winds although these constitute only 16% of the total winds throughout the year.[26]

II. Steppe Zone.

This zone includes the Central and Eastern Jefara and an area extending 30-50km's behind the coastal zone of Zliten and Homs which display homogeneous Mediterranean steppe flora. In this area the influence of the desert begins to prevail over the sea but the latter does not lose its general characteristics which are reflected in the behaviour of the temperature during spring and autumn; spring mean temperatures are lower and autumn means are accentuated which is the reverse of the more continental climates. The contrast between summer and winter is greater. At Azizia the mean minimum is 5°C in winter with the mean maximum reaching nearly 40°C in summer. However, the annual isotherm is only one degree higher than that at the coast being 21°C. The relative humidity is lowest in summer in contrast to the coast. Except during times of Ghibli the prevailing winds are from the north east.

Evaporation intensity is greater than that on the coast and Fantoli[26] indicates, from indirect estimates, that evaporation is 4-5 times greater than the annual rainfall.

III. Jebel.

Owing to the height, orientation and nearness to the sea, the Jebel, especially east of Garian, is a climatically favoured zone and one in which Mediterranean climatic characteristics reassert themselves. In general the Jebel has a climate intermediate between the steppe and the coast. Mean maximum temperatures are lower because of the height, on the other hand mean minimum temperatures of -5°C are experienced in the higher parts. The annual trend of humidity comes between that of the coast and the steppe. However, variations in the humidity when the wind shifts between the two most typical winds - north west and south east - are much less than on the coast.

The mean annual precipitation is generally lower than on the coast but rises to more than 300mm's in restricted areas around Cussabat and Garian with a marked decline towards the Tunisian border as the distance and shelter from the sea increases.

IV. Semi-desert.

Much of the western Jefara and the area succeeding the steppe and Jebel Dahar south of Garian and Homs is semi-desert. Maximum temperatures are lower than the steppe because of the increased altitude lying at 4-500mm's. On the other hand the intense loss of heat during the night by radiation means that winter temperatures drop below zero. Relative humidity is usually low though variable, depending on the change of winds which are prevalently north east.

V. Desert.

Beyond Sinauen, Mizda and Beni Ulid the climate becomes definitely desert and Saharan.

On the basis of average climatic conditions the distribution of climate, approximating to the Mediterranean type, is seen to be restricted to the northern edge of the Jefara, the lowlands of Misuratino and the Jebel. Interposed is a steppe regime which becomes increasingly continental and semi-desert west of Azizia. South from the Dahar corresponds also to the semi-desert. Thus, the area under which the olive thrives is discontinuous and restricted and forms only a small part of the region of northern Tripolitania. However, average conditions hardly express the true nature or significance of the climate of the region for these conditions vary both in time and space as is shown by the following analysis of precipitation.

Precipitation. Precipitation is singularly variable in time and space as a result of the low latitude of the region and its situation on the margins of the main cyclonic tracks which pass through the Mediterranean in winter. Yet the seasonal rhythm is always marked: wet winters are invariably followed by dry summers. Wide variations do occur in the degree of dryness and more particularly wetness. The important factors of relevance to farming are therefore the extremes and how often they occur. But the analysis and the corollary of prediction is difficult owing to the sparsity, discontinuity and frequently the unreliability of climatic data. For the purpose of illustrating the time distribution of rainfall it is proposed to use mainly the records of the Central Meteorological Office in Tripoli where rainfall records have been taken continuously since 1879. (Table 10 Appendix).

Periodicity of Rainfall.

Table 11 Rainfall by decades. Tripoli City. In millimetres.

Year	Total amount	Mean annual
1879/80-1888/9	3,670.3	367.0
1889/90-1898/99	4,707.6	470.7
1899/00-1908/9	3,879.3	387.3
1909/10-1918/19	3,385.0	338.5
1919/20-1928/9	3,919.1	391.9
1929/30-1938/39	3,626.8	362.6
1939/40-1948/49	3,482.4	348.2
1949/50-1958/59	Incomplete, 8 years only. 2,649.7	331.2

Historically there are no clear signs of a trend towards increasing rainfall or decreasing aridity as shown by the march of decade totals. Although no total trend is apparent, fig. 8 illustrates that annual totals for the earlier period were more variable than for the current period.

The periodicity of the rainfall which is truly a characteristic feature is confirmed by the 5 year moving averages and the accumulated deficits for Tripoli over a 35 year period. The 5 year running mean 1915-45 shows that only 5 years out of 31 have an average rainfall, 14 are below and 12 are good (fig. 9). Thus apart from the annual and seasonal oscillations the recurrence of wet and dry years has particular significance in the planning of a farm economy. The accumulated deficit for Tripoli over a 35 year period suggests that a marked deficit of rainfall occurs every 10 years and this is often prolonged (fig. 10).

<u>Mean annual rainfall</u>. Tripoli has a mean annual rainfall of 369.8mm's (70 years). However, this figure is a composition of both high and low figures; varying between 654mm's (1898/99) and 141.6mm's (1947/48). From year to year the annual precipitation experiences wide deviations from the mean (fig. 8). Usually a good year is succeeded by a poor rainfall year. The exceptional character of amounts over 600mm's and below 300mm's is revealed in fig. 11, whilst the falls of 250-300mm's and 350-400mm's are relatively frequent. On the whole the prevailing character of the series tends to be

quantities higher than 300mm's rather than below. Tripoli city lies, however, in the favoured climatic belt at the coast. Inland the frequency of amounts below 350mm's is absolute.

Monthly rainfall. The most dominant periodicity of rainfall is the annual fluctuation of rainy winters with dry, generally rainless summers; a distribution determined by the seasonal movements of the Mid-Latitude low pressure belt. This periodicity is usually and most conveniently expressed by the mean monthly rainfall.

Table 12.

Mean monthly rainfall of Tripoli City.
(Agricultural years)
(1879/80 to 1947/48 in Millimetres)

S	O	N	D	J	F	M	A	M	J	J	A	Year
10.13	26.3	65.6	95.2	74.3	42.5	25.8	9.6	5.2	1.3	0.5	0.7	369.8

In terms of the monthly rainfall the regime is seen to consist of a rapid increase from 10mm's in September to a maximum peak in December and January whence it falls less sharply from January to March. After April, which records 9.6mm's, there is a gradual decline to the central months of the year, July and August; these are virtually rainless. Fantoli(26) classifies this regime as continental which, although predominant over the 70 year period, does not exclude a moist Mediterranean type. This latter is characterized by a maximum of rainfall in December and November. South of the coastal belt observations of the winter rainfall at Azizia, Garian and Beni Ulid, corresponding to the Steppe, Jebel and Semi-Desert regions, suggest a growing importance of a secondary maximum in February and March.

Table 13.

Distribution of Winter Rainfall (Percentages)	Oct.-Nov.	Dec.-Jan.	Feb.-March
Tripoli City	30	50	20
Azizia	22	50	28
Garian	22	45	33
Beni Ulid	28.4	35.4	36.2

Monthly periodicity. The maximum mean total occurs in December, but all the months between October and March may be considered as 'wet', November to February each receiving more than 10% of the mean annual total and October and March slightly less. By contrast June, July and August each contribute less than 1% and April, May and September less than 3%. The rates of change are given in Table 13.

Table 14.

Rates of Change of Mean Monthly Rainfall. Tripoli City.

J	A	S	O	N	D	J	F	M	A	M	J
0.29	9.43	16.1	39.3	29.6	20.9	31.8	16.7	16.2	4.4	2.9	0.8
		Increasing						Decreasing			

From this point of view November to January might be considered as the wet months, separated on either side by a sharp rate of change, in the two lower rainfall months of October and February. Thus in terms of mean monthly rainfall the regime is seen to consist of an increase from virtual aridity in July slowly at first then but increasing steeply to an inclined plateau from November to January at between 60-100mm's. There is then a less steep falling off in February followed by a more gentle decline through April to the succeeding July. Naturally individual seasons will differ, but this is the average pattern.

The extent of this seasonal divergence is seen from the following table in which the % variability of deviation from the mean of each month is considered.

Table 15.

% Variability of mean monthly rainfall: Tripoli City (35 yrs)

S	O	N	D	J	F	M	A	M	J	J	A
120	112	58	62	55	57	89	87	100	100	166	166

The high percentage for the drier months reflect the greater number of years in which these months are wholly dry and the relatively heavy rainfall is the occasional storms, which do occur during some of these months.

October now stands out in contrast to November, December and January. The variability of this month also contrasts sharply with the spring months of February and March.

In connection with the seasonal periodicity the frequency of rainless months is also significant (table 15).

Table 16

% Frequency of rainless months for Tripoli City (70 year period)

S	O	N	D	J	F	M	A	M	J	J	A
28	10	0	0	0	1	3	17	21	58	85	81

This table reflects essentially the same pattern as

Table 9 (Monthly Means). In this series October is clearly marginal, sharing high drought frequencies with the drier months of the year from April to September. One feature of note is the number of spring months in which rainfall nearly always occurs but complete drought has been recorded for these months.

A more precise statement of the annual rainfall may now be made. July is the driest month of the year. The first indications of the rainy season come in September and are intensified in October. The rainy season proper usually comes suddenly in November, but occasionally in October, when falls for that month are likely to be heavy. Rains in November and the two succeeding months are heavy and generally reliable. February and March are appreciably drier after which rainfall markedly diminishes with increasing unrealiability to August, which, after July, is the driest month.

Daily Rainfall. The same characteristic regime is apparent in the monthly distribution of rainfall days. Although the term rain day is a useful analytical concept its quantitative implications are rather uncertain since the amount of rain falling in that period is extremely variable. However, assuming that a rainfall day is one in which the minimum rainfall recorded is 0.01mm's, the rainfall records for the 70 year period have been examined for the frequency of rainy days yielding certain critical amounts of rain. Unfortunately the available data only allow computation for calendar years.

Table 17.

Absolute frequency of rain days yielding certain amounts of rain for Tripoli City, 70 years. In millimetres.

	J	F	M	A	M	J	J	A	S	O	N	D
Total Rainless Days	1557	1614	1897	1927	1981	2146	2188	2192	1995	1938	1657	1538
Total Rain Days	644	396	304	173	119	54	13	9	105	263	443	633
Days with plus 20mm's	146	79	38	17	16	-	1	1	13	65	119	95
% Total rain occurring on days with 20mm's plus	21.7	15.8	12.1	8.5	12	-	-	11.1	10.7	22.5	26.3	29.3

The proportion of total rainfall in each month which falls on days with more than 20mm's is seen to be very high in the central months of the rain season and also in October falling away rapidly in the spring months (February-March). Only two such rain days has been recorded for the months of June, July and August. Thus absolutely and frequently heavier rainfall is more common in the period October to January. The high frequency of October is clearly related to its variability.

Structure of individual years. Just as there is great variability in monthly and annual rainfall totals so is there considerable diversity in the manner in which any individual year can be made up.

The dryness or wetness ofaa year is not necessarily indicated by the total rainfall since the distribution of rainfall throughout the wet season (Oct.-March) may enhance or depreciate its effectiveness or absolute value. A comparison of the monthly rainfall components during this period illustrates this contention. Four random years were chosen in each of the following categories and the annual deviation of monthly rainfall from the mean was computed for Tripoli City.

I. Years of low rainfall - 1886/7, 1914/15, 1935/6, 1947/8.
II. " " average " - 1883/4, 1931/2, 1940/1, 1944/5.
III. " " high " - 1893/4, 1906/7, 1932/3, 1943/4.

Table 18.

Monthly Deviation from the mean in years of High, Average and Low rainfall in millimetres, Tripoli City.

Low Rainfall Years.

	O	N	D	J	F	M
Average	26.3	65.6	95.2	74.3	42.5	25.8
1886/7	-26.3 -100%	-61.6 -81%	12.8 11%	-23.0 -31%	-19.2 -45%	-21.3 -87%
1914/15	-15.8 -60%	14.1 21	-68.2 -71%	-49.5 -66	- 7.5 -17	-18.7 -72%
1935/6	-22.7 -86	-28.4 -43	-19.5 -20	-62.6 -85	-40.5 -95	-23.8 -92
1947/8	-15.3 -58	-56.3 -85	-19.8 -20	-69 -91	-41.7 -98	8.3 32

Average Years.

	O	N	D	J	F	M
1883/4	21.7 82	20.4 31	-12.2 -12	18.7 25	34.5 82	- 9.8 -39
1931/2	- 2.13 -82	-42.1 -64	32 33	19.8 26	3.6 8	9.6 39
1940/1	- 4.5 -17	-44.6 -70	65.5 68	-35.3 -47	-29.6 -69	- 5.2 -20
1944/5	-18.7 -71	-33.4 -50	-27.7 -29	45 60	18.2 42	7.7 29

Most years rainfall begins in this way which is spasmodic. When the rainfall arrives in this fragmental pattern there is a tendency towards heavier individual falls which to some extent compensate for the absence of long rainy spells. In none of the records has a continuous unbroken sharply defined rainy season been evident. All seasons, however, have occasional spells of rain free (and therefore usually warm) weather. Such spells of fine weather are of considerable significance to the farmer whose ploughing and sowing must be executed in the wetter two or three months of the year.

High Rainfall Years.

(1893/4	58.2	-24.1	122	130.5	13	0.1
(	221	-36	128	175	3	0.7
(1906/7	1.4	124.2	-12.4	79.4	-8.9	-6.5
(	5	164	-13	106	-20	-24
(1932/3	24.7	14.2	-26.3	10.9	-11.3	234.6
(	94	21	-27	14	-26	909
(1943/4	23.3	128.7	-74.0	135.3	25.5	-11.1
(	87					

Low Rainfall Years. It has been shown previously that November, December and January are the three outstanding rainfall months. If there is a significant failure in any of these a low annual total would be expected (significant failure critical level being set at 25.4mm's or 1 inch representing % deviations of -60%, -81% and -65% respectively). Thirty two such cases have occurred but in eight cases the mean annual total was exceeded due mainly to exceptionally wet Decembers and occasionally wet Octobers, Januaries and Februaries. These exceptions were 1894/95 - 1898/99, 1903/4, 1908/9, 1924/5. Should rainfall fail sunstantially in more than one of the three principal months then a small total seems assured. Four such cases are marked but others come close to it.

__Exceptionally wet years__. The general pattern is comparable with that of previous table but the arrangement is reversed. Normally again, it is the November to January totals which would appear to be the controlling influence but 1893/4 and 1932/3 warn of the dangers of generalisation. In these two years the large total of the first is controlled by October although December and January are by no means deficient. In the second the large total is quite definitely controlled by the March total which affords a good example of a late rainfall season producing a fine total which is well above the average.
__Average Years__. Table 17 gives comparable date for four years whose annual totals approach most closely to the mean value. These years might be termed average years. There is, however, still abundant variety with months yielding a rainfall close to the mean value.

In the analysis of periodicity, although it would be valuable to dispense with the arbitrary monthly divisions, data of daily rainfall is lacking for any length of time. But the monthly data serves to illustrate the complexity of the rainfall distribution within the main rainfall period October to March. Two types of rainfall may be distinguished:

1. Type of year in which there is a long wet spell lasting 2 or 3 months, broken by short spells of fine weather.
2. Consists of short wet spells with relatively long dry spells.

In the main the rainfall of northern Tripolitania is convectional. Precipitation results from the rising air currents in turbulent air masses, the turbulence being caused by heating or by the contact of air masses of different temperatures. This overheating of the land and resultant instability is especially a feature of the early months of the rainy season and more particularly in October whilst the contrasting temperatures of different air masses is closely associated with the passage of depressions over the region; these follow three main tracks.

a. Depressions passing to North of Eastern Mediterranean. These depressions form mainly in the western Mediterranean or North West Africa and are common at all seasons. The cold front usually affects coastal areas and may bring showers but otherwise fine weather.

b. Depressions moving east in the region of Cyprus. These form in the same way as those passing to the north. Most frequently they follow this track in winter and spring. The cold fronts, moving south and east, affect the whole area in sequence. They usually cause showers or short periods of rain. The rainfall and extent of cloud masses associated with these depressions decrease with remarkable rapidity inland from the coast.

c. Khamsin depressions. The Khamsin depressions form over desert regions of North Africa as wave depressions on a front separating air which has been over Africa for some time and has been considerably warmed, from Polar air, which has recently crossed the Mediterranean and is much cooler. Usually they first appear over Libya then move eastwards. They are preceded by strong southerly winds which cause widespread sandstorms and excessively high temperatures. The passage of the cold front is marked by rapid change of wind to the North West. Once the cold front has passed the increased relative humidity of the North West air stream causes the formation of cumulus or cumulonimbus cloud types and showers may occur near the coast. These are most common in the period February-June.

Although the convectional element is largely responsible for the wide range of occurrences discussed earlier it seems clear that the orographic effects of the Jebel rising suddenly from the plains at some distance from the coast, to heights of 1,000 metres is significant if only in the sense that the resultant lifting of the air mass may occasionally trigger off precipitation in already unstable air. In summer the excessive heating of the air immediately above a light coloured surface will encourage instability and the development of incipient thunderstorms.

Storm rainfall. It is difficult to assign precise limits to what should be considered storm rainfall.

However a value of above 20mm's falling within a 24 hour period would seem to cause significant run off damage and suggest a notable and intense rainfall for this region.[26] Given the convectional nature of the rainfall it is also unlikely that a daily reading of 40mm's results from anything else but storm phenomenum.

The data for rainfall intensity is scanty and one can only repeat the observations made by Fantoli.[26] Of 695 monthly observations made in the 70 year period 1879-1947 at Tripoli only 79 cases have been recorded where rainfall in a 24 hour period is more than 20mm's. This represents only 8.8% of the total rainfall frequency series. They occurred almost entirely with the period October-March and predominantly October to January. Out of these cases, readings over 40mm's comprised something like 30% of the total. In the steppe, however, at Azizia, of 1078 observations made between the years 1919-49, rainfall over 20mm's constituted only 51% of the total and rainfall over 40mm's only 0.7%. On the other hand in the Jebel at Garian falls of over 20mm's comprised 21% of the total observations taken between the years 1924-42 and 45% over 40mm's.

Thus the two major centres for storm rainfall appear to be Tripoli and the environs of Garian separated by an area of less intensive rainfall at Azizia. In terms of rain days relative to total rainfall the greatest intensity of rainfall would appear to be in the Jebel (table 19).

The effects of such storms is difficult to assess over such a large area: they are beneficial and at the same time damaging.

Certain generalisations, substantiated during the author's visit in 1958/9 can, however, be made.

These storms are responsible for filling field cisterns, tanks and shallow acquifers whilst the rapid surface flow of the wadis clears some of the debris accumulated in the wadis so that

Rainfall and Raindays for selected stations

Table 19

STATION	RAINDAYS	RAINFALL (millimetres)
COAST		
TRIPOLI (Sidi Mesri)	53	378.9
ZAVIA	36.7	267.4
TAGIURA	32	
SABRATHA	36	272.5
ZUARA	38	223
HOMS	43.8	268.7
ZLITEN	38	215.7
MISURATA	46.8	247.4
STEPPE		
AZIZIA	37	214.4
CASTEL BENITO	44	296.6
JEBEL		
GARIAN	44.5	322.6
JEFREN	32.4	267.3
GIADO	25.7	226
NALUT	24.2	138.2
TARHUNA	44.4	259
CUSSABAT	48.3	321.2
BENI ULID	16.8	58.6

they function to better effect later in the year. But these benefits are extremely local and great difficulties are often experienced in the lower parts of the wadis where much of the mud, stones and rubble accumulates. The heavy rains are useful for leaching down the accumulated salts of successive summer irrigations. In restricted places the floodwaters bring about a redistribution of soil resources so that the lowlands benefit from a renewed fertile soil cover; but the uplands obviously suffer from soil erosion.

When the rains fall heavily damage can be caused in several ways: damage to the crops by direct impact: damage by lubrication, as when walls are weakened or underground seepage effects deep rooted plants. Heavy run off can cause damage to such structures as dams, walls, roads. A point in case is provided by the Wadi Megenin, notorious for its flash flooding and one of the most problematic of Tripolitania's wadis. It flows from the Central Jebel to the coast at Tripoli, a distance of 75 miles. The spread south of Tripoli's suburbs and the extension of agricultural land has accentuated the problem of controlling the intermittent floods. Deep diversion channels running through the area have been built but in heavy storms the wadi seeks its old channels which are wide and flat. Consequently, this important agricultural area suffers. In October 1957/8 (Ghibli) a heavy storm on the Jebel precipitated a flood in the Megenin. Between Castel Benito to the coast road land was flooded from a few inches to 3ft. The silting up of the

Megenin in its lower reaches involved work on dam sites and road clearance (PlateXIX).

Fortunately few standing crops are affected by the impact of these storms although vines suffer. Those farmers with flat land tributary to large catchment areas generally suffer most.

Flood waters cause much damage where slopes give them a rapid run off. These violent effects are most startling in the field of soil erosion, especially in the escarpment zone of the Jebel where the presence of steep denuded slopes, frequently without terracing, accentuates these effects. Whilst many attempts have been made to control the wadis in their lower reaches it is obvious the work of soil and water conservation must be carried out in the upper reaches. Revegetation of the catchment basins, terracing, damming and water spreading are techniques which must be applied extensively if the deterioration of the uplands is to be halted. The practices by the Libyan farmers of esparto pulling, grazing and tree cutting must also be controlled.

In the brief discussion of storm rainfall it has been shown that there is much variation of precipitation from place to place. This suggests that the rate of occurrence of heavy storms is higher in some areas than in others. Fig. 12 shows that this is also true for annual rainfall distribution. Although individual storms or less intensive daily rain may be centred in various parts of the region the total fall taken throughout a number of years is concentrated in certain well defined zones. Most of the rainfall is borne on the North West air stream which may cause heavy rainfall. Basically, much of that rainfall is conventional but the sudden uplift of the Jebel front from the plain is sufficient to increase the yield from a precipitating cloud and to stimulate rainfall in one that is becoming stable.

Rainfall reaches a mean maximum at Tripoli on the coast but the distribution is rapidly modified depending on height and aspect to the North West rainbearing winds. Much of the east coast appears to lie in the true rain shadow area of the Eastern Jebel except near Misurata where the Western Jefara appears to lie completely off the track. The profound influence of the Jebel uplift is clearly established. From the scarp and piedmont area there is a rapid increase greater in the centre and west where scarp is higher. It is succeeded by an area of little isohyetal gradient in which the highest means are found over restricted areas of Cussabat and Garian. Rainfall decreases gradually from the east to the west with the increasing distance from the sea. The southern slopes of the Jebel are defined by a rapid decline in rainfall and mark a true rain shadow area in which the annual falls are below 250mm's.

Rainfall variability. The variability of the mean annual, as we have seen, is a result of the nature and distribution of air masses.

Previously we have considered the rainfall variation in time, but the spatial distribution of variability from year to year and between months is of some important significance. Fig. 13 indicates the variability of mean annual rainfall. At once it is evident that the distribution of low variabilities coincides with the highest mean rainfall totals (with the exception of the northern edge of the Jebel). The coastal area between Tripoli and Garabulli records the lowest variability and there is a fairly compact group of stations in the Central and Eastern Jefara with 25-30% variabilities. Outstanding variabilities are recorded in the Western Jefara and the rain shadow Ghibla syncline area: areas which are marginal to and sheltered from the main rain yielding masses.

<u>Distribution of dry and wet years</u>. The spatial changes in good and bad years is clearly shown by comparing the distribution of annual rainfall during two four year periods, one very dry (1946/7) and the other very humid (1931/4). If one assumes that the desert begins where there is less than 200mm's then between these two periods the isohyet moved some considerable distance East - West particularly in the marginal rainfall areas of the west coast, Central Jefara and Western Jebel from Assaba to Cabao. The north-south movement of drought was in contrast less marked, being controlled by the alignment of the country (fig. 14).

In comparison to Tunisia, which was also affected by the drought of 1947, northern Tripolitania would appear to derive some benefit from its generally E-W wave alignment, since in Tunisia the 200mm's isohyet moved north about 200km's to effect some of the best farming land and major olive cultivation areas. In Tripolitania, however, the negligible harvests in the Jebel were compensated to some extent by fair harvests in the eastern Jefara and Coastal plain.

In all years there is localised drought which in exceptionally dry years may become generalised. The probability of occurrence of rainfall below 200mm's over periods varying between 10 and 35 years is illustrated in fig.15 and it broadly reflects the mean annual pattern. Again the southern slopes of the Jebel, the west and western Jefara are the areas of most probable drought.

<u>Other forms of Precipitation</u>. Snow is very uncommon in Northern Tripolitania, but coverings have been witnessed, as in 1949 when 1 metre accumulated in three days. A thin covering occurred during 1958. Hail occurs frequently and generally in association with convectional storms. In 1955 newspapers recorded that crops were destroyed and animals killed by hailstones of considerable size. These catastrophies are, however, fortunately rare. Apart from rainfall, however, dew is the only significant form of precipitation and it has not been measured by modern techniques.

<u>Dew</u>. The contribution of dew to the total moisture is frequently overlooked in arid regions. Although perhsps not measurable over the dry season, it is not inappreciable and probably contributes a significant quota to available moisture for crops and vegetation. During August and September very heavy dew

falls were observed by the author at Sidi Mesri lying a few km's to the east of the town of Tripoli. The problem is one for further investigation.

Evaporation. The meteorological factor of evaporation, together with the more hydrological considerations of run off, percolation and sub-surface drainage and soil moisture conditions, enter into the whole problem of water availability for crop growth. The climatic water balance is essentially a comparison of water requirement (potential evapotranspiration) with water availability (precipitation)[28]. Unfortunately measurements of evaporation are totally lacking and the meteorological data is insufficiently detailed to allow the computation from empirical formulas, such as Thornthwaites, of the rates of evaporation and the availability of moisture. It is possible, however, to use the monthly means of P.E. calculated for Malta[29] and compare them with the monthly mean of precipitation for northern Tripolitania which is obtained by averaging the figures for four stations - Tripoli, Azizia, Garian and Beni Ulid. The contradiction of site between Malta and the stations of Tripolitania means of course that the P.E. rates for Tripolitania will, in fact, be markedly higher owing to the extended period of summer drought in the latter and the lower and more variable rainfall.

The mean computed P.E. for Malta is compared with the mean precipitation for northern Tripolitania in Table 19. It should be noted that the P.E. is less variable than precipitation in summer, being dependent on less variable physical forces. During winter its greater variability is due to the lower temperatures and insulation, and increased humidity is likely to be associated with the unsettled conditions in which above average precipitation will occur.

Table 20.

<u>Crude Water Balance - Tripolitania</u>. (Millimetres)

	S	O	N	D	J	F	M	A	M	J	J	A	Year
Precipitation	89	16.3	34.6	53.5	46.0	33.9	27.3	10.6	5.7	1.1	.5	.4	249.4
P.E.	120	75	45	35.5	32.5	30.0	47.5	42.5	95.1	127.5	167.5	167.5	1002.5
Moisture surplus				18.0	13.5	3.9							35.4
Moisture deficiency	111.1	58.7	10.4				20.2	31.9	89.4	126.4	167	167.1	753.1

These facts of the water balance are essentially facts of climate. As it is seen annual P.E. exceeds annual P. by about 400%. In the three months December to January there is a total moisture surplus of 35.4mm's but in the remaining months there is a total moisture deficit of 753.1mm's; a value which is three times the mean precipitation.

In practical terms if an herbaceous vegetation was required to be maintained throughout the year and allowed to grow at its maximum rate of growth it would need to be provided with a total amount of water equivalent to 40 inches (1,000mm's) distributed according to the appropriate values of P.E. On the average, only a quarter of the water would be available and the remainder would have to be collected from other sources. Such is what happens in irrigated areas where water is imported to supplement the natural supply, though it need only be provided during the limited growing season. But the application of water at the Potential rate is harmful as the soil will not be properly aerated. However, cumulative P.E. can only be reduced by 25-50mm's without inhibiting the full development of the plant. Again some water will be stored in the soil from surplus months into deficiency months which can be used by plants. The amount of storage moisture available to the plants will depend on a number of factors including the type and depth of soil, and the nature of the crop.

The capacity of the soil to hold moisture will influence the run off water, for just as at the end of the rain season plants draw stored moisture from the soil so at the beginning of the rains, moisture surplus to current plant requirements will be needed to restore this moisture. Unfortunately there are as yet no measured values of moisture holding capacities of Tripolitanian soils (cf. p.95).

The moisture surplus does not take into account, however, the amount lost by run off, which in the Jebel is considerable, from the areas of rock outcrop. This loss is compensated to some extent by the relatively high water holding retentive soils in the sedimentary lowlands of the Jefara and Misuratino, and also by the fact that many of the wadis fail to discharge into the sea. On the basis that a quarter of the annual precipitation is lost by evaporation and transpiration (P.E.) and allowing a further loss of a third through run off the total available moisture amounts to about 25mm's which over an area of 67,390 km2 would total 1,687 million m's 3. This figure is to be compared with the estimates of 80 million M3 used annually for irrigation in the Jefara and at least 13 million M3 for industrial and urban usage at Tripoli, Zuara and Misurata[30].

The implications of the above for agriculture is that at the present the fraction of moisture evaporated and recoverable for dryland farming represents a much greater volume than that which is recovered by irrigation, but that there is sufficient water for irrigation. However, supplies of underground water available for irrigation are extremely localised. In fact, the greater part of available moisture (1,032 million M3), according to estimates made by Fantoli[31], is concentrated in a zone which includes only the northern edge of the Jebel and the Jefara.

From this calculation the water budget would appear to be sound but there are significant regional variations. An attempt has therefore been made to define briefly the water supply zones on the basis of mean rainfall, distribution of acquifers and their potentialities as regards sedentary agriculture. It will be necessary to recapitulate and expand the observations made in Chapter II where the distribution of water resources was considered. As was noted on p.25 the greater part of the water available for agricultural purposes is drawn from wells tapping underground acquifers. The most prolific yielding areas now under exploitation and likely to be increasingly utilised are situated the length of the coastal plain and in parts of the adjacent steppe. In the Jebel and the Dahar reconnaissance surveys in the past by Italians, more recently by U.S.O.M.* have failed to produce evidence of the existence of accessible acquifers which could be tapped to support an irrigated agrarian economy. Thus throughout the Jebel and in the adjacent lowlands where ground water is salty at a depth of from 60-80 metres, there are many tanks and cisterns (fig. 16). The capacity of these tanks is generally a few cubic metres. The use of these tanks and cisterns is a palliative measure absolutely necessary where the population is dispersed and wells are inadequate. The cisterns are generally situated near rocky slopes where absorption of rainfall by the soil is low and a large proportion runs off. This water is collected by means of small earth or stone walls and is run into a sedimentation pit; and on to an underground cistern. In general their capacity is small and they are utilised mainly by Libyans.

Water supply from the cisterns is more subject to drought influence than are wells since they depend on heavy rainfall and an adequate run off. However, the cistern is of value in extending land development to a greater distance from wells than would otherwise be possible. The well may be expected to give a small, but constant, supply of water at all seasons; the cistern provides water for most of the year. This is all that

* United States Overseas Mission.

is required, however, for the planting of trees. Whereas the mobile nomad can migrate when cisterns dry up the settled farmer is tied to a certain radius from a more permanent well or spring water supply. Where the natural impluvium is rocky and bare it lends itself to the collection of run off waters but in such cases the construction of underground reservoirs is difficult and costly. The distribution of wells in the Ghibla, largely defined by the drainage basin of the wadi Soffegin, is sparce although a systematic survey of the potentialities of the acquifers has yet to be undertaken. Water is more than 40 metres below the surface over much of the area and yields are generally low even though the soils of the wadi bed are susceptible to agricultural development. Cederstrom[32] suspects that, in the lower regions of the basins, water may occur at a moderate depth towards the coast but its use depends on further test drilling.

Surface waters. As a rule in North Africa surface water discharges almost always starts violently, sometimes even with such suddenness as to cause loss of life. In the Jebel, where there is an appreciable rainfall over steep slopes with only a sparse vegetation cover, the run off could amount to as much as half the rainfall, depending upon the dryness of the catchment area, soil depth, and the intensity and duration of the precipitation. Although no records are available for the rate of run off from any of these wadis, fed by their catchments, it is certain that those in the Central and Eastern Jebel are, at times, heavily flooded by reason of the fact that in their lower reaches they have to be bridged by large spans. The wadi Ramle draining north from Tarhuna had a bridge with a single span of 20 metres obviously designed for maximum flood periods.

Uncontrolled, these flash floods of the wadis are a threat to soil and moisture conservation not only in the Jebel but also in the plains where they reach the coast (Plate XX). The only systematic attempt to harness rain water disposal and prevent soil erosion seems to have been made by the Romans who between the 2nd and 6th centuries extensively colonised the more humid parts of the Central and Eastern Jebel. Their techniques were mainly designed to reduce the flow of wadi water by dams across the valleys in the mountain tract, diversion dams in the piedmont zone, thus creating humid areas fanning out from the foot of the scarp, and the reduction of surface and soil erosion by terracing of steep slopes and wadis sides. Aligned with hydrological practises as the extension of arboriculture on the watersheds and slopes where the extensive rooting systems of the trees held the soil and reduced surface run off. This rational system was allowed to decay during the occupation by alien Arab pastoralists, and being accompanied by the destruction of the plantations, the processes of erosion were rejuvenated. Similar technkques are still applied in restricted areas by the Libyan farmer today, but his ability to promote such schemes, as we shall see later, is limited by his attitudes and economic position. This seems evident from the contribution made by the state towards schemes for restoring some of this lost fertility to these areas of the Jebel. Since 1954 development agencies have been engaged on the construction of earth and rock dikes in several wadis flowing south to the Ghibla-Taraglat Tmasla, and Hazmein covering an area of 3,800 hectares (Plate XXI). The control of the Megenin, perhaps the most precocious of Tripolitania's wadis, is also being planned to develop an area of some 650,000 hectares. Emphasis is also being laid on self help programmes which demonstrate to farmers the importance of terracing.

Wells. The greatest concentration of wells is seen in fig. 15 to be in the coastal plain and adjacent steppe areas. The majority of these wells (18,000) tap the two superficial water layers whilst a further 58 exploit the deep artesian and semi-artesian aquifers. These artesian wells are situated at intervals along the coast from Psida in the west to Gioda in the east. There are 7 in the Tripoli zone and a cluster of 15 and 6 at Crispi and Gioda. A further 19 sub-artesian wells (these are sunk to the depth of the artesian wells but the water does not rise to ground level through its own pressure) are distributed in the Eastern Jefara and the coast with a concentrated group of 8 wells at Garibaldi. These wells at Garibaldi are, however, not in use.

The total irrigable area commanded by these wells amounts to about 70,000 hectares.

First Shallow Aquifer. This source of water is found of varying depths according to the height above sea level and the distance from the coast. It is the source of water for the numerous Libyan wells which have contributed greatly to farming since ancient times. The fact that it was the only water table in use prior to the Italian arrival is proof of its accessibility. The greater abundance of water and higher density of wells in the coastal depression is explained by the fact that the average slope of the acquifer from the coast is about 2:1,000. It is due also to the fact that the inclination of the aquifer is not uniform, being steep at the base of the Jebel and almost flat near the coast. At Tripoli the water table lies between 5 and 15 metres but towards the east its depth increases to 20 metres. West of Tripoli the acquifer is near the surface as evidenced by the presence of salt marshes and springs. At Azizia the water table is 40 metres below the surface and 92 metres at Bir el Ghnem. The movement of water is fast in the east but in the west, where the water table is near the surface, the flow is slow and not surprisingly saline. This phreatic water table either exists as one solid mass of waterbearing strata or as several thinner layers depending on the deposits, but lies above the Tyrrenhian clay at Azizia. North of Azizia the second acquifer passes beneath this clay layer.

<u>Potentialities of Aquifers</u>. The indigenous Libyan farmer makes good use of this shallow water layer and exploits it by means of the 'Dalu' system (i.e. a pulley system operated by animals)(Plate XXI). From the high concentration of wells in the Tripoli-Tagiura area

yields of from 4.5-13.5 m3 per hour are obtained but generally the farmer is content to draw 3-8 m3/hr., sufficient to irrigate an area of from $\frac{3}{4}$-1 hectare. Whilst this supply is inadequate for large scale irrigation to replace the Dalu by electric pumps, without first reducing the number of wells, would soon result in a depletion of the water resources.

In certain parts yields from this acquifer are as high as those obtained from the 2nd. At El Maia (west of Tripoli City) water is only 2-6 m's below the surface and yields of 20 m3/hr. are possible. Inland at Castel Benito water is at 19-25 m's and yields of 30-40 m3/hr. allow the irrigation of citrus, peanuts, lucerne and potatoes.

In the extreme east of the Jefara at Garabulli the 1st water table is rarely used for irrigation. At Corradini the water table is deep and yields from windpumps are low (2-4 m3/hr.). The low capacity of these wells is due to their inaccessibility rather than their paucity. In the Western Jefara at the foot of the Jebel the 1st acquifer appears as a line of springs, being notable at Tigi and Giosc. The flow of the spring at Tigi is only m3/hr. and could be made to yield higher by digging tunnels or trenches further into the break of slope along the spring lime and thus tapping water even in summer. The springs from Sceckshuik-Gasr el Hag have a higher discharge and support numerous palm trees, but at Nalut there are only a few springs, little more than sufficient for domestic water requirements. A few tree crops and terraces are found on the lower part of the escarpment. Although there is a flow of 152 m3/hr. from the Sciersciaria spring - north of Tarhuna - it disappears on reaching the plain.

Only at the coast and inland at Suani Ben Adem and Ben Gascir is the 1st water table sufficient to allow irrigation.

2nd Aquifer. Because of the higher yields this aquifer is of tremendous importance. Theodorou(33) clearly establishes the relative importance of the various aquifers in the region of Zavia (Table 21).

Table 21.

Number of Libyan and Italian wells exploiting the 1st and 2nd acquifers and artesian supplies in the Zavia area.

	Libyan	Italian
1st Acquifer	174	26
2nd "	0	129
Artesian	0	2

Water is abundant in this aquifer; it has formed the basis of Italian agricultural expansion. Along the coast, farmers with large holdings favour the use of this acquifer. It is exploited by large scale commercial farming enterprises, Italian demographic settlements and the town of Tripoli for domestic water supplies. Today there are probably about 2,000 wells drawing on its supply.(34)

The first and second aquifers are recharged continually by rainfall at the rate of about 15-20mm's per annum (Cederstrom, 33, for the Tripoli area). Where the rainfall is over 250mm's and groundwater is continually on the move (i.e. Central and Eastern Jefara), the quality of the water is good and not likely to deteriorate but in western parts of the Jefara and lowlands of Misuratino the first water table is of doubtful quality where the water is slow moving and rainfall is low.

The early exploitation of the second aquifer was carried out by drilling boreholes in the bottom of ancient shallow wells and pumping apparatus was placed at the bottom of the well to raise the water to the surface. But later the technique was to sink to a depth of 1 metre above the shallow water table, and then to bore a tube well down to the semi-artesian level and use the first well as a reservoir for the pure water. The water was then distributed in cement or light concrete pipes for flood irrigation or more recently by sprinklers which reduce the expense of levelling and increase the irrigable area.

The abundance of water in the second water table has been questioned as a result of recent observations of water levels in wells distributed in the Jefara between Tripoli, Bianchi, Suani Ben Adem and Castel Benito. The history of this area after Italian occupation has been one of new wells being constructed each year and pumps being replaced by larger pumps from time to time. From the fall in static levels noted throughout the area it seems that a drop in static level has exceeded recharge. In 20 years water levels have fallen as much as 15 metres near Castel Benito, 5 metres east of Tripoli City. The drop in level is convincing at Bianchi and Giordani. (Table 22)

Table 22.

Depth of water below ground level (metres)

	1938	1947	1950	Sept. 1951.
Bianchi Farm 150	11.10	13.20	13.90	14.50
	1939	1948		
Giordani Farm 55	14.50	17.50	17.90	

It is reasonable to assume that the 750 pumped wells in this area are robbing adjacent areas of supplies. Consequently this area, which has fostered an intensive development of cultivation, may be near the limit of sustained development, and locally sustained development is being exceeded.

<u>Artesian Waters</u>. As was noted in Chapter I there are three zones of artesian waters yielding from 20-350 m3/hr. under natural flow.

The development of their artesian waters has only been partial and several of the deep artesian wells have gone out of use as a result of corrosion of the tubes. Others are found to be in need of repair. Most of the sub-artesian wells in the third water table have been left undeveloped owing to lack of funds.

The high water yields of the artesian aquifers and their low running costs for irrigation are overshadowed by the low quality of these waters which have hindered development. In particular these waters are noted for their high content of sodium chloride.

The most salt tolerant crop is the date palm which can withstand up to 10 grams. per litre 1,000 of NaCL, although it prefers 3. The olive and almond can resist 3 grams. per litre, vines 2 and figs 2-3.

The effect of irrigation on crops in certain areas depends also on the type of soil and soil solution; large numbers of soils, particularly in the Jefara, are sandy, permeable and well drained, devoid of chloride, rich in Ca Co3 thereby allowing the use of some poor quality water for successful irrigation.

Water Supply Regions of the Jefara. Along the coast and as far inland as Azizia there is water in sufficient quantities for livestock, human concumption and irrigation, but in the Western and Eastern Jefara, and in the vicinity of Misurata water for irrigation is limited by increasing salinity and depth of acquifers (i.e. Eastern Jefara).

(a) West Coast. Here underground water is constituted by the phreatic and western artesian type with two acquifers. Pockets of freshwater are found amidst the dunes along the coast but saline water occurs on the surface. In the western areas freshwater is found in areas of higher elevation but they are limited in flow and quality.

(b) Central Part of Western Jefara. This area contains the spring line zone, and despite the low rainfall, numerous cisterns to collect and store surface water flow. In the sandy area to the south of Sorman-Zanzur wells are evenly distributed at intervals of approximately 2 miles. Water is of reasonable

quality and generally at a depth of 20 metres below the surface.
(c) Inner Jefara. Water is at 30-40 metres and wells are absent. The quality of water is low but may be available in reasonable quantities.
(d) Eastern Dune Jefara. This region is similar to the Western Dune Jefara. It is the zone of the deep phreatic water and wells are sparse.

Although certain underground water could be developed (e.g. Western Bianchi and dune south of Tripoli), the development elsewhere depends largely on finding cheap means of raising deep quaternary water. Much depends also on the better use of brackish water. The Italian settlement of Crispi provides an example of such utilisation of saline artesian waters. The initial scheme was for the semi-irrigation of salt tolerant crops excluding those with their whole life cycle in the summer. On a 10 hectare holding olives were planted 15 x 30 metres (almost dry cultivation spacing), leaving space for 4 hectares of cereals, 4 hectares of pulses, 0.5 hectare lucerne and 0.5 hectare of spring-summer grasses and a small area for industrial and horticultural crops. With only one fifth of the area irrigated and the land resting for 1-3 years the results have been encouraging. Olives and dates have done well but fruit trees (citrus) have given disappointing yields. Wheat, barley, pulses and sorghum seem to thrive but tobacco, potatoes and groundnuts have not done well. This example demonstrates clearly the value of the olive under semi-irrigation in an area of marginal rainfall and where irrigation waters are fairly saline.

The use of saline water on permeable well drained soils is not as dangerous as in heavy soil areas, since there is less chance of waterlogging and consequently more leaching of the soils. When a calcium soil is irrigated with water of a high sodium content the sodium tends to replace the calcium and the soil becomes saline, but this can be corrected by the application of gypsum (Ca So4) which is plentiful in Northern Tripolitania. Therefore there are distinct possibilities in the Misurata area.

The problems of water use and supply are complex. The physical limitations of the Dalu, although inexpensive and adapted to meagre supplies of water from the shallow water, are obvious. Italian developments of artesian and semi-artesian waters called for high capital investment but made possible the expansion of sedentary agriculture. Ultimately one must consider costs, and since land is relatively plentiful and water scarce and expensive there is much to be said for the development of relatively cheap water (artesian) for dryland cropping developments. This has been successful at Crispi where a rational rotation and limited use of brackish water was applied.

Thus in areas where water is brackish and techniques of water irrigation limited or costly there is much to be said for the development of dryland cropping in combination with fully irrigated crop areas. Even in the best water supply areas the problem of depletion of water resources can be mitigated by intensification of crops with low water requirements and suited to dryland cultivation. Furthermore, since 1945 the increased production of summer cash crops grown under irrigation, e.g. groundnuts, even by formerly subsistence Arab farmers has inevitably produced a strain on water supplies as has been noted at Bianchi.

Water costs. It is to be expected that in a country which has no flowing rivers costs of water will be high although varying with methods of drawing water and application. This is one reason why every effort should be made to profit as much as possible from the rainfall and employ cropping systems in which water requirements are at a minimum.

Considerable efforts were made by the Italian Government to develop irrigated farming and a schedule of water costs obtained on four different types of settlement indicates the pattern (Tables 22a and 22b). Appendix Breviglieri is a dryland settlement in the eastern Jebel where water is not easily found. While the capital cost of water per hectare is lower by far than on any other settlement, the capital costs per cubic metre and running costs per cubic metre are very much greater.

Olivetti is situated on the west coastal plain where water is easily obtained. Farms are smaller and the proportion of irrigable land on each farm is 10%. As might be expected, the capital cost of water development per hectare is higher, in proportion to the increased amount needed for irrigation, but the capital cost per cubic metre per annum is very much lower than at Breviglieri. Running and maintenance charges are also less.

On the Crispi settlement, owing to the fact that the water contains impurities, the whole farm area had to be developed with pipes and furrows to allow some rotation in the irrigated area each year.

That the irrigation of land in the semi-arid areas of Tripolitania is costly compared with dry farming on the Jebel is shown by the capital outlay on water developments in relation to the whole farm areas; that is £3.3. per hectare for dryland farming on the Jebel, compared with £22.2. and £44.4. elsewhere.

Climatic Extremes. Amongst the most important of extreme climatic phenomena affecting crop growth and production is the occurrence of the southerly winds (Ar. Ghibli). Snow is very uncommon but has been witnessed in the Jebel in 1949 when 1 metre accumulated in three days and covered most of the area. Hail occurs more frequently, and generally in association with convectional storms. In 1955 it is recorded that crops were destroyed and animals killed by hailstones of considerable size. Extreme minimum temperatures of $0^{o}c$ are rarely exceeded along the coast whilst $5^{o}c$ in the Jebel and semi-desert regions are normal, but such temperatures are rarely prolonged as to inhibit crop growth. Yet Broc recalls the injury of young trees by frost in the Jebel valleys at 8-900 metres.(23)

<u>The Ghibli Wind</u>. The Ghibli wind (the direction from which it blows supplies its name in Arabic) is a manifestation of the variability of climatic conditions in the region. It constitutes a hot dry current of Tropical air moving south and south west to the north across the country with its source in the Sahara. Usually it moves north over the east side of a depression over the Western Mediterranean or North West Africa. The size of the area affected depends largely on the synoptic situation modified by the local factors of relief, aspect and position; but whether a deep depression in the northern Mediterranean or a minor one over Tunisia almost the whole of the region comes under its influence with pronounced effects on the southern slopes of the Dahar and the continental parts of the Jefara lying to the north of the piedmont zone of the Jebel. Here, as a katabatic current coming down the scarp, it is associated with excessive temperatures experienced during the summer months.

Characteristically, the Ghibla is a hot dry wind and it is directly responsible for a sharp reduction in atmospheric humidity with rapid increases in temperature. It may raise temperatures to a maximum of 50^{o}c and changes in humidity from 90-10% are not uncommon. Its dryness causes an increased transpiration from plants and a more immediate evaporation from the soil. Amongst other things the Ghibla would appear to be responsible for the eye disease Trachoma which is prevalent amongst the rural Arab population.

During 1958-59, the author observed the onset of a Ghibli of which a short description follows. It was preceded by a lull in the prevailing (generally north west wind) lasting some 15 minutes. The onset of the Ghibli was accomplished in a matter of minutes. Wind force rose to 6 or 7 on the Beaufort scale and quantities of sand dust carried by blasts reduced visibility to ten yards and less. On average the first hour was stormy and hot; thereafter wind was less intense and visibility improved, but the temperature remained high. The end of the Ghibli came just as quickly with a sharp reversal in wind direction to the North and influx of cooler air.

During Ghibli out of door activity was virtually impossible for the whole duration of the wind. Europeans are less adapted than Arabs to high temperature and dryness during Ghibli. If the winds are strong then the heat haze is often accompanied by sandstorms and wherever the vegetative cover is disturbed by the misuse of soil (e.g. grubbing of plants for fuel or overgrazing) the winds tend to produce dunes.

On the other hand the Ghibla is essential for the maturing of the date harvest in the late summer. Along the coast the Ghibli are most frequent in the early and late summer, periods of critical rainfall, but they may arrive in November or early Spring. Normally, the duration of the Ghibli is no longer than three days but it may blow up to five and in rare cases eleven days. A similar pattern of occurrence prevails in the Jebel and steppe except that the winds are more frequent and less easily interrupted than at the coast by temperature inversions brought about by the sea winds. The wind is modified in the Jebel by local variations in relief and exposure.

Temperatures. The thermal regime tends to show Mediterranean characteristics in winter and Saharan in summer. Overall, the region reflects the position of the Mediterranean as a climatic contact zone.

There are notable differences in mean temperatures in time and space owing to the interactions of various climatic elements including distance from the sea, local relief, and difference in the constitution of the ground surface. As we have seen the seasonal change of mean monthly temperatures are most equable at the coast and in the Jebel with the greatest range in the steppe and semi-desert regions. The extremes of temperature are of some significance. Summer maximums are recorded for the steppe whilst winter minimum are highest in the Jebel and semi-desert. More important still, as regards crop growth, are the variations in daily temperatures whose large range is a marked feature of the climate. Lower night and day temperatures might be expected in the dunose and sand areas relative to the temperatures on the compacted wadi cultivable areas and sebkas. At the coast the daily range is moderated in summer by the cooling influence of the Mediterranean during the day and the relative warmth at night. Inland, however, this influence declines. High day temperatures and low night temperatures cause intense damage to maturing wheat and barley. Also the extreme diurnal variation in temperatures during the flowering phase can affect olives.

__Frost__. It is common knowledge that frost occurs along the coast, but more frequently in the high valleys of the Jebel, with highest incidence in January. In the oases on coastal margin they are likely to be less frequent than inland. Similarly hill foot and hill top sites have reverse relationship. On the higher slopes - frosts will be due to low temperatures of free air rather than the pondering up of cold air draining into wadi chollows and lowland basins.

Gravity flow of air would seem to take place in the evening. More equable temperatures on hill slopes may account for the fact that settlement is scattered along the hill slopes, surrounding the farming land.

The Libyan farming areas appear well adapted to the thermal regime at the coast. A dense cover of palms and other tree crops, including the olive, exists. Cultivation is carried on over restricted areas and a high percentage of the land in the oases is in constant use. Fallow land is invariably left with a weed cover after harvest. These practices give an insulating effect, especially on still nights when radiation is most intense.

In contrast Italian agriculture is characterised by the wide spacing of trees and dispersed cultivation strips scattered over large areas. Clean weeding is a common practice. The result of the European approach to land use is that the areas suffer badly from the effects of diurnal changes in temperature.

The human impact of these extremes is relatively small amongst pastoralists. In the coastal oases and steppe, however, less marked daily ranges have an immediate impact on the settled farmer to his benefit and detriment.

Implications of Rainfall Regime. The scarcity of rainfall is not the only inconvenience to agriculture; if the quantity of rain is repeated from one year to another with a certain regularity and with a good seasonal distribution then it is convenient for cereal cultivation. Instead, the total rainfall varies from place to place and with marked seasonal variability and contrary to the needs of herbaceous crops - scarce rainfall in autumn. But tree crops possess a notable resistance to climatic variations, and the techniques of dryland cultivation, rationally applied, can maintain the humidity in the soil. Since tree cropping in this form must be extensive it incurs certain limiting economic factors; the long waiting period before the olive fruits and the inherent dangers of monoculture may provide serious handicaps to arboriculture. The risks and delay can be ameliorated by irrigation and the development of intensive polyculture as opposed to extensive monoculture forms of cultivation.

The gradient of variability falls steeply inland from the coast. Even on the coast the reliability is such that irrigation is necessary everywhere if the quantity and quality of harvests are not to suffer and fluctuate violently. In this context the stabilisation of crop yields is as much a problem in

Tripolitania as the development of new lands. In spite of violent fluctuation in annual rainfall cheap irrigation from a shallow phreatic water table has enabled the growth of reasonably secure settlement in the narrow and discontinuous oases of the coast whilst the abundance of cisterns and tanks on the Jebel, whilst helping this stabilisation, have not completely assured stability. Where irrigation water is not available then the dryland farming of tree crops and the shifting cultivation of cereals becomes important.

The Impact of Prolonged Drought Conditions. In all areas other than the coast and Jebel the indigenous population has been able to adapt itself to a preponderance of bad seasons over good by a precarious nomad economy. Intense variability of insufficient rainfall has been, and will continue to be, a tremendous retarding element in agricultural development.

Development and stabilisation are complementary in Libya - each absorbing an equal share of national and foreign capital resources, e.g.

1. L.P.D.S.A. in 1955 spent £L200,000 on STABILISATION
£L110,700 in Agricultural Development.
2. 1956-7 comparable figures were £L124,000 and £L227,496 respectively.

Effect on Agriculture. Several conclusions can be made regarding the effect on agriculture of the aridity and instability of Tripolitania's climate and the limited distributional quality of water for irrigation.

(1) The climate of Tripolitania produces rain when there is

least demand for it. Consequently there is an accent on winter crops. On the other hand, in the season of greatest potential growth, summer, rainfall is absent. Such a situation puts a high premium on moisture storage, irrigation and dry farming. For crops dependent on the winter rains the growing season extends from October to March but is generally one month behind the Jebel. Activity is halted during the summer months for all crops except those that are able to withstand the drought by radicular development or alternatively those which receive irrigation water.

(2) Thermal climatic conditions in winter allow, on the whole, a wide range of crops but the rapidity in the change of temperature from summer to winter, which may be accelerated by a Ghibli, is a limiting factor. Thus crops with a short cycle of growth and which mature in early spring are favoured. Even during the winter months wind and temperature conditions can be marginal for such crops as tomatoes, melons and potatoes.

(3) The Ghibli, as the rainfall, but in a contrary sense, constitutes a climatic factor, regulating production and even distribution of crop plants. This infernal wind, whilst it may be essential for the ripening of the date palm in late summer and can be beneficial as regards phytosanitary conditions, has also a detrimental effect. By reducing humidity it increases transpiration and accentuates evaporation from the soil. Thus inducing drought conditions. Such action is also harmful to the reproductive organs of those plants which flower in spring

at a time when ghibli conditions are most frequent. Leone[26] observed this phenomena in several herbaceous plants and tree crops which flowered late. Therefore the cultivation of crops which flower before the period of strong ghiblis is most convenient. Barley is grown as the major dryland crop and it matures at the end of March. However, should the early rains be late then even this short cycle crop is exposed to the ghibli. In the same way the late rains in spring are valuable for the flowering of such tree crops as the olive. If these are absent then fecundation is negligible.

Through the centuries the farming calendar has been adapted to these natural phenomena, with the result that certain types of crop management can be distinguished (Table 24).

A. Rainwatered crops.

(i) Autumn-Winter and Winter-Spring crops. These are planted at the beginning of the rains or midway through the wet season and are often given supplementary watering until adequate moisture is available. These include Broad and Climbing beans, Lucerne, Herba medica, potatoes, tobacco.

(ii) Sown planted at the beginning of the rains. In all except drought years the moisture is sufficient to sustain the plant, i.e. barley and herba medica (forage crop).

B. Crops dependent on the soil moisture. They are planted late in the wet season and include several tree crops:

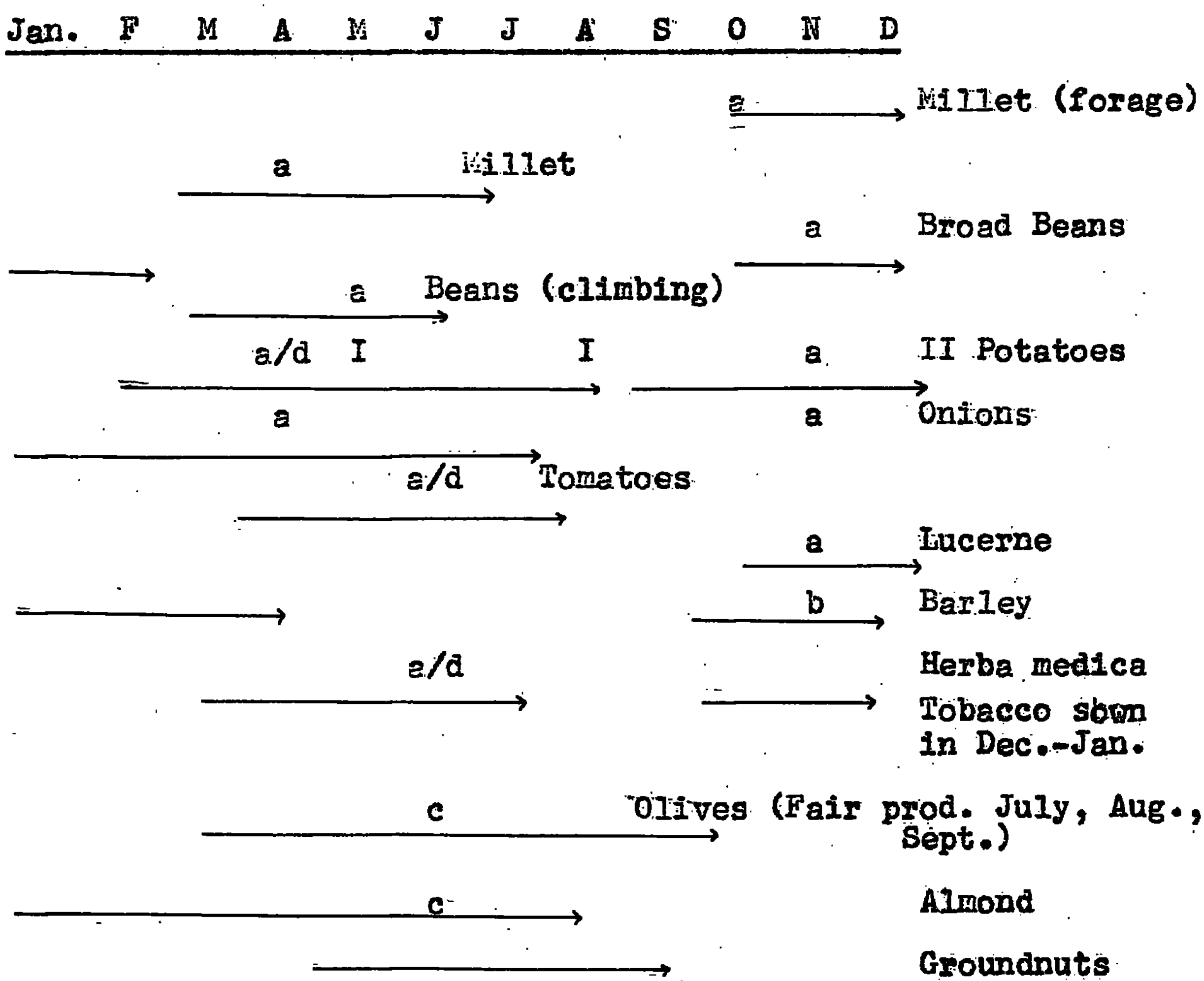
olive, almond, vine.

C. Irrigated crops are those which receive irrigations at regular intervals during the period of growth. Three crops are possible in a year but the wet season crop is less dependent on imported water than the other two. However, since most of the summer crops are planted in spring or early summer they do not rely on full irrigation: millet, groundnuts, tomatoes.

D. Planted late in the rainy season when available rainfall will be adequate for growth. However, the land has normally been empty of crops during the winter and constant surface ploughing has kept the soil free from weeds, thus reducing to a minimum water loss. Utilising these reserves the plant will develop during the drying summer, supplementary watering may benefit such crops where possible especially during a particularly dry summer.

Table 24.

Seasonal Rhythm of the Growing Season in Northern Tripolitania.



a. Planted at beginning or midway through wet season - given irrigation water until moisture adequate.

b. Sown planted at beginning of season; in all except drought year moisture adequate.

c. Those dependent on soil moisture.

d. Irrigated.

III. Groundnuts are the exception and require regular watering. Other high water requiring crops are tomatoes, tobacco, onions, alfa-alfa and pepper, and citrus crops (Table 25). More briefly there are i. Dryland crops

ii. Semi-irrigated crops

iii. Irrigated crops

The pattern of husbandry is largely controlled by the moisture regime and the crop system which it allows. Even where irrigation facilities are available the cropping system is arranged to take as full advantage as possible of the winter rains. Shallow ploughing with the native ard type plough drawn by animals is only possible after the onset of the rains when the hard crusts and soil clumps produced in summer are weakened. The need for moist soils is not so important for mechanised cultivation and deep ploughing may be carried out in high summer.

The uncertainty of the timing and violence of the onset of the wet season has induced farmers to aim at some conservation of soil and water resources especially in the Jebel, where run-off rates are accentuated and gully and sheet erosion is common. Damming and channeling are a feature of the wadis and hill slopes. Exceptionally wet seasons can prove hazardous. Attention must first be given to the fields scheduled for cropping and the conscientious preparations needed for irrigated crops and the work required in conservation may mean that the dryland crops are sometimes neglected. The timing

Table 25.

Irrigation requirements of crops during the summer, per hectare (COAST). (1)

CROP	No. Irrigations Time 3.15am. to 10.15am.	10.16 to 3.14pm.	Frequency 3.15 to 10.15	10.16 to 3.14	Amount M3 per irr. 3.15 to 10.15	10.16 to 3.14	Est. amount per year. Cu. metres
Olive	7	1		1 Nov.	300	300	2,400
Alfalfa	30	6	7	25 10c.-No.	800	500	27,000
Orange	18	4	12	1Feb-My	800	500	16,400
Peanut	18		7/8		600		10,800
Wheat	3	3	20		500-300		2,400
Potatoes							
Sept.-Jan.							3,800
Feb.-June							6,750
Tomatoes							
Oct.-Mar.							13,600
Apr.-July							14.400

Thus olives are given one irrigation of 300 cubic metres on March 1st then 7 irrigations of 300 M3 every 30 days thereafter.
The total required per hectare = 2,400 M3 of water
= 240 mms. rainfall

(1) From L.A.T.AS. Report (Reported by Dr. Casadio, Sidi Mesri).

of the early rains may also result in the sowing season clashing with the harvest of such crops as the olive.

The summer heat does have its advantages. Although plant growth terminates for herbaceous crops it facilitates the ripening of the olive, vine and date palm. The drying spring and early summer cereal ripening is less subject to the vaguaries of climate experienced in more northerly latitudes.

Rotation. The rainfall and its irregularity in time and space does not permit the adoption of a common rotation practice. As well, the rotation system varies with the inherent differences between the Libyan and Italian farming economies which have evolved under different circumstances and exhibit differences in location, size and management. Even so, the moisture regime and the availability of irrigation water in certain areas have induced a generally similar attitude to farming practice.

The following rotations are common:

(i) 2 year. Barley followed by fallow or in better rainfall areas legumes. This prevails in dryfarming areas. In the more marginal areas of the steppe and semi-desert several years of bare fallow often succeed a barley crop. The barley crop is sometimes grown together with perennial tree crops of which the most wide-spread is the olive.

(ii) 3 year. The more extensive rotation of fodder crops, fruit trees, vegetables and industrial crops, groundnuts, tobacco is normally practised on irrigated land.

Cereals and more particularly barley are the main crops on non-irrigated land followed by olives, almonds and figs. It must be emphasized that in the case of dryfarmed crops, especially barley, no systematic rotation is possible, since a field is sown with barley whenever it rains. Consequent on the irregular rains barley may be sown for 2 or 3 years in succession or the field may be left fallow for several years.

From an ecological point of view, current farming practices seem adjusted to the generalities of the season, but susceptible to departures from mean conditions. The amount and regularity of rainfall seem to be the decisive factors determining the agricultural possibilities.

Climatic effects on Agriculture and Land Use. The human approaches to the environment of Northern Tripolitania are therefore limited by poor rainfall and climatic extremes. Even on the coast much of the land is unsuitable for sedentary agriculture unless irrigation is possible. In the steppe zone except where the Italians exploited underground water resources climatic limitations have restricted agriculture to primitive shifting cultivation and stock rearing.

The essential pattern that appears is the integration of dryland and irrigated agriculture; it takes many forms depending on the abundance of water for irrigation and the proximity of urban markets. There are several types of cultivation according to water availability. They range from the traditional Libyan practice of integrating shifting and cultivation in the wadi beds and humid zones of the steppe and semi-desert, with intensive partial or full irrigation of annuals and tree crops in the oases of the coast and Jebel Wadis, to the intercultivation of dryland tree crops with irrigated herbaceous crops. This form of cultivation in contiguous plots has been developed in the most rational manner by Italian farmers.

Land Use. Since much of the land owned by Libyans remains unregistered or only worked occasionally the distribution and extent of land use types can only be roughly estimated. More precise is the size and location of Italian farming settlements, although the total area is not cultivated entirely. Some remains uncultivable or awaiting development.

Therefore both the statistical summary (Table 25) and areas marked on the map (fig. 17) are approximate.

The most reliable estimates of land use are those made by the British Military Administrative Survey in 1945.[15] It was based on research work and Italian maps. From these the total productive land in the territory was estimated to be 10 million hectares, comprising:

8 million	hectares of	grazing land
1,600,000	" "	shifting cultivation
400,000	" "	sedentary agriculture.

The greater proportion of the static farming area belonged to Italian farmers in 1945 (Table 26).

(1) Extensive Grazing Area. Totalling some 8 million hectares

the area devoted to extensive grazing is mainly flat. In general the climate and soils are too dry to permit cereal cultivation save in the wadi beds and small locally favoured places.

The natural herbage is grazed by wandering Libyan tribes and their animals are moved from place to place according to the dictates of the climate.

The Ghibla is traversed by large wadis and these are used mainly for shifting cereal cultivation. At present the watering places are barely sufficient to meet requirements of the animals and as a result the area is grazed for only two to three months during the rainy season.

(2) Shifting Cultivation. The area devoted to shifting cereal cultivation amounts to approximately 1,600,000 hectares: it is by no means homogeneous and is certainly not all ploughed either in one season or over the whole area. The demarcation of this area on the map merely indicates the distribution of land with a climate and soil which would permit cereals to be grown. Cereal production is confined to the coast, the Jefara and a narrow strip of the Dahar. It lies adjacent to the perennially cultivated land.

(3) Esparto Grass. The area shaded on the map indicates where halfa and esparto grow in some abundance in the Jebel. The topography is very varied and comprises both flat and steeply sloping facets. It provides valuable grazing as well as a harvest for paper manufacture.

Table 26.

Land Use in Tripolitania

Land Use	Area (Hectares)	
Coastal oases	50,000)	
Jebel Gardens	127,000)	177,000
Italian Concessions	127,000)	
Demographic settlements	)	
ENTE?	42,635)	206,188
INPS	36,553)	
Forestry	3,050)	
	386,238	

(4) Afforestation. Following agricultural development a commendable effort of tree planting has been made particularly in the area around Tripoli. This, on most of the sizable farms, has consisted of small plantations, hedges and wind-breaks. During the latter years of Italian occupation the concern of the Government in reforestation resulted in some measure of success. Since 1952 a considerable expansion in forestry activities has taken place. Altogether, particularly since 1952, an estimated area of 14,220 hectares of Government forest has been established, including 5,728 hectares on stabilised sand dunes.[36] Whilst this is a creditable effort it is a bare beginning. In the maritime zone alone, there are at least ¼ million hectares of sand dunes which ought to be stabilised at the earliest opportunity.

On April 1st, 1957 the Government Forest Estate was estimated at 10,700 hectares of established forest, including 3,800 hectares of fixed and planted sand dunes. Of this total area a considerable part was planted during the Italian regime. The most successful species planted are chiefly Eucalyptus and Acacia. It is assumed that the area of private forests is smaller than that planted by the State. Much of the private planting consists of windbreaks and shelterbelts, which are admirably suited to the climate and topographic conditions of the country.

Sedentary Agriculture. Only about five per cent of the total productive land is devoted to settled farming. This area is by no means fully developed and the greater part belongs to Italian farmers.

Although the choice of crops is large the area suitable for sedentary agriculture without irrigation is limited theoretically to regions where the mean rainfall does not fall below 200 millimetres. However, in the Steppe and semi-desert areas, the presence of accessible acquifers and humid wadi beds allow some cultivation; these factors compensate for the mediocre rainfall distribution.

The development of dry farming in all its phases, including the cultivation of crops requiring only a little water at one stage or another as well as water conservation work of terracing, and the controlled development and efficient use of ground water seem to be fundamental modes of land use in such an arid region as Northern Tripolitania. The best of the coastal lands are already developed and need only small scale help. Because the potential irrigable area is in the hot Jefara costs of extending fully irrigated agriculture will be high. The dryland development areas are large and situated mainly in the Jebel, where rainfall compensates for the higher costs of water. Robb estimated that 30,000 hectares of land could be brought under irrigation and a further 350,000 hectares of dryland development along the Jebel and better watered portions of the country.

It is not surprising, therefore, that the olive occupies almost forty-five per cent of the total area of settled farming. In general tree crops have two special virtues; they can be planted on broken terrain and they are efficient extractors of groundwater. Sown crops, on the other hand, are influenced by the need for recurrent fallowing. The olive tree can also play an important part in reforestation since it grows well in arid and semi-arid soils where shade is so essential; moreover an olive grove provides an excellent windbreak.

Since the growing season of the olive corresponds to the dormant period for dryland annuals, the tree extends the crop range and economic activities throughout the year. The longevity of growth and production plays an important part as a stabilising element lending continuity to an agrarian society.

CHAPTER V

Ecology of the Olive

The olive (OLEA EUROPEA) belongs to the family OLEACEE (GENUS OLEA) which comprises 35 species diffused throughout the countries bordering the Mediterranean and those countries with analogous subtropical mesothermal climatic regions, namely, South Africa, South West Australia, North and South America. The Mediterranean remains the heartland whilst these satellites owe the diffusion of the olive particularly to European colonising efforts in the late 19th and 20th centuries.

The olive is cultivated mainly for the edible oil derived from its fruit which is widely used for domestic purposes throughout the Mediterranean. The residue after oil extraction (SANSA) may be used as a fuel for burning, as a concentrate for livestock, or as a fertiliser. The sansa may be further subjected to extraction for edible oil, but more often it is used for industrial purposes, chiefly in soap making. In addition the wood of the olive tree makes good charcoal. A mature olive tree produces about 1½ tons of wood above ground and 2½ tons below ground which yields approximately a ton of charcoal when the time comes for replacement[ibid (15)].

Within the Mediterranean olive oil largely replaces animal fats. In Tripolitania itself the consumption of all edible fats and oils averaged 8 kilogrammes per head in 1958 of which 6.0 kilogrammes comprised olive oil.[(37)]

DISTRIBUTION

In Northern Tripolitania the tree is widely diffused and although the culture is predominantly concentrated north of the 32nd parallel, small stands and individual trees (all irrigated) are known to exist in the oases of Fezzan as far south as the 24th parallel. Small groves of stunted olives were observed by the author at Ghadames and Sebha but their yields were reported to be negligible. Many of these trees were introduced, in the past, by merchants from the coast. They consist mainly of edible varieties, noted for their size of fruit and scarcity of fatty substance.

In terms of longitude the tree is grown from the shores of Sirte to the Ouazzen on the Tunisian border. This distribution takes in climatic conditions ranging from the Mediterranean type on the coast to an extreme desert climate, typified at Ghadames, i.e., from a mean annual temperature of 19.6°c to 21°c and a mean rainfall of 368 mm's to less than 50 mm's.

The distribution of the olive has therefore tended to expand outside the true radius of Mediterranean climatic conditions (under which the olive thrives) where the minimum conditions for the tree's adaptation and growth are encountered.

North of the 32nd parallel the tree is unevenly distributed (Fig. ~~18~~ abc, Table 27 Appendix). Centres of major importance tend to be separated by areas of sparse cultivation or else by undeveloped, sometimes barren, tracts of land.

Approximately $3\frac{1}{2}$ million trees* distributed over an area of 180,000 hectares, in mixed or specialised orchards plus those scattered stands, are grown in the region at the present time. The majority (61% in 1944) are cultivated in the coastal belt from Zuara to Misurata, with important nuclei at Zavia, Sabratha and Tripoli, the Central and Eastern Jefara; the plains of Msellata, Tarhuna, Garian and the Western Jebel. Thus the map of the olive's distribution coincides for the most part with that of rainfall, the area enclosed by the 200mm's isohyet, and major centres of rural settlement. Since the olive is predominantly a dryland crop this is a natural relationship. Although (Fig. 19a) is only an approximation, and the area of cultivated land is not known, the density of olive plantings noticeably increase in the best rainfall areas, viz. Tripoli 368mm's, Cussabat 320mm's, Garian 340mm's.

In contrast where settlement is sparse, water supply poor, and rainfall below 200mm's, there is generally a diminution or complete lack of olive cultivation. Of course much of the Western Jefara and semi-desert area remains submarginal for sedentary agriculture. The areas of Sebkha and shifting dune are likewise negative areas for the olive. Even within the best rainfall areas there are some anomalies in the distribution of the olive. The oasis of Misurata compares favourably with that of Zliten as regards mean rainfall yet olive cultivation is much less predominant. In the

* Includes all trees; productive, immature, damaged wild. (Agric. Dept. Official Estimate).

former area compact and thin soils combined with the salinity of the water supply account for this anomaly.

On the other hand, in the steppe areas of Azizia and Crispi, where rainfall is no more favourable than at Homs, the olive is abundantly distributed owing to the excellent water supply which has encouraged land settlement. Large gaps appear in the plain areas of the Eastern Jefara and Tarhuna, where rainfall is above the critical level. These can only be explained by the traditional pastoral economies of the areas. Therefore, the distribution of the olive is a function not only of rainfall but also groundwater, economic system and morphology.

Areas of densest distribution are not always those in which the olive predominates amongst tree crops. Along the coast the olive invariably takes second place to the date palm and citrus fruit. For example, in the districts of Tripoli and Suk El Giuma olives comprise only 9.3% of the total tree crops. At Zavia the percentage rises to 10.8. Even in the low rainfall areas of the coast the olive forms only a relatively small proportion of total tree crops - 8.2% at Zuara and 6.0% at Misurata. (Fig. 19).

On the Jebel, however, the olive is the tree par excellence.

In addition there exists a nucleus of some economic importance enclosed in the depth of the WadiBeni Ulid constituted by some 13,000 trees of which about 11,000 are bearing (Plates XXIIIa & b). This nucleus has a particular importance since it demonstrates practically the ease of adaptation of this culture in a region situated on the extreme limits of agricultural possibility. It is also proof of the efficacy of compensating elements in the environment. At the same time the groves remain as evidence of a former localisation of the culture, where only archaeological traces of an ancient floridescence exist today. The olives at Beni Ulid form one of the largest and most southern aggregates of the culture, existing in the Mediterranean. Their existence depends essentially on the flooding of the wadi (generally every 3-4 years) and the receipt of an enormous quantity of water and alluvium which is trapped by stone walls and barrages traversing the wadi bed. Something of an analogy is found at Nalut on the extreme west of the Jebel Nefousa where rainfall is practically insufficient for the olive, although the altitude constitutes a climatic corrective of some importance. Here, there is a compromise between dryland famming and irrigation, in the sense that the moisture factor is enhanced by the particular method of erecting large soil barriers surrounding the foot of each tree. Thus the tree, which is situated in the centre of this unpluvium, benefits from moisture over an area of 100-300m^2. This wide distribution of the olive is in the first place due to the physiological adaptability of the tree to a variety of rainfall, soil and topographic conditions. Secondly to the economic system and stability of settlement.

The demands of the tree are small. It grows well on limestone soil of moderate fertility, suffers from cold winds and frosts, and flourishes in regions with relatively mild, moist winters and hot dry summers.

Whereas in the Northern Mediterranean lands the natural limits of the olive are defined by low winter temperatures, as for example, in Greece, where the limits of the culture coincide with the - 8°c minimum isotherm[38] in the Southern Mediterranean countries, the limiting factor is summer aridity.

Thus, the natural limits of the olive, under dry farming, mark the definite transition from those areas typically Mediterranean to others decisively Saharan. Usually this limit is taken as the 200 mm's isohyet, though, as we have seen this boundary is very arbitrary. Beyond this limit, however, only the assurance of irrigation from surface or underground water can maintain the tree's growth and productivity. The southern slopes of the Jebel and the steppe zone behind Zliten and Misurata, as yet, utilised extensively, are by no means unsuitable for the olive. Whilst the Dahar sites are exposed to the southerly winds, the light Hamra soils at the heads of southern thalwegs, especially, compensate forthe marginality of rainfall. The construction of cisterns and tanks would facilitate the extension of arboriculture but only by the construction of wells and the stabilisation of the population could any long term achievements be gained. Behind Zliten the middle wadi basins are well protected and offer more attractive sites for the extension of arboriculture.

The altitudinal limits for the olive are generally much higher in North Africa than the Europeam countries by virtue of the fact that an increase in altitude, depending on proximity and orientation to the sea, compensates for the greater aridity. In Europe the greatest altitude reached is 1,000 metres on the Sierra Nevada in Spain, but most of the groves are found below 500 metres. Olives spread up to 1,500 metres in Africa, and in Tripolitania the highest levels at which olives are grown is about 800 metres [39] (CAF TIGRINNA - 837 metres).

Most of the trees are found below 300 metres, on the well aerated hillsides and plains of Msellata, and the lowland plains of the Jefara and Misuratino. From the pointof view of natural oil quality the most favourable locations are the protected hillsides and plains of the Jebel where the lower humidity prevents the development of harmful insects and diseases. These sites are also less exposed to the enervating Ghibli whose progress over the interior of the Jefara and the Misurata is unhindered.

Productive Cycles of the Tree

The biological cycle of the olive consists of four phases:

(i) unproductive, (ii) productive, (iii) maturity,(iv) decline.

The length of the phases and rapidity of change have obvious economic consequences to the farmer and ultimately national production. A long unproductive phase inevitably produces a strain on capital resources whilst production can only be maintained by an equilibrium being established between the number of potentially bearing trees and those going out of production.

At the latest census [illegible] of tree crops in 1957, 66% of olive trees were in production compared to 50% in 1955. Whilst the gap between productive and total trees is still wide and enhances further production, this is likely to come from the Italian section of the farming community, who own 66% of all the trees. The majority of Libyan owned trees were in full production (72%) but the productive Italian trees formed only 33% of the total (Fig.18b).

Throughout the year the olive has four principal phases of vegetative growth. (i) Rest in winter, (ii) Budding and flowering - end of winter, beginning of spring, (iii) Development of fruit during summer, (iv) Maturation of the fruit at the end of autumn - beginning of winter.

In Northern Tripolitania the olive usually flowers in March, fruits in April and matures in October. This cycle is generally a month later on the Jebel than the coast because the onset of summer is retarded.

The olive grows well in a thermic regime in which calorific factors gradually augment from spring to summer, diminishing in autumn. In Northern Tripolitania, especially on the coast and Jefara the useful period of development is prolonged whilst in more northerly latitudes this period diminishes because of low winter temperatures. In consequence the dimensions of the tree decreases and the capacity for using soil and water resources is lower. On the other hand the cycle of fructification is more brief. In Tripolitania the high summer temperatures and summer drought prolong the development of the fruit. Since the tree lacks a pronounced rest in winter, except in the higher surfaces of the Jebel, it becomes particularly susceptible to the vagaries of rainfall and sustained drought.

In a particular way the olive is exposed to brusque changes in temperature which can cause the greater expansion in the movement of cellular liquid. This results in a higher transpiration and concentration of sugar and this can profoundly alter the equilibrium of the plant. When the range of temperatures reaches an extreme character, as in the desert oases, the plant continues to live but cannot yield a crop of fruit.

Temperature equivalents for the olive are difficult to establish because of the intervention of such factors as relative humidity, winds, soil moisture and the duration of temperatures. It is generally held that the plant suffers if maximum temperatures exceed 36-38oc or fall below -7 or -8oc (40)

But maximum temperatures for the olive would appear to be high. The olive groves of Beni Ulid have already been cited (p.). Here maximum temperatures of 50°c are normal. Another outstanding example, typical of the olive's resistance to high temperatures is offered by the plantations in the Jefara at Azizia. During summer maximum temperatures oscillate around 50°c and in 1932 an extreme temperature of 56°c was recorded.

Briccoli[(41)] states quite categorically, however, that where average temperatures exceed 32°c and 36°c during the months of flowering and fruit development then the tree's physiological balance can be disturbed. Throughout most of the olive growing areas in Northern Tripolitania these temperatures are rarely exceeded except when a GHIBLI blows. The consequences of this wind have already been discussed in some detail (p.). In the coastal areas the olives are sheltered from its full effects by the density of the tree crops but in the level steppe areas where the density of planting is lower, unless measures are taken in the form of wind breaks, the effects are deleterious.

In the opinion of Caruso [(ibid 39) p.233] the lowest temperature in winter, in order not to produce serious damage to the tree, should not fall below -7 or -8°c and not to be prolonged for more than 8 days.

Whilst minimum temperatures are rarely so low or prolonged, in the growing areas, so as to cause the mortality of the tree, the upper valleys in the Central Jebel and hill floor areas obviously suffer from diurnal changes in temperature. Young trees are especially vulnerable. During the harvest, which may extend from October to February, temperatures below freezing point are dangerous to the fruits; the pulp loses its natural colour and oil content is lowered. If only for this reason it would be advisable, especially in the Jebel for harvests to be completed before the lowest winter temperatures in December and January are experienced.

Fundamental amongst the climatic factors which condition the culture of the olive is rainfall, the most variable and precocious of climatic elements in this region.

The rainfall most suitable for the olive rarely surpasses 1,000mm's in the Mediterranean basin: more often it oscillates between 3-600mm's in the western climatic sector (Spanish coast), 4-800mm's in Morocco and Algeria; between 6-900mm's on the French and Italian olive growing areas; and between 2-500mm's in Tunisia and Libya (ibid 40).

On the basis of annual rainfall in relation to olive crop expectation, the following results were obtained. (Fig.20, Table 28).

TABLE 28.

YIELDS OF DRY FARMED MATURE TREES ACCORDING TO RAINFALL

Over 300mm's	Good crop	75 kgs. per plant
" 250 "	Fair crop	25-50 kgs. per plant
150 - 200 mm's	Poor crop	25 " " "
150 mm's	No crop	-

Much the same results were obtained by a study done in Tunisia (Table 29) for mature and healthy olives grown under optimum soil conditions.

TABLE 29.

Olive oil yield	Annual rainfall/or irrigation	Oil prod.((Kgs. per ha.)
Irrigated lands*	800 mm's	1,200
N. Tunisia	600-400 mm's	800-400
Sfax	200 mm's	300

If average rainfall conditions prevail only a small proportion of the total olive growing area produces a good crop (Fig.20). Three centres of production stand out, Zavia - Tripoli - Suani Ben Aden, Msellata and Garian.

The relationship between labour costs and requirements has been worked out by Morgantini (ibid 15) From the 1st - 6th year after planting, animal and man days labour are low. After establishment the tree requires little maintenance until the 7th year. But after the 14th year, when it is assumed that the tree has reached an economic bearing stage, man labour day requirements increase rapidly, as a result of the high labour demands at harvest times. Therefore the tree becomes increasingly labour intensive during period of full production although the labour units required for the perennial tasks of cultivation remain relatively stable.

One cannot estimate accurately the ages at which a tree passes through these productive phases since even old trees

* Under irrigation oil yield is increased regardless of olive crop.

yielding little, can be reconstituted by pruning and fertilisation. Especially uncertain are the periods when the olive begins to produce fully and when it declines since they are influenced by cultural techniques, the suitability of site and the care in cultivation. However some comparative data exists (ibid 39) According to Morettini in central Italy this cycle for dryland olives is divided into:-

(a) 1-12 years unproductive.
(b) 12-50 years increased production.
(c) 50-150-200 years maturity.
(d) 150-200 years declining production.

Thus the production of the olives grows until the 50th year, then remains stationary between 150 and 200 years, and finally declines with the ageing of the tree.

In comparison to the almond and citrus fruit trees which only yield for a period of 20 years the olive has an intrinsic advantage. A rough indication of the yields of olives to be expected during the productive phase is given by data obtained from observations made at Sfax in Tunisia. Rainfall (200mm's) and soil conditions are very similar to those found on the Jefara.

TABLE 30.

Average Returns from olive trees at Sfax 1898-99.

10th year	40	litres	olives
15th "	70	"	"
20th "	100	"	"
25th "	120	"	"

The productive phases of local olive varieties was estimated by Morettini in 1914 to be as follows:-

1st fruit - 3-4-5 years after planting.
Full fruits - 10 years " "
Up to 60th year full production.
Declining production 60-100 years.

It would appear that the olive derives some benefit from the thermic regime of Tripolitania since it enters into full production at an earlier age than Central Italy. The productive period is also longer. Many of the olives found today in the Jebel are reputed to have been planted by the Romans. This in itself is testimony of the favourable conditions for the olive. Under irrigation of course the tree can begin economic production as early as the 7th or 8th year after planting.

Rainfall is best distributed with the greater part during the period of development of the fruit and diminishing towards the end of fructification. Briccoli(41) has established certain rainfall equivalents for the olive. His computation is based on the vegetative periods of the olive and equivalent meteorological elements. In his opinion it gives an idea of the meteorological values corresponding to the empirical phenomena defined by the terms, drought, humidity, excessive cold and excessive heat.

(1) From February - April the lack of moisture comes to be felt if precipitation falls below 60 mm's for the 3 months. Briccoli determined an optimum value of from 90-120 mm's.

(2) May - June. Drought phenomena is experienced when rainfall is below 15 mm's. monthly.

(3) July - August are the critical months for the olive when rainfall is negligible.

(4) September - October. Two phases can be distinguished - waiting and recovery. In the period of waiting 30mm's rain is the minimum and 50 mm's is the period of recovery.

The period of rainfall deficiency is well marked in Tripolitania and extends from March to October. Since the rainfall season is later on the steppe and Jebel (p.) the impact of drought conditions during spring is not normally so great as on the coast. The olive appears to be well adapted to winds and drought - the leaves are small and leathery and have a comparatively thick cuticle on the upper surface that tends to restrict the loss of moisture. On the under surface the leaves are protected by a mass of peltate hairs, and are apparently uninjured by long periods of hot weather and dry soil conditions. But under drought conditions in the critical spring period of growth the subsequent crop can be seriously impaired. If the drought is prolonged the trees may be damaged. Whilst the conditions of drought cannot be controlled they can be alleviated by the choice of soils with high infiltration rates and storage capacities, and frequent cultivations of the soil; also by the siting of trees where irrigation from surface or underground water can be applied.

The heavy rains in November and December, the months of high precipitation in Tripolitania, tend to lower the oil yield and fill the fruit with water. Out of season winter rains can cause premature blossoming and falling of the fruit before it reaches maturity.

The increased olive planting carried out by the Italians has failed to eliminate the characteristic annual fluctuations in the production of olives. (Compare Figs. 23 and 24). During the 30 years 1928/9 - 1956/7 annual production only exceeded the mean on 10 occasions. Generally a good crop is succeeded by a poor year and occasionally a succession of poor years. The variability in the olive crop is a well marked feature in all Mediterranean countries especially in the areas where olives are a dryland crop and thus exposed to a highly variable rainfall both in time and space. About 77% of the total area devoted to olives is dry farmed (140,000 hectares).(43)

It is generally agreed that the causes of alternating production are manifold being a function of the intrinsic physiological and biological character of the tree in relation to the external factors of the environment under which the tree is cultivated - climatic, edaphic and biotic.(ibid 39) In a high rainfall year the production of a good crop seems to exhaust the reserves of the tree. The failure of the flowers to grow is normally attributed to deficient rainfall or interspersed winds, whilst drought summers and parasite

Table 30.

Production of Olives and Oil 1927-28 to 1957-58 in relation to annual rainfall amounts.
1949-50 = 100.

Year	Prod. Olives Metric Tons	Prod. of Oil Metric Tons	Rainfall mms.	% Olives	% Oil
1927-28	8,000	900	202	16	11.25
1928-29	8,000	1,000	385.7	16	12.5
1929-30	35,000	3,000	275.3	70	37.5
1930-31	4,000	500	298.1	8	6.25
1931-32	25,000	2,500	359.7	50	31.25
1932-33	23,000	800	589.1	46	10
1933-34	8,333(Est)	1,500	323.3	16.6	18.75
1934-35	14,000(Est)	2,800	404.0	28	35
1935-36	4,500(Est)	900	182.8	9	11.25
1936-37	11,500	2,300	276.9	23	28.75
1937-38	250	-	468.3	5	-
1938-39	19,700	2,700	479.3	39.4	33
1939-40	5,000	800	207.3	10	10
1940-41	9,000	1,600	357.4	18	33.75
1941-42	12,000	1,800	235.3	24	22.50
1942-43	25,000	3,400	265.1	50	42.5
1943-44	10,000	1,200	594.6	20	15
1944-45	20,000	3,300	368.4	40	41.25
1945-46	13,000	1,800	430.2	26	22.50
1946-47	5,500	616	376.7	11	7.7
1947-48	6,500	936	141.6	13	11.7
1948-49	10,000	1,500	511.8	20	18.75
1949-50	50,000	8,000	400.1	100	100
1950-51	40,000	7,000	273.7	80	87.5
1951-52	30,000	5,000	314.9	60	62.5
1952-53	5,000	1,000	260.7	10	12.5
1953-54	40,000	6,500	379.1	80	81.25
1954-55	10,000	1,800	402.2	20	22.5
1955-56	11,000	2,500	263.2	22	31.25
1956-57	10,000	2,000	355.8	20	25
Average	14,340	2,288.4			

Table 31.

Production of Olive Oil by Provinces
(Metric Tons).

Year	Tripoli	Western	Eastern	Central	Total
1944	80	740	1,000	180	2,000
1945	600	700	500	200	2,000
1946	300	150	200	42.4	692
	Tripoli & Western				
1947	811		125	-	936
1950	3,000		4,000	700	7,700
1952	300		500	200	1,000

attacks cause the fall of the fruit.

It is rare also that the same conditions prevail in the same year throughout Tripolitania. The contrast between good and bad years throughout Tripolitania is seen in years 1947/8 - 1949/50. Severe drought occurs when rainfall at Tripolitania is only 141.6mm's. This disturbed the production of the following year even though rainfall was high. But in 1949-50 with high rainfall production was exceptional (Table 31). Although production in the west coast and Jefara is relatively constant, a good rainfall year brings high yield from olives in Jebel and east coast (Table 32).

It is not easy to eliminate this phenomena, which of course has repercussions on the stability of the whole oil industry. By increased plantings or the reduction of the dry cultivated olives and the increased attention to the tree this can be ameliorated.

Climatic conditions noticeably influence the chemical content and commercial suitability of oil in the olive. Although this can be modified by the selection of appropriate varieties, and by rational cultural and harvesting operations. The oils of the southern Mediterranean regions are generally more fatty, more rich in solid glucerides whilst in the colder northern areas are less greasy and more rich in liquid glucerides. As a result the oil of the southern Mediterranean countries requires considerable demargarinisation before it becomes acceptable to consumers in the Northern

Mediterranean who are not accustomed to this type of oil.

The damage caused to the trees by such phenomena as frost, hail, mist, diseases and insect pests influence ultimately crop production. The effects are not easy to measure accurately. On the basis of random samples a rough estimate of trees injured, on an average, each year have been made by the Department of Agriculture in Tripolitania.

TABLE 33.

Injury to olive trees caused by climate, pests, diseases.

Climatic damage		Region		
Frost		Jebel, 10% each year.		
Hail		Rare in all areas, 2% each year.		
Mist		In all regions 15% each year.		
Diseases:	Fungi	Nil		
	Bacteria) Virus)	Central and Western Jebel) and Tripoli zone)		10% each year
Insects:	Euphyllura Olliuina, everywhere		50%	every 5 years.
	Dacus oleae -	Under irrigation	20%	each year
		Coast	5%	" "
		Jebel	1%	" "
	Rodents	Everywhere	1%	" "

The damage caused to the trees by climatic phenomena is not considerable and affects mainly the young non-bearing trees. The development of diseases and parasites is dependant primarily on climatic conditions[44] but also on the cultural conditions; some varieties are particularly subjected to attacks of cancer. The absence of care in cultivation and pruning also favours the development of these diseases. The care of the trees and pruning tends to decrease in isolated areas and generally amongst Libyan farmers. Even in some of the best agricultural areas of the coast there is neglect. In the Zavia area of 70 selected Libyan farms only 22 asserted that they pruned their trees and then only every 3-4 years. Bushy plants are particularly susceptible to the attack of Psilla, cochineal and cancer, because of having trapped excess humidity in their crown. Physiological deficiencies result from a lack of care, non adaptable varieties or rainfall deficiency.

The dryland cultivation of the olive is almost perfect where the mean rainfall is 200-300 mm's and the major factor in the failure of the olive to blossom is one of nutritional deficiency.

The most dangerous insect in Northern Tripolitania affecting the olive is the Dacus Oleae, which attacks the fruit and causes it to fall prematurely. It was widely known in the Mediterranean in antiquity, as Pliny mentions it in his writings. Depending on the region and the year it may destroy the total harvest. It also diminishes the quantity and quality of oil extract. The olive fly is a species which develops when climatic conditions permit. Usually in regions with cold winters the larva hibernates in the ground. This is the case in the Jebel and semi-desert, but the mild winter and high humidity in the coastal area permits the rapid development of the fly; it is generally hatched in March and spreads through the orchards from May to July. In the coastal belt there are usually two periods of flight, February - June, and August - December. Winter born flies are less important because of the summer heat and drought. The onset of the Ghibli also effectively combats their activity during these periods. Because of climatic conditions and density of crops, the fly is endemic on the coast but can rarely maintain itself for several successive seasons in the steppe or Jebel. (Fig. 21).

Measures to protect the tree involve the application of DDT to the trees but the scattered distribution of the culture, the lack of knowledge and inspection amongst Libyan farmers prevent any systematic campaign being carried out. Taking once more the evidence obtained in the Zavia area of 70 Libyan farmers only 1 farmer reported the control of insects and plant diseases. Of 70 Italian farmers 20 replied in the affirmative.

Olive tree varieties.

The essential problem of the most suitable olive varieties to be grown in Northern Tripolitania is still under discussion and investigation. The length of time it takes an olive to come into production is a great handicap in experimental work. Moreover until recently there was little control placed upon methods of reconstituting and planting orchards. In fact the choice generally lay with the individual farmer and his assessment of the quality of the diverse varieties. Of great importance is the suitability of introduced Italian varieties under the prevailing ecological conditions in Northern Tripolitania. It seems evident that many of them are unsuited to dryland cropping.

The olive varieties may be classified according to origin.

(1) Local varieties.

Of these the most important are Enduri, Gargasci, Zabbugi, Krusi and Chemlali. (Plate XXIV). These are dominant in the traditional Libyan gardens. They have a small fruit, are late maturing and apparently very productive. Rasli is the prevailing variety in the Eastern Jebel; it gives a medium sized fruit and is late maturing. Some of the Zarrasi variety is found in all Libyan gardens but yields best results and a medium sized fruit in the Eastern Jebel. Rughiani is common to the Tripoli District and Zavia area.

(2) Varieties introduced from Tunisia.

Since 1926-7 when Italian farmers brought Chemlali cuttings from Sfax this variety has become increasingly popular and utilised mainly to graft unproductive trees. Not unnaturally it is most widely diffused in the west coastal zone where cultural contacts with Tunisia have been strong (Plate XXV).

(3) Italian varieties

The Italian varieties were imported during the Italian administration; they comprise Frantoio, Moraiolo and Leccino from Tuscany, Piangente and Coratima from Apuglia and Sicily. (Plate XXVI a & XXVI b)

Frantoio and Coratina are most common in the coastal belt but the former has been so successfully adapted to conditions in the Jebel around Tarhuna that farmers multiply it themselves.

In addition to these cultivated an unknown number of wild trees are scattered over the Jebel. Very little use is made of these trees except for firewood as they yield a small fruit with little pulp.

In commercial olive cultivation the main emphasis is placed on economic returns of the variety which depend on three factors;

(1) Quantity and quality of the production.
(2) Oil yield of olives.
(3) Organic qualities of the extracted oil.

As well, the size of the drupe and the relative ease with which it can be detached from the peduncle must be considered.

Of the 2-3 million olive trees planted by Italians Marroni(45) estimates half should be grafted. He regards the question of variety one of the most decisive factors of economic yields.

TABLE 34.

Variety Oil	Weight or size of one fruit	Yield % by weight	Resistance to fly	Productivity
Enduri	1-1.5 grm's	18-25	5	5
Rasli	1-2.6 "	20-25	4	4
Rughiani	1-5.2 "	15-20	3	2
Frantoio	2-2.5 "	20-28	2	2
Chemlali (Sfax)	1-5.2 "	18-25	4	4

5-very high, 4-high, 3-medium, 2-poor, 1-very poor.

Table 35

Variety	Region	Syst. of cult.	Age Tree	% oil extracted, by weight
		Italian Varieties		
Frantoio	Tarhuna(J)	Dry cult.	?	D 24.56 - 1956-7
"	Coast(C)	" "	"	D 21.3 - 1957-8
"	Azizia(S)	" "	"	D 25.65 - " "
"	Suk es Sebt(S)	" "	10	D 21.98 - 1937
"	El Maia (coast)	" "	9	D 23.34 - "
"	Collina Verde(C)	Irrig.	9	I 24.23 - "
G.Garribulli	" "	Semi Irrig.	9	I 29.10 - "
Coratina	Azizia(S)	Irrig.	?	I 15.67 - 1956-7.
"	Saiad (Coast)	Dry cult.	"	D 19.90 - 1957-8
"	Azizia (S)	" "	"	D 26.72 - " "
"	Collina Verde(C)	Irrig.	9	I 22.62 - 1937
Piangente	Azizia (S)	"	?	D 19.82 - 1956-7
"	"	Dry cult.	?	D 10.24 - 1957-8
"	Saiad (Coast)	" "	"	D 24.30 - " "
"	Suk es Sebt	" "	10	D 17.50 - 1937
"	El Maia(Coast)	" "	10	D 20.43 - "
Moraiolo	Azizia	Irrig.	?	I 7.77 - 1956-7
"	Tarhuna	Dry cult.	"	D 30.85 - " "
"	Azizia	" "	"	D 20.56 - 1957-8
"	Saiad(Coast)	" "	"	D 20.80 - " "
"	El Maia "	" "	10	D 24.73 - 1937
"	Collina Verde	Irrig.	9	I 29.0 - "
Leccino	Tarhuna	Dry cult.	?	D 23.16 - 1956-7
"	Azizia	" "	"	D 19.28 - 1957-8
"	Saiad(Coast)	" "	"	D 16.26 - " "
"	Suk es sebt	" "	10	D 21.75 - 1937
"	Collina Verde	Irrig.	9	I 26.01 - "
		Local Varieties		
Enduri	Tarhuna	Dry cult.	?	D 27.29 - 1957-8
"	Sidi Mesri	" "	29	D 16.56 - 1937
Rasli	Tarhuna	" "	?	D 24.82 - 1956-7
"	Azizia	" "	"	D 19.86 - 1957-8
"	Cussabat	" "	"	D 28.46 - " "
"	Sidi Mesri	" "	29	D 19.85 - 1937
"	Cussabat	" "	-	D 13.19 - "
Zarrasi	"	" "	-	D 22.79 - 1956-7
"	Tarhuna	" "	-	D 32.91 - " "
"	Cussabat	" "	-	D 30.25 - 1957-8
"	"	" "	-	D 23.55 - 1937
Krusi	Sidi Mesri	" "	-	D 19.79 - 1956-7
"	Guassem	" "	-	D 19.49 - 1957-8
"	Garian	" "	-	D 27.84 - " "
Gargasci	Cussabat	" "	-	D 29.40 - 1956-7
"	"	" "	-	D 28.90 - 1957-8

Table 34

Italian varieties are, on the whole, larger and easier to pick. They compare favourably with the local varieties as regards yield in oil but their resistance to the DACUS OLEAE and productivity is considerably lower. Whilst the Chemlali from Sfax is only a medium sized fruit it contains a relatively high yield of oil and is highly resistant to insect attack.

Table 35

Although the data is admittedly very inadequate, in duration of experimental results, and is dependent on several varieties certain useful facts emerge.

The highest yields in oil are obtained in the Eastern Jebel with local varieties (Rasli) Most Italian varieties seem adapted to conditions in the Eastern Jebel and yield well under dry cultivation. Local varieties yield less well in the steppe and coastal areas. However, Frantoio under irrigation, yields exceptionally well at the coast.

In general local varieties are more adapted to climatic conditions and produce more regularly but the size of drupe is small and adds to the difficulty of harvesting. They encourage the malpractice of beating the tree at harvest time.

The Frantoio variety constitutes something like 60% of the plantations in the Jefara and coast but seems to require irrigation to be truly successful.

In terms of oil quality the Italian varieties have a lower value of solid fatty acids, whilst the higher values for Enduri and Rughiani makes them less adaptable from a commercial point of view.

Another aspect of the differing importance of varieties is that recent research has shown the existence of allogamons (which cannot fructify without the pollen from other varieties), and autogamons (which are self fecundated) although they may benefit from cross fecundation.

On the authority of S. Bresciani (Dept. Agric.-Cyrenaica) the following table was compiled:-

TABLE 36.

Variety	Self fertile F " sterile S	Suitable pollinator.	(Frantoio t (Pendoline p (Moraiolo m (x-any of varieties quoted
Frantoio	F		
Corregiolo	S	t	
Leccino	S	mtp	
Moraiolo	S	mtp	
Piangente	S	t	
Coratina	F		
Chemlali	F		

Regions of olive cultivation

Since annual rainfall is highly variable in quantity and distribution it would be an oversimplification to define the olive cultivation regions by means of isohyets. Moreover the effectiveness of rainfall is influenced by topography, soils and evaporation. Therefore, in an attempt to obtain a more accurate definition of the climatic exigencies of the olive it is proposed to subdivide the region according to the intensity of existing olive cultivation and the potentialities of planting areas for the growth and fructification of the tree. Thus, such factors as number of trees, density of plantation, health of trees, type of cultivation (mixed or specialised cultivation) and yields are relevant to the exposition. But, it is impossible in many areas to treat the analysis statistically. The statistics department of Tripolitania is in its infancy and has to contend with such problems as an unresponsive rural population, confused land rights and approximate administrative boundaries. In consequence much reliance has had to be placed on personal observation and on the spot enquiry, in an attempt to supplement and bring up to date the existing literature which remains unco-ordinated and sometimes inaccurate.

Owing to the vast size of the territory and the lack of good secondary roads several areas were traversed only superficially by the author. These included the Western Jefara, interior parts of the Eastern Jefara, and the steppe zone of Misuratino. With these exceptions most of the olive growing area was inspected. Traverses were made the whole length of the coastal plain, from the Tunisian border to Gioda, across the Jefara from Tripoli, through Azizia and Garian to Beni Ulid, and along the northern edge of the Jebel from Homs to Nalut and south to Ghadames. It is significant to note that Libyan farmers in the Homs - Misurata zone and Garian were less hospitable and reluctant to impart information than those of Cussabat and the western coastal plain. Broc(23) found the same at Cussabat and he says 'the inhabitants are very pleasant and it is surprising to notice their evolution and agricultural knowledge. They only wish to learn and are very keen.' Italian occupation and a Berber heritage would appear to be responsible for the reticence of the people in the former areas.

Coastal Belt (Fig. 22).

The coastal plain is homogenous from the point of view of climate which approaches most closely the Mediterranean type of climate; the optimum environment for the olive. But the distribution of olive cultivation, although the most continuous in the region, is notably irregular. Rainfall is generally adequate although it approaches the limit of 200mm's for dryland cropping on the eastern and western extremities. Minimum and maximum temperatures are rarely so high or low as to produce a strain on the vegetative growth of the olive except in times of Ghibli. Farmers in the coastal plain attributed the long unproductive period of their trees to salty maritime winds (Farm Sample 8). But the effect of the winds only extends a few kilometres inland. Rarely are olives planted near the shore even though soil conditions are favourable. Usually the cultivable lands are devoted to salt tolerant palms or herbaceous crops.

The low lying nature of the land, combined with the high humidity and density of crops, especially in the Tripoli-

Zavia stretch noticeably affects the health of the olive. As we have seen the fly DACUS OLEAE is endemic to this area.

Topographically the region presents few problems for the olive, except where the encroachment of sand dunes is extensive. The saline expanses also limit the area suitable for cultivation. Where, however, these harmful salts are leached by irrigation or seasonal rainfall, the tree is not seriously affected.

The otherwise favourable soil and climatic conditions are enhanced by the presence of underground a~~c~~quifers, superficial and artesian but the best quality oil and crop yields are generally obtained in the high rainfall zones (Fig. 20). Thus in the marginal rainfall areas available irrigation water is commonly reserved for the herbaceous crops and palms even though the olive requires little water and has a relatively high degree of tolerance to harmful alkalis.

The olive is cultivated ubiquitously in the east and west coastal plains by both Italian and Libyans. Tree densities per hectare of cultivated land range from more than 50 in the Italian plantations to less than 20 in many of the Libyan gardens. Nevertheless these densities are generally higher than elsewhere in the territory and in many cases are well above the average for the country. This average is about 30 trees per hectare for groves of pure stand and only 20 trees per hectare for those in mixed stands. In 1944 the east and west coastal plain accounted for 19% and 42%

respectively of the 3,381,000 trees existing in Northern Tripolitania. Throughout the coastal plain, with the exception of the oases of Tripoli and Zuara, olives come second only to palms in total number of tree crops cultivated (Fig.19)[Table 37]. But this proportion varies between Italian and Libyan farms. On the latter the olive, except in local instances, is the basic crop especially where irrigation is limited.

By far the greatest number of trees are still owned by Italians. In 1937 (the latest available information on Italian Concession) their olive plantings numbered 1,029,422 trees. This total amounted to 55% of the total trees on Italian concession in the west coast plain from Gasr Chiar to Zuara and less than 7% on the plain from Homs to Misurata. Of the 445,967 olive trees on Italian collective farms in 1954 about 19% and 14% were distributed in the west and east coastal plains respectively.

In the best rainfall zones, where irrigation is possible, cropping is intensive (Plate XXVII). In the small Libyan gardens the olive is cultivated alongside palms and fruit trees which shelter the more delicate fodder and vegetable crops. This agricultural system reflects not only the natural fertility of the region but also the subsistence nature of much of the agriculture.

Most of the Libyan olives and those on the early developed Italian concessions are in full production, but only 60% on the Italian demographic settlements have reached maturity.

Sub Regions

(a) Tunisian border - Mellita

From the Tunisian border to Mellita the area devoted to sedentary cultivation is limited and dispersed. Here the coastal plain forms a depression mostly below 20 metres with an average width of 5 kms. between a marine dune coastal facade and a broken line of continental dune formations. The cultivated land is scattered to the north and south of the sebka lowlands, in the oases of Zuara, Zelten, and El Argab. El Assa lies almost within the semi-desert area. Soils are mainly sandy and very susceptible to wind erosion. The encroachment of the dunes is evident even in the town of Zuara and many gardens were seen to be abandoned in the southern oases. The low value of the land is reflected in the substantial areas utilised for military training purposes. Everywhere rainfall is low, generally about 200 mm's. Water supply is limited both in distribution and quality. The oases amidst the dunes derive some benefit from rainfall percolation. For the most part, olives are found in dry gardens. The total number of bearing olives is about 17,744 concentrated mainly at Zuara and Regdaline. But the palm is the foremost tree crop.

The whole area has a retrograde character and is definitely marginal for olive cultivation. Crop expectation is low; it is estimated that there is one good crop in every four years and in 1957-8 the average returns per tree was only 18 kgs. olives.

The best areas for the extension of tree cropping would seem to be south of the dunes, which are now shifting cultivation and grazing lands - but such developments would depend on the provision of wells. More could possibly be done by improving the existing orchards.

(b) Sabratha - Zanzur.

In comparison to the previous region this area has a more fertile aspect. The same physiographic divisions are present except that the area of salt flats is smaller and rarely found east of Zavia. Except in the vicinity of Sabratha, dunes give way to a rocky coastline. Rainfall augments from west to east 200-300mm's. The decline in rainfall south of the coastal plain is not so rapid as at Zuara. The undulating Jefara extends almost 50 miles south of the coastal belt which is marked by the limits of cultivation. South of Zavia the cultivated area extends for 5 kilometres, where it gives way to grazing and shifting cultivation lands.

The region comprises the Libyan oases of Zanzur, Garguza Tuebia, el Mattred, Sorman, Zavia and El Agelat. All except El Agelat are situated in flat depressions surrounded by numerous Italian concessions and the Demographic settlements of Olivetti, Hascian and Maamura (now Libyan). These occupy the gently undulating terrain rising to the north and south of the depressions. The area of rock outcrop is small. Together with the extreme dune areas this forms the land least susceptible to cultivation. Soils are mainly sandy and sandy loams, but at Agelat they become increasingly saline. Wind erosion is something of a problem but many areas of light sand have been colonised with Acacia and eucalyptus. These were seen to be growing well 23 kilometres south of Zavia. The area is blessed with a good water supply, and the construction of many new wells exploiting the first water table was observed near Sorman.

The proportion of olives to other tree crops increases markedly over that of Zuara (38% of all trees olives).

Total olive trees:	85,522	Libyan
	64,265	Italian Demographic Farms
	351,335	Italian Private Concession Farms

The olive is the predominant tree crop on Italian farms. On 70 of the Italian farms, olives accounted for 74% of all tree crops but only 42% on a corresponding number of Libyan farms.(ibid.33)

Crop expectation is reasonably good for the area - 2 years good, 2 poor and 2 average. Little information exists for crop yields, but between 1957/8 these varied from 10-25kgs. per tree for dryland olives. The existence of abundant water adds to the natural quality of the soil. However, there is frequent damage to the crop from the Dacus Oleae. The presence of a good water supply to the south and the favourable rainfall would allow some expansion of olive cultivation, where now, a precarious crop of cereals is obtained.

The Oases of Tripoli

Between Zanzur and Tagiura the coastal plain widens and a belt of intensive cultivation almost unbroken extends inland for 10 kilometres (Plate XXVIII).

Thereafter the cultivable area extends in tentacles to Suani Ben Adem where the surrounding dune formations are discontinuous. Lying twenty kilometres south of Tripoli, Suani Ben Adem can be said to mark the boundary of transition between the coastal plain and the true steppe lands.

The Libyan gardens, which immediately surround the city of Tripoli, cover an area of 5,244 hectares and contain over 55,000 olives (11 trees per hectare). A further 690,000 trees belonging to Italians are grown outside the Libyan nucleus.

The region is favoured by a high rainfall, an irrigation surplus and proximity to Tripolitania's largest urban market - Tripoli City. In consequence olives are of secondary importance and fruit trees, predominantly citrus, are highly valued.

Extensive colonisation by acacia plants of the dune areas to the south have reduced the threat of wind erosion and the suitability of the olive trees is indicated by the great dimensions which they reach (Plate XXIX). However, the density of cropping is conducive to pest attack.

Tagiura - Gasr Chiar

This long tract, from the Tagiura to the foothills of the Jebel at the Wadi Ramle, is distinguished by limited distribution of cultivated land even though rainfall and humidity are not unfavourable. Morphologically, this area is diverse; large stretches of the coastal belt are formed by marine dunes, partly fixed. Inland, continental dune formations are extensive. The area is deeply incised by wadis gushing from the Jebel and towards the east, soils are formed by outwash fans. Much of the area is undulating and large flat topographical units only occur around Garabulli and Gasr Chiar. Here, soils are deep and apparently very fertile. The area is sheltered from the full effects of the southerly winds by the Jebel escarpment.

Water supply is not so favourable. The water table is deep and yields are low. Libyan gardens and olive groves have sprung up at watering points along former caravan routes whilst Italian farms are strung out along the main Tripoli - Homs road. Most of the olive plantations are dry farmed.

Crop expectation is high - 9 years good, 3 fair, 1 poor - and damage from pests and diseases to the trees is negligible. Depending on water supplies there seems to be ample opportunity for the expansion of arboriculture. A start has already been made and several new Libyan gardens had been established close to Gasr Chiar (Farm sample B.)

Homs - Wadi Caam

The coastal plain east of Homs to the Wadi Caam is narrow and comprises an area about 2,500 hectares. The area, settled and cultivated, varies in width between 50 and 2,000 metres and is concentrated predominantly in the oases depressions. At the coast, marine sands, limit cultivation. South of the oases a featureless plain, extensively utilised, provides a sharp contrast to the oases areas; this is backed by a small scarp feature (Fig. 23).

In the oases water is of a good quality and reached at a depth of 7-12 metres but rainfall is low. Olive trees, which number 14,000, are mainly intercultivated. Farmers complain of mists but at the same time report little Dacus infestation. Yields were much lower than those at Zuara (11 kgs. per plant 1957/58).

Farmers in the oases area utilise the interior plain largely for cereal cultivation and grazing but several olive groves are sited at the foot of the scarp where they benefit from a season of inundations. But the potentialities of this area for tree cropping has only been realised by Italian colonists. South-east of Homs extensive olive plantations (45,000 trees) are grown on the Italian Valdagno estate (Farm Sample) (Plate XXXI).

Zliten

This Libyan oasis is situated at some distance from the coast, between the confines of Gheran oasis and the Wadi Caam. The cultivated area resembles the shape of a giant jelly fish with numerous tentacles diverging into the southern hill zone where the scarp is broken through by wadis. In an area of about 18-20,000 hectares, the coastal dunes, tracts of sebka and superficial calcareous crust zones remain uncultivated. Rainfall is marginal for tree cropping but water supply for irrigation is found at depths of 10-20 metres. The olive is second to the palm and is noticeably relegated to poor soil areas beyond the reach of irrigation facilities. South west of Zliten several dry gardens have been abandoned.

Yields per tree are low (1957/8 - 2-7 kgs.) Except in the wadi beds of the piedmont zone the periphery of the oases is extensively utilised.

East of Zliten, the vigorous growth and care in cultivation of the trees on the Italian demographic concession of Garibaldi, stands out in marked contrast. Most of the 89,349 olive trees are dry cultivated on the gently sloping and flat light soil areas (Plate XXXII).

Misurata.

In an area of 9,000 hectares only about one fifth is cultivated. Marine dunes extend south and west from to the town of Misurata. West of the town, a prolongation of the main sebka to the south limits cultivation. Compact soils with a tuff surface and the salinity of the water supply are unfavourable to the olive and palms represent 90% of the trees cultivated. Rainfall is slightly better than at Zliten but the region is exposed to the southerly winds.

Some 10,131 olive trees are cultivated at an average density of 5 per hectare. Yields in 1957/8 were low (10 kgs.

per plant).

Before reaching the oases of Misurata there is a bifurcation turning to a large Italian concession. This plantation of 35,000 olives is situated below the broken scarp on suitable soils. Yields of 22 kgs. per plant were obtained in 1957/8. A few hillocks have been judiciously planted with pines and eucalyptus. Inland good soil extends for 10 kilometres after which the high interfluve areas rapidly become infertile.

Interior Plain.

The interior plain comprises the Jefara, the hilly steppe land and plain of Misuratino. Unlike the coastal belt olive cultivation in this zone is mostly a pioneer enterprise because its development after 1920 was mainly a result of the Italian expansion of sedentary agriculture into areas formerly utilised for grazing and cereal cultivation. This movement was facilitated by the discovery of the second water table and artesian supplies south of Misurata. Extensive olive plantations, an example of the monocultural system, characterise the margins of cultivation in the Jefara (Plate XXXIII). Libyan olive groves are scattered throughout the Jebel piedmont zone of the Eastern Jefara, on the lower slopes and upper wadi basins in the hill zone of Misuratino. In 1935 Libyan owned trees in the Jefara numbered only 2,000 (0.082% of total trees in Tripolitania). By 1944 Italian plantings had increased this proportion to 18% and the number of trees to more than 500,000.

The olive is the principal tree crop on Italian farms and most of the plantations are dry farmed. Yet where irrigation facilities exist, as at Bianchi, Micca, Giordani, Suani Ben Adem, C. Benito, Crisp and Gioda, olives located near the wells are partially irrigated and intercropped.

Cultivation is less intensive than on the coast and the planting distances of the mature trees is at least 20 metres by 20 metres. Phytosanitary conditions are generally good and excellent at Suani Ben Adem. However, wind erosion of the light soils of the plain is intensive and dune formations in some orchards are becoming a serious hindrance (Plate XVIII). In spite of this the olives appear to be thriving.

Sub Regions.

(a) Western Jefara: West of a line Zavia - Azizia - Jefren the increasing aridity, the presence of crustal soils and dune formations, in addition to the poverty of water resources are all factors limiting land settlement and tree growth. Rainfall is everywhere below 200mm's and without irrigation it is doubtful if the trees could withstand the summer drought and excessive temperatures.

Apart from economic and social considerations certain areas, in the opinion of Caswell (ibid 18) and Robb (ibid 15), do seem susceptible to sedentary agriculture. These extend in a semi-circle from the undulating Jefara south of Sabratha, east to Bianchi and south-west to Bir El Ghnem. The soils are structively adapted to the low rainfall and water has been found at depth. Shifting sands present a problem in the north. An experimental station has already been established near Bir El Ghnem.

(b) Central Jefara: Except for the mobile dune area, the Triassic rock outcrops, and lithosols of the Jebel piedmont, much of the area is intensively cultivated where the second acquifer has been exploited.

Rainfall is lower than at the coast, and fluctuates between 150-250 mm's; it decreases rapidly to the south. The land rises southwards to about 200 metres.

Over 400,000 olive trees are cultivated in this area and many have yet to reach full production. In response to rainfall the density of planting decreases from 30 trees per hectare at Suani Ben Adem to 25 trees per hectare at Azizia. The dimensions of the trees noticeably decrease southwards as conditions become more arid and wind exposure intensifies.

From the size of the trees and their productivity the southernmost cultivated parts at Azizia and Suk es Sebt appear to be a zone of challenge where the tree can resist and grow but yield poorly. At Suk es Sebt one farmer reports that it has taken 30 years for the olives to enter economic production (Farm Sample 10). Development to the south of Azizia would depend on irrigation. However, during the summer Ghiblis are frequent. The summer inferno is intense. This is confirmed by Leone (ibid 35) who says that 'the Jefara has a very good soil but the Ghiblis dictate the law'. Between the Jebel and Azizia no Roman remains have been unearthed; this may indicate that no agricultural utilisation of the land other than the cereal cultivation and grazing at the present had been effected in the past.

The peripheral zones of cultivation at Bianchi, Suani and Castel Benito could all be developed for the olive.

(c) Eastern Jefara. The Eastern Jefara is a very sandy region and very little known since it is served only by tracks. The inaccessibility of underground water has limited settlement and the intensity of wind erosion is very great.

(d) Hills and plain of Misurata.

Hill Zone of Misuratino. Climatically, this area corresponds to the drier parts of the Central Jefara, but from a morphological point of view it is less uniform. Italian influence here has been negligible. Rising sharply from the coastal plain a heavily dissected surface extends for some 50 kilometres to the south. Rainfall decreases rapidly from the coast and ranges from 150-200 mm's. Traditionally, the hill zone is an area of tree cropping, cereal cultivation and grazing. Clumps of olives are scattered over the lower hill slopes, and wadi heads where run off water can be concentrated (Fig. 24). Most of the highest parts of the interfluves are devoid of soil (Plate VIII) Densities are low and the area of possible expansion is limited.

The coastal plain extends south of Misurata between the

Sebka of Tauorga and the eastern flank of the hill zone. Rainfall is marginal for the olive, being less than 200 mm's, but artesian waters have permitted sedentary agriculture. On the two Italian demographic settlements of Gioda and Crispi over 75,000 olives have been planted. Most of them are semi irrigated and intercropped. Yields are variable depending on rainfall (average 1955/57 - 10 kgs. per plant). West of the villages the encroachment of dunes has forced the abandonment of several farms. However, between the villages an area of 1,000 hectares is capable of being further developed. South of Gioda conditions became extremely arid and cultivation is limited to wadi beds. The trees suffer from the Ghibli winds as the plains are very exposed.

Gioda has become almost a ghost village. The herbaceous crops, on which the farmers depended until the olives came into production, have suffered due to excessive salinity of irrigation water. The movement of families out of the area and abandonment of property has been a result of successive crop failures. Without careful cultivation these soils rapidly revert to their natural state. The oasis of Tauorga has a soil which is only indicated for the palm tree and no agricultural development of the olive can be contemplated where sea water infiltration is certain.

<u>Jebel Piedmont</u>. On the actual piedmont zone of the Jebel tree cropping is only possible where run off water from the scarp can be accumulated. Rainfall is low in the west and summer

temperatures offer little respite for the tree. Springs are brackish and palms are predominant in the small oases of Tigi, Scecsiuch and Giosc (Plate XXXIV). The best area which occurs at the foot of the Eastern Jebel is traversed by the wadis Megenin and Ramle. At present only a few scattered groves are found here.

<u>The Jebel</u>. Apart from a unique physical aspect the Jebel is differentiated from the coast and interior plains by its traditional village society and tree culture (Plate XXXV).

Roughly 65% of the 814,787 Libyan owned trees were grown in the Jebel in 1935 and were distributed as follows:-

270,000 in the Eastern Jebel.
68,335 in the Central Jebel.
195,000 in the Western Jebel.

Although Italian plantings raised the number of olive trees in the Eastern Jebel to 500,000, the Central and Western Jebel has suffered a regression. By 1944 olives grown in the Jebel represented only 21% of the trees in the territory.

Physical conditions are quite different from those at the coast. Mean annual rainfall varies between 100-325 mm's and is more intense. Fifteen-twenty kilometres south of the scarp rainfall is marginal for tree crops except in connection with water conservation. A great part of the steep and sloping land is unsuitable for cultivation, especially where the top soil has been eroded. However, the higher gently undulating surfaces offer favourable sites because of their soil depths and structural adaptability.

The altitude and lower humidity are unfavourable to the development of harmful insects and thus some of the best olive growing areas are found in the Jebel.

Eastern Jebel.

(1) Msellata. This region rises in steps from the coast for a distance of 30 kilometres to the Wadi Turgut in the west. Although there are local variations, as a result of the morphological variety, this is one of the best rainfall zones of the Jebel and temperatures rarely fall below 0°c in winter. Relatively disease free, this area of the Jebel is one of the most healthy for the olive. Where soils are deep the tree can reach large dimensions.

The olive trees, which number 344,978, 50% of all trees in the Jebel, are distributed predominantly over the Cussabat plain, the low hills and wadis of Sciogran and wadis and depressions to the south-east of Cussabat.

Sciogran	44,000
Msellata	156,644
Cussabat	114,000
El Amamra	7,500
Corradini	24,834

(2) Cussabat Plain The plain is distinguished by the great number of old olive trees (Plates XXXVIa & b). It is formed by a wide wadi depression and covers an area of 10,000 hectares. The typical form of rural settlement is the village situated on the higher rock outcrop areas. The landscape is a mosaic of olives and patches of cereal

cultivation.

The plain extends to the north of the village of Msindara where the terrain becomes intensely dissected by the upper wadi tracts. The olive moves into the deeper soil areas of the wadi slopes and terraces (Fig. 25). Near the scarp, where several tributaries of the Chabbaza converge, the alluvial flats are devoted to cereals and olives are dotted on the hill slopes. The upper slopes are denuded and support only poor grasses.

(2) To the west and south of Cussabat the plain narrows and is heavily dissected by wadis. In general, the interfluves are devoid of a soil cover and cultivation moves into the wadis. (Plate XXXVII). The olive becomes increasingly strung out along the wadi beds and slopes.

Tarhuna West of the Wadi Targut - Gsea (a wide flat bottomed valley) conditions are completely different. Rainfall is 100 mm's less than at Cussabat and wind erosion is much more intensive. Land settlement and the development of sedentary agriculture in the wadi itself has proved difficult, because of the lack of a domestic water supply. The large flat basin and suitable soils attracted an Italian settlement but this has since been abandoned owing to water supply deficiencies. Over 17,000 olives were planted and cultivated with vines and cereals (Plate XXXIX), but production of the mature trees has been negligible.

In the past the valley was a domain of the semi-nomad and his livestock. Very few Libyan gardens and trees have been laid out in the upper reaches.

This valley represents an area of transition between the olive growing regions of Cussabat and the Central Tarhuna plateau. Little appreciated in the past for olive cultivation, the plateau has been intensively developed by Italian farmers (Plate XXXVIII) Although rainfall is low, soils are suitably adapted to the 230mm's rainfall; they are deep and free draining.

The plateau is separated from Marconi by 20 kilometres of infertile passes. The large surface, lying between 400 and 500 metres is admirably adapted to the extensive orchard cultivation. On its serrated northern edge the cultivable area is limited to the wadis and upper basins but the interfluves are heavily eroded nearer the scarp.

Libyan farming is relatively unimportant in this area (19,000 olives) and has been hindered by an unstable economic system which prevailed ower the area in the past.

On the other hand Italian planting is prolific (184,000 trees).

Southernmost farms at Breviglieri have been encroached upon by shifting sands; (this phenomena is more marked nearer Tarhuna village).

At Abbiar Miggi the land is broken and enters the Jefara through a gorge-like valley where the soil is often very shallow. Rainfall is lower and only if terracing is effected can planting in the scarp zone take place.

Tazzoli is a former Italian settlement centre. Here the soil is calcareous and shallow. A tuff subsoil is covered with moving sands which have overrun the roads and houses. Although some 18,000 olives were planted by the Italian farmers they have not been successful and since they were taken over by the Libyan Government their deterioration has accelerated. Many of the trees have been irreparably injured by livestock.

The best area is undoubtedly in the northern part of the plateau. Southwards, except in the upper wadi basins, thin soils, shifting sands and inaccessible water tables are limiting factors.

However, north of the plateau in the Upper and Middle Wadi basins where soils are deep developments could take place (Fig. 26). - 150 years ago Gasr Doga was capital of the area. Its water supply was derived from nearby springs.

Central Jebel

West of Tarhuna the first olive reappears at the head of the Wadi Guassem in the Central Jebel. The heavily dissected and eroded 5-600 metres surface intervenes and offers little scope for settlement and cultivation. Some cereal growing in the wadis and esparto grass gathering from the hillsides in addition to livestock grazing are likely to remain the main economic activities.

Although the rainfall map would signify a special climate for the Garian area, it belies the actual situation. Rainfall is highly variable.

The natural limits of the cultivated area are soon reached on three sides by the Jebel scarp and the deeply incised valley of the Wadi Meginin. Winters are more severe because of the increased altitude but phytosanitary conditions are perfect.

From information gathered on the spot olive trees produce very little and only every 5 years. On an average crop expectation is about 25 kilogrammes per tree.

Over 60,000 olives are grown in the area predominantly on the Plains of Guassem and Tigrinna. THe plain of Guassem is composed of deep red soils. There is little damage from winds but soil erosion is a threat. The trees are cultivated with cereals and are terraced on the wadi slopes. The plain of Tigrinna has a similar aspect of fertility. (Plate XL)

The plain of Assaba differs from the other two. It is higher and more exposed to southerly winds. Soils are lighter and rainfall lower. This plain, the soil of which rapidly becomes calcareous, possesses suitable crust which would have to be pierced to ensure tree growth - only 2,000 trees could be developed.

El Baten is a wide wadi depression adjacent to Assaba, and devoted to grazing and cereals. Like Assaba it would be possible to prepare the land for tree cropping.

Western Jebel

West of the Wadi Zaret there is practically no other cultivation than the olive and fig. These together form over 70% of the total tree crops.

The main centres of cultivation are at Jefren, Chicla and Giado on the high plateau surfaces, and near the scarp edge where light Hamra soils allow dryland cultivation. (Plate XLI). To the south and west aridity increases and the olives must seek wadi locations (Plate XLI).

In this area the limiting factor is summer aridity and low winter rainfall. 'When it rains the yield is greater' is a proverbial saying amongst local farmers. Ten kilometres south of Nalut olive cultivation ceases.

Semi Desert

Apart from the three principal areas, the coast, steppe and Jebel, a fourth useful planting area is constituted by the wadis which scour the country to the south and south-east of the Jebel. The only large planted area is that at Beni Ulid where 10,000 mature trees gave an average yield of four kilogrammes of olives per tree in 1958. However, in these areas the ecological balance is easily disturbed and depends on the variable flooding and systematisation of the wadi. Even this cannot assure crop production for in April 1954 Broc noticed that even the olives in the middle of the wadi were withering.

Conclusion

It is apparent from the foregoing discussion that the oliveis now cultivated in the most favourable ecological zones, with the exception of restricted areas in the Eastern

Jefara and Eastern Jebel. There are no large areas awaiting development.

In terms of yields and oil quality the olives of Northern Tripolitania compare favourably with the major producers of the Northern Mediterranean.

Moreover the olive farmers benefit from a longer production cycle.

The optimum regions with respect to crop yields are undoubtedly the coastal belt and Eastern Jebel where Mediterranean climatic conditions prevail. Outside these areas there is a transition to a zone of challenge where, by virtue of a particular microclimate created by dryfarming techniques and irrigation, the olive can grow and occasionally yield a heavy crop. The ultimate limit of the olive is the 24th parallel but it is obvious from yields and regularity of production that in these areas of the semi desert, Western Jebel and even the coastal plain, the olive does not produce an economic crop except under irrigation. These areas by their poor ecological conditions lend themselves to subsistence cultivation.

As an indication of the regional exigencies of ecological conditions the production of oil is revealing (Table 32.I).

In years of fair to average rainfall Tripoli and the Western Province (including the Eastern Jefara, West Coastal plain and Central Jefara) accounts for approximately 30-40% of oil production in Northern Tripolitania. On the other hand in drought years (e.g. 1947) about 81% of the oil production came from these two provinces. In the same year production was negligible in the Eastern Province (corresponding to the East Coastal plain and Eastern Jebel), and non-existent in the Central Province (Central and Western Jebel). Production of oil in the Central and Eastern Provinces, where the olive is mainly dry cultivated, is fairly high in years of high rainfall but is less consistent over several years than the Tripoli and Western Province.

The fluctuation in production which is governed mainly by the varying ecological conditions, has inherent disadvantages. The wide range of production has implications for the domestic and export market. Glut and famine crops render the market very unstable. (Table 38 Appendix)

Irregularity of production is less pronounced on the coast than elsewhere in Northern Tripolitania primarily because of the practice of semi-irrigating the olive. The Frantoio variety constitutes 60% of the plantations in the Jefara and only does well under irrigation.

As we have seen there are no large areas awaiting development. The area of shifting cereal cultivation extends over a range of climatic variability bordering on the semi desert and the well watered crop conditions to be found associated with the static farming areas on the coast and Jebel. Whilst the major part of this land cannot be considered suitable for the development of settled farming the better parts could furnish some of the land for this type of agriculture.

Estimates of land potentially suited for sedentary agriculture and olive cultivation have varied greatly depending on the criteria adopted for the classification of land. De Cillis (46) calculated that 553,000 hectares of the total area of Northern Tripolitania was capable of being utilised for dry farmed olives at 20 trees per hectare, (i.e. 11 million trees). This estimate was based mainly on rainfall and must also have included very extensive irrigation development, since a more recent estimate dis-agrees widely.

Robb's estimate of land, (Table 39) based on botanical and historical evidence, potentially suitable for sedentary agriculture is more modest and amounts to 800,000 hectares. Since it is extremely unlikely that such a large area (twice the present area of settled farming) could be developed in the near future he recommended the development of 220,000 hectares of land in the Jebel and Eastern Jefara and 2½ million trees to be planted in new areas.

At the time of this report there were some 3½ million trees in the country producing on average 3 kgs. each per annum. Theoretically annual consumption amounted to 3,500 metric tons (750,000 x 6). Thus annual production averaged 2,000 tons below consumption levels. If these developments could be carried out it was envisaged that 5,500,000 trees

Table 39

Robb's proposed extension of olive growing area in 1945.

	Area ha's	Total area ha's	Total trees Olives Cereals	Total Trees	Present land use
Irrig. with dry-land agric. by means of wells & pumps as at Oliveti & Fonduk in area west of Bianchi	-	30,000	750,000	750,000	Shift.cult.
Dryland development as at Breviglieri Olives & Cereals					
Suk el Giuma (C. Verde)	40,000		1,000,000		Shift.cult.
N.Breviglieri & Marconi	40,000		"		" "
S. Zliten	"		"		" "
S. Homs	"		"		" "
S.of Breviglieri	20,000		500,000		" "
S.E. Garian	40,000		1,000,000		Exports
Assaba-Jefren	40,000		"		20,000 Shift.cult. 20,000 exports.
Wadi deltas					
S. Jefara 7 N. Jefara Giosc	20,000		500,000	7,000,000	Shift.cult.
Completion of plantings on Italian static farming.	230,000	230,000	1 mill.	-	Stat.farm
Arab static farming.	170,000	170,000	1¼ mill.	2¼ mill.	" "

could produce 16,500 tons annually of oil; sufficient for domestic needs and 13,000 tons for export. If there were no further plantings then 3 million trees (10% mortality) could produce, at 3 kilograms per tree, 9,000 tons of oil annually with an export of 5,500 metric tons.

Although the olive is widely distributed and adapted to a variety of conditions the best yields and quality of oil comes from the Eastern Jebel and it is in this area, particularly in the middle basins and heads of northern thalwegs, that any new expansion of olive cultivation should be considered first. The rainfall, soils and existing orchards, all verify the suitability of conditions here.

Plantations could similarly be laid out in the following areas:-

(a) South of Sabratha and Zavia where soils and water supply are similar to that of Bianchi and Giordani.

(b) Zone south of Zliten - the wadi interfluves and slopes form excellent sites for arboriculture.

(c) Plains of Assaba and El Baten in the Central Jebel remain undeveloped only because of their pastoral association and tribal ownership of land.

(d) Apart from favourable soil conditions north of Giosc, the hot Jefara climate is likely to impede olive growth. West of Jefren the poor yields indicate that only by placing olives in wadis can production be assured.

With regard to those areas already developed and planted some intensification could be carried out in the Jebel and steppe areas but especially in the indigenous farming areas of the coast the density of crops is often excessive.

Most of the Italian estates contained land suitable for development. These could be most easily brought into use.

CHAPTER VI
Evolution of Olive Cultivation

As well as the regional variations in the distribution of olive cultivation (resulting from differences in water supply, morphology and economic systems), the culture has further experienced long term vicissitudes. These reflect in part the wider changing pattern of human conditions and land use. The past history of the area provides some of the reasons for the present place of the olive in the economy and landscape, and further affords indications of the inherent possibilities of the country for tree cropping.

Both the Italian and French administrations in North Africa devoted much time and interest to an analysis of archaeological evidence and written records appertaining to past land use, in order that the full potentialities of the soil and water resources should be evaluated. The rapidity with which, apparently, unfertile sand can be made to produce a crop by application of water warns against land use surveys based purely on average conditions of rainfall. De Cillis attempted to do this but his generous estimate of the potentially cultivable area is considered excessive.

The evolution of olive cultivation and land use systems can be considered in 4 periods:

(1) Phoenician.
(2) Roman.
(3) Pre-Italian.
(4) Italian and present day.

1. Phoenician

The name Libyan (Lebu), which first appears in Egyptian texts of the second millenium B.C. was originally that of a tribe or group of tribes inhabiting Cyrenaica, but the Greeks extended it to all the Hamitic peoples of North Africa, whose language and physical characteristics distinguished them from the negro and negroid Ethiopians of the Sudan.

The earliest account we have of the Tripolitanian Libyans is that givenby Herodotus, who wrote in the 5th century B.C. He describes the names and positions of the chief tribes inhabiting Tripolitania. To the east and south of the Gulf of Sirte the Nasamones were dispersed. Their western neighbours were the Macae whose territory extended as far west as the Wadi Caam area. West of the Macae the Jebel was inhabited by the Gindanes, the coastal plain by the Lotophagi or lotus eaters, followed by the Machyles, who stretched as far as the Shot el Gerid in Tunisia. In the interior of the country were the Garamantes, inhabiting the oases of the Fezzan. This tribal pattern given by Herodotus remains substantially unchanged throughout the greater part of antiquity.

Contrasting them with the sedentary agriculturalists of the Atlas region, Herodotus describes the Libyan tribes of Tripolitania and Cyrenaica, as milk drinking and flesh eating (i.e.pastoralnomads). No doubt this generalisation was broadly true but cultivation was by no means unknown amongst the tribes of Misuratino, and much of their movement seems to have been no more than seasonal migration between fixed areas.(47) For example, the Macae drove their cattle up into the Jebel every summer for water but Herodotus himself remarks on the bumper crops harvested in the Wadi Caam region which surpassed even the proverbial Babylon in its yield. Date palms were cultivated in the southern oases to which the Nasamones migrated every year leaving their cattle on the coast. The Garamantes, probably the largest of the tribal groupings, were entirely sedentary and cultivated their wadi beds by 'laying earth upon the salt'. Nevertheless in a country so near the margin of drought as Tripolitania, pastoralism and hunting and still more primitive forms of food collecting must always have played a major part in the economy.

The question has often been asked whether climatic conditions were easier for these peoples in antiquity, for the remains of their farms are frequently found deep in the semi-desert area of the Ghibla. The evidence is difficult to assess. Like other Mediterranean countries the northern part of the country was probably more thickly wooded in antiquity; Herodotus, for instance, speaks of the Hill of Graces (Msellata) as tree-covered and Strabo mentions woodlands on the promontary of Cephalaa (Cape Misurata). In such areas precipitation was no doubt a little higher; run off and soil erosion slower, than it is now. But other passages in ancient writings warn against sweeping generalisation. Herodotus hastens to add that it was the exception in a treeless and rainless land; Strabo speaks of the interior of Libya beyond a littoral belt as a desert, rocky, sandy, dry and sterile, and Lucan declares, with perhaps a little poetical exaggeration, 'there is not a green branch to be found in all the stretch of arid sand between the burning Lepcis (Homs) and the torrid Berenice (Benghazi)'. However conditions in the interior seem to have been definitely more humid, as presupposed by the rock drawings of elephants, rhinocerous and giraffe in the Fezzan. Pliny mentions the 'wilderness of elephants in the hinterland of the Western Jebel'. The main explanation for the presence of such animals is probably to be sought in the fact that enormous reserves of water, accumulated under the Sahara during the humid Pleistocene period, had not sunk so far beneath the surface as now. In addition, rainfall was probably 50 or even 100 mm. higher than today.

The Phoenicians more than any other people were responsible for the diffusion of the olive throughout the Mediterranean. Before the Phoenicians entered Tripolitania, shortly after 1000 B.C., the olive was unknown.(47). Although climatic conditions were similar to or slightly better than today the socio-economic organisation was geared to pastoralism and seasonal migrations. By 1,000 B.C. the Phoenicians had opened up the Western Mediterranean to their trade and were making regular voyages to Spain from the thriving parts of Tyre and Sidon. It is probable that the first visits to the shores of Tripoli were induced by inclement weather in the Mediterranean. Because of the straight coastline and lack of natural harbours places like Sabratha, Tripoli (OEA) and Leptis, where coastal reefs lent themselves for conversion into even modest roadsteads, would become the natural choice for harbours.

Tripolitania was well placed to tap the resources of the Sudan which could supply goods in great demand in the ancient world; gold, precious stones, ivory, ebony and negro slaves; and Tripolitania itself was rich in ostrich feathers, whose eggs and feathers were highly prized. The opportunities for exploiting the trade in these luxuries did not escape the Phoenicians for long. Excavations have revealed that an intermittently occupied Phoenician trading post had been established at Sabratha in the 8th century B.C. and others were probably founded at Leptis, Oea and Sirte.

After 500 B.C. these stations eventually became colonised and permanently settled. An attempt by the Greeks to colonise an area near the Wadi Caam was repulsed by the Macae with the help of Carthaginian forces; as a result Carthage claimed Tripolitania as her protectorate. This association is of some significance with regard to the development of olive cultivation. Whilst the wealth of these coastal stations was based primarily on the Saharan caraven trade their devotion to sedentary agriculture was by no means neglected.

With the advent of the Carthaginian era the primitive ecological balance between wild animals and man, forest and natural grazing land was disturbed. The influx of urban capital demanded bigger returns from the soil. Land was made to produce more by the expansion of cultivation of cereals, fruit trees and olives.

The Phoenicians were among antiquity's most skilful agriculturalists, having been schooled in intensive garden cultivation on the narrow coastal plain of Syria. Later Carthaginian capitalists had successfully adopted the Hellenistic system of 'monoculture' or the scientific exploitation of large estates by the exclusive cultivation of a particular crop for which they were best suited. In Tripolitania this crop was, and still is, the olive. It was without doubt Phoenician enterprise and capital resources which initiated the cultivation of the olive in Tripolitania, together with the implements for its promulgation. It is probable also that they at least began some of the schemes for water control and conservation which were later developed so well by the Romans. Strabo mentions the existence of a Phoenician dam near the mouth of the Wadi Caam. In antiquity the oil of the olive was held in high esteem and utilised for illumination, as a condiment, as a linament - in religious and funeral rites. But in Tripolitania the oil was used principally for heating and lighting.

It seems therefore that the olive was introduced to the coastal plain and parts of the Jebel but elsewhere the nomad remained impregnable.

Roman.

The successes achieved by the Phoenicians in introducing the olive to Northern Tripolitania and encouraging a predominantly semi nomadic indigenous population to participate in the expansion of its cultivation was augmented by events culminating in the interference and eventual colonisation of Northern Tripolitania by the Romans. By occupying Messina in 246 B.C. the Carthaginians precipitated a struggle with Rome that was to end more than a century later in the destrution of Carthage and the establishment of Roman rule in Africa. After Hannibal's excursion to Italy had ended in disaster, Scipio, with the help of a Libyan chieftain Massinissa, finally broke the power of the Carthaginians with a decisive victory at Zama. Carthage was forced to cede Spain and reduce her fleet to 10 ships, but was allowed to retain the Tripolitanian Emporium. The loss of commerce benefited agriculture because it caused the diverting of capital into land development which spread considerably inland. At the same time Rome encouraged the territorial aspirations of Massinissa by handing over to him the former Numdian Kingdom (Algeria). Massinissa, a man of foresight and ambition, continued to promote Phoenician methods of agriculture and Government amongst the Libyan tribesmen. Statesman 'as well as warrior' 'he turned', says Strabo 'nomads into farmers and welded them into a state.' Massinissa overreached himself when he provoked Carthage into a war which he easily won. Rome retaliated and in 146 razed the city to the ground. However, this Roman intervention was concentrated only in Tunisia and the Emporia remained in the hands of Massinassa's successor who further sponsored olive cultivation and sedentary agriculture. But after the fall of Carthage, in order to preserve the olive plantations, the Romans codified the normal principles relative to their cultivation and established for example:

(1) that the tree be planted at regular intervals of 20 x 22 mm's to be practised in Sialine soil near Sfax. Moreover the fundamental canons of dry farming were to be applied to assure to each plant a sufficient area under the low rainfall regime and to allow the expansion of the root system.

(2) that plantations were to be effected between autumn and midwinter on the hills, on clays or dry places amongst the land devoted to pasture and cereals.

(3) Finally, the practice of grafting the oleaster (wild species) which seems almost exclusive to the African countries and proves in their regions the pre-existence of the oleaster before the diffusion of the domestic subspecies (Olea Sattiva).(40) This marked the beginning of important technical improvements in olive cultivation which were to be duplicated at a later date in Tripolitania.

A period of instability and war followed in 118 B.C. which resulted in the dispatching of Roman Troops and their installment at the request of the town of Lepcis.

Until the entry of the Vandals in the early part of the 5th century A.D. olive cultivation seems to have expanded generally even though oil production fell, due mainly, to defective methods of conservation and manufacture (ibid 41)

Although the Trans-Saharan caravan trade must have been stimulated by the security of communications and world wide markets, resulting from Roman Rule, the basis of the economy appears to have been settled agriculture and the export of olive oil. Although African oil was generally considered too coarse for culinary purposes, there was an ever-growing demand for it for lighting, and use in bathing establishments. Roman emperors had the habit of distributing oil gratuities to other rulers in the world.

The annual fine of 3 million pounds of oil inflicted on Lepcis by Caesar, for allying itself with Pompein forces, gives some idea of the scale of olive cultivation in the pre-Roman period. According to Gsell[48] this fine would amount to 10,678 hectolitres. Gsell infers there were 2,300,000 olive trees, of which he believes 1,000,000 were planted on the Eastern Jebel. He presumes that the fine amounted to a tenth of the total production.

This seems to be a fairly good estimate. An average of 80 kilogrammes of olives per tree would approximate to 18 kilogrammes of oil for each adult tree in good condition. Thus the number of producing trees would amount to about 60,000. On the presumption that the fine inflicted amounted to a tenth of the production, we reach a figure of 600,000 producing trees. By allowing for at least 100,000 being immature the total trees would be 700,000 which if distributed regularly at intervals 20 x 20 mm's would cover an area of 35-40,000 hectares. This corresponds roughly tothe Cussabat Plain, Marconi, Brevighlieri and Tarhuna areas. About half this area has been preserved for olive cultivation.

The motives behind the Roman occupation of Tripolitania were substantially political and economic.

The acquisition of the coastal entrepot cities was undoubtedly an important factor. Moreover there existed a settled agrarian vocation amongst the populace of the coast and Jebel which had been sponsored by the Phoenicians and rulers of Numidia. The problems which faced the Romans were essentially similar to those encountered by the Italians in the 20th century. The aridity of the territory and the containment of the warlike pastoral tribes were chief amongst these. Like the Italians the Romans would no doubt have benefited from the experience of indigenous farmers and the existence of olive groves.

The Romans offered protection, security, capital resources and the stimulus of an export market. They adopted the olive as a principal crop in the light of its already successful growth, as a means of sedentarising nomadic peoples, expanding territorial power, and furnishing the imperial economy with oil. (ibid 22)

During the first two centuries of Roman rule the predominantly military forces of the Romans were preoccupied with the subjugation of the desert tribes, the Nasamones and Garamantes, and their activities were restricted to the coastal cities from which they sent out expeditionary forces. But great progress was made towards the end of the 2nd century and a static defensive system was established in depth - the Limes Tripolitanus - which consisted of 3 distinct zones. This system was to remain practically unchanged untilthe end of Roman Rule. It was during this period of maximum security that olive cultivation prospered and its cultivation was extended far south into the semi-desert areas.

The most advanced zone was constituted by the great isolated forts of Bu Ngem, el Gheria el Garbia and Cydamae (Ghadames) situated on the three main lines of communication between the interior and the coast (Fig. 27). They were garrisoned by Roman troops. Behind these outlying forts Alexander Severus created a zone of Limitanei settlements in the area covered by the basins of the Wadis Soffegin and Zemzem. The innermost defensive systemwas formed by a strategic road running along the crest of the Jebel and joining Tacape (Gabes) in Tunisia with Leptis. The road lay well to the north of the Garian and Tarhuna plateaux. This decentralisation of power resulted in an expansion of sedentary cultivation. The defence of the actual frontier became increasingly in the hands of recruited peasant soldiers.

Legend has greatly contributed to distorting the nature and extent of olive cultivation during the period of Roman occupation. The evidence of Gsell obviously testifies to the importance of the Msellata region. For the remainder of the country it is still undecided as to whether the numerous Roman ruins that can be seen (rural dwellings, oil presses and dams) are sufficient signs for the re-establishment of olive plantations from which, it would appear, they resulted.

The wealth and magnificence of the coastal towns, Sabratha, Oea and Lepcis, can hardly be considered as a criterion of affluence of their hinterlands (Plate XLIIIa & b) Nothing proves that their wealth did not depend on commercial activities other than oil export or the personal taste of an emperor such as Alexander Severus. The vivid contrast at Leptis between the marbles and sculptures of the large forum attributed to Severus and the more modest forum of the 1st century A.D. is worth noting. The latter probably gives a better indication of the economic status of the country at this time.

Accounts of two aqueducts bringing down the oil harvest from the Jebel from Tigi-Sabratha and Tarhuna - Lepcis have never been substantiated and must be dismissed. However, ancient writers acknowledge the importance of the country with regard to cereal and oil production.

Recent archaeological investigation, particularly in the Eastern Jebel and semi-desert areas, has confirmed the correlation between the size and extent of Roman farms, the distribution of oil presses with the importance of olive cultivation.

The archaeological evidence of less obvious relevance, e.g. Road Systems, types of settlement, water conservation techniques were also taken into consideration. There is no proof of any Roman farms existing before the 1st century A.D. although there was a substantial production from indigenous farmers, particularly in the Eastern Jebel. The intensive development of the interior was impossible without roads capable of carrying wheeled traffic. Therefore it is likely that the first appearance of specialised olive farms in any number is synonymous with the construction of Aelius Lamia's highway in A.D. 17.

Roman artafacts are distributed principally throughout the coastal belt, eastern Jefara, central and eastern Jebel and the semi-desert areas of the Ghibla. Thus, the easiest routes for warring nomads from the south to the coast were effectively controlled. The western Jebel and the western Jefara appear to have held little interest for the Roman farmer.

There was no effective Roman settlement south of the 30th parallel. As well as the three major cities in the coastal belt Leptis, Sabratha and Oea (Tripoli) and several smaller towns the prêdominant types of rural settlement were the village, the estate and the fortified farm; these were dispersed throughout the coastal plain, the eastern Jefara, the Jebel (from Zintan to Homs) and as far south as Ghirza in the semi-desert. Road stations were sited along the main highways but these were rarely permanent settlements. These forms of rural settlement reflect the manner in which the Romans effected agricultural exploitation of the land in consideration of strategy and security, density and stability of the indigenous population, and requirements of the Metropolitan economy; and ways of settling their own population.

The large urban centres and small towns were situated along the coast in the best water supply zones and where routes inland focussed on natural harbour sites (Fig. 26).

(1) <u>Villages</u>. The village was extremely rare in the agricultural zones apart from the coast and reflects the paucity of water supplies, except from the 1st phreatic water table. The dispersal of rural settlement also indicates the degree of security which the Romans had achieved. One of the most important villages was Mesphe (Gasr Doga) in the Eastern Jebel where water supply was assured from a spring flow.

(2) <u>Villas</u>. These indicate a country residence or farm. There is still some doubt existing as to whetherthese country seats were simply residences or farm estates. Further excavations may necessitate a reclassification of some known olive farms as villas[49]. Assuming that these estates were, in fact, cultivated, they formed an important link with the urban centres, around which they are clustered, since they were owned by wealthy citizens. In this way capital derived from commercial enterprise was absorbed into land improvement.

(3) Farms. These farms, which had no other function than the production of crops, have a wide distribution and are most common in the Eastern Jebel (Plate XLIV). They are dispersed over the plains of Cussabat and Tarhuna where well water could be supplemented from cisterns and tanks. They are usually accompanied by the massive frames of Roman olive presses from which it is assumed that their main activity was the cultivation of the olive. There is also a large concentration of their farms in the ancient domain of the Macomades. They were easily accessible to the market and port of Leptis.

In the Central Jebel only a few farms have been discovered.

(4) Fortified farms and towers. These are extremely abundant in the upper basins of the southern thalwegs and along the shores of the Gulf of Sirte. Groups of them are commonly found at the southern extremity of Roman control where larger forces were needed to maintain order. But they are also dense at the confluence of the main wadis with their tributaries. These tower-like buildings were 1-30 metres square andusually two or more storeys high. Their structures had inner courtyards and olive presses have been found built into the inner walls. In the fertile areas of the Jebel, they are usually ditched and occupy the most commanding sites. In the southern pre-desert areas they normally stand on the wadi banks; the beds of which were terraced and cultivated.

Inscriptions show that in many cases they were the homes of Romano-Libyan Limitanei. These pseudo-agricultural settlements had an important social and economic function in North Africa.

Essentially defensive sites they were first manned by Roman veterans. A ditch running on the southern boundary represented not only a line of defence but also an economic frontier. It marked with great accuracy the division between the cultivated land and the desert; the nomad and the cultivator(50).

The Limitanei were granted frontier lands free of tax, in return for a hereditary obligation to defend the soil against Rome's enemies. The earliest of these belong to the 3rd century but most of them were established in the 4th century. Therefore it had taken nearly 300 years for agriculture to be expanded from the better rainfall zones. At some stage Warmington thinks that members of nomadic tribes were attracted from the outside into these areas, since they had been deprived of their traditional grazing and cereal lands. These men were organised in semi-military fashion and settled around Centenaria. The number of associated mausolea (Plate XLVII) and agricultural installations, particularly those connected with water supply, indicates, according to archaeologists, not merely a series of outposts but a widespread structure of society. Doubtless the discipline and co-operative effort needed to maintain the system gradually encouraged the complete sedentarisation of these people even though Romanisation, in some cases, could only have been slight.

A particularly noteworthy example of such a settlement is that of Ghirza which has been intensively excavated(51). It is situated about 250 kilometres south east of Tripoli on the desert margins. Although predominantly military in character, this settlement and others of a similar nature carried the limit of cultivation well into the desert provinces.

The existence of this settlement depended on the cultivation of the adjacent wadi bed.(Fig. [illegible]). At the present day the wadi only floods every three years. Water was reached at a depth of 30 metres and drawn from two wells and five cisterns. The inhabitants took steps to obtain the maximum advantage from the flow of wadi waters by building transverse stone walls at regular intervals. Below its confluence the wadi is about 360 mm's wide and the dams were located at intervals of 60-70 metres. Therefore the cultivated area has been estimated to be approximately 250 hectares. In this area, where grain harvests are extremely irregular, the main crops were fruit trees (mainly olives) which are grown by subsistence communities today. It is probable that this pattern of cultivation in the Wadi Ghirza resembled that in the Wadi Beni Ulid at the present time. Olive presses discovered near one of the farms confirm the fact that olives were amongst the principal crops as it is hardly likely that olives were imported, such a distance, to be pressed. (Plate XLVI).

Extensive use made of the wadi barrage system is a feature of Roman agriculture. Climatic conditions were much the same;

rainfall was low and irregular. Thus, in areas of dissected terrain or where aridity was extreme, the wadi bed was highly valued. The barrages were constructed to prevent soil erosion and to check excessive run off so that it could be diverted into irrigation channels and storage cisterns. At the same time the silting up of these dams in the steeper wadis formed cultivable terraces in which fruit trees and herbaceous crops could be grown. It is clear from such evidence, as exists, that the system played a vital part in developing olive cultivation on a scale unequalled before.

In this way, the fertile wadis of the Ghibla were exploited. Two large dams were built across the Megenin at Sidi Gilani to protect the coastal oases from violent floods and to divert the waters over the neighbouring Jefara.

These settlements in the semi-desert had closed economies. A variety of crops were grown to support a population whose only wealth was the land which they held. Although served by comparatively good roads distance from the main market centres on the coast and eastern Jebel contributed towards this self sufficiency. Undoubtedly the commercial centres of oil production were on the plains and hillsides of the climatically favoured Eastern Jebel constituting the hinterland of Leptis. The area economically dependent on Lepcis originally terminated near Tarhuna, but later extended to the Wadi Zaret.

Land Systems. In Northern Tripolitania, as in other parts of North Africa, all land acquired by conquest reverted to the state and later to ruling Emperors.

The exploitation of these Imperial domains was delegated in two ways:-

(1) A resident proprietor would survey work himself and retain the royalties.

(2) A proprietor could rent a part of the total area of the domain to several farmers (CONDUCTORES) who would pay an annual rent. The conductores, whose contract was renewed every 3 years could sublet parcels of land to colonial peasants (Coloni).

On the private lands the COLONI were recruited from the Libyan population who had been displaced from their tribal lands. Therefore in the best olive growing areas the control of the land was largely in the hands of wealthy citizens of Leptis and run on monocultural lines with the olive being the basic crop. These capitalists could afford to wait until the olives came into production. Inflated oil prices at Lepcis contributed to the extension of this land system. Capital investment in the soil was readily forthcoming and much land improvement was carried out. Many tribesmen were induced to farm neglected or uncultivated lands, by the granting of security of tenure and tax concessions on olive trees until they came into full production. The usual forms of agriculture on the coast appears to have been the mixed farm which aimed at self sufficiency and produced a small surplus for local markets.

By the end of the second century the whole of the Eastern Jebel from Tarhuna to the sea at Homs, was densely occupied by farms. There were also extensive plantations in the Eastern Jefara.

The absence of Roman oil presses and the general paucity of remains in the Western Jebel does not indicate an absence of olive cultivation. In this region numerous troglodyte dwellings, containing oil presses, exist today from which the Roman type may have been adapted.

The Decline

The zenith of olive cultivation was reached in the 2nd and 3rd centuries in Northern Tripolitania. The culture was most widely diffused even into areas marginal for the tree's growth. The problems of soil conservation and water control were understood even by the Libyan peasant and under the stimulus of an export market, security, and a wealthy trading centre at Leptis, the olive became the primary cash crop. But the conditions which had sponsored the expansion of sedentary agriculture and oil production deteriorated after 235 A.D. when Alexander Severus was murdered. His death brought to an end the dynasty of African Emperors. Civil war and invasions from outside affected predominantly the land owning and commercial bourgeousie of the provincial cities[ibid 47]. Taxation was markedly increased and as a result of increased military expenditure trade was brought almost to a standstill.

This economic decline was greatly accelerated in the second half of the 4th century by a renewal of tribal unrest. In the first invasions of the Austurians (probably a Sirtic Tribe) the territory of Lepcis was laid waste. Little resistance was offered to them by the LIMITANEI whom Haynes believes were probably in league with the invaders. In a second raid the whole of the coastal plain seems to have been devastated. Many trees in the Eastern Jebel were cut down and this contributed to the decay of Leptis and the widening gap between rural and urban areas. The only sedentary peoples to have prospered in the 4th and 5th centuries were the LIMITANEI. In their wadi bottoms, south of the Jebel, they grew enough corn, dates and olives to make their economy self sufficient. With the collapse of Roman authority, they formed a virtually independent society.

Roman influence ceded to the Vandal conquerors who were themselves replaced by forces of the Byzantine Empire. A temporary halt to the decay of agriculture and city life was achieved. Tribal interference continued in the 6th century in the Jefara and Misuratino lowlands, greatly strengthened by the use of the camel. The camel not only increased the mobility and striking power of the nomads but made possible the extension of pastoralism, and their method of shifting cultivation. During this period the wadi systems of the Jebel piedmont and Misuratino scarp were allowed to fall into disuse. The Wadi Lebda broke through its dam and this accentuated soil erosion (Plate XLVII). At the beginning of the 6th century the great Berber tribal groups of Tripolitania, the Nefousa and Houara, emerge; they were to contend bitterly with the Arabs for the possession of their country.

The period from the 7th century to the 16th century marks a retrenchment for sedentary agriculture and arboriculture. The decline in Roman influence resulted in the cessation of security and protection. Moreover, export markets and internal trade were disrupted. The country became increasingly vulnerable to pastoral intruders. Libya became a routeway for those nomads migrating to the Maghreb along the coastal plain and the Jefara. However, in the densely settled areas of the Jebel, where the resilient Berbers inhabited defensible positions, the Arab invaders were temporarily thwarted. In the same way the densely populated coastal oases maintained their traditional forms of settled agriculture. But the Jefara, the low hill zone of Misuratino as well as some of the accessible Jebel valleys, were overrun by waves of nomads who destroyed the trees and allowed the water control systems to decay. Rural depopulation of these areas and the alien culture of the Arabs contributed to the decline in the cultivated area and the number of trees; these were constantly ravaged by camels.

The Berbers of the Central and Western Jebel offered fierce resistance to Arab nomadic tribes by withdrawing from the Dahar wadis and plains to the high summit levels of the scarp areas thereby relinquishing trees and farming systems in these areas.

The invasion of the Beni Hilal and Beni Solaym Arab tribes in the eleventh century destroyed the last traces of the ancient prosperity, although agriculture struggled on. The 11th - 16th centuries were marked by a period of anarchy. In the Jebel, particularly round Tarhuna, areas were abandoned to the Bedouin tribes, and transformed into sheep pasturage and cereal producing areas, as in the time of ancient Libyans. The Jebel Nefousa was partly devastated and depopulated and the Berbers became the slaves of the nomads in the Jefara and Ghibla. Coastal agriculture suffered greatly also, and barely survived in the oases, which recovered slowly after being sacked in the Beni Hilal invasion.

As wells and cisterns fell into disrepair and the communication systems were neglected it was inevitable that a parochial attitude towards oil production was adopted. The loss of some of the most fertile areas to the nomad and his livestock was conducive to this trend. Without an export market and inflated land values, and because of the increasing void between the coast and interior, olive cultivation came to a standstill. These conditions affected first the large estate farms whose economy was based on olive cultivation. Some protection, however, could be afforded to the villages and communally cultivated lands. State owned lands and those leased to a wealthy landowner class came under the auspices of the tribe, which was the basic socio-economic unit of the Arabs as well as the nomadic Berber. Depending on accessibility and economic value even village life suffered. The changing circumstances of the village of Gasr Dauun illustrates well the decline. During the Roman era Gasr Dauun was a thriving village situated in the Wadi Gsea between Tarhuna and Msellata, the present site of Marconi. Two periods of agricultural developmet have been recognised by archaeologists(52). The initial pioneering work of land settlement was carried out by Roman farmers who extended the dry cultivation of the olive on the valleys and slopes surrounding the large flat wadi. These farms were taken over by a prosperous native society during the late 4th and 5th centuries. Farms varied in size according to water availability and morphology. The large number of ruined olive presses in the district suggest the preoccupation of the inhabitants with the production of oil for export, by the technique of dry farming, which was the only method of cultivation on nine-tenths of the land. This was made possible by the terracing of wadi beds in their steppe courses with stone barrages: a technique comparable with those adopted at Ghirza. (cf. p. The village of Gasr Dauun thus lay amidst a forest of olives. But the Wadi Gsea and Tarhuna plateau provided a gateway for nomadic tribes to migrate in summer to the pasture areas of the Jebel escarpment. Thus exposed, the care and attention required for arboriculture became impossible. Today, apart from the former Italian orchards at Marconi there are not more than 20 trees clothing the hillsides.

Some areas have never recovered from this disturbance of the ecological balance. The Jebel scarp between Abbiar Miggi and Garian has been intensively eroded back and the 5-600 surface now constitutes a very dissected stony covered terrain. Scattered patches of cereal cultivation, esparto gathering and modest grazing comprise the only forms of economic activity. Within the area is a magnificent Roman Mausoleum, called Es Senama(ibid 46). The historical connections are obvious. The low interfluve areas of the Eastern Jebel and much of the Dahar surface have undergone a similar depletion of soil resources. The pebbly surface is indicative of wind erosion (Plate XVIII). Frequently, single stands of stunted olives accompanied by the remnants of oil presses are all that remains on these knolls and hillsides.

The control of unstable soils gone, the wind was free to transport the eroded material northwards to the moist coastal lands, and encroach upon the cultivated lands. Lepcis was almost engulfed by marine dunes and the plantations of Sabratha suffered a similar fate.

The success of Rome was based on the stability and high technical development of a society that could permit the release of capital necessary to limit the menace of soil erosion and to undertake the works of water conservation. When Rome fell, security and protection ceased, and settled farming was doomed in all but the thickly populated areas which could be defended. The outlying regions reverted to the nomad and shifting cultivation. The decline in Roman peace combined with the contraction of export markets, decay of city life and the disappearance of the large commercial plantation, were all responsible for the decline of commercial olive production. The hazards of poor harvests were not now met by the capitalist but increasingly by migration. Moreover the entrance of a people with little tree vocation led to the widespread devastation of orchards in some of the best olive growing areas.

Pre Italian

Prior to the arrival of the Italians in 1911 the total number of olive trees belonging to indigenous Libyan farmers amounted to only 500,000 (Turkish Census), the majority of which were bearing and probably in a declining phase of production. Thus, in a period of 1300 years olive cultivation had declined by at least five-sixths. Moreover some of the best oil producing areas, in terms of yields and regularity of production, had been ravaged by the natural agencies of erosion and leased to extensive forms of agriculture. Over 75% of the olives were grown in the Jebel where the Berbers had maintained their traditional society, despite the stresses imposed upon it by the predominantly pastoral Arabs. However, a large percentage of the trees were spread out over the Western Jebel, notorious for the irregularity of harvests and low yield. Thus, the olive, which had been a primary crop during Roman times, became only a standby crop in some of the best regions of the coast and eastern Jebel. By reason of the fact that a major proportion of olive trees were cultivated in the arid Western Jebel one can even assume that they contributed far less to the economy. Some compensation was derived from the regional diversity but there was little opportunity to expand. However, the fact that the olives were preserved in the Jebel and southern oases meant that some equilibrium was achieved.

The country was in a state of decadence. Trading wealth had been lost. Internecine warfare and anarchy prevailed to keep in constant check population growth. Town life was restricted to Tripoli and it provided the only strong contrast between town and country. In short, modes of life tended to fix themselves in accordance with physique, climate and cultural traditions. Stagnation of economic life resulted.

With the regression of arboriculture and annexation of large parts of the Jebel and steppe lands by nomadic tribes the stability of agriculture was greatly endangered. Tree crops, such as the olive, for the best yields and regular production, require careful attention. The seasonal ploughing of the land and harvesting tended to fix at least a portion of the farming population to the soil and represented fixed capital assets. But without the prerequisite of security such activity became limited. Anarchy and tribal conflict characterised the subsequent history of the territory and the beginning of pastoralism was firmly established. The increasing attention to flocks, to cereal cultivation and ploughing over wide areas entailed the displacement of population from the settled and temporary dwellings. The size and length of this displacement varied according to the size of the tribal area, its fertility and water resources, annual rainfall and the economic system.

Essentially, nomadism implies movement necessary in order to integrate fully the resources of a particular environment as they alter in time. Semi-nomadism, on the other hand, occurs when the nomadic population is settled during part of the year and it is usually associated with restricted movements. The contrasting environments of the coast, steppe, Jebel and semi desert offered scope for such population movements in accordance with the pasture needs of the flocks and cereal cultivation. Throughout the whole of Tripolitania semi-nomadic communities were to be found and although they varied considerably in detail, the physical features of the economy, integration of resources and social structure were common to all. The particular physical environment together with the influences of social evolution and historical development modified conditions only slightly[53].

According to De Agostini's classification of population[54] in 1914, based on type of residence and distance of movement, out of a total population for the territory of 483,833 about 63% were settled, 25% semi-nomadic and 12% completely nomadic. These were distributed as follows:

* Table 40

Distribution of Population in 1914 in Tripolitania By Percentage

	Coast	Steppe	Jebel	Ghibla
Settled	68%	1.9%	20.8%	0.3%
Semi Nomadic	9%	40%	51%	-
Nomadic	-	-	23%	77%

Sedentarisation on the coast and Jebel was obviously encouraged by the relatively favourable conditions of rainfall, water supply and the economic system which relied for the most part on tree cropping and intensive cultivation of herbaceous crops. The Jebel dwelling Berbers are reputedly more conscientious farmers than their Arab counterparts and cling tenaciously to their cultivated plots. On the coast where shallow wells provided an adequate water supply rural settlement was dispersed in contrast to the grouped settlements in the Jebel. Here, the sparsity of wells together with the

* (1) By settled is meant normal residence on farm or in village in a determined area and only periodic migration and transhumance for floods and cereals.

(2) Semi-nomadic: where migrations were outside their own territory.

(3) Nomadism: migrated over large areas for long periods.

needs for defence accounted for this characteristic form of rural settlement. Villages cling to scarp edges and highest promontaries.

The coastal areas were integrated with the steppe which served as pasture and cereal lands whilst the Jebel, the Jefara and Dahar were combined to form a single economic unit.

Even on the coast, especially in the Western and Eastern margins, where water supply and rainfall were less favourable, there was a greater concentration on flocks and cereals. The Western Jefara, as it is today, was a natural domain for the semi-nomadic tribes who owned a few date palms in the gardens of the spring line oases. In the Western Jebel the Nefousa integrated the Jebel with the Jefara. Here, semi nomadism was village-based and within the economy of the Berber tribes pastoralism was less exclusive with more sparing use of the Dahar pastures than in parts of the Eastern Jebel. Practices varied according to tribe but arboriculture tended to prevail. The flocks of the more nomadic tribes were thus limited by the demands of tree culture in the more restricted humid belt. Such movements of flocks as in cultivated areas were the responsibility of profession shepherds.

Similar conditions prevail among the Djebelia of Tunisia, except that there is a greater actual movement of population within a more balanced economy[55]. Garian was transitional in character with pastoralism diversified by extensive olive gardens and considerable settlement with the troglodyte villages. Only in the south, in the Ghibla and semi-desert

Orfella region were the true nomadic tribes to be found. It appears that the nomadic tribes annexed the Jebel for its water resources and better summer pasture. Success was achieved in the least defensible zones where Roman traditions had been weakened. Here pastoralism remained unchallenged until the Italian invasions after 1911.

Social Organisation

From the beginning of the Moslem conquests it was customary to divide all lands between the conquerors and conquered; in Tripolitania this was between Arabs and servile tribes including the Berber peoples who were obliged to pay a tribute. The unit of society was the tribe and the head of the tribe became a religious leader. The family was the base of the social pyramid with family groups forming LAMMAT which in turn formed the CABAIL (SING. CABILA) or tribal units. The tribe as a socio-economic group is still the basic unit of society amongst indigenous Libyans, although economic and social changes within the country in the last 60 years have affected its whole structure and functions[56].

Each tribe had its WATAN or homeland with arable and pasture land and wells. These lands were vested in the tribe which had residual rights on them. Each division of the tribe had its WATAN.

Each tribe owned land in the fertile part of the Jebel and coast; these were integrated with strips of land on the Dahar and steppe utilised for winter sowing and pasture. The size of the tribal area varied with the strength of the tribe and physical conditions of the area. Thus in the drier parts of the Western Jebel the parish strips extended unbroken well into the Ghibla (Fig. 28). Both sowing and pasture lands were held in common. The actual sowing areas within any tribal land was, and still is, determined by the distribution of rainfall. Where there was tree cropping and a semblance of intensive cultivation then land rights were more specifically defined and land was individually held. Thus, lands in the densely populated coastal oases and those surrounding the villages in the Jebel were zealously guarded and carefully attended. Outside the area of intensive cultivation land rights were vague and disputes over tenure, particularly in drought years, were often serious. Amongst the pastoral tribes the tent was the universal habitation (Plate L). In many cases it was rarely moved from one spot, although it was common pactice to change the type of tent each summer and winter. The families possessions were few, beyond the primitive but effective Ard plough, and the tent.

Economy

The economic base throughout much of the country was pastoralism. The animals were the wealth of the tribes providing food, clothing, leather and bargaining power. Flocks composed of hardy indigenous goat and the fat tailed Barbary sheep formed the nucleus around which life revolved. Camels were important as beasts of burden. Livestock numbers fluctuated violently each year. Pastoralism was supplemented by shifting cultivation of cereals, mainly barley. The family income was supplemented by the hand pulling of esparto, an occupation particularly useful in drought years. Other family needs were supplied through the various local markets. Many of the poorer families also found work in the orchards of the settled farmers at harvest time. There was a large scale migration in particular from Tarhuna to Msellata. Here they were joined by similar groups from Orfella, Amama and Zliten, being paid in kind, usually one seventh of harvest. A number of small souks existed at convenient route centres, e.g. Suk el Giuma (Jefara) Ain Uif (Garian) Garabulli.

These semi nomadic communities often possessed a few trees including olives in oases of the coast and dry gardens. of the Jebel but because of their seasonal movements they were badly cared for and rarely expanded beyond family needs.

The agriculture year began in September for these people, with the harvesting of the dates and olives when temperatures were lower.

There were movements, particularly amongst poorer tribal segments, to the olive plantations of the eastern Jebel and on the coast. But for the predominantly pastoral families the first rains in autumn were of greater significance. Whilst the livestock were becoming thinner, and cisterns dried up they were patiently waited for. Immediately the rains came there was a transhumance of the peoples to the cereal grounds in the Jefara and Dahar. Small groups of owners or hired labour selected suitable terrains in the Dahar, the Wadis and Spurs of the Jebel and the basin lands of the Jefara.

Simultaneously there was a movement of the flocks, often in the care of shepherds, to the traditional grazing grounds in the steppe zones and Dahar.

By January the flocks were in the pastures and the cereals had been sown. The families based on the steppes and Dahar had moved to their camping grounds whilst those remaining in their settled residences attended to the trees and the gathering of esparto grass. This was a lean period in the year for the more pastoral peoples.

The beginning of April saw the exhaustion of the winter pastures and the first stages of the return of flocks and families. The animals moved to the summer pasture in the vicinity of the main wells and larger cisterns. Here they remained in great congregations until October as the decidedly wooded remnants of the vegetation had to be supplemented by the watering of the animals every 2 or 3 days.

In early May the commencement of the cereal harvest precipitated another movement to the plains and Dahar wadis. After the harvest the grain was stored and the members rejoined their flocks and villages. Although the principal tasks of the agricultural year were now over the season was extended especially in the Western Jebel by the fig harvest. But again this was a critical period for the semi-nomadic groups.

These temporary migratory movements involved most families but amongst the settled Berber farmers and the oases dwellers they were of a more limited nature. Under this system drought years proved disastrous to the purely pastoral tribes. Their conditions were ameliorated to some extent by the tribute paid them by the servile tribes. The shifting labour force which the poorer tribes provided were valuable for the olive harvests, but as no statistics are available the volume and reliability of such movements cannot be tested.

The tribal system was co-ordinated by the great mobility of the population. The less fertile of the Jebel Gardens and oases did not constitute economic units and were subsidised by the sowing of cereals and pastures on the Dahar and Steppe appendages. But this movement and susceptibility to recurrent droughts limited the extent to which land improvement could be carried out, and capital accumulation was small. Moreover the joint ownership of land in the steppe and Dahar were drawbacks to the more intensive utilisation of these areas.

The overwhelming majority of the Libyan population were Moslems and their rules of land ownership and succession were governed by absolutely unchangeable Moslem laws. Moslem law distinguished five categories of land.[57].

(1) MULK - property held in full ownership by private persons.

(2) MIRI LANDS - public property and lands belonging to the state.

(3) WAKF LANDS - the lands alienated in Mortmain and therefore not liable to transfer.

(4) METROKE LANDS - lands free for public use.

(5) MAWAT LANDS - waste or uncultivable lands.

In Cyrenaica much of the land remained MULK since the inhabitants had surrendered freely to Moslem invaders. However in Tripolitania when the resistance of the Berbers was overcome their lands became MIRI and by sale to tribes or individuals(ibid 56). Sometimes the State forced the tribes to buy land. This happened when it desired to populate a district and fix on it the wandering nomads. It forced them to pay a price, often a nominal one and to dig wells. Nearly all the Jefara was thus imposed to tribes and became the MULK or private property of the tribe.

State and Wakf lands cannot easily be transferred. As to MULK, it may be disposed of by the ordinary ways. As in other countries, by sale, exchange, donation, legacy, expropriation and inheritance.

Thus the regulation of the use of land in all except the individually owned land in the coastal oases and surrounding the Jebel villages, was governed by tribal needs. Invariably the land devoted to olive orchards was mulk and therefore highly prized. In theory everyone held land, but the access and use of land was dependent primarily on the flocks and wealth of the individual. Because of the large Jewish section of the population and the Berber resistance the tribal structure was less strong than in Cyrenaica. Yet the implication of the tribal system - co-operative effort in the management and use of land - were still rigidly maintained.

The social system and the subsistence economy contributed to the growth of the dispersal and fragmentation of property; these two features of land division markedly affected the efficiency and ease with which agricultural activities were carried out and also the viability of the farm economy.

The dispersal of property was a common feature of the rural villages of Jebel as well as the farmsteads in the coastal oases. Land within the immediate vicinity of the settlements and water points was highly valued and generally intensively cultivated. But outside the limits of varying distances agriculture became more extensive as population density declined, and water resources less accessible. It was desirable for each farmer to hold land adjacent to the village for summer and winter cropping; in addition land further from the settlement was useful for grazing and cereal cultivation.

The only information available on the dispersal of cultivated land is given by Theodorou(ibid 34) for Libyan farms in the Western Coastal plain. Whilst these cannot be representative of all regions, these farms indicate the degree of dispersal and land use common to all areas. In the Zavia area the land of the Libyan farms is located in three areas:-

(1) The oases boundaries of the coastal zone where the residence was established and water supply from wells supported intensive cultivation of trees and herbaceous crops in the small bounded gardens.

(2) 50-65 kilometres from the residences in the plain Jefara the land is devoted entirely to shifting cereal cultivation.

(3) 25-50 kilometres from the residences in the undulating Jefara is found the main grazing lands.

In the Zavia area 85% of the land of a single farm unit was found in the Jefara. Only 2.6% was formed by the irrigated oases garden. Out in the Jefara there was little attempt to define cultivation boundaries by means of Tabia.

Similarly in the Jebel, except perhaps in the fertile regions of Msellata, the farm units comprised the Jebel terrains of varying fertility, the arid Dahar lands and the piedmont flats of the Jefara. Where the dry gardens are individually owned they are surrounded by stout Tabias or mud walls, but elsewhere open fields prevail. The time required to traverse these various sections of the farm is obviously wasteful of labour and encourages transhumance.

The fundamental cause of fragmentation of property was found to be the desire to hold all categories of land necessary in a subsistence economy. The Moslem inheritance laws tend to break down lands into very small categories. On the death of a Moslem his estate goes by the following successive order; to meet funeral expenses, to settle debts, and to meet bequests and legacies. The remainder is divided amongst his heirs. Male members receive double the portion of the female. There is therefore no limit to the sub-division of an estate, however small the property may be.

This process of fragmentation was accentuated on the Mulk lands which were almost entirely transferable.

Even tree crops are subject to these laws and single trees can become the property of numerous people. The author remembers a case in Garian where a single olive was owned by 60 people and the majority were resident in Cyrenaica. Since the tree was everyone's responsibility it was not surprising that it was badly tended.

The scale of fragmentation was investigated by Theorórou In the Zavia area, on average, the land of 70 Libyan farms was divided into seven parcels. Four of these were located in the oases gardens and the remainder in the Jefara. The average size of parcels was 0.32 hectares and 12.9 hectares respectively. Owing to the lack of employment in other fields the farmers sons generally became farmers also. Combined with the prevailing multi-household this contributes greatly to subdivision of property. The oases gardens and the village were formerly the only areas where farmers could set up new farms and therefore land was constantly divided. Fragmentation also resulted from the differences in the quality of land parcels. This was particularly emphasized in the Jebel where topographic variety and series were less uniform.

In the Jefara fragmentation has had an additional cause; erratic rains make it necessary for the farmer to have land in different parts so that there is no more likelihood of sowing and harvesting a crop each year.

Population growth increased without a simultaneous increase in the cultivated area. Consequently property became further sub-divided.

The forces of the twin agencies of Islam and kinship were strongly ingrained in the rural society, being both the base of and escape from existence. Land use was governed by tradition and custom. The political fragmentation of the country, and subsistence agriculture were responsible for the low living standards, little agricultural improvement and the low level of olive cultivation.

The Turks entered the country in 1553 but only established any control in the 18th and 19th centuries. To them is owed the resurrection of Trans-Saharan trade and the rise of TRIPOLI as the main entrepot. However the development of British and French interests in the Gulf of Guinea brought this commercial activity to an abrupt end. Northern Tripolitania, deprived of interior caravan routes was no longer a sea coast for a distant hinterland. The country became, in consequence, no more than a very mediocre agricultural region where a primitive subsistence economy allowed little indulgence in land improvement, and the extension of arboriculture. Population increase was low.

<u>Italian</u>

A feature of olive cultivation in the present century has been its rapid extension and intensification as a result of Italian colonisation. At the first Turkish census in 1910 olive trees numbered 500,000 (450,000 in production) and the total area devoted to sedentary agriculture was

Table 41.

Growth of Olive Cultivation in Northern Tripolitania.

Year	Libyan Trees		Italian Trees		Total Trees	
	Productive	Total	Productive	Total	Productive	Total
1910-11	400,000	450,000	-	-	400,000	450,000
1914	500,000	550,000	-	-	500,000	550,000
1920	?	600,000	-	-	?	600,000
1925	?	?	-	68,000	?	?
1930	?	676,000	?	954,000	?	1,630,000
1932	?	?	?	1,342,00	?	?
1935	685,713	828,624	?	1,545,000	?	2,373,000
1937	?	?	?	1,745,000	?	?
1940	?	?	?	2,054,000	?	?
1944	?	970,000	?	2,411,000	?	3,381,000
1953	612,125	827,928	588,059	1,779,655	1,200,185	2,607,583
1955	?	?	?	?	1,400,000	3,000,000

certainly no more than 177,000 hectares (i.e. 3 trees per hectare of cultivated land). By 1957 the number of olive trees had grown to nearly 3½ million and the cultivated area to about 450,000 hectares (i.e. 8 trees per hectare). At the same time average production of olives has increased from 16,000 metric tons (1927/8 - 1931/32) to 27,000 metric tons (1948/9 - 1952/3), although the wide fluctuations from year to year still persist. However the number of scarce producing years has decreased.

Although the total number of cultivated olives has been increased by 677% (7 fold) during this time Libyan owned trees has expanded by only 87% (Table 41). By contrast Italian owned trees in the space of 28 years (1925-53) increased from a mere 68,000 to 1½ million. Libyan olive cultivation has therefore only expanded gradually and in 1953 represented only 31% of the total trees (74% in production). In the same year Italian owned trees accounted for 69% of the total (62% in production).

Apart from the national expansion in olive cultivation there have been significant changes in the distribtuion of the trees (Table 42). Absolutely and relatively there has been an increase in the number of trees on the coastal plain and Jefara, accompanied by a slight expansion in the semi desert nucleus at Beni Ulid. In comparison the Jebel has experienced a decline relatively and absolutely. Whether this represents a diminution in the cultivated area or a

Changes in the distribution of olive trees 1910-1957.

Table 42

Year	Coast West	Coast East	Coast Total	Interior Plain Jefara	Interior Plain Dafnia	Interior Plain Total	East	West	Central	T	Semi-desert
1910-11	70597 (13%)	36-39000 (7%)	109597 (20%)	591 (1%)		591	130048	196500	96000	422548 (79%)	7301 (1%)
1937	1076255	227637		474358			354147	213078	126272 (185322)		13000 1.22
1944	1346655 (42%)	636076 (18%)		472464 (18%)			529516	132579	42224	704319 (21%)	13000 (1%)
1955	Tripoli and Western Province			Eastern Province				Central Province			
	1600000			1100000				300000			
	Western Province			Tripoli Province				Northern Province			Central Province
	891202 37% in production			1016472 (37%)				954477 (54% prod.)			561434 (66% prod.)

decreasing density of existing orchards cannot be easily measured since land areas are unknown. It is probably a combination of both. At least it means that old trees are not being replaced. On the other hand plantings in the Eastern Jebel, largely due to Italian colonisation, have more than doubled in the last fifty years. Most marked is the declining importance of the olive and agriculture generally in the Western Jebel.

The rate of growth has varied considerably. The slow characteristic growth of Libyan olive cultivation contrasts vividly with the accelerated expansion of Italian trees. A peak was reached in 1944 thereafter declining quite sharply to recover again by 1957. This decline after 1944 is perhaps a result of war damage and unstable conditions but the author has found that it is probably due to the fact that many Italian varieties in the coastal areas, gave disappointing yields on coming into production.

Like that of their Roman predecessors, the Italian occupation and rural colonisation of Tripolitania, at the beginning of the 20th century, represented an extra-territorial expansion of a people technically and economically, superior to the indigenous population . Many problems facing the Italians were paralleled during Roman times. These included the limitation of the nomad's territory, the subjugation of the intensely independent Jebel dwelling Berber peoples and the restoration of Tripolitania's lost fertility and commercial wealth. There had been a prolonged deterioration of soil and water resources on the periphery of the cultivated zones due to overgrazing and rapacious systems of shifting cultivation of unstable soils. Moreover, the local farming population comprised for the most a peasant community who had withstood centuries of instability and economic regression by accepting a low standard of living. Tree orchards, considered to be the final stage of development in traditional farming had failed to expand at the same rate as the population or subdivision of property. This disproportion was due to a number of reasons amongst which the most important were the depth of underground water, land ownership, lack of funds necessary for the establishment of orchards and the parochial attitude of the population. To these may be added the gradual contentment with deprivation. In 1954 members of the Yaddem tribe in Western Zavia, numbering 530 lived on an area of only 70 hectares(58). Communications were poor and consisted mainly of well-worn tracks. With the exception of Tripoli, urban life was undeveloped, and the larger villages of the coast and Jebel merely functioned as markets and centres of small handicraft industries.

The land systems of the Italians and methods of creating olive plantations increasingly reflects, from 1920 onwards, an attempt to solve the growing economic problems of Italy itself induced by an alarming rate of population in some of the poorest parts of the country. Thus, social and political motives came to override the purely economic aspects of land settlement and reclamation in Tripolitania. Three phases may be distinguished.

(1) 1911-21 - Occupation and conquest.

(2) 1922-33 - Reconquest and pioneering phase.

(3) 1933-40 - Crystallisation of socialist approach to intensive demographic settlement.

The feature of the early years of the Italian occupation was that, legal means were created to enable the State to acquire land in the territory other than by a voluntary mutual agreement with the owners. The State was thus in a position to acquire land either by means of expropriation for the purposes of public utility or as punishment to those who took up arms against Italian administration. Land was taken over by the Italian Government in three ways according to established laws.

A brief review of the other methods is sufficient to clarify the action of the Italian Government in this sphere and the implications this held for the indigenous rural society. (Quereshi-ibid 58-gives a fuller exposition)

(1) <u>Nationalisation</u>. The State directly acquired those lands which Moslem and Ottoman land codes considered as 'dead lands' (MEWAT). These were those communal lands which if necessary any person could, with the permission of the Government, break up and cultivate provided that whenever such lands are subsequently abandoned for a period of three years, they would revert to communal lands. These lands were generally very little improved and provided with neither roads nor water. Usually they were flat sandy stretches utilised by Libyans for

grazing and shifting cultivation. Where ownership could be established compensation to the indigenous tribes was paid. However, the Italians widened laws governing nationalisation of land by defining the type of cultivation which could be considered an adequate safeguard for the owner against the expropriation of his land. Thus the Government in a Royal decree of 1923 was able to expropriate land, individually or collectively owned, which had not been improved by planting of trees or other rational cultivation for at least three years. In this category the seasonal cultivation was not considered as proper cultivation of the soil. Any property cultivated to even a minimum degree (from a garden to a few plants around a dilapidated well) was considered not subject to nationalisation; transfer of such property to the Italian Government was wholly voluntary and an appropriate price freely negotiated. This is proved by the fact that gardens owned by the natives still exist within the zones which have been cultivated and settled. In some cases the periphery of a nationalised area could be acquired by interested parties. The acts of nationalisation following in principle certain criteria: appropriate distribution of the nationalised zones in Tripolitania, and selection of the flat sandy zones of more limited interest to the Libyan; exclusion from nationalisation of tree planted zones. Apparently, therefore, the Italians paid due regard to the needs of the Moslem and to the particular equilibrium existing between the oases and steppe lands.

Moreover it must be pointed out that of the 250,000 hectares nationalised between 1913-40 about 100,000 have remained practically at the disposal of previous Moslem owners, for seasonal sowing and pasturing. Another 7,000 hectares were allocated for Moslem colonisation.

Nationalisation of lands was also used to confer special favours on Moslem families.

(2) Purchase. Foreby the sale of land in the nationalised zones the Italian Government made arrangements to purchase land suitable for a particular cultivation. Thus Tigrinna was deemed suitable for tobacco cultivation. In one case about 3,000 lira per hectare was offered for the land.

(3) Confiscation. Properties confiscated were those arising in respect of actions of a political character. All property belonging to rebels was confiscated and delivered to certain companies and municipalities for their development.

The extent of properties appropriated by the State, in view of the cancellations and limitations mentioned above, have been definitely of modest proportions, as can be seen from the table below.

Table 43.

Lands Nationalised or Purchased 1913-1940

	Ha's	Ha's
Total lands acquired by the State	265,000	
Sandy and rocky zones, approx. 5%	15,000	
Nationalised exploitable lands		250,000
Lands in effective ownership and of use by Italians		153,000 *

* An area approximately 20% of steppe lands in Northern Tripolitania capable of exploitation.

1st Phase. 1911-21[59] Efforts to subdue the indigenous population and overcome the Ottoman Regime resulted in insignificant colonising progress. Local rebellions and the 1st world war restricted activities to a military native except for the expropriation of 9,000 hectares surrounding the oases of Tripoli. During this time the most significant achievement was in the construction of railroads radiating from Tripoli to Zavia and Tagiura, and inland to Azizia. This first attempt at conquest precipitated the migration from the Western Jebel, in particular, of large numbers of the Berber inhabitants. This was accompanied by the destruction of several villages. By mid-1913, according to French estimates[60] 35,000 Tripolitanians had sought refuge in Tunisia, although a considerable number soon returned home.

1922-33. The reconquest of the territory was achieved in 1924 and under the capable administration of Count Volpi Italian colonisation began in earnest. It was preceded by decrees in 1922 (cf. p.), relating to land ownership which were to have far reaching results. Tripoli became the capital of the Province and economic expansion took place from this nucleus. Between 1922-31 830 kms. of roads were built stretching the whole length of the coastline, to Garian in the Jebel and along the whole length of the Jebel from Nalut to Homs.

The State acquired, by means already stated, 202,825 hectares of land between 1922 and 1932. It was situated predominantly in the coastal belt from Mellita to Garabulli

(Fig. 29), in the central Jefara between Tripoli and Azizia and in the Jebel at Tarhuna. These were the most favourable agricultural zones. Of this area about 50% was given in concession largely to private owners comprising capitalists, industrialists, companies and professional men who were attracted by the low land costs and opportunities for speculation. The land occupied by the concessions was originally tribal and devoted in the main to extensive forms of agriculture. It had therefore been deemed uncultivable. Thus, the concessions surround the coastal oases and the more undulating light soil areas; these were well adapted to plantation agriculture. In theory the displaced local population were to become attached as labourers to these farming interests.

Whilst many of the concessions prior to 1922 were less than 50 hectares in size very often these later concessions were over 400 hectares especially in the Jebel and Jefara where water supply conditions induced a more extensive farming organisation (Farm Samples 8, 9, 10)

This expansion was facilitated, particularly after 1928 by the discovery and exploitation of the second water table and artesian sources. An added factor was the emigration from Tunisia of many wealthy Italian landowners well versed in farming practices under semi-arid conditions.

Until 1923 the landowners were forced to rely on their own capital resources for development. However, land was cheap (generally less than 50 lire per hectare: 100 lire = £1) and no tax was required for at least 25 years. But after 1925 General de Bono, one of the great fascist leaders was installed as Governor of Tripolitania. He continued the work of his predecessors and introduced new credit schemes designed to expand land reclamation. These were of three types: (ibid 59)

(1) Short term credit for annual crops, livestock and equipment to which was attached an interest rate of 6.2%.

(2) Credit to help in the planting of such short cycle crops as vines. This could be repaid over a period of 10 years.

(3) Credit for long cycle crops - olives, almonds - construction of wells and houses which could be repayable after 30 years.

The usual arrangement between the State and landowners was that on being given the land an immediate payment of half the value was required. Subject to certain conditions full ownership could then be obtained. These obligations included:

(1) The construction of wells, reservoirs and buildings.

(2) The levelling of surfaces for irrigation and tree planting.

(3) The provision of plots of land for Italian families who would work on a sharecropping basis.

Apart from the controls the owner was allowed a great deal of scope as to the cropping system and methods of husbandry. On the fulfilment of these requirements the proprietors could expect full title deeds to the land. Half the area of the holding was to be put into production, as soon as possible and the remainder at a later date.

Reclamation of such large areas could only be achieved by capitalists who could withstand the long waiting period before fructification of such long cycle crops as the olive. But this system failed to attract the large numbers of peasant families which it had hoped even though conditions were stable and land investment high. This led to an intensive campaign by De Bono and others to provide by law for the resettlement of Italians in Libya. Increasingly Libya was thought of as an extension of Italy and the colonial concept was integrated with that of the National one. Increased grants and loans during the period of tranquility from 1929-33 seems to have had little effect. This led to the introduction of a second scheme in 1932[61]. The plan entailed the setting up of agricultural villages or collective settlements for the purpose of resettling Italian peasant families on divided plots. It was proclaimed that to colonise successfully was needed not a few landowners "but a mass of peasants, who later on would become small holders of the same land, deeply rooted in it because they had conquered and reclaimed it".

Three parent organisations - Ente Per Colonizzazione della Libia (ENTE), Istituto Nazionale Previdenza Sociale (I.N.P.S.) and A.T.I. were set up to carry out the fundamental agrarian transformation of the land - constructing basic facilities and supplying financial aid until the appropriate cash crops came into production.

Great care was given to the organisation of public services in the various settlements with a view to dispelling at once, in new settlers, the feeling of loneliness and abandon and to give them security. Each centre had its church, school and civic services - market, shops and crop stores.

The greater part of the families were recruited from the provinces of the Padana Valley and Central and Southern Italy. Amongst the standards adopted for choosing families were the following:-

(1) The family must be of genuine peasant stock and composed of 8 or more members.

(2) Each member must be physically healthy.

(3) The unimpeachable morality of each member must be guaranteed.

(4) Families or heads of families must be registered as members of the National Fascist party.

(5) Illiterates were to be excluded.

(6) Families must be offspring of ex-small holders and sharecroppers.

Families were distributed over the settlement areas so as to avoid the concentration in any one village of people from the same district. Initially, therefore, the farming population was to comprise peasant Italians well versed in the art of survival but with a low technical knowledge and little capital.

There was particularly close control over these settlements as regards husbandry and type of farm. The usual procedure, after basic facilities had been constructed, was to appoint a technical commission to determine cropping practices, size and character of farms, the number of years necessary for working up the farm, the amount of irrigated land, the number of families to be settled, and the price to be paid for the farm. In the original evaluation any single farm unit was to consist of two zones; one for immediate development and a periphery margin for further expansion. (Plate XLIX)

The contract between the farmer and ENTE envisaged the farmer starting off for a brief period on a fixed salary. For a period of 5 years after this the colonist was placed on a share cropping basis. After the 6th year he became a full holder of the land and assumed direct management and the produce belonged to himself. During the first three years of this period the farmer only paid interest on a sum corresponding to the cost of the farm. But after the 10th year he was obliged to begin redemption of the farm by means of amortisation of the debt in not more than 27 years. In short the colonist became the holder of the farm after five years from the beginning of the contract, full owner after 12 more years and must have paid his debt by the 35th year.

The INPS contracts differed from this in that the colonist was maintained until he had fully liquidated his debt.

At this time Italy was obliged to import oil from Tunisia and Greece.

The regions selected for settlement were principally on the interior plain and eastern Jebel, where population density was low; lands which were unimproved or devoted to shifting cultivation and grazing (Fig. 28). Amongst other factors, the cropping pattern was arranged in conformity with the limiting factor of rainfall. Hence by reason of its low water requirements and economic value to the Metropolitain economy the olive was selected as a principal crop. In the western coastal plain, where water resources were abundant, three hectares out of fifteen hectares were designed for dryland olive cultivation. But on the completely dryland farms in the Jebel nearby 50% of the total area of each farm, averaging then 50 hectares, was allotted to the olive.(ibid 17).

Three different types of farms were laid out:-

(1) Farms suitable for irrigation of an area of 15 hectares of which 10-12 were to be irrigated and 3-5 hectares under dry farming, e.g. CRISPI and GIODA.

(2) Farms suitable for semi-irrigation of an area of 25-30 hectares of which 5 or 6 were to be irrigated and 20-25 to be dry farmed, e.g. OLIVETTI and BIANCHI.

(3) Farms suitable for dry farming of 50 hectares in size (to be later divided between two families) e.g. BREVEGLIERI.

Government contribution towards capital costs of development for these farms was extremely high; it included 15-30% of the cost of buildings, 10-20% of the cost of clearing the land, 25-30% cost of wells and cisterns, 20-30% cost of machinery, 30-50% for windbreaks and 30-50% for roads. As well the Government paid 1,000-15,000 lire (100 lire = £1 at the time) per hectare for irrigation equipment, 200-300 lire per hectare for trees and vines, 400 lire per hectare for olives and a further 50 lire in poor soil areas, and 300-500 lire per hectare for dune fixation.

The collective settlement of Breviglieri is perhaps one of the most typical and beautiful of the Italian estates[62]. It comprises an area of 12,000 hectares of undulating terrain situated on the central Tarhuna plateau and linked by road to Homs and Tripoli, the land slopes gently to the south at a variable height of between 4-500 metres and is traversed by the heads of the south flowing wadis. (Plate L)

The Ard Hamra is the predominant soil formation but gives way in the wadi beds to clayey alluvium. Although it does not have a notable rainfall (230 mm's per annum) the marked period of vegetative dormancy in winter and lower maximum temperatures allow it some advantage over neighbouring steppe areas for arboriculture. On the other hand cereals, legumes and forage crops suffer from the irregular and capricious rainfall distribution. The greatest problem in the area was one of water supply owing to the extreme poverty of spring and underground water tables. Irrigation from the water table located at about 50 metres is still inconceivable.

The evaluation of the land was begun in 1935 with research into water resources, and in 1936 an active phase was entered when the first 62 farms were laid out. In 1938 another 100 were added. Each farm averaged 50 hectares and the total area amounted to about 8,500 hectares arranged in a system of rectangular, contiguous plots. On these farms were settled

168 families with a total population of 1,335. A large periphery area intended for further development formed the southern and northern edges of the improved land.

Because of the high cost of water and well construction, farm houses were situated in groups of 4-6 so that wells, pumps and reservoirs could be used communally. Those without wells were fed by an aqueduct from a good well which had a total length of 25 kms. The settlement area was well served by good secondary roads.

The cultural organisation of the farms was based essentially on the olive, vine and almond which were eminently adapted to the low rainfall and soil conditions. Moreover the general uniformity of the topography has facilitated mechanised cultivation of the orchards. Some livestock were to be reared to meet domestic requirements. ENTE stipulated the following land use plan:

Specialised olive plantations	20 x 20 metres	-	24 hectares
" almond "	10 x 10 "	-	5 "
Olives and vines	3.30 x 1.25 "	-	½ hectare
Eucalyptus and conifers			½ "
Specialised fruit			½ "
Figs (for fodder)			½ "
Cereals			14 "
House, road and buildings			½ "

Whilst the trees were young interoultivation could be practised. Therefore a further 10 hectares could be sown annually; the remainder lying in bare fallow. The Eucalyptus and conifers marked the farm boundaries and acted as windbreaks.

It was intended that the farms should function for the most part on a co-operative basis. To this end ENTE provided for the construction of an olive factory designed to manufacture olives from the 14,000 hectares planted. For purposes of cultivation machines could be hired at a modest fee.

The total cost of each farm at Breveglieri was 135,000 lire compared with 138,000 lire for Crispi and Giodo, and 166,500 lire for those at Giordani, Oliveti and Bianchi. The cost of land improvement, as quoted by Morgantini, amounted to 2,000 Lst for each farm at Breveglieri. This is a cost of 40 Lst per hectare. 1,500 Lst of this total was debited to the colonist to be repaid over 25 years, so that the Italian Government, in the event of repayment being completed in the specified time, would have brought into production 50 hectares for a clear grant of 500 Lst - or 10 Lst per hectare. Such costs were heavy for a government to carry amounting per hectare to a loan of Lst 30 to be repaid over 25 years and a grant of Lst 10. It is unlikely that such expense could be incurred in the future development of new land.

The success and viability of Italian land settlement schemes cannot easily be judged for conditions operating during Italian occupation have been radically altered by the granting of independence to Libya. The effect of the second world war was to halt effectively the ultimate development of agriculture as envisaged by the Italians. The situation was ameliorated to some extent after the war by the British Military administration who brought stability and maintained the status quo until independence in 1952.

In the space of thirty years the Italians have achieved much. The pacification of the tribes and the development of communications laid the way open for the systematic development of the territory by a centralised government. Not since Roman times had this been possible. In addition to the schemes for agricultural development the Italians were responsible for the expansion of the functions of the coastal villages and the growth of Tripoli as the capital city. Economic opportunity was further enhanced by the growth in the indigenous population as a result of increasing attention to medical facilities, living conditions, and the cessation of warfare. This was augmented by Italian colonists themselves. The total population of the territory increased from 477,000 in 1911 to 738,338 in 1954, of which 37,658 were Italians. Of utmost importance to a predominantly agrarian country was the investment in land and the development of a rational method of intensive farming under arid conditions. Moreover agriculture production was released from the inertia of a closed economy as Italian markets became available. This was accompanied by an increased demand on local markets.

However the story has not been solely one of success. In the early stages of colonisation there were many setbacks due mainly to a lack of understanding by Italians of local conditions. Although there are no statistics to prove it there were many cases of bankruptcy and subsequent loss of land. But from what scanty information exists, it seems that most of the private concessions have now fulfilled their contracts regarding the development of their holdings. After the war only about fifty of the private concessions had obtained full title deeds to their properties since they had satisfied their conditions of ownership. The remainder, either because they did not follow the contract or because they had insufficient time, were only regarded as managers of their property. Yet under the British Military administration about 350 full title deeds were distributed amongst the 550 who held no rights. After Libyan independence of the remaining 150 only 11 were recognised as official holders of their lands.(63)

The Italians resident in Libya before 1950 and planning to return to Italy were allowed to sell or transfer their property to Italy. This concession was to operate until 1960.

The fate of the demographic settlements was partially settled in the Libyan-Italian Treaty in 1956.(ibid 63) Certain areas have remained wholly or partially Italian. These include Azizia, Fonduk el Togar, Bianchi, Giordani and Corradini. Many farmers on these concessions have fulfilled their contracts or will shortly do so. This is the case of all settlements controlled by I.N.P.S. who are winding up their affairs in the present year.

Howeverthe settlements at Castel Verde Marconi, Gioda, Maamura and Tazzoli have been restored to the Libyans.

The abandonment of the settlements at Tazzoli, Marconi and Gioda have been occasioned by the failure of the Italian administration to take into account conditions of climate and water supply. At Gioda of the 95 families originally settled only 10 remain. Successively poor herbaceous crop yields are attributed to the acute salinity of irrigation water and to the unrelenting power of the Ghibli winds which blow unobstructed in this area. These areas are being resettled by people unrehearsed in arboriculture. The fact that many still prefer to live outside the Italian houses in their tents only confirms that their transition to settled farmers will be a slow process. Some of the Italian farmers from these areas have been resettled in the coastal and steppe settlements but as most of these show no significant population increase it is obvious that there has been emigration to Italy and abroad. (Tables 4a & b)

The established settlements have not remained unaffected. Their marginal peripheral zones have been appropriated by the Libyan Government. Thus there will be a gradual containment of the Italian population into well defined areas. Whilst future expansion is not envisaged the redevelopment and intensification of the farmsteads is being encouraged by the Government in order to offset the loss of land trees at Tazzoli and Gioda. The following various re-evaluations of land use of the settlements was to be undertaken in 1956 and to be completed by 1960.

(1) Corradini. The programme of development for this area foresaw in the first place the development of irrigation

Table 44a

Developed Land and Population of the Collective Italian Farms in 1945.

INPS	Area conceded by Govt.			Area developed.		No families	Total working popula. 1954	Hectares to be developed.
Settlement	Total ha.	Discarded ha.	Net ha	ha's	No. of farms	Area		
OLIVETTI	1,393	57	1,336	1,282	72	-	291	54
HASCIAN	354	15	339	339	19	5	43	-
BIANCHI	6,121	1,777	4,344	4,165	167	412	532	179
GIORDANI	5,207	257	4,950	4,725	189	105	520	225
MICCA	4,843	1,085	3,758	3,758	148	41	378	-
CASTEL VERDE	2,200	575	1,625	1,625	65	400	5	-
CORRADINI	2,973	413	2,560	2,560	66	-	170	-
MARCONI	8,282	1,598	6,684	6,684	150	-	208	-
TARHUNA	14,755	3,798	10,957	10,957	180	-	291	-
ENTE								
GIODA	2,288	488	1,800	1,200	100	20		600
CRISPI	9,140	1,940	7,200	3,700	370	50		3,500
GARIBALDI	19,869	1,469	14,400	9,420	314	10		4,980
BREVIGLIERI	14,085	2,685	11,400	8,400	168	50		3,000
FONDUK	1,235	235	1,000	810	27	150		190
OLIVETTI	1,657	57	1,600	14,700	49	50		130
AZIZIA	5,569	1,349	4,220	1,200	30	20		3,020
MAAHMURA	715	200	515	500	125	5		15
NAIMA	500	-	500	-	-			500

Table 4b

PRIVATE CONCESSIONS IN 1945

Total land in concession	- 127,000 ha's
	- 3,050 " afforested
Area of olives in specialised cultivation	- 27,174 "
" " " " mixed cultivation	- 17,558 "

Specialised olive cult.		Olives and Almonds		Olives and Vines		Olives, Almonds and Vines	
No. trees	Hectares	No. trees	Hectares	No. trees	Hectares	No. trees	Hectares
631,141	21,153	727,677	27,158	239,045	8,039	46,235	1,417

Total number of farms 513 (1933)

343 - 75 ha's
99 - 400 "
61 - 1000 "
10 - 1000 "

Area land under irrigation 2,155 hectares.

resources. Fifteen wells are to be dug and divided amongst the existing farmsteads. After evaluation an additional 450 olives and 450 almonds were to be planted, together with 5 hectares of vines and 350 trees. About 1 hectare of land per farm is to be brought under irrigation on which barley, forage crops are to be intercultivated with 50 olives and several fruit trees. Foreby the intensification of the holdings two tractors are to be bought and used co-operatively.

(2) Garibaldi. Originally the settlement comprised 318 farms - now the number has declined to 200 with the remainder transferred to the Libyan Government. Each farm is about 30 hectares in size to which are to be added some 100 - 120 parcels. By contract the Italian Government should have provided 1 well per farm but this was never fulfilled. The existing wells exploit the 1st water table by means of wind pumps and are limited in output and extent. A further 100 wells tapping the 2nd aquifer are to be completed in the current year and fitted with electric pumps but the yield will still be low (between 20 - 10 litres per hour). These pumps are 2.15 h.p. and use 2½ litres of diesel oil per hour and are thus expensive to run. The new wells cost something in the region of £100 each and the author was informed that if the government did not bear out this expense a mass exodus was foreseen. Already in the last 5 years one third of the Italian population had emigrated. On 16 additional parcels of land 10 hectares are to be devoted to olives (250 trees, 2 hectares olives and vines, 2 almonds). It is assumed that

with the new wells and sprinkler irrigation system 1-2 hectares will become irrigated and destined for vegetable and forage crops for livestock consumption.

(3) Crispi. Here artesian water is the livelihood of the community. In the peripheral development area it would be necessary to construct new wells. But the actual cultivated area of the farms is practically complete and there are no rules for further planting, except for the addition of 50 hectares of acacia to help prevent the spread of sand which seriously affects the south and western margins.

(4) Breveglieri. Here at Breveglieri the intensification of soil workings was deemed necessary and the addition of between 1,000-1,500 tree crops, almost exclusively olives and almonds was envisaged.

(5) Azizia. The cultivated area of the 13 farms at Azizia was to be extended by 16 hectares comprising 10 ha. dry farmed - 500 almonds, 3 ha. - 600 Eucalyptus, 3 ha.

(6) Bianchi, Micca and Coradini. These settlements on interior steppe were to be intensified with the addition of 700 olives, 100 almonds, 1 ha. vines, 150 citrus, 500/600 young trees for afforestation. Also 2½ - 3 ha. brought into irrigation depending on water reserves of each farm.

Also 5 tractors were to be bought and used in co-operation.

The responsibility for evaluating these settlements lay with ENTE and INPS. It is clear that the reorganisation is committed to consolidating and intensifying cultivation. The Government still remains responsible for maintenance of buildings, irrigation work, wells, lands and roads.

A useful comparison can be made between the land systems adopted by the Italians for the expansion of olive cultivation and those utilised by the French in Southern Tunisia. Despois draws attention to this in his 'La Colonisation Italienne en Libya'.(64)

Despois comments that France was rich in capital and had few French colonists to offer. Italy conversely was poor in capital and rich in human resources.

"The region of Sfax and Southern Tunisia is closely similar and related to Tripolitania in natural conditions. But in parts Tripolitania through a better rainfall and better underground water supplies, is less poorly situatedthan the Sfax region.

Recent development of Sfax has dated from the beginning of the 19th century, under the French.

Around the town and the belt of dry gardens, the Sfax natives had planted 380,000 olive trees between 1800 and 1880, further plantings being rendered difficult by conditions of insecurity and lack of capital. During the peaceful conditions following the French occupation capital was used with Sfax labour on the Mghasa contract system to plant olives. Prior to Italian colonisation this system existed in Tripolitania. The owner of the land cedes it to the contractorwho must convert it into an irrigated garden. When this has been done the contractor becomes joint owner of the property and receives half of the net plot. In the past this contract enabled the expansion of the coastal oases in Tripolitania but it was abolished by the Turks.

The French adopted this contract and as a result about 2½ million olive trees have been planted over the Sfax plain. Well may it be called the forest of olives. A few managers were able to supervise the properties, the labour and crop shares. Shortly after the 1914-18 war, when high prices were paid for oil, the French capitalists sold a large proportion of the groves to Sfaxians at high prices. This benefited the local population until the depression in 1933 when labour was difficult to get because no means had been introduced to settle Bedouins and the olive was grown as specialised crop.

It may be observed that only the latter development of demographic settlements provided for labour. The large concessions had to rely on an unstable local supply.

<u>Impact on indigenous population of Italian ingression</u>.

The Italian entrance into Tripolitania brought abrupt and revolutionary changes. Italian rule was established only after a long period of pacification. The whole territory was finally subdued by 1929, and between 1922 and the outbreak of war in 1939, the works of colonisation were instituted. The remodelling of the rural economy of the plains and central and eastern Jebel, together with urbanisation have had a profound effect on the indigenous economy.

The direct effects of conquest and subjugation of the local population have been most noticeable where fierce resistance was encountered. In particular, the semi-nomadic communities of the Jefara and Jebel reacted strongly. The settled peasants of the coastal oases tied to their trees were easily overcome. In Tarhuna at least 1,500 men were lost in battle and 4,000 massacred by the Italians(ibid 47). Villages were destroyed and resources depleted in the Western Jebel. With the land grabbing trident of nationalisation, expropriation and compulsory purchase, and also by rural colonisation, the Italians endeavoured to contain these people and change the whole way of life of the nomads. At the same time the Italians introduced a system of land registration whereby it was hoped that mulk and waqf lands could become available for their settlement purposes. In general where ownership by the individual could be established it was respected. Otherwise the Ottoman land code was to remain unchanged. Outside the coastal oases and villages of the Jebel, however, land ownership was vague. Very often the land was held only by Usufruct. Because no individual ownership could be established the Italians were able to expropriate them. Between 1911 and 1954 there has been a vast redistribution of population. In all areas of the Jebel with the exception of Cussabat population has declined; some cases as much as 60% (Fig. 30). This decline may be attributed to the loss suffered during the pacification, to the physical destruction of settlement and dry gardens, to the Italian confiscation of land and finally to the opportunities for employment in the coastal area that accompanied development. In Tarhuna alone, at least 40,000 hectares of tribal land (ibid47) became Italian property and 80% of this was later developed as privately owned estates or demographic farms. The panacea for such losses lay, for the poorer elements, either in enlistment in the Italian levies or migration to the coast, and, for the wealthier proprietors, in continued resistance with eventual withdrawal to Egypt or Tunisia. Throughout, migration, either permanent or temporary, grew to unprecedented proportions.

This migration of the people from the Ghibla, Jebel and Jefara to the coast was initially caused by the disruption of the integrated economies of these areas.

Tribes in the Western Jefara have remained little affected and retain their traditional pastoral economies supplemented by small gardens in the spring line oases. But the tribes occupying the less dry steppes have suffered from the effects of Italian colonisation. Many were forced to become agricultural labourers where their lands were expropriated. Others confined to limited areas have increased ploughing at the expense of pasture.

In the same way the coastal oases where they have been encircled by Italian concessions have suffered from their loss of pasture and cereal lands. Fortunately the opportunities for other employment can ameliorate the pressure on resources caused by the growth in population.

This movement to the coastal towns was interrupted by the second world war but was quickly re-established as a result of government development schemes, the discovery and exploitation of oil resources and the rise of industries in Tripoli. Thus the once traditional temporary movement is becoming increasingly a permanent one though this is limited at the moment to the individuals rather than families. Formerly many were absorbed by the army and police but the extension of secondary education is modifying the pattern. This migration is growing not only as a result of a desire for increased economic independence but also of growing dissatisfaction among urban employers with the shifting nature of labour. Formerly the displaced local population were employed on Italian estates but many more are now moving to the towns. Italian colonisation together with government encouragement of sedentarisation, is leading to some divergence from the traditional semi-nomadic economy which compensates locally for the drift to the towns. At the last census in 1954, the semi-nomadic and nomadic communities represented only 13% and 7% respectively of the total population. In order to illustrate the divergence from the traditional pattern it is proposed to examine 3 Cabail, typical of the present situation in the Jebel Tarhuna.

(1) The El Darahib cabila lies in the lower part of the Wadi Milga in north-east Tarhuna. About a kilometre from the Jebel scarp the wadi has been filled with detritus so that the bed is now encased between wide and high terraces. In

this area the Italians laid out a small estate (W. Milga) which owing to the outbreak of war remained undeveloped. A short distance upstream there are two small wells, which despite the demands from four cabail are perennial. A comparatively wealthy individual possesses these wells together with the strips of land across the wadi and, on the neighbouring watershed. In addition he hires sowing land on the now Government owned estate at £10 per hectare. This family has access to winter pasture in the WadiTmasla. The group consists of 18, living in three households. Of the seven men, two are permanently employed in Tripoli with another in Al Khadra (Breveglieri). The flocks, comprising 150 goats and 100 sheep, usually go to the Dahar in November in the hands of shepherds, returning to Milga in late April. However, he complains that he wishes to turn his attention to arboriculture but is frustrated by the huge congregation of flocks near the wells in summer. The group remains permanently in this place, the work of sowing being delegated to a son and mixed labour.

(2) The Cabila Auasa is one of a group of cabail that lie to the north of the Italian estates in the vicinity of Gasr Doga. The tribe lost much of its land to the Italians and it is now separated into a number of isolated sections. Some families have been forced to settle permanently on the Dahar in the Wadi Taraglat. The result of such separation is manifest in reduced animal numbers and in virtual economic specialisation of the scattered groups. Thus in the vicinity of Gasr Doga

one group has turned to tree cultivation with a few strips reserved for cereals and an area for pasture and fuel collection. In the Taraglat cereal growing and a little pastoralism are the chief functions of the groups. About six families live off this combination of resources, but income is supplemented by work at military barracks of Tarhuna on Italian estates and in Tripoli. The emergent pattern of mutual specialisation is fairly typical of this area and it is the first stage on the arduous journey to more complete settlement.

(3) Part of the Cabila Aulad Hamed lies on the Dahar at the junction of the Wadis Taraglat and Tamamera. One family owns a strip of land in this area across the wadi covering about 3 acres. The wadi is wide with gorse pasture, shade (from pistacchio trees) and land suited to barley and wheat. On this land there can be seen the only dry garden on the Dahar fed by a large cistern and containing badly kept olives and almonds. Low rainfall has in former years prevented this family from remaining in their lands during summer. But newly constructed earth and stone dams built across the Taraglat have enabled the Arabs to conserve a greater amount of water and thus remain there after the flocks have been sent to the wells of Gasr ed Dauun. Three members of the family are employed in Tripoli permanently whilst another finds occasional work in Misurata. Again sedentarisation is evolving in this and neighbouring Cabail. It is not unique in Tarhuna alone but also common to the peoples of the Nefousa and

Garian.

The Italians did little to render this process more rapid. Although they constructed a few small settlements for displaced peoples they have never been completely utilised. However, the traditional social grouping of the tribe has been altered particularly in those areas close to towns and in proximity to Italian estates. Thus the individual family group is replacing tribal ties.

The use of larger areas for training British forces has further limited lands available to the tribe. The position is such that each year the pressure on resources grows without compensation of new terrains and new wells or range control (already the wells at Gasr ed Dauun support 8,000 people and their stock).

Moreover the success of the Italian estates on the steppes and Jebel remain a permanent testmony that arboriculture can provide a lucrative alternative to pastoralism. As a result some families have a desire to settle and cultivate the olive.

The Government appears to be encouraging this trend. Plans are based on the gradual expansion of olives, almonds and fruit trees in the Jebel. A programme of experiment and demonstration is being pursued and a beginning has been made towards rudimentary education in tree culture. At Garian and in Tarhuna demonstration plots have been based on the cheap method of construction of earth terraces along the contours of the rolling landscape (Plate LI[illegible]). Trees are available to farmers at 5 piastres (1/-) per plant and these consist of suitably selected varieties imported from Tunisia or else reared locally in Government nurseries. At the same time the movement is being led by the redevelopment of the vacant Italian estates on which the local population will be settled.

In areas predominantly pastoralist the Government would thus appear to envisage a gradual transition towards cultivation with at the same time a decline in pastoralism. However, any such schemes must take into account the present exclusive role of the flocks. Thus, tree planting should usually be slow and concentrated in those areas of the inner basins little used for pasture owing to the absence of wells. It is possible that certain areas may be reserved for cereals and pasture on the humid plateau with other zones devoted to the olive, in association with almonds and vines to give a quick cash return.

The system is slowly emerging in embryo, although there are several complex problems to be considered. The differing systems of land ownership - communal pasture, family sowing lands and the Italian estates, together with the growing tendency to register land in private ownership, are likely to prove the main stumbling blocks. Very little land is at the disposal of the State for controlled development (40,000 hectares out of 10 million).

Although sedentarisation is in its early stages some of its effects are already apparent. On the extreme northern edge of the plateau, arboriculture is rapidly spreading either in the traditional dry garden framework or based on the Italian model as in the case of the Cabila Auasa. In these areas the tent is being abandoned. Small limestone houses have been built from the shallow quarries in the Garian limestone beds (Plate LII). In the Taraglat and at Uesctata small box like huts are replacing the tent.

Sedentarisation also means individual land ownership and the gradual disruption of family groups. These divided groups tend to concentrate on one form of activity and there is already considerable resentment either at the encroachment of trees on former pasture, or at the demands on water resources made by stock. Thus in Tarhuna the traditional antipathy between nomad and cultivator is being reintroduced. Amongst the more settled cabail there appears to be less temporary but greater permanent movement which can have serious repercussions on labour supply. This movement moreover is made mainly by the young and vigorous individuals of the families leaving behind them an ageing group.

In some ways the semi nomadism of the Jebel Tarhuna is unique for the relief, climate and soils are manifestly suited to the type of arboriculture found in Msellata, Nefousa and Garian. The answer to this anomaly lies in the historical evolution of the area. Berber nomadism was replaced by Roman arboriculture only to cede to the Arabs pastoralists. The present sees an attempt to reintroduce arboriculture.

The increased security brought by the Italians and their example has obviously encouraged some of the Libyan farmers to increase plantings (Table 45). Most of the areas in

Table 45

Changes in Distribution of Libyan owned Olive Trees.

District	1910	1935	1957
ZUARA	6,581	15,111	9,940
AGELAT	3,648	8,396(?)	
ZANZUR	15,543	23,075	25,349
ZAVIA	15,543	56,385	47,970
TAGIURA	1,735	5,451	
TRIPOLI	15,641(?)	50,866	
URSCEFFANA	591	2,287	
EASTERN JEFARA	12,000	66,299	
HOMS	40,000	53,930	
SAHEL	14,000	14,612	
ZLITEN	10,000	74,084	
MISURATA	12-15,000	26,753	
MSELLATA	130,048	145,195	322,144
TARHUNA	few	8,403	19,699
GARIAN	96,000	68,335	69,612
JEFREN	81,500	68,706	
FASCATO	80,000	80,768	
NALUT	35,000	19,848	
BENI ULID	7,300	13,837	
MIZDA	1 tree		

MUDIR statistics not available.

close touch with main urban centres and Italians have increased tree population.

Conclusion.

The long history of cultivation within Tripolitania has shown that the olive is generally well suited to prevailing soil and climatic conditions and that its cultivation probably represents the best long term use of land. The periods when olive cultivation has been widely expanded seem always to have coincided with times of economic prosperity and political stability. At the present day, although independence has apparently brought political stability economic viability would not seem to have been achieved as the budget remains in deficit. Therefore it is unlikely that any rapid expansion of the culture will take place in the immediate future.

The Italian experiments have been invaluable, methods of planting in particular have been most successful. However their new political status is unlikely to give them much confidence in the future. Production of olive oil from this sector of the economy will continue only because young trees are maturing. It is unlikely that they will undertake any major schemes designed to expand the area of arboriculture. Already INPS and ENTE have wound up their interests in Tripolitania.

In Roman times part of the success of extending olive cultivation beyond the strict limits as set by natural conditions must be attributed to the engagement of the local population in an attempt to bring order to the territory.

Many of the difficulties which the Libyans now face in the field of agricultural development are a direct result of the failure of the Italian Government to integrate the indigenous population into their schemes of agricultural colonisation.

Since gaining independence in 1947 the Libyans have faced many problems in taking over all the administrative duties and farms relinquished by the Italians. Fortunately post-war reconstruction and the exploitation of oil have acted as outlets for a largely unskilled population.

External forces are still in evidence although these now act in different capacities. Financial and technical aid through the United Nations agencies is contributing to agricultural development. Change is being wrought as a result of contact with new ideas, the development of communications and increasing Government concern with improving the utilisation of the resources of Libya as a whole. In Tarhuna and similar areas where the semi-nomad can be settled the sedentary base may be fixed by the olive as it was in Roman times. But only the northern edges of the Jebel may thus be changed. On the Dahar the climatic conditions and lack of groundwater restrict arboriculture: Nomadism in general may be replaced by a simple form of transhumance, but the flocks should not be replaced, only improved.

Whether it is the stabilisation of semi-nomad communities or the extension and intensification of sedentary agriculture it is obvious that the olive has an increasingly important part to play in the future.

CHAPTER VII.

Systems and Techniques of Olive Cultivation

The systems and techniques of olive cultivation are notably diverse owing their origin to the interaction of physical and historical factors which have been discussed in earlier chapters. The olive is cultivated by commercial and peasant farmers alike; in specialised orchards as well as mixed groves; both as a dryland and irrigated crop. Since olive oil production in Tripolitania is governed largely by the requirements of domestic markets or protected by the concessions given on Italian markets, the interplay of economic factors, associated with external or world markets, are absent. Therefore regional specialisation of the culture and standardisation or rationalisation of techniques of cultivation is not nearly so pronounced as, for example, in Tunisia, the largest exporter of olive oil in North Africa.

Essentially, the methods of farming are dominated by the contrast between the Libyan and Italian approach to agriculture and tree cropping. As we have seen the Libyan system has evolved slowly under conditions of political and social instability in a closed economy. By comparison the Italian system of arboriculture has developed rapidly under the stimulus of an export market; the development of communication and the inflow of capital.

On the basis of land use characteristics and farm economy certain systems of olive cultivation can be defined (fig.17).

These include the following:

1. <u>SANIYA</u> (plural Sueni) - small irrigated garden. Agglomerations of these form the so called oases.

   (a) Coastal Saniya) together
   (b) Interior Saniya)
   (c) Spring line Saniya
   (d) Jebel Saniya

2. <u>Dry Gardens</u>

   (a) Ginan - small gardens with mixed tree crops.
   (b) Gaba Zeitun - specialised olive groves.
   (c) Menga - Mixed tree crops and annuals.

3. <u>HAWAZA</u> (AR. Modern Farms).

   (a) Libyan
   (b) Italian Concessions

4. <u>Demographic Settlements</u>

   (a) Libyan
   (b) Italian

1. <u>COASTAL SANIYA</u>. (Farm Sample I)

Throughout the coastal plain the Saniya is the most common form of native cultivation. The system is dependent on irrigation from wells exploiting the first shallow acquifer. The total area of the Saniya agglomerations amounts to approximately 50,000 hectares[15].

Information on the characteristics of Libyan farm families in the coastal plain is meagre. Some details have been supplied by Theodoron from interviews with 70 Libyan farmers in the Zavia area; these can only give a general indication of the position obtaining in the remaining oases.

Land was reported to be individually owned but most farm operators supported a multi-household. They had frequently to support widows, and orphans of their deceased brothers, due to co-ownership of farm property. In many instances married brothers of the farm operators continued to live with them. They participated in the farm business and their families were supported by an income derived from the same source. In the Zavia area the average number of persons per household was about 11. Only 18% of the total farm population was literate and the majority of these were in the younger age groups. All of them, however, reported life long experiences in farming.[33]

In addition to farming, some of the farm operators also worked outside their farms, operating small grocery stores or little cafes in the Cabila villages, or in the marketing activities on market days. Other opportunities exist for some work on the American and British military bases or else on the larger farms. This helps to supplement the income of the family where members are numerous. Some of them happened to be Sheiks of their tribes and devoted part of their time to administrative duties in their Cabail.

The size of the Saniya in the oases is exceptionally small varying from less than one hectare to 1.3 hectares in the Zavia area and about 4 hectares in the oases of Tripoli. This situation is a result of a combination of factors; high densities of population, Moslem inheritance laws and the limited capacity for irrigation of the ubiquitous Dalu. It seems also that many of the Libyan farmers have shown little interest in operating large farms, preferring to work on the large farms and leave the responsibility and increased risks to the owner. The yield from such wells equipped with the Dalu is only sufficient to irrigate 1 hectare or about 30 olives per day.(65)

Apart from the small area of these holdings the garden plots are generally distributed irregularly in parcels amongst tortuous sandy tracks. Usually they are defined by high concretionary earth mounds (Plate LIII). Whilst these form useful windbreaks and protect the crops from animals the time and energy expended in their upkeep wasteful. Moreover they obviously reduced the cultivable area. Often the Tabia are surmounted by a line of prickly pears which are useful for animal fodder.

In most cases, except where the proprietor has a regular income outside agriculture, the Saniya does not represent the total land area of the farm business. It is usual for the farm operators to own scattered parcels of dry farmed land outside and around the peripheries of the oases. Italian encirclement of the oases has subsequently limited the area of such land in the western coastal plain. Other plots of land are situated to the south of the oases in the Jefara up to a distance of 65 kilometres and in the Steppe zone south of Zliten. With the addition of these lands the average farm size rises to about 50 hectares at least in the west coastal plain of which approximately 85% of the total farm area is represented by lands in the Jefara (Table 46). The Jefara land belongs for the most part to the Cabilas but members have access to it for sowing of cereals and grazing. Almost all the land of Libyan farms can be considered as cropland, but its use for production, particularly in the Jefara and Steppe zones, varies from year to year depending on rainfall and other climatic conditions.

Irrigated land is highly prized amongst local farmers owing to the climatic vaguaries which can effect even the most favoured rainfall areas. Irrigation is considered as a secure way for agricultural production. Thus lands without wells tend to be neglected or cultivated extensively. For example, although tree crops represent the most important type of capital investment in the Zivia area and most of the coastal plain only about 0.5% of the non-irrigated cropland on Libyan farms is planted with trees and therefore cultivated intensively. (Plate LIV).

Table 46.

Summary of Size Values per farm of 70 Libyan farms in the Zavia area, 1952.

Total land (hectares)	50.0
Irrigated land (Saniya)	1.3
Total number of Trees	199.0
Olive trees - numbers	85
Date Palm "	94
Citrus fruit "	4
Almond trees "	3
Other fruit trees "	15
Livestock units	7
Farm Capital £L	1,530

(after Theodorou)

The value of trees on Libyan farms in the Zavia area in

1952 represented 34% of the total capital investment.

The most important tree crop on Libyan farms is the date palm followed by the olive. The majority of the Libyan trees are grown in the irrigated saniya but because of its restricted area the Libyan farmer attempts to utilise it as fully as possible. Therefore trees are planted densely and under them, vegetables, grains, alfafalfa and legumes are grown (farm sample I. The crowded situation in the saniya, coupled with the disorderly way in which the trees are planted and mixed with one another makes it difficult for the farmer to apply systematic and efficient cultivation. Furthermore, a great deal of the irrigated land, which is planted to trees, cannot be intercropped with success because it is heavily shaded. Such conditions favour the spread of cryptogamic plant diseases and weeds.

The Libyan farmer has shown little inclination to colonise the undulating Jefara south of Tripoli and Zavia, even though the water supply is not unfavourable and the soils are well adapted to dryland olive cultivation. However, a gradual transition to intensive cultivation is taking place throughout the hinterland of Homs and Zliten both on the plains and in the wadi beds. (Farm sample 2).

Most of the farm produce is consumed directly but small quantities of olives, dates and barley find their way to local markets.

The income(1) of those farmers is low by European standards

(1) Income includes gross receipts of farm products sold, income from other sources and net increase in inventory.

(£165 per farm at Zavia in 1952) and fluctuates mainly with the wide variation in cereal production in the Jefara land.

<u>FARM SAMPLE No. I</u> (fig. 36).

This small saniya is situated a few kilometres south of Suk el Guima and is operated by a government official who lives in Tripoli. It represents his sole interests in agriculture.

The holding comprises 4 hectares of level land; it is split up into three plots (two of 1 hectare and the other of 2 hectares). For the management and working of the land the proprietor relies on a foreman and hired labour which under present conditions, is abundant and cheap in this area. Wages are very low averaging about £L.0.1 per man per day (2/- per day).

The whole economy of the farm is geared to intensive crop production under irrigation. A few animals are retained merely for work and transport. Amongst the farm implements the accent on hand tools was very definite. The farm was equipped with two ploughs; a wooden ARO type plough used for light cultivation in winter and a heavier iron plough utilised for summer ploughing and weed control.

Unlike many of the adjacent holdings there were no large tobia surrounding the plots. Small earthen walls and irregular lines of olive trees formed the boundaries.

Water for irrigation was supplied from a well exploiting the first acquifer yielding in the region of 20 m3 of water per hour. The original Dalu had recently been replaced by a small diesel pump which enabled almost two thirds of the farm to be brought under irrigation normally. From two storage tanks the water was transferred to each plot by means of subterranean pipes close to the well and stone channels thereafter.

Tree crops represented the main type of cultivation and these were distributed at regular intervals over the entire holding. Some attempt had been made to introduce the row system, especially for the fruit and citrus trees. Judging by the existence of a small citrus nursery such crops were becoming increasingly important.

The tree crops were intercultivated with winter sown fodder crops, beans and peppers mainly for domestic consumption. The economy was further diversified by tomato planting in summer for which an area of about ½ hectare was reserved. These were planted in the traditional gedula system of small rectangles which during summer could be flood irrigated every three to five days (Plate LVII).

Whilst most of the herbaceous and citrus crops received regular irrigations, the olives distributed around the periphery were given water occasionally during the critical period in February and March. Throughout the winter they would of course benefit from the irrigation of the intercultivated crops.

All the olives were in full production and stood very high, forming together with the palms a dense canopy of shade. The land around the trees was ploughed more than twice a year but the irregular shape and size of the trees was evidence of these being pruned without due regard to the physiology of the trees. They received no fertilisation.

The farmer could not or was unwilling to give information concerning yields of the olives. He did however report a maximum yield of 100 kilogrammes per tree which could be expected in such a favourable rainfall zone where supplementary water was available. The olives were of the local variety but again the specific variety was not disclosed. With the exception of the fodder crops, the beans and peppers, the crop produce was destined mainly for sale off the farm. The olive crop was generally sold before the harvest to merchants in Tripoli who had the responsibility of transporting and manufacturing the olives.

This small saniya holding represents the gradual intensification and land improvement which can be effected with a little knowledge and capital.

The acquisition of the motor pump has enabled the farmer to expand the area of irrigation each year and to use the water more efficiently. He also reported that this had considerably reduced labour costs. As well the increase in irrigation capacity has facilitated the conversion of the cropping policy to higher income, but high water consuming crops such as fruit trees and citrus; market Tripoli.

Unfortunately comparative details of cost and income from these crops was unavailable.

Throughout the coastal belt the conversion from the Dalu to the motor pump is lamentably slow, even though many of the farmers express a desire to make the change. The consequences of increased exploitation of the first acquifer should also be considered since its recharge is governed largely by rainfall. Only research and practical experiment can provide an answer to this problem. Obviously the capital resources available to this wealthy landowner is unlikely to be raised by the majority of the peasant farmers whose income and indebtedness tend to nullify initiative.

The effect of this development on the olive cannot yet be assessed except that its cultivation has reached a standstill. There is no preparation for the replacement of the old trees and the farmer does not envisage any further expansion.

The raising of the economic level of the farm has not been accompanied by any marked improvement in methods of husbandry. Some alignment of the trees has taken place but the patchy cultivation remains. However it is encouraging to witness that the fallow land was no longer left to the growth of weeds, but was well tilled.

Unlike the majority of the farmers most of the produce is for sale off the farm.

FARM SAMPLE No. 2 (Plate LVII)

More typical of the farming economy in the coastal belt which integrates saniya cultivation with dryland cropping and livestock rearing, is this farm located near Homs.

The farming household consists of eight persons; an ageing head of the family, two brothers, their wives and children. All senior members have had lifelong experience in farming. The land owned by the family includes two hectares of oases gardens adjacent to the Wadi Lebda and several hectares of land two kilometres south of these gardens, which lies across the wadi bed itself. In addition, the family have access to communal grazing and sowing lands further south.

It is obvious that these Libyans were formerly a semi-nomadic group as they have no established residence in the Saniya. The family is now settled for most of the year in a stone house overlooking the Wadi Lebda to the south of the saniya. Winter transhumance is practised with the goats and sheep but the head of the family and one son remain.

The saniya is equipped with one well and a dalu; water is obtained at 11 metres. The garden is devoted to palms, barley and vegetables which are mostly for domestic consumption. In good years however the surplus is sold in the local market at Homs. Only about one third of the holding can be irrigated each year, and the remainder is left in fallow which generally means a dense weed cover. The well was badly in need of repair but the costs of cementing were reckoned to be excessive for any improvement to be carried out.

One of the sons, who had a special interest in the garden also found work outside the farm. He earned £1 per week as a gardener at the nearby British Military establishment. He spoke English reasonably well and he was obviously instrumental in the land improvement carried out by the family in the wadi itself. The olive is absent from the saniya since according to the farmer it doesn't need much water.

In the bed of the wadi about two hectares have been laid out for tree crops, winter cereals and legumes. The deep alluvial soils contrast strongly with the low, denuded interfluves on which the house is sited. Small transverse barrages have been constructed in the wadi bed and advantage has been taken of Government Nursery schemes to plant out 65 young olives of the Rasli variety. These are spaced at 9 x 5 metre intervals on the rectangular basis and it is expected that they will bear fruit in five to six years time. The root stocks were purchased from Homs at a cost of five piastres each (1 shilling).

Lying adjacent to the olives is a small dry garden, enclosed by a formidable wall of earth and gorse, in which are grown several fruit trees.

The traditional modes of agriculture are still evident in this holding, with the reliance on a mixed economy and small garden cultivation. The low capacity of the well and the dispersal of the cultivated land still prove a handicap to increased productivity and farming efficiency. However under the inspiration of the younger members of the family, whose contact with the Europeans has inevitably increased their horizons, some considerable development has been achieved. The planting of pre-selected olives in a rational arrangement represents an advance, and an intensification of farming outside the immediate zone of the saniya.

This expansion of the olive on the dryland to the south of the oases is found all along the coastal plain between Homs and Zliten. In the author's opinion, it is due to a combination of factors. In the first place the shallow wells in this area are less prolific yielders than those in the oases of Tripoli or Zavia. After a few hours work they quickly run dry and at least twelve hours has to elapse before work can be recommenced. Where, as in this case, the wells are badly in need of repair, then the efficiency of irrigation is reduced further. Thus there has been some incentive to develop the cheaper form of dryland cultivation. Whilst the wadi bed is just as well suited to cereal cultivation, the availability of cheap olive rootstocks of guaranteed quality, and the example provided by the nearby Italian estate, have obviously influenced the selection of the olive for planting.

Finally, contact with Europeans and the extra income obtained have facilitated this expansion.

Obstacles still remain to the better management of the agricultural enterprise. The holding is dispersed over several kilometres and consolidation is virtually impossible since the land intervening is privately owned.

Outside the coastal belt the saniya has a limited distribution because of the increasing depth of water southwards and the general poverty of water resources in the Jebel.

Springline saniya. At the foot of the Jebel in the western Jefara along the spring line, located four to five miles in front of the escarpment, are distributed several oases of cultivation. Many of the springs have, however, been badly excavated and until recently clogged with vegetation. Bad management of springs also causes considerable wastage of water which is accentuated by percolation along inefficient earth irrigation ditches and evaporation in shallow distribution tanks. Outside the oases the aridity, sparcity of wells and historical evolution has determined a semi-nomadic, pastoral economy. Only a very small percentage of the Libyan tribes inhabiting this area are sedentary and this section is entirely localised in the spring line oases. The population live in small villages varying from over 300 (Glosc) to less than 50 linked by poor, unsurfaced tracks, European colonisation and urbanity has little effected this area. Combined with the traditional background of semi-nomadism it is little wonder that the cultivation and use of water is inefficient. In quality of water, irrigation system and management these are inferior to the saniyas of the coast.

Predominant amongst tree crops is the date palm which is tolerant of the generally brackish waters and thrives under the excessive summer temperatures. Some improvement in husbandry was noted at Giosc and Tigi where the gedula system of irrigation is operated: here a greater variety of crops are grown including the olive; figs, pomegranates, cereals, vegetables and peppers. The function of the olives is merely as a standby subsistence crop. Many of the trees are old and bear all the signs of ill-management - bushy crowns, high stature and misshapen trunks. Even if irrigation efficiency was to be increased only intense herbaceous cultivation can alleviate the lot of these people since saline waters and summer temperatures limit the success of the olives.

Jebel Saniya. Irrigated gardens in the Jebel constitute only a very small proportion of the cultivated land. In the whole of Tarhuna there are only five or six such gardens of which four are situated in the valley of the Wadi Ramla. They are more common in the wadis of Msellata - Safrania, Ghelil and Amam, - where the water is held perennially and reached by wells of no more than 5-10 metres in depth. At Garian there are several small gardens located in the Wadi Gan deriving their water from springs and shallow wells. Smaller groups are dispersed throughout the western Jebel where wadis incise the scarp and shallow acquifers. (Plate [illegible]).

The areas of these gardens is much smaller than those at Tripoli; they are generally no larger than ½ hectare. Those gardens, irrigated from springs, are frequently terraced and dammed by earth and stone barriers so as to maintain a better control over the water distribution. Since these gardens are individually owned and highly prized they are usually enclosed by dry stone walls. Although the land is devoted mainly to palm trees and horticultural crops the olive is by no means excluded.

Dry Gardens. A second type of native agriculture is represented by the dryland cultivation of trees and herbaceous crops in gardens.

The nature and forms of dryland farming are diverse but they all have one feature in common; an almost complete reliance on rainfall and surface waters for crop production. Whilst the dry garden is frequently an adjunct of the saniya in the coastal belt, it constitutes the main form of land use and livelihood for many of the settled Jebel dwellers. Here the area of dry gardens amount to approximately 125,000 hectares. The dry garden is becoming increasingly important to the semi-nomads of the Dahar and Tarama where it is found in various transition stages.

The existence of dry gardens on the coastal plain is determined primarily by the nature of the subsoil and the abundance and quality of water for irrigation. Secondly, much of the area outside the limit of the oases is vaguely owned with only traditional access to individuals for grazing and sowing rights. Thus in the oases of Zliten and Misurata, in particular, where soils are compact and water saline small dry gardens are common. Usually one finds palms, fruit trees and olives in an irrigated association (Plate LVII). As a result of their relegation to marginal soil and water areas outside the suanis the productivity of the olives is not very high. Moreover it appears that as dryland olives they don't receive the same cultivation or care as the crops in the irrigated plots. Often the gardens are without substantial boundaries and animals are allowed to move at will amongst the trees. The land surrounding the trees was left in fallow and used for grazing. Population is fairly dense in these areas and lack of labour cannot be responsible for this bad management. In the author's opinion it results solely from a subsistence assessment of resources and the preoccupation with irrigated farming.

Amongst the dune areas of the west coast oases of Regdoline, Agelat and Zuara, small dry gardens containing similar crop associations are common. Here the land suitable for irrigation is limited by the topography. Moreover the saline water is unsuitable for staple crops such as the olive. Management of crops is again inefficient but poor yields are related mainly to the low rainfall. An additional factor is that several of the dry gardens are owned by semi-nomadic groups whose farming practices do not allow for the attention which tree crops require.

Only recently has there been any attempt by native farmers in the coastal belt to develop the dry garden as a separate entity. This has occurred in the coastal stretch forming part of the Jebel piedmont in the Eastern Jefara (Farm Sample No. 3). Usually the olive is cultivated with fruit trees in small bounded gardens.

FARM SAMPLE No. 3. (fig. 32).

This farm is situated on the gently sloping light soil area a few metres south west of the village of Gasr Chiar in the Eastern Jefara (Plate LVIII). The whole area forms a vast piedmont plain broken by the mounds of outwash fans. Rainfall is high and fairly reliable and the plain is sheltered from southerly winds by the Jebel escarpment.

Twenty hectares of land are devoted entirely to dry land crop production since a shallow well provides water only for domestic consumption. The farm was established in 1956 by a wealthy Arab landowner. Previously it had been utilised extensively for pasture and cereals. Subsequently the holding was divided between his two sons when they married.

The total capital investment which included the purchase of plots P and B and a further plot B2, the construction of a house, well and laying out of crops and field boundaries was reported to be approximately £150. This is considerably lower than the total farm capital of old established farms at Zavia where the average farm capital for farms in the same size category amounted to £793 in 1952.[33]

The economy of the farm is based on cereal and olive cultivation both of which are intended for sale off the farm. The olives, numbering about 100 were supplied from the Government nurseries; on plots A and B they are planted in regular rows. But on plot B2 they are irregularly dispersed. These latter olives are 7-9 years old and were planted by the previous owner. Most of the other olives are less than five years old, well-cared for and pruned. They are intercultivated with barley and a few fruit trees. A strip of winter beans meets domestic requirements.

The land is ploughed twice or even three times per year when under herbaceous crops. Ploughing of the land between the trees costs up to £10 for the whole area whereas the open land costs only £5. The implications this holds for the densely planted oases gardens is obvious.

Much of the work of cultivation is done by contract as both brothers have alternative employment. One is a merchant in Tripoli and the other works in an office. Both reside in Tripoli and make periodic visits to the farm and their families. Since the trees are not yet in full production the activities of the farm are limited and can be left in the main to the women and hired labour.

This development of the dry garden in an area adapted to olive cultivation has not been achieved without initiation and capital investment. Fortunately these individuals could withstand this and also the long waiting period before the olives came into full production. Additional employment helps and the intercropping of barley gives some quick returns. Yet already the traditional society and attitudes to agriculture influenced the land use pattern. The public highway effectively splits the holding. The strip of beans has the same effect. Moreover the farm is legally divided amongst two families and unless further expansion can be effected fragmentation is likely to be increased when their descendants come of age.

<u>Dry Gardens of the Jebel</u>.

The dry gardens of the Jebel consist of three main types, known locally as

(1) Gaba Zeitun - essentially specialised olive groves.

(2) Menga - tree crops (generally the olive) intercultivated with cereals.

(3) Ginan (plural Ginanat) - small cultivation of mixed tree crops, figs, olives, cereals.

1. <u>The Gaba</u>. The large unbounded olive plantation of Gaba is a feature of the plains and light hamra soil areas in the Jebel where extensive cultivation is favoured by the paucity of water supply. The extension of these groves is also associated with the more settle farming areas, namely, Msellata, Garian and the Nefousa. Often the trees are undersown with cereals but there seems to be no established ratation as the land may lie fallow for several years depending on rainfall; it then constitutes valuable pasture land.

In Tarhuna and the plains of Assaba and El Baten the instability of settlement and the preoccupation of the population with livestock and cereals hasn't favoured the evolution of such extensive groves.

The Gaba is situated at some distance from the villages and is owned by families resident in the villages. It is difficult to distinguish the fragmented property since no attempt is made to define the areas by low walls. Thus the trees remain exposed to the ravages both of animals and intemperate winds. The position is further complicated by the fact that in many cases the land around the trees comes under separate ownership. This is very often either abandoned, used for common pasture or sometimes sown with cereals. Because the soil is of less importance than the trees, these can become inherited by several members of the family.

In the Western Jebel the Gaba is found in three areas, Es Rehibat-Fassato Er Rodjeban (50-60,000 olives), Ez Zintan-Er Riaina (30-35,000 trees) and the third is at Jefren and Chida (30-35,000 trees). It is the light hamra soils and the stability of settlement which alone explain the presence of the Gaba here, where rainfall fluctuates between 200-230mm's, humidity is low, and where winds are generally violent.

The olives are old and always insufficiently worked. Their branches are high and bushy and so increase transpiration of the sap. In parts the soil is not worked sufficiently to combat the water-poaching weeds. In fact to see olives on the trees two years in succession is an exception.

Towards the east in the humid plains of Guassem and Cussabat cultivation is more intensive and the rotation of cereals and cultivation of the soil is more regular but the same disregard of the trees physiology is apparent.

2. Menga. Together with Gaba, the Menga or mixed cultivation of tree crops and cereals is widely practised in the plains of Garian and Cussabat. Here the higher rainfall assures a more consistent production of winter sown crops.

FARM SAMPLE No. 4. Menga cultivation in the Cussabat plain.

Menga cultivation is typified by this farm sample, which comprises 28 hectares of cultivable land, located at the head of the Wadi Bechier in the Cussabat plain. ([illegible]). Dryland crop production of olives, a few fruit trees and rotated barley forms the base to the farm economy. Income from these products, which are mainly for sale, is supplemented by the returns from an olive press.

The owner of the holding lives in the village of Beni Let about 2 kilometres from the fields. Two cows and two camels are retained for work and transport.

Some 360 olives (13 per hectare) are planted irregularly over the land. They consist of mixed local varieties - Rasli and Gargasci, which are reported to yield an average of 50 kilogrammes of olives per tree. Each year the farmer carries out only 2 ploughings associated with the sowing of barley. There seems to be a two year rotation with barley being followed by green fallow.

After pressing his own olives and those of other clients the oil is sent to Cussabat where it is bought by local merchants.

The farmer envisages no marked intensification of arboriculture except the replacement of the trees as they went out of production.

Very often the soil is built up around the trees to trap the surface run from slight declivities after winter inundations. Plate LIXII). Channels are dug in the slopes to feed run off water to the trees. This practice can initiate severe gully erosion.

3. Ginan. The most efficient farming cultivation in the Jebel is represented by the small dry garden or Ginan, containing mixed tree crops. These are well adapted to areas of broken terrain, wadis and piedmont zone sites. Consequently they are very dispersed and their size varies with the wealth of the families, the size and disposition of the wadis and slopes. They are common in the low dissected hill lands of Msellata, the peripheries of the Guassem plain in Garian and in the small subsequent valleys of the Western Jebel. Here the fig tends to replace the olive on the clay soils. Essentially they depend on surface runs of water to supplement annual rainfall.

The ginanats are characterised by the way in which the farmers are constantly preoccupied with techniques of increasing water supply, protecting plants from weather vaguaries and animals (fig.33).

The system of lateral and transverse terracing is reminiscent of the Roman techniques of water control and soil conservation. The formation of these small tree groves has been favoured also by the contract system of Mogharsa. Wealthy landowners leased land to labourers who were responsible for the conversion of the land and erection of the ginans. Until the crops came into production the labourers existed on a meagre wage. Thereafter the land was either divided between patron and labourer or else production was shared.(66)

In the heavier clay soils of the wadi beds the fig usually replaces the olive which predominates on the hillsides and in piedmont zones.

There is no information on yields from these ginans but they are reputedly higher than in the Gaba or Menga olives.

The gardens are bounded and well cultivated often 2-3 times a year. Since the areas are small - one-fifth of a hectare - this work can be done rapidly by the light and plough (Plate LIX).

The association of these three main types of cultivation forms the basis of settled agriculture and dryland farming in the Jebel. The dispersal and fragmentation of their holdings can only be detrimental to efficient cultivation. This is especially noticeable in the irregular plantations of the

Western Jebel.

Italian demographic farms. In 1949 it was estimated that the total area of demographic settlements amounted to 103,000 hectares on which 11,000 Italians were settled.(68) Since 1956 both the number of Italians and total area of the settlements has declined as a result of failures in land settlement leading to the emigration of Italian families.

The family forms the basic social unit amongst Italians. In contrast to Libyan farms the average number of persons per household is generally much smaller. At Zavia the average number of persons per household was six.(33) In education and literacy the Italians have an advantage over the Libyans but not all have had lifelong experience in farming. Since these farms have only been established with the last 25 years most of them are still being operated by the persons who acquired and organised them. Although most of the farmers find little opportunity for work outside their farms, the better educated female members can find lucrative employment in Tripoli. As typists they can command a wage of forty pounds a month from oil companies.

The Italian farm is composed of a single piece of land on which the farmer's residence is located. Each settlement is well served by major and secondary roads.

Coastal Plain. The Italian demographic settlements in the coastal plain include Olivetti (Giuddaiem), Hascian, Fonduk Togar, Castel Verde (Garabulli), Corradini (Ghanima) and Garibaldi (Dafnia). Maahmura has been wholly restored to the Libyan Government together with the majority of farms at Castel Verde.

The settlements are invariably sited on the lighter soil areas between the oases depressions. With the exception of Corradin, located on the Miocene outliers of the Jebel, the topography is gently undulating or flat.

The average size of farm ranges from 32 hectares at Garibaldi to 17 hectares at Olivetti according to the possibilities for irrigated agriculture. Thus the Italian farms, on the whole, are smaller than the Libyan farms. However, the greater part of the area of the Libyan farms is situated in the steppe zone and cultivated extensively.

Except at Corradini and Garibaldi the area of irrigated land is considerably higher on Italian farms.

Table 47.

Proportion of dry and irrigated land on 17 Demographic Farms in the coastal belt in 1958.

Settlement	Farm No.	Size (ha's)	Dryland (ha's)	%	Irrigated (ha's)	%	Irrigable (ha's)
Olivetti	47	17	12	70	5	30	17
	14	24	12	50	12	50	20
	72	39	29	74	10	26	39
	13	27	15	55	10	45	25
	35	20	12	75	8	25	19
	41	44	30	68	15	32	35
	1	64	50	78	12	22	25
	57	12	66	66	4	34	12
Fonduk Togar	11	30	28		2		25
	18	60	50		2½		30
	17	24	12		12		
Corradini	36	59	59	-	-		-
	9	40	39.98		0.02		
	8	84					2
	58	38	37		1		2
	54	89.4	89.39		0.1		10-15
	33	52	52				

At Olivetti the land under irrigation ranges from 12-50% of the total area or an average area of 9.8 hectares. The land is predominantly dry farmed at Corradini and Garibaldi because of the low yielding acquifers and incomplete well borings in the case of the latter. Wind pumps are used at Corradini and their yields are extremely low (3-5 m3 per hour). Moreover the amplitude of relief at Corradini limits the area which can be served by the present system of pipe and canal irrigation. On the other hand the land at Olivetti, Hascian and Fonduk Togar is gently sloping. The second acquifer is high yielding and most of the farms are equipped with diesel and electric motor pumps. Moreover the adoption of the sprinkler system of irrigation has enabled several farmers to expand the original area served by canals and pipes.

There are significant differences in the use of land between the collective farms and the Libyan farms. Only a small proportion of the Libyan farm area is intercropped because the greater part of the farm lies in the steppe plains. By comparison at least 25% of the area of Italian farms is intercropped.

The farms have a mixed economy combining dry farming and irrigation with livestock. All the farmers reported having trees, foremost among which was the olive followed by the almond. There were exceptions.

Table 48.

Tree Crops on 22 Demographic Farms.

Settlement	Farm No.	Area (ha's)	Citrus	Fruit	Olives	Almonds	Vines
Corradini	9	44	6	-	681 (27 ha)	1180	20,000 (11 ha)
"	8	84	3	-	1144 (45 ha)	1222	37,000 (23 ha)
"	58	38	-	-	523 (18 ha)	822	19,000 (11 ha)
"	36	59	-	-	635 (23 ha)	663	21,000 (12.5 ha)
Fonduk Togar	17	24	220 (52.1½ ha's)		600 (19 ha)	350	-
"	11	30	-		1072 (27 ha)	1050	5 ha's
"	18	60	253	454	1856 (47 ha)	1850	9 ha's
Corradini	54	89	6	-	1122 (45 ha)	1023	22,000 (22 ha)
"	33	52	13	-	773 (15 ha)	571	20,000 (11 ha)
Olivetti	72	39	-	-	950 (39 ha)	350	-
"	51	17	400	-	360 (17 ha)	-	-
"	47	17	20	-	460 (17 ha)	200	-
"	14	24	100 (½ ha)	-	329 (20 ha)	-	(3.5 ha)
"	41	44	150 (.4 ha)	-	606 (39 ha)	160	5 ha's
"	1	64		-	775 (38.5 ha)	200	4 ha's
"	57	12	420		275 (12 ha)	-	-
"	13	27	-	-	380 (19 ha)	50	4 ha's
"	35	20	120 (.3 ha)	-	425	100	4 ha's

At Olivetti the planting of citrus fruit for export is becoming increasingly important where the sprinkler system of irrigation is applied. Thus several farmers envisage the stabilisation of olive cultivation and the expansion of citrus fruit production. But at Corradini and Breviglieri the olive, together with the almond, remain the primary crops (Farm Samples 6, 15, 16, 17.). Owing to the poor prices of wine and high taxation rates, the area devoted to vines is being diminished and this will allow the further planting of the olive and almond. The greater part of olive production is for sale off the farms. Most of the farmers reported pruning their trees every other year but the use of commercial fertilisers was not common. Harvesting in nearly all cases was carried out by handpicking rather than the beating of the tree which is a characteristic Libyan technique (Plates LXI and LXII b,c) Those olives which can be irrigated are rarely given full irrigations. Usually they benefit from the irrigation of intercultivated herbaceous crops or else are given light waterings during the critical periods of February and March. Full irrigation is reserved for the high value summer grown annuals, vegetables, tomatoes, melons and groundnuts. Water is given to them every 4-7 days during summer according to their needs. With partial irrigation farmers have found that their yield of olives can be increased fourfold. There is much to be said for the semi irrigation of the olive since it can bring greater stability to olive production. Ultimately the question of irrigation depends on the cost of water usage and crop prices. Many of the farmers preferred the citrus trees and groundnuts to olives under irrigation.

Steppe. There are six collective settlements in the steppe zone; Bianchi (Azzahra), Micca (El Amiria), Giordani (Annasira), Azizia, Gioda ( ) and Crispi (Tummina). Except for 10 families the greater part of Gioda has reverted to the Libyan Government. The others remain almost wholly Italian.

Bianchi, Micca, Giordani and Azizia are situated on the undulating Jefara to the south of Tripoli. The distribution of the farms coincides with the second phreatic water table. The settlements of Crispi and Gioda are situated in the more arid plain south of Misurata where artesian water supplies are abundant.

The olive is everywhere cultivated as a cash crop and the oil is sold on Tripoli markets. The techniques of cultivation are comparable to the best farms on the coast; the trees are pruned and the land after cultivation is left in bare fallow. One danger in the dryland orchards is the continued association of almonds with olives after the latter have come into full production when their water needs are increased. Harvesting techniques are efficient but some of the farmers complain of the shortage of labour.

FARM SAMPLE No. 5. (Fig. 34). Farm No. 72. Olivetti by I.N.P.S.

The farm was given in concession by I.N.P.S. in 1938 and the proprietor has since gained full title deeds to the land. He holds an elevated position amongst the settlers as he is its agent for I.N.P.S. as well as manager of the co-operative oil press.

The farm comprises 39 hectares of cultivable gently sloping terrain. It is located on the main Tripoli-Zavia highway. The economy of the farm is based on the partial irrigation of olives and almonds and full irrigation of citrus trees and herbaceous crops. Water is supplied from a well exploiting the second aquifer at a depth of 25 metres. This is centrally situated in the cultivated area. It is equipped with an electric diesel pump which yields 45 cubic metres of water per hour. The water is distributed from a reservoir by the pipe and sprinkler system which would enable him to irrigate the whole area (Plate LXIII). In 1958 only about 10 hectares received irrigation water. The reservoir has a storage capacity of 200 cubic metres.

The farm plan is laid out in the typical rectangular pattern and divided into two plots. Eucalyptus, pines and cypress trees form the boundaries on two sides and act as useful windbreaks.

Olives and almonds are the primary tree crops foreby one hectare of oranges which surround the farm house (Table 49).

Table 49 Land Use 1957/8.

Tree Crops	No.	Area	Specialised	Intercropped
Olives	950 (100 prod.)	38 ha's	37 ha's	10
Almonds	350 (all prod.)	10 "	-	10
Oranges	-	1 ha		
Annuals				
(a) Winter				
Barley		4 ha's	(Irrigated)	"
Wheat		2 "	"	"
Beans				
(b) Summer				
Groundnuts		10 ha's		
Forage		2 ha's		

Ten hectares of olives are intercultivated with almonds at distances of 10 x 20 metres whilst the remainder lie in specialised rows. The trees are aligned in echelon fashion and are ploughed by tractor three to four times a year. The olives comprise 200 of the Chemloli variety and 750 of Frantoio. But the grafting of these with Chemloli is in progress. Only 100 trees are in full production but in a good year they can produce 1000 quintals of olives, (100 kilogrammes per tree). But on the average production is about 500 quintals, which is for sale off the farm.

The farmer practises a type of strip rotation amongst the lines of olives. During winter at least 4 ha's of wheat and barley and two hectares of beans are intercultivated and given light irrigations. Whilst during the summer of 1958/9 10 hectares of groundnuts and 2 hectares of forage crops were grown and intensively irrigated.

The farmer estimated that he irrigates these crops 21 times during the summer at 300 m3 per hectare. This figure may rise to 28 during a ghibli. At an average cost of 2 millimes per m3 the expense incurred amounts to about £120 for the summer.

Fifteen hectares remain uncultivated amongst the trees each year. This land is meticulously ploughed bare to encourage water storage.

The olive trees are well shaped and pruned every two or three years. Although the trees could all be irrigated only those which are intercultivated receive any considerable amount of water. Otherwise the specialised trees are given water only at critical periods. Excluding any irrigation cost, the cost of harvest, pruning and ploughing works out at about 70-80 piastres per tree (14-16/-).

The farmer intends to plant 400 citrus relying on irrigation water and prefers the high cost products - i.e. groundnuts, citrus and other fruit trees. The farm relies largely on hired labour, which is plentiful in this area.

Jebel. The Demographic settlements in the Jebel have experienced mixed fortunes: almost total failures in land settlement have been recorded at Tazzoli and Marconi. However the farms at Breviglieri are representative of some of the best dryland farms in the country. The 168 farms are well established and most of the farmers have gained full ownership.

FARM SAMPLE No. 6 (Fig. 35).

This farm was one of the first to be completed in Breviglieri. It occupies some of the best land near the centre of the settlement. Typical of the family farm the household consists of six persons. The father and two sons are responsible for the management of the farm. In addition one paid labourer is employed throughout the year.

Before occupying this farm the owner originally worked for four years one of the nearby private concessions. The total value of the farm, as estimated by E.N.T.E. amounted to £1,300 (i.e. £26 per hectare approximately). This debt has now been completely paid off.

The farm comprises 56 hectares of undulating land which is incised by the tributaries of a south flowing thalweg. The banks of the wadis have been carefully planted with Acacia and prickly pears to control erosion. In the lesser wadi, running by the house, a small dam has been constructed to spread run off waters over a fruit orchard. The larger wadi is unused and here semi nomads, who come for the harvest, are allowed to reap a frugal crop of barley.

Thin soil and rock outcrop account for seven hectares of uncultivable land. Otherwise the soils are admirably suited to tree cropping. The fields are well protected from vigorous winds by eucalyptus and pine boundaries.

Thirty-three hectares are devoted to olives and almonds (24 x 12 metres) containing 590 olives and 100 almonds. Olives (119) intercropped with vines cover an area of 5.3 hectares (24 x 24 metres). (Plate LXVII). The remaining 9.7 hectares are laid out to specialised almonds, fruit trees and windbreaks.

The olives, of the Frantoio variety, are in full production. They are deep ploughed twice a year and pruned every 2-4 years, so that each year about one third of the trees are out of production.

Barley and wheat are rotated in strips each year amongst the olives and almonds.

The crop is sent to the Breviglieri co-operative factory and the oil is sold to merchants from Tripoli.

In the 1957/8 season 100 quintals of oil were produced from the farm which gives a yield of 100 kilogrammes per tree. This compares favourably with the trees on the coast at Olivetti.

The farms are generally larger than the irrigable collective settlements on the coast. This is represented by a greater area devoted to dryland cropping. However at Crispi and Gioda, where rainfall is submarginal for all except the most adapted crops, the proportion of irrigated land to dryland is much greater than in the Jefara. The fact that the farms at Azizia are equipped with low yielding windpumps also accounts for the accent on dry farming. But at Bianchi, where wells yield in the region of 50 cubic metres of water per hour and many of the farms possess electric and diesel pumps, the size of the irrigated area is accordingly increased.

The land use of the farms is essentially similar to that prevailing in the coastal belt; a combination of dryland and irrigated agriculture. In the same way the olive is the basic dryland crop and in the best irrigated zones receives supplemented irrigation. At Azizia however the olive, either in specialised plots or associated with the almond, is entirely dry farmed.

The shift to high water consuming, high income crops, as was noted on the coast, is evident at Bianchi. The area is favoured by proximity to Tripoli markets, a reasonable electricity supply and high yielding acquifers. Groundnuts and citrus fruit cultivation is expanding even though their water consumption and cost of production is higher than that at the coast. These developments are taking place through the use of electric pumps and sprinkler irrigation equipment. However falling water levels in a number of the farms may create serious difficulties in the future. There is something to be said for the irrigation of crops, such as the olive, requiring low amounts of water, if indeed the falling water levels represent a permanent decline in the water table.

Italian Concessions. In size, financial status, and management there are substantial differences between the

Italian private concessions and the collective farms. The concessionaire is typically an Italian of relative wealth, or at least with some financial backing. Although the cropping systems and techniques of cultivation are broadly similar to the Italian collective farms, the concessions have been allowed greater scope as regards method of land settlement and farm organisation. The larger farms are comparable to a typical plantation type of farming operation in a moderately well advanced commercial agricultural area. Whilst the demographic farms were based primarily on the goal of self sufficiency, the concessionaires have had the freedom and choice of economic specialisation. (Plate LXIV).

The concession is rarely a family farm. The work is generally performed by hired labour, primarily Libyan, although some proprietors still employ Italian subforemen and Italian working families. However on those farms where crop production is limited to a single period in the year, the reliance on a fluctuating labour supply is providing difficulties.

Questionaires were distributed to several concessions in the coastal belt and three farms were visited (Farm Samples 7,8,9). In the coastal belt the area of irrigated land decreases proportionately with the increase in size of the holding. In every case the olive, vines and almonds were the main dryland crops.

Libyan Hawaza. The Libyan Hawaza forms a special farm category. They are organised on the same lines as the large Italian concessions and owned by wealthy Libyans who, in many cases, were granted land by the Italians. They are found predominantly in the west coastal plain.

FARM SAMPLE No. 7.

This Libyan Hawaza is located on the northern fringe of the oasis Di el Harscia which lies to the west of Zavia. It is owned by a lawyer who lives in Tripoli. The management of the farm is left to a Libyan foreman and hired labour. The land is rolling and the light soils are well suited to dryland arboriculture. However the accessibility of water in the second water table has encouraged irrigation. A small diesel pump feeds the water to newly acquired sprinkler irrigation pipes.

The total area of the farm amounts to 186 hectares of which 36 hectares is planted with 1,100 olive trees of local varieties. These are now being grafted with the Tunisian chemloli. Approximately 20 hectares of olives (600 trees) is intercultivated with vegetables and cereals, and regularly irrigated. The remaining 16 hectares is completely dryfarmed and devoted solely to olives. A small nursery has been planted to permit the planting of established varieties (Plate LXVI).

Every three years the trees are pruned and the branches are occasionally sold. (Plate LXVII). The farmer complained of the irregular labour supply at peak periods caused mainly by the conflict with the cereal sowing and movement of labourers on to the interior plains. The olives are crushed locally and oil is sent to Tripoli since the farmer reported overproduction and poor prices in this area.

The farm manager envisaged the increased use of irrigation for the olive and the steady replacement of local varieties with the Tunisian chemloli. In efficiency and equipment this farm compares favourably with the better Italian concessions.

FARM SAMPLE No. 8 (Fig. 36).

The Italian concession Valdagno is the largest private farm in the east coast plain. In 1937 the concession was bought by an Italian industrial company who invested £1½ million at a time when Italian foreign investment was being encouraged by tax exemptions.

It was planned to divide up the land into plots, furnish each with irrigation water and settle sharecroppers. By 1940 most of the preliminary work was completed and 32 sharecropping families were settled. As a result of the war and emigration since Libyan independence only 11 families remain. Most of the concession is now directly managed whilst the sharecroppers still maintain a 50-50 basis.

Most of the settlers came from rich farming areas in Northern Italy (Venetia) and this may account partly for the general industrious and fertile aspect of the area.

Originally the land was tribal and devoted to shifting cultivation and grazing similar to the land on the eastern margins of the concession (Plate

The estate comprises 774 hectares of arable land, 7.50 hectares of woodland, 368 hectares of undeveloped land and 7.50 hectares of uncultivable rock waste. The concession is sited on the piedmont flats which is overlooked by the small Misuratino scarp. The area is well protected from ghibli winds but saline maritime winds are reported to retard tree growth. Lying adjacent to the Homs-Misurata coastal road the concession is easily accessible to markets at Homs and Tripoli.

The southern boundary is formed by eroded scree which, in the lowest parts, has been afforested.

Water is supplied from deep sub-artesian wells. It is pumped by motors capable of yielding 50 m3 per hour. The water is distributed by subterranean pipes to gedula plots (Plate LXVIII). Each well serves about 11 hectares.

The economy of the estate is based on livestock and crop production. Over 200 Barbary sheep and 100 locally bred cattle are kept.

Amongst tree crops and field crops the olive is pre-eminent. Some 45,000 trees occupy an area of 385.50 hectares compared to 100 hectares of barley, 100 hectares of eucalyptus trees and 60 hectares of tobacco. The olive, together with the vine, tobacco, eucalyptus and livestock products provide the main cash sales of the estate.

159 hectares of olives are dryfarmed in specialised groves, whilst the remaining 226 hectares receive full irrigation and are found in both mixed and specialised stands. Because of saline winds even the irrigated olives only reach full production after their 15th year. Many of the trees are still only 7-8 years old with a maximum age of 22 years. At present the average production is around 400 tons of oil which is sold to merchants in Homs. Production is likely to be increased as the younger trees mature, and also because the olive is steadily replacing the vine.

Labour requirements of the concession are very high. An average of 250 employees during the year rises to more than 600 at the olive harvest.

Although it is likely that the olive production will expand, the future of the estate is not at all certain. Expansion is limited by shortage of capital, the political situation and the shortage of technicians.

FARM SAMPLE No. 9 (Plate LXIX I).

The Concession Fontana Piacento extends over an area of 1,300 hectares on the north western perimeter of the central Tarhuna plateau. The topography is undulating and the light hamra soils of the crests and hill slopes become more coherent in the valleys. The highest summits are denuded of soil cover.

The economy of the farm is devoted almost entirely to arboriculture and large plantations of olives and almonds clad the rolling hills. Amongst tree crops the olive is predominant. 520 hectares is devoted to specialised olive cultivation containing 12,000 trees of which 8,000 are in production. In smaller parcels of land the olive is found intercultivated with almonds.

The trees are planted in a rectangular pattern 20 x 20 metres and entirely dry farmed. They comprise the following varieties, Coratina, Leccino, Pradente and Frantoio.

Every year the land around the trees is ploughed 2-3 times, depending on rainfall and the soil kept absolutely bare. Also pruning is carried out every 3-4 years.

The average production of each tree was reported to be 25 kilogrammes of olives although in 1958/9 season a yield of only 16-18 kilogrammes was obtained. Each year an average of 2,000 quintals of olives is produced. These are pressed in the farm mill and oil is sold to merchants whom the farmer claims give better prices than the local co-operatives.

Future plans envisage the maintenance of olive production at the expense of almonds.

FARM SAMPLE No. 10.

Concession Morabito lies on the southern limit of sedentary agriculture in the Jefara. It was granted in 1928 at a time when there were no roads. For one year the proprietor lived, as he says, like a pioneer amidst virgin steppe! Between 1928 and 1931 all buildings were erected and a well was constructed. In addition olives, almonds, pistacchio and cereals had been planted and sown. The proprietor's experience in farming has been derived in the last thirty years; before that he was a lawyer. Originally eight families were settled on plots on the concession but these have since emigrated to the coastal towns and Italy.

The total area of the concession is 487 hectares of which 200 hectares is laid out to specialised dry cultivated olives. This area contains approximately 6,000 trees. All of them are of the Italian variety and predominantly Frantoio.

Four to five ploughings with a tractor are undertaken each year amongst the olives. Pruning of them is carried out every two years.

Because of the arid conditions it has taken nearly 30 years for the trees to come into economic production. In 1956/7 6,000 quintals of olives were produced yet in 1957/8 production was negligible.

The labour problem was found to be acute in this area because of the specialised production of the farm and the practise of the Libyans to extend the sowing area in good years and therefore prolonging their operations. Throughout the year 20-25 Libyans are employed but between 100-150 are required at harvest time. In an effort to decrease this problem the proprietor intends to maintain rather than expand olive cultivation.

The olive crop is manufactured in the farm press and sold privately to merchants. Although the cropping system and husbandry is adapted to the area where rainfall is marginal and soils windblown the farmer faces great difficulties of labour and distance from markets. These are expressed in his confessed lack of confidence in the future.

<u>A comparison of the Libyan and Italian Systems of olive cultivation</u>. From the preceding survey of farming systems there is little doubt as to the technical superiority of the Italians over the majority of the Libyan farmers. Only in the west coastal plain and on the Libyan Hawazas do the skills and knowledge approach anything like the standard achieved by the Italians. Undoubtedly the Italian example, combined with the wealth of the Hawaza owners, has been responsible for the transformation.

The Italian system of planting trees equidistant to rainfall not only allows mechanised cultivation and therefore more rapid cultivation, but facilitates intercropping of the trees in strips. This is invaluable during the long unproductive period of the olive. By this method a form of rotation can be practised. However it is a system mainly adapted to gently undulating hill lands or plateau surfaces and its use is limited in dissected terrains where the nature of the wadis and impluviums dictate the distribution and arrangement of the trees.

Under conditions of dryland farming, as with irrigation, the pruning of the tree is essential to control the form and shape of the tree as well as its regularity of production.

The high stature of Libyan trees, combined with the practise of cutting the lower branches to prevent injury from animals encourages the widespread method of beating the trees at harvest time. This may also reflect a shortage of labour. This not only injures the tree but can effect considerably the quality and the yield in the fruit itself. Especially in those districts of the Jebel where population has seriously declined is there a need to reduce the work and effort required in the harvest.

The fact that the olive harvest often coincides with the sowing of cereals produces further pressure on population resources. Consequently harvests may be prolonged for several months after October with the deterioration in quality and oil yield of the fruit.

Most Italian farmers, on the other hand, carry out some form of pruning. In the coastal plain this very often takes place every other year. Whilst this means that a third of the total trees may be out of production each year, the pruned trees in the following year help to stabilise production.

Neither the Italian or Libyan farmer carries out much fertilisation of the trees except when they are under irrigation and intercultivated. The system of handpicking the fruit from the trees by means of step ladders is widespread amongst Italian farmers.

There is very little in the way of an established system of rotation for intercultivated annuals in the irrigated coastal gardens. In many cases the land is continually worked. The parts that are left in fallow are rarely allowed to accumulate a soil moisture reserve since the weed cover is hardly ever removed. Thus any benefits the olive may have derived from a fallow is lost. Although weed control is not everywhere practised on the irrigated Italian farms, the high proportion of land left in fallow is generally kept free. The practice of strip rotation amongst the olives enables the trees to benefit from the rains.

The meticulous cleaning of the land in the dry farmed plantations of the steppe and Jebel is common amongst Italian farmers. In the specialised olive groves the trees are ploughed 3-4 times per year depending on the rains and vegetative growth. This is easily done by tractor and plough. Winter cereals and legumes are intercropped over a restricted area and after the harvests the land is usually left in bare fallow. However the soils in these areas tend to be light and unstable. Deep ploughings can facilitate soil erosion by winds. One method of counteracting wind erosion is to plough pruned twigs and branches back into the soil and thus help to bind it. This practise could easily be disseminated amongst Italian farmers since they make little use otherwise of the pruned wood.

The Libyan method of reproducing the trees is usually successful. The best branches are cut from an old tree and planted. By this method, however, the tree is slow to become established. In contrast Italian orchards are mainly developed from seedlings which under such arid conditions are liable to have a high mortality rate.

Both the Italian and Libyan farmers should be encouraged to replace their trees by means of the ovule or cutting from roots of successful varieties (Plates LXIX and LXX). The advantages of greater resistance to drought, assured productivity, and more rapid growth are all to be recommended.

The practise of intercropping the olives is widespread amongst both Italian and Libyan farmers, especially where irrigation water is available. This feature is essentially related to the long unproductive period of the olive and to water use. However under dry farming there is a limit to crop density set by rainfall. The Libyan practise of sowing cereals amongst olives is well adapted to rainfall conditions in the Eastern Jebel. But amongst Italian farms the practise of associating olives, vines and almonds after the olive has entered its full productive phase, is liable to upset the equilibrium of the tree.

There ought to be a natural evolution to specialised orchards like the Libyan ginanats, if yields and regularity of production are not to be effected.

Both the Italians and Libyans recognise the importance of auxiliary irrigation for the olive. The olive can benefit from irrigation in the early stages of planting and during the period of full production. Supplemental irrigations are invaluable during a ghibli. The periods for irrigating the olive are during flowering (March-April), the development of fruit branches (July, August) and when the olive is maturing (October).

Although the olive comes into production sooner with irrigation costs of cultivation are naturally increased. Allowing for the variation in market prices and natural hazards to the crop Marroni has shown that it is the productivity of the plantation in terms of density and yield that effects income. (Table 50). He shows that the irrigated olives are four times more profitable than those completely dry farmed. Moreover the rapid development of the olive under irrigation is important where the greater part of the rural population lives at subsistence level and can ill afford to wait 15 years for the olive to produce.

However there are certain technical, economic and geographic difficulties to the extension of irrigation and the conversion of dry farmed orchards. The expansion of irrigated agriculture can only be expected in the coastal plain and the Jefara where both superficial and deep waters have been proved to be of good quality and sufficient yield. In the existing oases gardens it is doubtful if the replacement of the dalu by the electric pump can alleviate the crowded situation. Such a conversion could only place a strain on the shallow water tables which even now only yield after

Table 50 (1)

Cost of Production from a dry farmed and irrigated olive plantation at Castel Benito.

A. Annual cost of specialised plantation per hectare in dry cultivation.

Number of trees 25 (20 x 20 metres)		
Pruning 3 times at 15 pire	45	lire
3 Cultivations	135	"
Fertilisation	50	"
General Expenses	50	"
Interest, payment, maintenance	20	"
" mortgage	60	"
	360	"

B. Annual cost of specialised irrigated olives.

Number of trees 100 (10 x 10 metres)		
Pruning 12 times at 15 lire	180	"
5 Discing and ploughings	225	"
Fertilisation	200	"
Number of irrigations 3 at 2,500 m3.		
Cost of water 1/5 lire per M3	375	"
Cost of diesel pump	100	"
Cereal costs	100	"
Maintenance, mortgage	30	"
Interest, new plants	80	"
	1,290	"

Assuming an average production of 60 litres of olives for both irrigated and dry olives.

Dry cultivated 25 x 60	750	litres
Irrigated 100 x 60	3,000	"

Deducting 20% from each for harvesting and transport the productivity of the irrigated olives is 4 times greater i.e. 600 - 2,400 litres.

(1) After Marroni. Aspetti ed economici dell' olivo in Tripolitania in rapports all irrigazione (Boll. R. Officio agrario della Tripolitania) 1934, vol. XII.

periods of recuperation.

One solution is to replace several dalu by one motor pump but there are social and economic barriers to such consolidation.

Water depletion in the Jefara at Bianchi also warns against the danger of over exploiting resources which depend on annual rainfall for their replenishment.

Any expansion of irrigated agriculture must consider the relative costs and advantages of each system. The dalu requires an animal and at least two men to irrigate an area of about ¼ hectare. This explains why there is a desire amongst Libyan farmers to acquire a motor pump. The electric pump enables a much larger area to be irrigated and consequently a greater scope in land use. Dalus depreciate rapidly and 2 or 3 goatskin bags have to be bought each year.[(34)]

Comparative studies have been made of the cost prices per m3 of water pumped by wind engine, diesel pump, electric motor and artesian well. Allowing for the capital outlay and maintenance the borehole, despite considerable investment, was found to be the cheapest. Farmers on the collective and private concessions are increasingly adapting the sprinkler irrigation system instead of the traditional gedula methods of water distribution. But the cost of using electric pumps and sprinklers runs out at about £100 - 120 per hectare.[(34)] Such costs inevitably encourage the farmer to concentrate on high income cash crops e.g. groundnuts and citrus have begun to displace the olive along the coast.

The use of electric pumps is also restricted by the distribution of the electricity grid which operates from Tripoli along the coast and inland to Suani Ben Adem. Electricity costs are very high owing to the obsolete nature of the power plant in Tripoli. Most farmers, however, receive a subsidy of 8 millemes towards the total cost of 19 millemes per hour.

Running costs of irrigation could be reduced if farmers were to irrigate during the cooler parts of the day or at night instead of at midday when evaporation is intense. This applies to both Libyan and Italian alike. The needs of the tree as regards moisture do not appear to be fully understood by many Libyans and Italians. There is no established irrigation system amongst Libyan farmers, the water use schedule is governed by the low capacity of the dalu and the state of the field crops. Italians show greater appreciation of the physiology of tree and normally irrigate at the critical periods and during a ghibli.

The Libyan systems of olive cultivation are by no means ill adapted to the environmental possibilities. In the Msellata region especially, the farmers possess a rich tradition in arboriculture and the soils are well cultivated. The trees are protected from animals and their productivity compares favourably with Italian plantations on the Jebel and even with the irrigated orchards of the coast.

The failings in the Libyan systems and techniques of olive cultivation result from a combination of factors. These include:

(a) On the coast olives are of secondary importance in the native economy and tend to receive less attention than the valuable irrigated crops.

(b) On local markets the quality of olive oil is unimportant and therefore there is no price incentive to raise the standard of cultivation and consequently the quality of the oil.

(c) Because of the low standard of living and tribal affiliation accent is placed on varied crop production.

(d) The gradual evolution of agriculture under conditions of political and economic stability has hindered efficient and rational use of land and water resources.

(e) Problems of land and water ownership, fragmentation and dispersal of land impede improvements in productivity.

(f) The low level of technical knowledge and low capital accumulation originate from the prolonged existence of subsistence agriculture.

A comparison of farm incomes emphasises the technical difference between Italian and Libyan farms.

Some idea of farm income is provided by Theodorou.(33) In 1952 the average value of farm production from 70 Libyan farms at Zavia (ranging from Saniyas to Hawazas) amounted to £277 of which 73% was from crops and crop by-products. Only £99 was obtained by selling products off the farm; the remainder was consumed by the household. Table 51.

Table 51

Average Value of crop production from 70 Libyan farms at Zavia in 1952.

Barley	£50
Wheat	15
Olive oil	18
Dates	21
Vegetables, grapes, alfalfa	67
Total	£171

1952 was an average rainfall year and typically barley was the most important crop. Since barley, wheat, olive oil and dates account for 60% of income annually then fluctuations in any of the harvests will noticeably effect the total income. From an economic viewpoint alone there is thus a need to stabilise olive crop production.

By comparison the value of crop production on 70 Italian collective and private farms averaged £1,313 of which £947 was from the sale off the farm of crop products. 85% of the value of farm production was obtained from crops and their by-products. (Table 52)

Table 52

Average value of crop production from 70 Italian farms at Zavia, 1952.

Barley	£41
Wheat	99
Olive oil	127
Groundnuts	415
Citrus	52
Almonds	54
Vegetables, grapes, alfalfa	237
Total	£1,025

On Italian farms groundnuts accounted for over 40% of the total value of crop production; olive oil was second in importance.

Naturally the order of the value of crop products is not constant but varies with climate. Thus fluctuations in the dryland crops significantly influences total income. These problems of fluctuating crop production are accentuated in the dry gardens of the Jebel and cannot be stabilised by irrigation. On the whole the lack of stabilisation in the Libyan crop economy exists because most of the trees are old and of the same age. Therefore in years of poor rainfall all go out of production. The lack of pruning means that average production cannot be raised by having a part of the orchard coming into production each year. The absence of stability is only relieved by indebtedness. The ordinary small Arab farmer can only obtain credit from merchants and moneylenders. One way is to sell the olive crop before harvest. In doing so he relinguishes the benefit of high market prices.

Because the banks and credit agencies require certificates of land ownership, security and credit is difficult to obtain. Moreover the credit which is available is only released for relatively short periods and thus long term policy changes in land use and equipment are impeded.

However, change is gradually being wrought as a result of government intervention. Programmes for improving techniques, educating the farmer and subsidising certain activities are well under way. Small agricultural departments now serve each province. These provide the services of trained field workers. Pilot demonstration schemes of soil and water conservations have been commenced at Tarhuna and Garian. Already several nurseries have been established throughout the region, where the most adapted varieties are

Table 53

Number and Variety of Young Olive Trees planted in Government Nurseries 1954/7.

Nursery	Type of cultivation	1954/5	1955/6	1956/7	Variety
Sghedeida	Dry	10,000			Chemlali
	Irrigated	37,224			Local from Cussabat
Garabulli	"	2,291	4,530		"
Homs	"	4,500	9,300	9,500	"
Misurata	"	4,524	7,232	9,500	"
Garian	Dry	19,669	9,636	16,625	Local from Garian
Jefren	"		5,809	10,335	Local from Jefren
Tarhuna	"		12,551	24,000	Local from E. Jebel
		78,208	49,059	69,960	

being grown so as to give confidence to local growers in the future results of the plantations. (Table 53) It is essential that these plans be implemented on a regional scale because of the marked variations in climatic and water conditions.

During 1956/7 and 1957/8 teams of expert pruners carried out pruning operations along the coast and eastern Jebel. Some 40,000 trees have thus been pruned.

Although the Italians have demonstrated their techniques of dry farming and irrigated olive cultivation are generally successful under the prevailing environmental conditions, there is still some doubt as to the economic viability of their settlement schemes. These have been heavily subsidised both in the initial capital investment and subsequent running expenses of the farms. Their change in political status has resulted in the termination of both Ente's and INPS's work.

Economic Results of Olive Cultivation. In attempting a comparison of returns from various systems of olive cultivation in Tripolitania one is immediately faced with certain problems. Briefly, these are as follows:

(1) The wide geographical distribution of the olive and the variety of the farming systems.

(2) The general lack of cost accounting amongst Libyan farmers and the reluctance amongst Italian farmers to disclose the facts of their economy.

(3) Since many of the farming systems concentrate on mixed cropping, yields, costs and incomes cannot easily be estimated for the olive alone.

(4) To show fluctuation in earnings information over several consecutive years is desirable.

Some facts do emerge from the few cases which were examined (Farm Sample 5). There are significant differences in the yields per hectare, per tree, costs of cultivation and income between Arab and Italian farms, and between those dry farmed and irrigated. These differences are related less to environmental factors than to systems of tenure, and techniques of cultivation.

In general yields per hectare were found to be greatest on Italian concessions. This is related to the higher density of planting and prevalence of monoculture. However, under irrigation, high yields can be maintained which in good rainfall years can be matched by dry farmed olives. Thus at Breviglieri and Olivetti, where conditions are very dissimilar, yields per tree in 1958 were remarkably similar.

Assuming that the average wholesale price for olive is £2.7 per quintal (i.e. 1957/8) then both total income and income per hectare from the sale of oil is notably higher amongst the large private concessions. Under irrigation the olives at Olivetti give an income almost twice that of dry farmed olives at Breviglieri.

Most of the Italian farmers sell the by-products of the olive, notably sansa oil, and occasionally wood from the pruned tree, but no information was available as to the quantities sold or prices paid. In contrast the Libyan farmer rarely sells the by-products. The income from by-products ought really to be considered in addition to that obtained from the production of oil.

The costs of cultivation, excluding those for transport, pressing of olives and interest payments is high on the large concessions of Morabito and Valdagno. They are equivalent, however, to the costs of cultivation for irrigated trees at Olivetti where the cost of irrigation represents 1/5 of the total outlay.

Naturally the costs of cultivation and pruning will remain fairly constant, whereas the costs of harvest and irrigation will fluctuate with the year. This phenomenon has special implications for the small farmer whose fluid assets are small.

The profit derived from the production of oil amounted to £70 at Breveglieri but both the Morabito concession and the farm at Olivetti recorded a net loss. However, in the case of the latter farm only 100 trees out of 950 are in full production and depending on the price of oil a net gain is likely in the near future.

Income is determined largely by the yield of the trees and market prices for oil, whilst costs are clearly related to farm sizes.

The costs of production are more stable generally than income which fluctuates with the yield of the trees and market prices. Fig. 37 indicates the amplitude of these fluctuations in yields on several demographic settlements over a four-year period. Yields from irrigated olives have in all cases been more stable than those which were dry farmed. The highest yields have been obtained on the coast where climatic conditions and irrigation practices are beneficial.

The range in farm sizes and number of olives would seem to be important factors influencing yields and earnings. The farm of 56 hectares at Breveglieri appears to be efficiently managed and provides a relatively substantial income from dry farmed olives. The margin of profit is similar for the Libyan farm at Cussabat although the turn-over is not so high.

However the large dry farmed concessions, where monoculture is practised, with higher overheads, is entirely at the mercy of markets and weather vagueries. Income was virtually nil for the Morabito concession in 1957/8 season when only 3 quintals of olives were produced. Some diversification is obviously required, or else the farm is too large for efficient management.

The smaller demographic farm of about 50 hectares, with a more diversified crop production, seems more adapted to prevailing climate and market conditions than to the large concession which also is experiencing difficulties of labour supply.

No conclusion can be drawn regarding the viability of the irrigated farm at Olivetti since most of the trees are not yet in full production. Whilst irrigation costs will increase perhaps 8 times and the addition of 700 trees yielding an average of 50 kilogrammes a year could make a substantial difference to the earnings from the culture.

The additional cost of taxes scarcely affects olive cultivation since taxes per annum on the olive amount to over £L0.031. Moreover a large section of the Italian community is still exempt from tax dues (only those farms which have operated for more than 25 years have to pay tax).

Economic Results of olive cultivation.

1. FARM SAMPLE 6.

Brevèglieri - farm 80 - dry farmed.

Total trees 6,500
Area 38 hectares
Density 13 trees per ha.
Production of olives - 1957/8 - 50,000 kilos.
Yield per tree - 100 kilos.
Per hectare - CI342 "
Production of oil - 100 quintals.
Income
100 quintals of oil @ £2.7. = £270 = £7 per hectare.
Costs of cultivation
2 ploughings @ £1 for 30 hectares = £2. 12s.
Harvest - 1/- for 12 kilos of olives = £200.
Pruning - total cost - £202. 12s.
Cost per hectare - c.£5
" " tree c.8/-

2. FARM SAMPLE 14.

Cussabat - dry farmed.

Total trees - 360
Area - 28 ha's.
Density - 13 trees per ha.
Production of olives 1957/8 - 18,000 kilos of olives.

Yield per tree - 50 kilos
Per hectare - 643 kilos olives
Production of oil - 36 quintals of oil
<u>Income</u>
36 quintals of oil @ £2. 7s. = 97.3 = £3 per ha.
Only cost of ploughing and harvesting.

3. FARM SAMPLE 5.

<u>Both farms are near oil presses</u>.

<u>Olivetti</u> - Farm 72 - irrigated.

Total trees - 950 (100 in full production)
Area - 38 ha's.
Density - 25 per ha.
Production of olives 1958 - 10,000 kilos of olives
Yield per tree - 100 kilos
Per hectare - 2,500 kilos olives
Production - 20 quintals of oil
<u>Income</u>
20 quintals of oil @ £2. 7s. = £54 = £13.10s. per ha.
<u>Cost of cultivation</u>
Irrigation - 6,400 m's3 at 2 mills. = £12. 6s.
Cost of cultivation, pruning, harvesting - £80 (16/- per tree)
Total cost = £92. 6s.
= 23 1/6d per hectare
= 18/- per tree
Deficit = £38.

4. FARM SAMPLE 8.

<u>Valdagno</u> - East Coastal Plain.

Trees -
35,000 irrigated olives on 226 hectares
Density - 159 trees per hectare
10,000 dry farmed olives on 159 ha's.
Density - c.50 per ha.
Production of olives - 2,000,000 kilos of olives in 1957/8
Yield per tree - c.44 kilos olives
" " hectare - c.5,200 kilos
Production of oil - 4,000 quintals of oil
<u>Income</u>
4,000 quintals of oil @ £2. 7s. per quintal = £10,800 = £28 per hectare.

<u>Cost of cultivation</u>

(1) Irrigation - 226 ha's @ £4 per ha. = £904.

(2) Ploughing, etc. - 385 ha's @ £21 per ha. (i.e. 3 times or £7 per hectare) = £8,098.

(3) Cost harvest - 40 piastres per quintal of olives = £8,000.

Total cost - £17,002; per ha. = £44; per tree = £0.3
Deficit - £7,802.

5. FARM SAMPLE 10.

<u>Morabito Concession</u> - Jefara - dry farmed.

Trees - 6,000 olives on 200 hectares
Density - 30 olives per ha.
Production of olives 1956/7 6,000 quintals;
1957/8 3 quintals.
Yield per tree - 100 kilos
" " hectare - 3,000 kilos olives
Production of oil - 1,200 quintals of oil
<u>Income</u>
1,200 quintals of oil @ £2. 7s. per quintal = £3,240 = £16. 2s. per hectare
<u>Cost of cultivation</u>
Ploughing 4-5 times per annum @ £2. 10s. per hectare = £2,000
Pruning every 3-4 years of ½ of olives = £285.
Harvest - 40 piastres (8/-) per quintal of olives = £2,400.
Total cost 1956/7 - £4,685.
Deficit £1,445.

Cost of cult. per hectare = £23.47
per tree = £0.78

Questionnaires were distributed to a number of Italian demographic and concession farms located in the coastal belt and Jefara. It was felt that because of the pronounced illiteracy amongst Libyan farmers and their familiar practice of offering misleading information, similar questionnaires, even if returned would prove of little value. Five sheets were, in fact, sent out to Libyan farmers but the reponse was negligible.

The primary aim of the questions was to examine land and water use. The results clearly demonstrate the importance of the olive, on all types of farms, as a dryland crop. They also show however that the orchards are increasingly coming under irrigation with the acquisition of new equipment. In nearly all cases, even where irrigation facilities did not exist the partial irrigation was advocated on the grounds of higher yields and more regular yielding years. Where the sprinkler system is being adopted it is most noticeable that the cropping systems are being arranged to expand the high income crops such as groundnuts and citrus trees. The necessity for increased irrigation during a ghibli is well brought out.

Most of the farmers reported that their trees were pruned at appropriate intervals but few fertilisers were applied. On the other hand all harvesting was carried out by hand picking.

It would seem from these random samples that Italian farmers at least along the coast and Jefara are improving their techniques of olive cultivation or at least maintaining existing standards. Increased planting does not appear to be extensive although where intensification is taking place where irrigation water is available. The olive is notably replacing the vine. Inevitably however under full irrigation the emphasis is placed on high income crops. These are tending to gain at the expense of dryland crops.

The lack of confidence amongst several farmers must be taken as an ominous sign. It is obviously the political situation rather than their economic predicament which is at the root of this dissatisfaction.

Italian Demographic Settlements.

6. Farm 11.

COAST

Olivetti - Ente farm. Now under full ownership. 1938.

Land Use
(a) Size of farm - 64.03 hectares
(b) In 1958 - 49 ha's dry farmed, 15 ha's irrigated (25 ha's could be irrigated)

(c)	Winter 1956/7	Winter 1957/8	Summer 1955/6	Summer 1956/7	Summer 1957/8	
Wheat -	5 ha's dry	5 ha's dry	Groundnuts			
"	2 " irrig.	2 " irrig.	4 ha's	4 ha's	4 ha's (irrig.)	
Beans -	2 " "	2 " "	Forage ½ ha.	½ ha.	½ ha.	"
Potatoes -	½ ha. "	½ " "	Tomatoes 1½ ha's	1½ ha's	1½ "	"

Tree crops.
Olives - 775 (300 Italian and 475 Local Varieties) = 38.50 ha's
Almonds - 200
Vines - 4 ha's

Irrigation equipment
Wells - 1 (water at 20 metres) yield - 30 metres p.h.
Electric pump - 5.5 h.p. - capacity of 27 m's3 p.h.
Cost of water use 3 milliemes per m3.

Irrigation schedule.
(a) Tree crops only receive supplemental irrigation
(b) Groundnuts are irrigated 16 times per year with 300/350 m's3 at each irrigation.

General.

The vegetables and legumes are consumed directly by the family, but the remainder of the crop products are for sale in the local markets and for export through Tripoli. Most of the olive trees are in full production. They are pruned every other year but only when intercultivated with herbaceous crops are fertilisers applied and then only every five years.

The farmer intends to maintain this cropping system. He could give no indication of future plans because of the existing market situation.

7. __Farm 12.__ Ente farm, now under full ownership. 1938.

__Land Use__

(a) Size of farm - 27.94 hectares
(b) In 1958 - 15 ha's irrigated, 12 dry farmed (25 hectares irrigable)

(c)	Winter			Summer	
	1956/7	1957/8	1955/6	1956/7	1957/8
Wheat	2 ha's (Irrig.)	2 ha's (I)	Groundnuts 3 ha. (I)	5 ha. (I)	4 ha.(I)
Barley	9 ha's "	9 ha's (D)	Forage 30 ha's (I)	1.30 ha.(I)	.30 ha(I)
Beans	1 ha. (I)	1 ha. (I)	Tomatoes 1 ha.(I)	2 ha's (I)	1.5 ha.(I)

__Tree crops.__
Olives - 380 (180 Italian and 200 local varieties) - 19 ha's
Almonds - 50
Vines - 4 ha's

__Irrigation equipment__
Wells - 1 (water at 31 metres) - yield of 30 m3 p.h.
Electric pump - 7 h.p. - capacity of 29 m's3 p.h.
Cost about 3-3.5 mills. per m3.

__Irrigation schedule__
(a) Olives receive supplemental irrigation only - all could be irrigated.
(b) Groundnuts receive 16-18 irrigations of 350 m3 each.

__General.__
All vegetables are for family consumption, otherwise the crop products are for sale off the farm. The olives are well pruned but are not fertilised. The method of harvesting is by hand picking.

8. __Farm 13.__ Ente farm. Under full ownership.

__Land Use__

(a) Size of farm - 24.19 hectares.
(b) In 1958 - 12 ha's dry farmed. 12 ha's irrigated, (20 ha's irrigable).

(c)	Winter			Summer	
1956/7	1957/8	1955/6		1956/7	1957/8
Wheat 1 ha. (I)	1 ha. (I)	Groundnuts 4 ha's (I)		4 ha's (I)	4 ha's (I)
Barley 8 ha. (D)	8 ha's (D)	Forage ¼ ha. (I)		¾ ha's (I)	¾ ha. (I)
Beans and Potatoes 1½ ha's (I)	1½ ha's(I)	Apples 1 ha.		1½ ha's(I)	2 ha's (I)

Tree crops

Citrus - 100 - ½ ha.
Olives - 329 (150 Italian and 179 local and Tunisian varieties) - 20.70 ha.
Vines - 3.5 ha's but diminishing.

Irrigation equipment

Wells - 1 (water at 21 metres) - yield 30 m3 p.h.
Electric pump - 7 h.p. - sprinkler system - reserve water tank holding 100 m3.

Irrigation schedule

(a) Groundnuts are irrigated 16-18 times with 350 m3 each.

(b) The Citrus trees are irrigated 20 times with 400 m3 at each.

General

The olives are all dry farmed and intercropped with vines. However the farmer believes that because the olive crops are more abundant and regular that he will convert them to irrigation. Already a number have been grafted with the Tunisian Chemlali. The crop is hand picked and sold in Tripoli.

Farm 72. I.N.P.S. now under full ownership.

Land Use.

(a) Size of farm - 39 hectares
(b) In 1958 10 hectares irrigated, 29 dry farmed (25 hectares can be irrigated).

Harvest

	Winter 1956/7	1957/8		Summer 1956/7	1957/8	1958/9
Wheat	4 ha's (I)	2 ha's (I)	Groundnuts	6 ha's (I)	8 ha's (I)	10 ha's (I)
Beans	2 ha's (I)	2 ha's (I)	Forage	1 ha. (I)	2 ha's (I)	?

Tree crops.

Olives - 950 (200 Tunisian, 750 Italian) - 39 hectares
Almonds - 350

Irrigation equipment.

Wells - 1 (water at 25 metres) yield - 45 m3 p.h.
Electric diesel pump
Sprinkler irrigation system

Irrigation schedule.

(a) Tree crops receive mainly supplemental irrigation
(b) Groundnuts are irrigated 21 times per year with 300 m's3 per hectare at each irrigation.

General.

Farmer prefers the groundnut, citrus and fruit tree production under irrigation. The olives are pruned every 3 years. Harvesting is done by hand picking.

Corradini

Farm 26.

(a) Size of farm - 39 hectares
(b) In 1958 10 hectares irrigated, 29 dry farmed (25 hectares can be irrigated).

Harvest

	Winter 1956/7	1957/8		Summer 1956/7	1957/8	1958/9
Wheat	4 ha's(I)	2 ha's(I)	Groundnuts	6 ha's (I)	8 ha's(I)	10 ha's(I)
Beans	2 ha's(I)	2 ha's(I)	Forage	1 ha (I)	2 ha's(I)	?

Tree Crops.

Olives - 950 (200 Tunisian, 750 Italian) - 39 hectares
Almonds - 350

Irrigation Equipment.
Wells - 1 (water at 25 metres) yield - 45 m3 p.h.
Electric diesel pump
Sprinkler irrigation system

Irrigation schedule.
(a) Tree crops receive mainly supplemental irrigation
(b) Groundnuts are irrigated 21 times per year with 300 m's3 per hectare at each irrigation.

General.
Farmer prefers the groundnut, citrus and fruit tree production under irrigation. The olives are pruned every 3 years. Harvesting is done by hand picking.

15. Corradini.

Farm 36. I.N.P.S. full ownership.

Land Use.

(a) Size of farm - 59.56 hectares
(b) No land is irrigated, all dry farmed (0.1 ha's could be irrigated).

Harvest

	Winter 1956/7	1957/8
Wheat	3 ha's (D)	3 ha's (D)
Barley	4 ha's (D)	4 ha's (D)

Tree Crops.

Olives 635 (200 local, 435 Italian) - 23 hectares
Almonds - 100 - intercultivated with olives.

Irrigation Equipment.
Wells - 1 (uses together with farms 33 and 34). Yield 3-4 m3 p.h.
Wind pump.

General.

Because of the scarcity of water irrigated cultivation is practised only for vegetables. No further tree plantings are envisaged. Little fertiliser is applied to the trees but they are all pruned regularly.

216 Farm 9. I.N.P.S. full ownership.

Land Use.

(a) Size of farm - 44.4 hectares
(b) Mainly dry cultivated except for 0.2 ha's in 1958.

	Harvest Winter 1958		Summer 1958
Wheat	2½ ha's (D)	Groundnuts	0.2 ha's (I)
Beans	1 ha (D)		

Tree Crops.
Orange - 5
Lemon - 1
Almonds - 1,180 (600 mature)
Vines - 20,000 (11 hectares)
Olives - 681 (20 local, 661 Italian) - 27 hectares, of which 10 hectares are intercultivated with almonds. Twenty of the Italian varieties have been grafted with Chemlali.

Irrigation Equipment.
Well - 1 (used in common with farms 7 and 8). Water at 60 metres, yield 3-4 m3 p.h.
Wind pump
Canals and gravity flow.

Irrigation schedule.
Groundnuts irrigated 15 - 20 times with 100 m3 per hectare.
Citrus trees are irrigated 12-15 times.

17. Farm 8. I.N.P.S. full ownership.

Land Use.

(a) Size of farm - 84.13 hectares
(b) All dry cultivated (2 hectares are irrigable)

		Harvest	
	Winter 1956/7		Summer 1956/7
Wheat	4 ha's (D)	Groundnuts	0.2 ha's (I)
Barley	4 ha's (D)	Forage	0.2 ha's (I)

Tree Crops.

Citrus trees - 3
Almonds - 1222 (800 immature)
Vines - 37,000 - 23 hectares
Olives - 1144 (300 local, 844 Italian) - 45 hectares, of which 4 hectares are intercultivated with almonds.

Irrigation Equipment.
Wells - 2 (1 in common with farms 7 and 9 and the other is under construction). Water at 60 metres. Yield 3/4 m3 p.h.
Wind pump
Gravity canals

Irrigation schedule.
Groundnuts were irrigated 7-8 times (20-25 in ghibli) at 1,000 m3 per hectare.
Citrus trees irrigated 10-12 times.

General.
Thirty Italian olive trees were given irrigation water as an experiment. These brought a fifty per cent better harvest. No future olive plantings are intended but the farmer is going to maintain the olive, almond and vine as primary crops. The trees are well farmed and obviously pruned. No fertiliser is applied. The harvesting is carried out by the hand picking method.

18. Farm 58. I.N.P.S. now under full ownership.

Land Use.
(a) Size of farm - 38 hectares
(b) Mainly dry cultivated but 1 hectare irrigated in 1958 (2 ha's could be irrigated).

Harvests

	Winter 1958	Summer 1958
Barley) Wheat)	2-3 ha's (D)	Vegetables 1 ha (I)

Tree Crops.

Almonds - 822 (400 not yet in production)
Vines - 19,000 - 11 hectares
Olives - 523 (200 local, 323 Italian) - 18 hectares, of which 2 hectares were mixed with almonds.

Irrigation Equipment.
Well - 1 (used on common with farm 54). 72 metres depth of water, yielding 3/4 m3 p.h.
Wind pump
Gravity canals

General.
Farmers plan to concentrate on the dry land cultivation of olives, almonds and vines. Pruning and hand picking of olives characterise techniques of cultivation.

19. Farm 54. I.N.P.S. full ownership.

Land Use.
(a) Size of farm - 89.40 hectares
(b) Mainly dry cultivated except for .01 hectares irrigated groundnuts.

Harvest

	Winter 1956/7	Winter 1957/8		Summer 1956/7	Summer 1957/8
Wheat	3 ha's	½ ha (D)	Groundnuts	.01 ha's	.01 ha's (I)
Barley	4 "	4 " (D)			
Beans	2 "	½ " (D)			

Tree Crops.

Citrus - 6
Almonds - 1023 (923 immature)
Vines - 22,000 - 22 hectares - diminishing
Olives - 1,122 (200 local, 922 Italian) - 45 hectares (470 immature)

Irrigation Equipment.
Well - 1 (used in conjunction with farm 58. Water at 72 metres - yields 3/4 m3 p.h.
Wind pump
Gravity canals.

Irrigation schedule.
Groundnuts irrigated 15-20 times (25 in a ghibli) at 1,000 m3 each irrigation.

General.
Farmer plans to better the cultivation of his olives, almonds and vines by mechanising operations. He intends to prune the trees more regularly every 2 years.

20. Farm 33. I.N.P.S. full ownership.

Land Use.
(a) Size of farm - 52 hectares
(b) Mainly dry farmed except .02 hectares in 1958 - (10-15 hectares could be irrigated).

Harvest

	Winter			Summer		
	1956/7	1957/8		1956/7	1957/8	
Wheat	3 ha's	1 ha (D)	Groundnuts	.01 ha's	.01 ha's	(I)
Barley	6 "	6 " (D)	Vegetables	.01 "	.01 "	(I)

Tree Crops.

Citrus - 13
Almonds - 571
Vines - 20,000 (11 ha's) stable
Olives - 773 (200 local, 573 Italian) - 15 ha's - 150 (young)

Irrigation Equipment.
Wells - 1 (used with farms 34 and 36). Water at 80 metres - yields 3/4 m3 p.h.
Windpump
Gravity canals

Irrigation schedule.
Groundnuts are irrigated 10-12 times (20 in glibli) with 500 m3 per ha.

General.
Farmer thinks that vine and olive are best suited to natural conditions, but does not exclude the almond. Trees are well pruned and fertilised every five years.

21. Bianchi.

Farm 20. I.N.P.S. full ownership.

Land Use.
(a) Size of farm - 20.99 hectares.
(b) Mainly irrigated - 18 ha's in 1958 (18 hectares are irrigable).

Harvest

Winter 1957/8			Summer 1957/8		
Barley	1.0 ha	(I)	Groundnuts	5½ ha's	(I)
Wheat	1.5 "	(I)	Forage	1 "	(I)
Beans	1 "	(I)			

Tree Crops.

Oranges - 330
Vines - 1 ha. (diminishing)
Olives - 550 (350 Italians, 200 local) - 18 hectares
(480 young)

Irrigation Equipment.
Well - 1, depth 32 metres - yield 40 m3 p.h. (Level has fallen 6 metres in recent years)
Electric pump (5 h.p.) - 40 m3 p.h.
Cement canals

Irrigation schedule.
Groundnuts irrigated 25 times (30 in glibli) with 680 m3.
Oranges - irrigated every 10 days in summer - giving 200 litres per tree.
Olives - all irrigated.

General.
No further plantings of olives are intended. Vines are decreasing in importance. The farmer plans to concentrate on cereals and forage crops in winter, groundnuts in summer. All the trees are pruned but no fertilisers are applied.

22. Farm 40. I.N.P.S. full ownership.

Land Use.
(a) Size of farm - 30.87 hectares.
(b) 10 hectares remain fallow each year, 6 ha's were irrigated in 1958 (20 irrigable) and the remainder dry farmed.

Harvest

Winter 1958			Summer 1958		
Wheat	1 ha	(I)	Groundnuts	4 ha's	(I)
Legumes	½ "	(I)			
Forage	½ "	(I)			

Tree Crops.

Citrus - 642 (250 young)

Vines - 1 ha (diminishing)
Olives - 402 (150 Tunisian, 172 Italian) - 16 ha's
(260 young)

Irrigation Equipment.

Well - 1, depth 26 metres, yield 40 m3 p.h. (level fallen 8 metres in recent years)
Electric pump (6 h.p.) - capacity of 50 m3 p.h.

Irrigation schedule.
Groundnuts irrigated 22 times (26 in ghibli) with 1,000 m3 each time. Citrus trees receive 1,500 litres per tree every 15 days in summer
Olives - all irrigated

General.
Olive plantation is complete. Another 200 citrus trees are to be planted in accordance with the expansion of irrigated cropping. The olives are hand picked at harvest time. Pruning campaigns are carried out every 3-4 years.

23. Farm 86. I.N.P.S. full ownership.

Land Use.
(a) Farm size - 55.5 hectares
(b) 15 ha's remain fallow each year. In 1958 25 ha's were dry farmed, 30 ha's irrigated (30 hectares are irrigable).

	Harvest			
	Winter			Summer
	1956/7	1957/8		1958
Barley	5 ha's(I)	10 ha's(I)	Groundnuts	12 ha's(I)
Beans	2 " (I)	2 " (I)		

Tree Crops.

Citrus - 276 (170 young)
Vines - 1 ha. (diminishing)
Olives - 815 (215 local, 600 Italian) - 32.5 ha's (770 young)

Irrigation Equipment.
Well - 1, 32 metres depth, yield 35 m3 p.h. (Level has fallen 6 metres in last year).
Elecrric pump (5 h.p.) - capacity of 40 m3 p.h.

Irrigation schedule.
Groundnuts - irrigated 24 times (28 in ghibli) with 500 m3 per ha.

Citrus trees - receive 1 m3 per tree 3 times each month during summer
Olives - Italian varieties irrigated.

General.

Further plantings of olives are envisaged. In the immediate future the farm economy is being based on irrigated groundnuts, cereals and forage. The farmer reported both pruning and fertilising of the olive trees.

24. Fonduk Togar.

Farm 17. E.N.T.E. full ownership.

Land Use.
(a) Size of farm - 24 hectares
(b) In 1958 12 were irrigated, 12 dry farmed. Each year 2 ha's remain fallow.

Harvest

	Winter 1956/7	Winter 1957/8		Summer 1958
Wheat	1 ha (I)	1 ha (I)	Groundnuts	4 ha's (I)
Beans	2½ ha's(I)	2½ ha's(I)	Apples	1½ " (I)
			Forage	½ " (I)

Tree Crops.

Citrus - 220
Fruit trees - 52 (2 ha's)
Almonds - 350
Vines - 6 ha's
Olives - 600 (200 Italian, 400 local and Tunisian) - 19 hectares.

Irrigation Equipment.
Well - 1, depth 20 metres, yield 25 m3 p.h.
Electric pump 5.5 h.p. - capacity 28 m3 p.h.

Irrigation schedule.
Groundnuts irrigated 15-17 times (18-20 in ghibli) with 300-350 m3 at each irrigation.
Citrus trees irrigated 22 times in summer with 400 m3 at each irrigation.

General.

Fruit trees will be augmented. The olive trees are pruned and hand picked at harvest time.

25. Farm 11. E.N.T.E. full ownership.

Land Use.

(a) Size of farm - 30 hectares
(b) In 1958 2 hectares were irrigated, 28 dry farmed (25 hectares can be irrigated)

	Harvest			
	1956	1957	1958	1958
Barley	5 ha's (D)	5 ha's (D)	5 ha's (D)	Apples 1½ ha's (I)
Wheat	5 " (D)	5 " (D)	5 " (D)	Forage ½ ha. (I)

Tree Crops.

Citrus - 105
Almonds - 1,050
Vines - 5 ha's (diminishing)
Olives - 1072 (local and Tunisian) - 27½ hectares

Irrigation Equipment.
Well - 1, depth 20 metres, yield 25 m3 p.h.
Wind pump - capacity 5 m3 p.h.
Canals and gedula.

Irrigation schedule.
Citrus trees irrigated 20 times or 400 m3.
50 olives are irrigated.

General.
Future plantings of citrus and fruit trees are intended when the wind pump is replaced with an electric pump, enabling 10-15 hectares to be irrigated.

26. Farm 18. E.N.T.E. full ownership.

Land Use.

(a) Size of farm - 60 hectares
(b) In 1958 50 hectares were dry farmed and 2½ hectares were irrigated (30 hectares are irrigable)

	Harvest		
	Winter 1956/7	1957/8	Summer 1958
Wheat	10 ha's (D)	10 ha's (D)	Apples ½ ha. (I)
Barley	10 " (D)	10 " (D)	Forage - o.2 ha. (I)
Beans	1 ha. (I)	½ ha. (I)	

Tree Crops.

Citrus - 253
Fruit Trees - 454

Almonds - 1,850
Vines - 9 ha's (diminishing)
Olives - 1856 (local and Tunksian) - 47 ha's intercultivated
with almonds

Irrigation Equipment.
Wells - 2, depth 20 metres, yield 30 m3 p.h.
Wind pump - capacity 5 m3 p.h.
Canals and gedula.

Irrigation schedule.
Citrus trees irrigated 22 times with 400 m3 at each irrigation.

General.
Plans are afoot to acquire an electric pump and sprinkler irrigation system. The olives are pruned and hand picked at harvest time.

PRIVATE CONCESSIONS

27. Location: Tagiura.

Land Use.
(a) Size of farm - 45 hectares
(b) 12 hectares irrigated, 33 ha's dry farmed (12 hectares irrigable).

Harvest

Winter 1957	Summer 1957
Forage 2 ha's (I)	Groundnuts 1 ha. (I)
Pears 1 ha. (I)	
Wheat 4 ha's (I)	

Tree Crops.

Olives - 100 (Italian varieties)

Irrigation Equipment.
Wells - 2, depth 12 metres.
Electric pump - water distributed by canals

Irrigation schedule.
Groundnuts irrigated 20 times with 500 m3.
Olives - all irrigated.

General.
Under irrigation Italian olive varieties produce well. Farmer prefers sprinkler irrigation system but wishes to sell farm. The trees are all pruned regularly but are not fertilised.

28. Location: Sabratha.

Land Use.
(a) Size of farm - 200 hectares
(b) In 1958 2 hectares were irrigated, 198 hectares dry farmed (2 ha's irrigable).

Harvest

	Winter 1956	Winter 1957	Winter 1958		Summer 1956	Summer 1957	Summer 1958
Forage	1 ha(D)	1 ha(D)	1 ha(D)	Groundnuts	2 ha's(I)	2 ha's(I)	2 ha's (I)
Apples	1 ha(D)	1 ha (D)	1 ha(D)				

Tree Crops.

Olives - 6,000 (4,000 Italian, 2,000 Tunisian) inter-cultivated with almonds (all in production).

Irrigation Equipment.
Wells - 1, depth 40 metres.
Electric pump and canals.

Irrigation schedule.
Groundnuts receive 400 m3 16 times during summer.

General.
Farmer plans to better his olive culture by increased attention to pruning and hand harvesting operations. He believes that irrigated olives give better returns.

29. Location: Zanzur - Zavia.

Land Use.
(a) Size of farm - 93 ha's
(b) 31 hectares are dry farmed, 30 hectares irrigable and irrigated (30 hectares remain in fallow each year).

Harvest

	Winter 1956	Winter 1957	Winter 1958		Summer 1956	Summer 1957	Summer 1958
Barley	(D)			Groundnuts	1 ha(I)	2 ha's(I)	6 ha's(I)
Wheat	(D)			Forage	2 " (I)	2 " (I)	2 " (I)

Tree Crops.

Orange - 400 (1 ha.)
Almonds - 100
Vines - 8 ha's. (diminishing)
Olives - 800 (800 Tunisian) all dry farmed.

Irrigation Equipment.
Wells - 4, depth 30 metres, yielding 40 m3 p.h.
Electric pump 6 h.p. and sprinkler irrigation.

Irrigation schedule.
Groundnuts - 16 times with 400 m3 per hectare.
Oranges irrigated 12 times with 300 m3 each time.

General.
Farmer plans to increase the irrigated area and the cultivation of citrus trees. The olives at present are well attended. They are pruned and fertilised.

30. Location: Zavia.

Land Use.
(a) Size of farm - 1,029 hectares
(b) In 1958 70 hectares were irrigated, 739 dry farmed (50 hectares remain fallow each year).

Harvest

Winter	1956	1957	1958	Summer	1956	1957	1958
Barley (D)				Groundnuts	2 ha's(I)	2 ha's(I)	2 ha's(I)
Wheat (D)				Forage	5 " (I)	5 " (I)	10 " (I)
Beans (I)							
Potatoes (I)							

Tree Crops.

Oranges - 800 - 2 hectares
Almonds - 35,000 @ 700 hectares
Vines - 20 hectares
Olives - 32,000 (Italian) - 740 hectares - all inter-cultivated with almonds.

Irrigation Equipment.
Wells - 10, depth 30 metres, yield 30-90 m3 p.h.
Electric pump and diesel generator (150 h.p.) - with capacity of 30-90 m3 p.h.

Irrigation schedule.
Groundnuts irrigated 16 times at 400 m3 per hectare.
Olives - partially irrigated.

General.
The expansion of irrigated cultivation is being expanded. All the olives are pruned.

31. Location: Gurgi (S.W. of Tripoli).

Land Use.
(a) Size of farm - 400 hectares.
(b) In 1958 80 hectares were irrigated, 320 remained dry farmed.

Harvest

Winter	Summer	1956	1958
Barley (D)	Groundnuts	30 ha's (I)	50 ha's (I)
Wheat			
Beans (I)			
Potatoes (I)			

Tree Crops.

Citrus - 1,600
Vines - 2 ha's. (diminishing)
Olives - 500 (all young) - 10 hectares

Irrigation Equipment.
Wells - 8, depth 26 metres.
Electric motor and canals.

Irrigation schedule.
Groundnuts irrigated 15 times at 400 m3 per hectare.
Citrus trees 12 times in summer with 500 m3 each time.

General.
The development of irrigation and the expansion of citrus trees and forage crops is planned.

32. Location: Gargaresch (S.W. of Tripoli).

Land Use.
(a) Size of farm - 18 ha's.
(b) In 1958 8 hectares were irrigated and 10 dry farmed.

Harvest

Winter	Summer	1956	1957	1958
Barley (D)	Groundnuts	2 ha's (I)	3 ha's (I)	2 ha's (I)
Wheat (D)	Forage	1 " (I)	1 " (I)	1 " (I)
Beans (I)	Tobacco	1 " (I)	1 " (I)	1 " (I)
Potatoes (I)	Apples	½ " (I)	½ " (I)	½ " (I)

Tree Crops.

Citrus - 400 - 1 hectare
Olives - 500 (Italian varieties) - 10 ha's - all young.

Irrigation Equipment.
Wells - 1, depth 25 metres, yield 30 m3 p.h.
Electric pump 6 h.p. and canals.

General.

Citrus tree planting is envisaged in the immediate future. Al present all the olive trees are pruned and hand picked at harvest time.

33. Location: Tagiura.

Land Use.
(a) Size of farm - 597 hectares.
(b) 6 hectares irrigated, 591 ha's dry farmed.

Harvest

Winter	Summer	1956	1957	1958	
Wheat (D)	Groundnuts	2 ha's	2 ha's	2 ha's	(I)
Barley (D)	Forage	2 "	2 "	2 "	(I)
	Vegetables	2 "	2 "	2 "	(I)

Tree crops.

Almonds - 15,000 (5,000 young)
Vines - 10 ha's
Olives - 15,000 (Italian) - 400 ha's intercultivated with almonds - all dry farmed (5,000 are young)

Irrigation equipment.
Wells - 1, depth 25 metres, yield 60 m/ p.h.
Electric pump, canals.

Irrigation schedule.
Groundnuts - 20 irrigations with 400 m3 per hectare.

General.

Farmer proposes to intensify the dry land farming of olives and almonds. The trees are well pruned. At harvest time the trees are hand picked.

'The increase and improvement of agricultural production is strictly connected with all the problems which can be included in the term 'settlement'. Settlement in Libya means fixing the nomadic and semi-nomadic parts of the population, a better distribution of rural population, a remedy for town overcrowding, a better use of land and water, and the achievement of individual and community welfare, and political and social stability'.(68)

The whole problem of increasing and improving olive cultivation must take place within this general context. The olive is the main resource of the Italian farming community. In the Jebel alternative uses of land or occupations are limited for Libyan farmers. Moreover the present crowded situation in the coastal oases and the poor techniques of irrigation cannot support a high standard of living for the small Libyan farmers. Fluctuations in the olive crop productions therefore effect the well being of large sections of the rural population, the subsistence farmer as well as the plantation owner, the labourer as well as the employer. As for all tree crops appreciable long term increases in production can only be achieved by the maturing of new plantations. Factors such as the constant improvement of oil extracting equipment, the increased use of pesticides, and dissemination of better cultural techniques affect the expansion of production more gradually. The fact that many Italian trees have yet to reach maturity is no reason for complacency since the Libyan trees are for the most part well advanced in their cycles of production. The need is to stabilise olive production both in terms of regional and annual production. This will involve not only a raising of yields but a reduction of low crop years.

In the author's opinion there are four ways in which it could be possible to attain these objectives:

(1) The extension of the farming area devoted to tree cropping.

(2) The expansion of rural settlement on to virgin lands and the resettlement and reorganisation of vacant Italian farms.

(3) Stabilisation of semi-nomadic population.

(4) Intensification of olive cultivation on existing farms.

(5) Improvements in the methods of crop husbandry.

1. Potentially the Libyan farming economy of the coastal plains offers significant opportunities for expanding the area devoted to the olive. The coastal population is accustomed to a fixed residence and possess a long tradition of arboriculture.

The area is climatically favoured and only on the eastern and western extremeties is it marginal for dryland agriculture. Moreover there is a great need for a better utilisation of the irrigated land adjacent to the oases boundaries; at present these areas are underutilised and either yield a fluctuating catch crop of barley or provide additional grazing land. Furthermore the small irrigated garden can only support, as we have been, a low standard of living; this could be relieved by a more intensive and secure use of the unirrigated areas.

Indeed many farmers have expressed a willingness to increase the area devoted to tree crops. Already, as we have seen (in the majority of Farm Samples) there has been a movement to intensify agriculture on the dryland areas south of the last coastal plain. Without much effort or expense similar colonising schemes could convert the southern fringes of the coastal oases elsewhere to arboriculture. Such holdings would need to be at least 50 hectares in size.

Little expansion of the Italian farm areas in the coastal plain can be foreseen by reason of the following facts:

(1) Italian colonisation and agriculture is at a stage of consolidation or even contraction.

(2) The development areas of the collective settlements are now owned by the State.

(3) Farmers on the coast and steppe are paying increased attention to intensification of production by means of new irrigation equipment.

(4) As a result of the Italian-Libyan treaty made in 1956 and the restrictions of credit facilities the desire to sell farm property is by no means isolated.

2. <u>New Settlements</u>. The ecological, economic and social problems connected with the construction and siting of new rural settlements are not likely to face the Libyan Government in the immediate future. Outside of the coastal belt and more fertile parts of the Steppe and Jebel there is a marked tendency for a decline in the rural population. The surplus population of the coast has now a fairly wide range of employment outside agriculture. There is therefore no great pressure on land and water resources which could impel new

colonising schemes. It is obvious also that the community as a whole have not yet attained the standards of education in modern farming to be able to take over such farming schemes.

Whilst the Libyan budget remains in deficit it is doubtful whether the economy could withstand the enormous cost of establishing rural settlements in an arid environment. Although it is generally accepted that the Italian demographic farms are overcapitalised the cost of their construction indicates the resources needed. (e.g.).

A more pressing problem and one which is receiving attention is the resettlement of Libyans on vacant Italian farms. Temporary solutions have been adopted for the problem of allocating Italian settlements to Libyans. First of all the Cabila system was adopted; only families could settle on the farms by paying a modest rent for a period of three years. Because of the uncertainty of tenure after three years very few of the Libyans bothered to maintain or plant new olive trees. The example of Tazzali warns against the simple leasing of the farms to uneducated semi-nomads. Stringent selection measures are needed to ensure that the stipulated farming practises are carried out. Very few of the Libyans would qualify at present. The basis of husbandry now is the fruit trees and secondly herbaceous crops. Very few of the semi-nomadic population has the experience in the management of a farm and cultivation of these crops.

3. Stabilisation of the seminomad peoples can bring respite to the Jebel dwelling inhabitants as well as to the dense oases population. As we have seen there are signs that gradual sedenterisation is taking place (cf. p.). But only much greater government participation, direction and propaganda can speed up the process and ensure the correct adjustment to settled farming.

4. Because the cultivation of the vine is diminishing and since there is ample evidence of the increased use of water for irrigation, especially in the coastal belt, it would appear that attempts are being made to intensify the cultivation of the olive. Re-evolution of the Italian demographic settlements will contribute substantially to this trend. There is, however, a limit as we have seen to the density of olive plantations; in dryland orchards rainfall is the limiting factor whilst under irrigation it is more the incidence of disease which sets a limit to increased planting. The greatest obstacle to the partial irrigation of the olive is the necessity of setting up an extensive irrigation system. Although the electric pump and sprinkler irrigation system meets these requirements the capital cost is likely to be too great for the ordinary Libyan farmer.

5. Perhaps the most marked progress can be made in the field of crop management. Libyan farmers especially, for long guided by custom, need to be encouraged to adopt better

standards of cultivation. By simple demonstration, the art of pruning, hand picking, in addition to soil and water conservation techniques, could be easily assimilated by the Libyans. Where the Libyan farmer is in close contact with Europeans and Government services it is noticeable that new ideas and techniques are readily accepted. The transfer of modern farming methods is however a much slower process in those areas of the Jebel and Steppe where Italian influence has been intermittent. Education of prospective farmers aligned with field demonstration and financial relief could indirectly effect the quality and regularity of olive oil production. In this connection the establishment of extension service centres in each of the provinces has helped not only to distribute new olive varieties but also to disseminate more rational cultural practices.

The increase in tree tax could make the Libyan peasant more aware of the value of the tree.

All these suggested improvements require the whole hearted participation of an enlightened and stable political regime. Although the Libyans are open to suggestion and respond well to advice and demonstration only government aid and concerted cooperative action can bring about a quick change in the practises and economy of the rural population.

<u>Conclusion</u>. The olive is cultivated under a variety of systems but the main distinction is between the peasant

Libyan and commercial Italian systems. The distribution of the types of farming is determined by several factors, historical, economic and environmental.

The Farm samples and questionnaires revealed that:

(1) The Italians are technically more advanced than all the Libyan systems with the exception of the Hawazas. But changes are occurring as a result of cultural contacts, overseas aid and the stimulus of independence. The Hawazas and expansion of regular olive plantation in the Steppe areas signify some advance.

(2) The reliance on irrigation for high yields and regularity of production is increasing along the coast and Jefara. This is a response to new external markets and to new irrigation equipment.

(3) Peasant agriculture is gradually being replaced by small commercial economies especially in the coastal oases where Italian and European influence has been strongest and where the tribal system has virtually ceased to operate.

(4) The Jebel and peripheral areas of the Steppe are suffering from a permanent loss of population. In padticular the loss of a labour pool is effecting Italian private concessions from which the previous Italian labour groups have emigrated.

(5) There are serious dangers in the system of monoculture as practised by large Italian concessions. The problem of labour supply is felt even more acutely on such

farms where only seasonal labour is required. In poor crop years these farms suffer badly from their reliance on one crop.

(6) The expansion of olive cultivation is only likely to come from the Libyan sector of the community. It is expected that the Italians will concentrate on consolidation with some intensification.

(7) The differences in the two systems result from experience in education and capital resources rather than the environment. Whilst Italian and Arab systems of olive cultivation are generally adopted to the environment they suffer from certain economic and social defects. These are

(a) under prevailing conditions of aridity the dry farmed, specialised olive plantations on the large Italian concessions would appear to be uneconomic

(b) Arab farms in the coastal belt are generally too small and should be increased to at least fifty hectares.

Although economic returns are difficult to estimate it appears from the examples quoted (p.   ) that the large private Italian concessions are experiencing certain difficulties induced by labour problems, the climate and the system of monoculture.

There are four ways in which the raising of yields and more regular production could be achieved. They are bound up with the problems of land settlement in an arid zone and the best way to rehabilitate economically and socially a rural population, the majority of whom are illiterate. All the suggested solutions involve a high degree of government action so that political stability is essential. This is necessary not only for rapid attention to problems but also to continue to attract the economic and technical help of other nations.

These problems should all be assessed in a regional context.

In contrast to the coastal plain many parts of the Jebel, with the exception of Msellata, are faced with the prospect of a declining population. There is therefore no population surplus to encourage the expansion of the cultivated area. Moreover there are few large areas where extensive developments could take place. In order to make up for the deficiency in numbers any ideas of expanding the dry farmed area must rely on cooperative effort or group action; where rainfall is adequate and water is available for flooding systems.

The settled population of the Jebel is accustomed to building rudimentary dams, terraces and the execution of these by cooperative undertakings would enhance olive cultivation and lessen the demands on a small population. Development of watershed basins particularly in the eastern Jebel, by families of the same cabila would appear to offer possibilities.

CHAPTER VIII

Olive Oil Industry and Commerce

Production.

Olive growers in Northern Tripolitania are primarily interested in the production of edible olive oil: the production of inedible or sansa oil remains a secondary industry. There are no specialised plantations devoted entirely to the production of edible olives. Each year only about 1,500 metric tons of pickled olives, both green and black, are produced.

World production of olive oil has shown a long upward trend in the present century, increasing by seven million quintals from 1934-1947 with a minimum of five million quintals and a maximum of eleven million.

Table 54

World Production of Olive Oil

Average Year	Production (1,000 quintals)	% 1909-14 Production
1909-10 to 1914	5,900	100
1924-25 to 28-29	7,510	127.3
1929-30 to 1933-34	8,562	145.1
1934/35	8,163	138.4
1935/6	7,246	156.3
1936/7	10,961	122.8
1937/8	7,376	185.8
1938/9	7,150	125.0
1939/40	9,100	121.0
1940/41	6,990	154.2
1941/2	8,470	118.4
1942/3	-	143.6
1943/4	-	-
1944/5	6,550	111.0
1945/6	5,330	90.3
1946/7	8,200	122.0

This trend is associated with the growth of new plantations and the improvement in manufacturing techniques. Between 1949/50 and 1954/55 world output of olive oil has averaged 1 million metric tons of which 99% was produced by Mediterranean countries. During the last six years a third of the world production has come from Spain and one quarter from Italy. These two, together with Greece, Portugal and the countries of North Africa, have accounted for approximately 90% of the total volume of production. In the last 30 years this increase in production has been at the rate of ½% or about 5,000 tons. In terms of area cultivated Tripolitania comes seventh to Spain, Italy, Greece, Portugal, Tunisia and Turkey.

Table 55

Area, number and density of olive trees in selected countries of the world.

	Area 1,000 ha's	No. of trees in production 1,000's	Density per ha.
EUROPE			
Spain	1,900	176,000	75
Italy	1,161	154,000	135
France	80	12,500	160
Greece	500	60,500	120
AMERICA			
Argentine	7	200	100
U.S.A.	11	1,600	150
ASIA			
Palestine	54	6,500	120
Turkey	750	26,500	40
Syria & Lebanon	90	9,000	100
AFRICA			
Algeria	-	8,500	-
Tunisia	300	13,300	60
Tripolitania	105	2,488	23
Total Average	5,500	488,200	90

Other olive growing countries inculde Albania, Portugal, Yugoslavia, Chile, Mexico, Peru, Uraguay, Cyprus, Iraq, Persia, Egypt, Morocco, Australia.

The density of the plantings for trees in production is however the lowest of all countries. Although Tripolitania only produces on average 0.4 % of the total output in the Mediterranean, the production of oil per tree compares favourably with the leading producing countries.

Table 56

Average Production Oil per Trees (1950).

	Oil (kilogrammes)
Tunisia	2.6
Algeria	2.5
Spain	2.1
Tripolitania	2.0
Greece	1.6
Italy	1.3

Olive oil production in Tripolitania has exhibited a more rapid expansion. In the pre-war years between 1927/8 and 1944/5 there was an average production of 2,111 metric tons of oil, as against the average of 3,179 metric tons for the years after the war, 1945/6 to 1956/7. However the relative proportion of low producing years has not shown any signs of decreasing. They made up 55% of producing years before the war and 60% afterwards.

The gradual expansion in oil production is a result of the extensive planting carried out by the Italians. It is expected that production will continue to augment as nearly 50 % of the trees are still immature.

The outstanding feature of oil production in Tripolitania and the rest of the Mediterranean countries remains the pronounced fluctuation from year to year. This provides a wonderful opportunity for the speculator and hoarder. Moreover the most difficult economic problems stem from the extreme variability of the crop. The fact that the annual fluctuations occur more or less regularly, and is due to irrêgular olive harvests, should be stressed since their magnitude is sufficient to be the dominating factor in the price, income and trade situation in the olive oil economy, and all measures adopted must take into account the virtual certainty that this phenomena will continue. (Table 57)

It is seen from the table that years of scarce and glut production do not always coincide for all Mediterranean countries. Harvests in Spain and Italy have shown a pronounced tendency to rise and fall together, whilst the size of the Tunisian and Tripolitanian crop frequently varies at the same time in the opposite direction.

Sansa oil production has shown the same tendency to fluctuate whilst the tabled olives have a steady production since most are grown under irrigation and production is small.

As well as the national variations in output, the regional variations within the country are of some significance. The plantations of the coastal plain and the Jefara control the national output. In outstandingly poor rainfall years, production from the dryland plantations of the Jebel is negligible. Even so these are capable of extremely high production in good years. But in drought years production of oil retracts to the coastal plain where the semi-irrigation of the olive seems to prove a saving factor. Because the Jebel remains primarily an olive growing area, but highly susceptible to rainfall vicissitudes, there is much to be said for increasing the semi-irrigation of the olive in the good water supply zones, so that national production can be maintained in drought years. On the other hand new plantings in the Jebel could ameliorate the wide changes in production experienced.

Value of olive oil output. The importance of oil production in the material economy is emphasized by the fact that olives for crushing represent one of the principal sources of cash income for a large section of the population - labourer, farmer, merchant and oil mill proprietor alike. In value of total crop production olive oil ranks second only to barley and livestock products. A similar situation prevails in Tunisia, whilst in Spain olive oil production comes fourth in its contribution to the value of crops: cereals, grapes and fruit trees surpass it. Thus fluctuations in the value of the crop can prove disastrous for the small farmer who relies solely on the olive as a cash crop.(70)

Table 58 illustrates for all years that statistics are available that the influence of variations in the volume of output has determined the general direction of changes in

Table 58 (a)

Production of Olive Oil in relation to value, 1933-1944 1946/7 - 1950/51.

	Metric Tons	Value (Mal.)
1933/4	1,500	40
1934/5	2,800	38
1935/6	900	50
1936/7	2,300	60
1937/8	-	75
1938/9	2,700	64
1939/40	800	84
1940/41	1,600	122
1941/2	1,800	122
1942/3	3,400	186
1943/4	1,200	208
1944	3,300	156

(b) **Wholesale index prices for Tripoli**

	Metric Tons	Value
1946/7	616	100
1947/8	936	110
1948/9	1,500	126
1949/50	8,000	100
1950/51	7,000	63

Mal = £240

the value of the product at wholesale level and in actual value. Exceptional years are recorded for the war years (1939-45) where prices tended to move in accordance with production. The severe drought of 1946/7 is marked by higher than average wholesale values. Total value has tended to move in the opposite direction to production: prices are low in productive years and high in poor crop years.

Changes in gross returns to oil producers is difficult to measure since there is no complete information on prices received by growers for olives and for ex-factory prices of oil. Such vicissitudes are more likely to effect the Italian farming community rather than the peasant Libyan farmers who are mainly interested in the immediate crop rather than the market price.

At the present there is virtually no price discrimination for the quality of oils. The oil that is marketed is mixed and blended. It is all sold at the same price.

<u>Consumption</u>. The demand for olive oil is determined by a special reference for this type of oil. There is in practise less substitution for olive oil in food habits than between other vegetable oils, and the price of olive oil is correspondingly to some extent independent of other soft oils. On the other hand sansa oil which is used mainly in the manufacture of soap can be easily replaced by almost any other vegetable oil including groundnuts, soya bean and castor seed.

There is therefore greater competition and less reliable consumption demands for sansa oil. Because of the high price of olive oil it is not used as a component of manufactured products nor is the edible oil, as are other soft oils, used to any extent for non-food products.

In Tripolitania the sansa oil is mainly consumed by some 40 small soap manufacturers. There is practically no competition for the olive oil industry. Only a few factories press castor seeds and groundnuts are mainly exported. Moreover in comparison with other fats and oils, where a more elastic demand results from the major possibilities of substitution, the potential demand for olive oil is relatively stable. Usually consumption demands bear a direct relation to population changes.

In the Mediterranean area as a whole the population of the producing and consuming countries has increased more than 1% per annum since 1937[70] which is nearly double the rate of increase for olive oil output. On this basis alone it seems fairly safe to assume that markets for the oil within this area could be further exploited.

No official information is available to show the internal consumption of olive oil in Tripolitania.

The total consumption annually can be estimated indirectly. It is based on the difference between production and exports of oil over the 5 years 1950/51 - 1954/5. If the assumption is made that stocks at the beginning of 1950/1 were equal to those at the end of 1954/5 then the average annual consumption amounts to 3,180 metric tons, which works out with a population of about 750,000 at just over 4 kgs. per capita. The standards of consumption therefore appear lower than in other parts of North Africa where the average is 5-7 kgs. per capita. In Spain and Greece consumption runs out at the very high figures of 12 and 10 kgs. per capita respectively.[70]

The domestic market expanded rapidly when the Italians entered the country and today with a population of 738,000, increasing at the rate of 1% per annum the potential demand amounts to 2,952 metric tons. This is likely to augment at the rate of 29½ metric tons per annum. At present the total capacity is sufficient to meet this demand only if provision is made for stocks to be carried over from one year to the next so as to stabilise fluctuations in production.

The potential demand varies regionally of course with population distribution. If a further assumption is made that demand is the same for all classes of the population - nomad, sedentary, rural and urban - then the west coastal plain and Jefara have a potential demand for 1,542 metric tons per year, the central and western Jebel, 456 metric tons and the eastern Jebel and east coastal plain, 960 metric tons. With the decline in Jebel population demand is likely to fall. But this loss will be made up by the ever growing demands in the coastal plain.

Between the years ~~1944~~-47, 1950 and 1952 oil production in the Western Province fluctuated between 450 and 3,000 metric tons. Only on one occasion did the production meet the potential demand. It was met on two occasions in the Eastern Province and only once in the Central Province. Unless output can be increased and surplus years production carried over it is quite obvious that Libyan can only enter the export market in a small way. A further limiting factor for producers and exporters is the Moslem preference for strong, well flavoured oil. These are the acidic oils which are unacceptable in markets abroad. Whilst these oils can be exported to refining countries the prices obtained are naturally much lower.

Fabrication of oil and allied industries. The olive oil industry in Northern Tripolitania is represented by four oil refineries, four mills devoted exclusively to the manufacture of sansa oil, and at least six mills which combine the processing of olives with the production of sansa oil. The sansa oil is normally supplied to forty small soap factories and any surplus is exported. Foreby these there is an array of olive processing mills ranging from hand operated types, rope and timber contraptions, to the most up-to-date super-presses and centrifuges operated by diesel electric power. There were 715 such establishments in 1953 to which a further thirteen have recently been added. [1]

1. Inventory of oil mills 1958 - Dept. of Agriculture.

Both the nature and the capacity of the oil industry has changed as a result of Italian expansion of olive cultivation and the adoption of European processing equipment and techniques. In the last thirty years the industry has been characterised by the increased specialisation and diversification in the processes of oil manufacture. This is manifested in the rise of oil mills, sansa factories and refineries which are divorced from the actual cultivation of the olive. The import of duty free machinery and fuels, together with the electrification of the coastal towns, enabled the Italians to increase the capacity for oil production. In contrast the techniques in indigenous mills for processing the olives have remained virtually unchanged since Roman times; the crushing of the olives, the pressing of the paste and the separation of the juices from the water remain as basic features of this segment of the industry.

An indication of the magnitude of the transformation in the oil industry is given in ~~fig. 40.~~ Table 59

Table 59

State of the oil industry in 1932 and 1953.

	Tripoli/ Western 1932	Tripoli/ Western 1953	Central 1932	Central 1953	Eastern 1932	Eastern 1953	Total 1932	Total 1953
Oil Presses								
Mechanical	31(7A)	77	10(8A)	7	21(12A)	57	62	135
Hand and		7		269		196		472
animal								
operated)	64)	29	302)	196	537)	18	903)	108
Sansa Mills	2	3(6°)		-	1	1	3	10
Refineries	-	4	-	-	-	-	-	4

(7A) - Machine equipment but animal traction.
1932: A. Ferrara: L'industria aleoria in Trip., Rome 1934.
1954: Department of Agriculture.

It appears from the table that most progress in the conversion of inaminately operated presses to motor powered presses has been achieved along the coastal plain and Jefara and naturally in the areas of Italian settlement. Outside these areas the Libyan grower still relies for the most part on the primitive hand and animal operated presses.

The majority of the mechanical mills, sansa factories and refineries are owned by Italians, in cooperatives. Only 18 are privately managed. Practically all the Italian demographic settlements contain the cooperative oil press. Usually the larger concession farms are equipped with their own presses. The Libyan owned mechanical mills are located mainly in the coastal belt and eastern Jebel. These are managed cooperatively or else by a landowner. Elsewhere in the western and central Jebel most of the hand operated presses are owned by the farmers themselves whilst the animal operated press remains as a separate entity.

Oil Presses. The mechanical mills now account for the greater part of oil production in Northern Tripolitania but this varies according to harvests and their distribution. In a high productive year many of the primitive presses are brought into action but in an average year they command less than 5% of the oil manufactured.

Table 60.

% of national output of olives processed by oil mills in Northern Tripolitania.

	Number	%National output of processed olives.
Old mechanical mills	580	3%
Standard Mechanised Mills	100	52%
Modern Mills	35	30%
Others ?		15%

Old Mech. mills = Hand and animal.

Working capacity. Because of the diversity of oil producing factories and the fluctuations in the olive crop it is difficult to estimate the working capacity of the different mills. Such statistical information as exists can only give an approximate producing capacity with which there may be wide deviations. Whilst the difference in working capacity between modern mills and the most primitive types is marked, there is a whole range of medium sized mills whose capacity range is not very dissimilar. These are designated standard mechanical mills and on average their daily working capacity amounts to about 3 metric tons of olives in an eight hour day. By comparison the modern mills can manufacture about 5 metric tons of olives per day whilst the older mills process only 0.2 metric tons in a day.

Table 61

Distribution by Province of oil presses according to the amount of olives processed in a 10 hour day.

Capacity (in quintals)	Province: Tripoli/Western	Eastern	Central	Total
0-4	24	134	321	481
5-9	15	50	9	74
10-14	14	33	-	47
15-19	15	10	-	25
20-29	21	12	-	33
30-39	8	25	-	33
40-49	8	5	-	13
50-74	2	2	1	5
75-99	3	-	-	3
100-199	1	-	-	1
	715	113	271	715

The table illustrates that there are 715 oil mills in the region capable of processing between 3960 and 7500 quintals of olives per day. Assuming the total length of the working season to be 60 days, the total potential capacity for olive processing varies between 237,600 and 450,000 quintals. The quantity of olives worked could of course be doubled or even trebled by extending the daily working period or the season to 90 days. In view of the fact that the production of olives averaged 379,000 quintals between 1953-4 to 57/8 with a maximum of 713,000 quintals it appears that the existing facilities are adequate for present needs and those of the immediate future.

There are however significant regional contrasts in the distribution of the oil mills.

The Jefara and west coastal plain appear adequately served by a large number of medium and high capacity mills. In a season lasting 60 days the mills located in this area can manufacture between 110,700 and 161,100 quintals of olives which is adequate even for the very productive years as in 1950 when 150,000 quintals of olives were produced.

The manufacture of olives is carried out in the eastern Jebel and east coast plain by medium capacity mills and a relatively large number of low capacity mills with a daily productive capacity of between 121,800 and 201,240 quintals. In an average year they are capable of manufacturing all the olives produced. But in the western and central Jebel the oil industry is monopolised by the low capacity mills which can barely meet glut production years.

The correlation of oil mill capacities with oil production on a provincial basis can only give an approximate idea of the adequacy of oil pressing facilities. The exact distribution of the primitive presses is not known since they are rarely in use year after year.

In a very general way the higher and most consistent producing areas are served by the medium and high capacity mills. However the distribution of the mills according to ownership needs further research. Most of the high capacity mills are owned by Italians for the manufacture of their own olives but the proportions are unknown.

<u>Refineries</u>. The four olive refineries are localised at

Tripoli and have a total yearly processing capacity of 20,000 tons of oil which appears ample for present requirements and in the immediate future.

Methods of Processing. The methods of processing olives have been grouped into three categories according to their diverse phases of origin.

(1) Pre-Italian
(2) Italian
(3) Post-Italian

In general those oil processes which were in use before the Italians arrived are operated by hand and animal; the later models are operated by water

Pre-Italian. The extraction of the oil prior to Italian colonisation was carried out by the rudimentary system of Darb-el-Me (separation by water) and Masara (from 'Assara' to press).

The Darb-el-Me system consists essentially in the crushing of the olive between two large stones or with a rotating arm; in placing the crushed paste in a tub or hole in the ground, or in a series of stone lined holes, communicating with each other; pouring hot and cold water over the paste and beating or trampling the paste to separate the oil from the water (Plate LXXII).

With the second system of Masara the extraction is accomplished through pressing. It repeats in detail the Roman or pre-Roman technique.

The Masara is frequently constructed underground and therefore it lacks light, air and cleanliness. It was reported that this preference was in order to keep a constant temperature during the period of extraction in autumn and winter, so as to render the oil more fluid, and thus assure a greater return from the pressing; easier separation and purification of the oil. Typically it consists of a narrow entrance and steeply inclined shaft which leads underground to a large cavern (fig. 41). Here the main area is destined for the working of the olives. The simple crusher and press is set up here. Around the cavern are small recesses for the storage of olives and oil residue. Close to the press are situated several small recipients for the decantation and storage of the oil. Local materials of olive wood, palm binding and stones are used in their construction.

The distribution of the darb-el-me coincides with that of the olive groves and more humid areas. Whilst this is true of the Masara the miocene clays and calcareous crust have an obvious localising effect in the Jebel.

Sample A.

A typical Masara was examined close to the town of Garian (fig. 41). The press was privately owned and operated by two men and a camel. The press was reported to work only in abundant crop years and was inactive during 1958/9 season. But in the 1957/8 harvest it had worked fifty days. The recent installation of a modern cooperative oil press at Garian was reported to have taken away much of the custom. Each workman receives two litres of oil every twenty four hours and the proprietor is likewise paid in kind.

In a twelve hour day the Masara has a maximum capacity of 4.8 quintals of olives with a return in oil of about 13%. However the oil is strongly acid with a content of 6-7%.

No use is made of the black water left after separation but the dry sansa is retained as fuel.

Post-Italian. The Italians transformed the local olive oil presses by adapting them to electric and diesel power. Although they have retained the same processes of crushing, pressing and separating, mechanisation has greatly facilitated the operations and increased the productivity. Typically the mills are built above ground and enclosed. The processes are organised on a factory basis with the equipment arranged in a successive order of use. The mills vary in size and range of equipment, depending on the wealth of the proprietor(s), and the objectives of production. Their distribution is closely related to olive growing areas and also to the electrified zone in the coastal plain.

Sample B.

This Arab-owned mill was located in the village of Beni Let on the Cussabat plain. It is typical of the standard mechanical mill with a productive capacity of 80 quintals per day yielding about 20 - 25% in oil. The owner combines mill operations with farming.

The equipment of the mill comprises a small diesel motor, which operates a crushing machine and two hydraulic presses. In addition there is a large storehouse for olives and sansa. The oil is marketed at Cussabat.

Sample C.

This Italian cooperatively owned factory at Olivetti is in operation, on an average, 2½ - 3 months a year beginning in October. It caters for 70 demographic farms and processes olives mainly of the Enduri and Gariani varieties.

With a mechanical crusher, two hydraulic presses and a centrifugal separator, the mill can produce 70-80 quintals of olives in 24 hours. The yield in oil from the pressed olives is about 18% by weight. All the sansa is sold to the Homs factory.

Sample D.

This private Italian olive factory is one of the most modern in Tripolitania. It is situated in the centre of the S.A.F.I.C. estate which is located on the northern edge of the Tarhuna plateau (fig. 42). (Plate LXXVI)

The factory serves a private Italian concession on which 20,000 olives are grown in extensive dry farmed plantations. The equipment and processes of the mill ensure an oil of high quality (1% in acidity) and a yield of about 27% of oil from the olives. In season, the factory which has a productive capacity of 200 quintals of olives per day, works for about

12 hours a day. During this period nineteen men are employed. By working only the olives from the estate the homogeneity of the oil can be assured as also can the speedy transfer of fresh olives to the factory. All the oil is sold to merchants from Tripoli.

In productive efficiency, capacity and quality of oil produced the Masara and Darb el Me methods of processing cannot compare with the modern European mills. The former are only of value in a peasant economy as they can be easily constructed from local materials found in the olive growing areas.

European hydraulic presses yield in the region of 30% of oil from the processed olives. But with the Masara and Darb el Me the pressure is sufficient to obtain only 22.7% oil and 13.8% oil respectively ([illegible]).

Turning now to the question of oil quality we find that from the researches of Dr. Moreschini (1914) (71) olives processed by these primitive methods in Msellata and Garian yielded an oil with a 6-8% acidity. He estimated that this was a result of a delay in harvesting and pressing. This was caused by the low production capacity and poor storage facilities of the processing units. In the standard mechanical mills the quality of the oil does not differ pronouncedly from that obtained by indigenous mills. But in the modern mills, especially those equipped with washing machines, adequate storage space and centrifugal separators, the acidity in the oil is generally below 1% and three or more grades of oil can be obtained. (Plates LXXVIII & LXXVIIa,b)

This brings us to a third distinguishing feature of the primitive presses. In these mills the number of pressings is limited so that only one grade of oil is obtained and little use is made of by-products. However in the modern mills two to three pressings are possible. The first produces the high grade oils. The rest can be blended with high grade oils and made acceptable for consumption.

The indigenous presses have not the power to press green olives so that the producers are forced to wait until the fruits are soft and often overripe. In such a condition the acidity of the fruit is naturally increased. Little use is made of the pulp remaining after the first pressing.

There are other reasons why olives in their best state are often prevented from being processed immediately.

Most of the large Libyan farms and Italian farms rely on hired labour. When however cereal sowing coincides with the olive harvest labour problems arise. As a result the olives cannot be harvested in one campaign: where storage facilities amount to no more than holes in the ground then the fruits become susceptible to fungi and diseases. Since the local market requires highly acidic oils there is little incentive to apply corrective measures.

In general the Italian oil mills and modern European presses are confined to olive growing areas. Most of them are permanently sited close to the plantations they serve. There is in consequence very little mobile equipment which could be transferred to different areas depending on the variable climatic conditions. By and large they serve relatively homogeneous plantations in the same region. But the indigenous presses are used to manufacture olives from different varieties and in different states of preservation and consequently the quality of the oil suffers. However in times of drought or poor producing years they can be closed down easily whereas the modern mills are seriously affected by short seasons and fluctuating production. One solution to this seasonality of production would be for the factories to manufacture oil seeds for the remaining months. These could be blended with olive oil for the domestic market and thus release more of the latter for export.

In an effort to modernise oil processing mills in Libyan farming areas a scheme for the erection of cooperative modern oil presses was devised by the Government. Because of the cost of installation and working the factories were to be run on a cooperative basis.

Operation Zitun (AR. olive) was initiated in Tripolitania at the request of L.P.D.S.A. (Libyan Public development and stabilisation Agency). Its general purpose was to help Libyans produce olive oil, especially in the Jebel zone, to be extracted in improved conditions so as to become of exportable quality, to be eventually blended with other good oils produced by modern extracting plants on the coast, to form uniform lots of properly graded standard quality to be offered in the international market, eventually under their own Libyan band. The scheme illustrates the cost of erecting modern mills and the extreme difficulties faced by producers in the Jebel who have to rely on small capacity mills. The cost of conversion from animal and hand operated presses to mechanical motor driven units is normally too high except for the more wealthy Libyans or cooperative societies.

It was hoped also that the adoption of new machines might lead to the improvement of growing and picking techniques (upkeep of nurseries, tree-pruning campaigns, anti parasitic campaigns etc.). These could hardly be justified in the eyes of growers if olives were continually being wasted in the old Roman presses, producing a barely edible fluid. The scheme was to be operated on a cooperative basis which might subsequently be extended to other fields such as finance and credit.

Only one comparatively modern press existed for 240,000 trees between Garian and Nalut. It was therefore suggested that four small, portable, modern high pressure presses should be set up as near the olive groves as possible at Jefren, Garian, Giado and Nalut. The proximity to the olive groves of the machines was essential if the processed olives were to be packed fresh, unbruised and of low acidity.

Although there was initial enthusiasm amongst the growers it was followed by indecision, fear of responsibilities, attack by merchants and money lenders, and intertribal antagonism. Finally after many weeks' work the Government granted a subsidy of £40,000 to the cooperatives and the L.P.D.S.A. provided £L20,000 for the purchase of superpresses. These were bought and installed by a specialised mechanic who gave instructions to local mechanics on the method of processing the olive crop. In 1956 a limited company was set up consisting of representatives of the olive grove owners. This so called 'Jebelia' Company provided financial backing to the building of the cooperatives and the presses were set up in the October of that year. By the 11th of October of that year there were 610 cooperators at Nalut with 6,100 olive trees, 275 at Giado with 4,300 trees and 96 at Jefren with 2,800 trees.

According to the status of the cooperatives the cooperator who brings olives must leave 10% of the oil produced as payment. After substracting this amount the cooperator can sell all or part of the remaining oil to the cooperative and get a provisional price which will be adjusted at the end of the olive campaign. The prices of the olives are to be fixed on the basis of oil quality and yield in oil of the olives. Those farmers not wishing to become members of the cooperatives could still sell their olives and obtain a final price. Each of the mills can process about 500 tons of olives which would yield roughly about 100 tons of oil.

L.P.D.S.A. produced £10,000 from their 1956/7 budget for the erection of the four mills. £20,000 was donated from the Libyan Finance Corporation. This was used as noted for the purchase of presses. Operations began in the 1956/7 season.

Table 57.

Production of oil from the Jebel cooperative oil mills.

1956/57			1957/58		
Garian	q.li	55,97	Garian	q.li	71,96
Jefren	" "	42,99	Jefren	" "	57,12
Giado	" "	57,51	Giado	" "	41,38
Nalut	" "	27,88	Nalut	" "	27,34

In the following year production at Garian and Jefren was exceeded whilst Giado and Nalut suffered only slight losses.

Sample E.

(3) Cooperative Oil Factory at Garian. This small factory is located on the main road about ½ mile from the centre of Garian (fig. 43). The factory was erected as a result of L.P.D.S.A. enterprise and capital and is run on cooperative lines. Anyone can bring their olives to be processed, provided that they leave 10% of oil in payment. It has been used predominantly in poor harvest years whereas bonanza years have brought the more widely dispersed primitive mills into action (Plate LXXV).

25-27 quintals of olives can be processed in a day yielding on average 25-30 litres oil every quintal of olives.

The collection and marketing of the oil is carried out by Consorcio Agrario on behalf of the producers. Sansa is sent to the Gheradi mill at Tripoli. Responsibility is therefore taken out of the producers' hands and their interests are carefully guarded on the market.

Six workers are employed at the mill, three labourers, a mechanic, clerk and watchman. During the 1958/9 season 398.1 kgs. of olives were worked for a return of 10 litres of oil. The season only lasted 20 days.

The total cost of the mill installation amounted to £30,000.

Subsequently five more modern olive oil extracting plants of the same type were set up entirely by private Libyan capital and initiative. Three were erected near Zuara, one in Cabao, one in Gasr el Chiar and one at el Khadra. Table 57 shows the production of oil from the far Jebel presses in 1956/7 and 1957/8.

Small farmers using cooperative oil mills are faced with many problems. All of them want to use the facilities at the same time. Since there are only certain days which are suitable for pressing large quantities of the olives will have to be stored. During this period, if storage facilities are below standard, then the quality of the olives and consequently the oil will diminish.

Another problem involves the management of the cooperative presses. If an expert is employed and the season is short then expenses will obviously be excessive. On the other hand if the selection of a manager is not strict the resultant work may be inefficient.

Some difficulties of labour and poor communication have been encountered at Nalut but the rest would appear to be prospering.

Storage capacity. The oil and olive storage capacity of the mills, farms and warehouses is very limited. In the mills themselves only 5,000 quintals of oil could be stored and carried over from one year to the next. Unfortunately the storage capacity outside the mills, in private warehouses and Government establishments, is not known but it is not likely to exceed 20,000 quintals of oil. At the moment therefore, with average production of oil oscillating between 2,000 and 6,000 metric tons, olive stocks cannot be carried over from year to year to help reduce crop fluctuations and wide price movements.

The storage of olives, except in the modern mills, is also very unsatisfactory. Usually in the modern mills the olives are stored in racks or sacks and are thus relatively safe from damage. Medium sized mills have a storage capacity of between 5-30 quintals, and large mills between 20-30 quintals. However in the indigenous mills the olives are stored temporarily in holes and rock caverns which are liable to pest attack and have a considerably smaller capacity. Because of the low productivity of the equipment in these mills storage is often prolonged with a consequent deterioration in the quality of the olives.

As a means of alleviating this situation Consorcio Agrario have recently acquired a former wine storehouse at Castel Benito. Here practically 1,000 quintals of oil can be stored, blended and exported. Other opportunities like this ought to be considered since such measures can contribute substantially to the stability of the oil industry. Good storage facilities are necessary also to counteract the wide dispersion of olive plantations and mills particularly in the Jebel.

A comparatively short visit was made to Sfax in Tunisia during the olive harvest of 1958/9. It was interesting to compare the techniques of oil fabrication in the two areas which have broadly similar environments and where European influence has been effective. Unlike the olive producing areas served by Sfax the areas of cultivation in Tripolitania often suffer from inaccessibility and isolation. For example the western Jebel is poorly served by main roads. Furthermore the specialisation in oil production for export is more limited than in Sfax where even the small farmer is a commercial producer. There is therefore in Tripolitania a greater diversity of oil manufacturing equipment with a dispersed distribution, whereas in southern Tunisia the oil pressing industries and commercial centres are localised at Sfax. Whilst the French encouraged the Arabs to produce for export, the Italians neglected their counterparts in Tripolitania.

Sansa oil mills. The Italians were responsible for the growth of the sansa oil industry; it was prompted by the high price of oil on the Italian market during 1920-30. All the mills are localised in the coastal areas and predominantly in the vicinity of Tripoli.

Normally 100 kilos of olives yield about 150 kilos of sansa in which remains at least 8% oil. The methods of extracting this oil is done by a solvent process.

Sample E.

Sansa oil and soap factory at Homs (Plate LXXV).

The sansa factory at Homs was established in 1925 to work the sansa from Msellata, Homs and Zliten. Its hinterland now includes customers in Tripoli, Misurata and Tarhuna. Foreby the extractor there is now a small soap factory.

The process consists essentially of drying the sansa in a large chamber by passing hot air through it. The dry sansa is then transferred to 6 extractors with a capacity of 50 quintals of sansa. Trichloritine is passed through the sansa. It absorbs the oil which is then transferred to two distillators where the solvent evaporates and leaves the oil extract. The solvent passes below into water where it is stored for further use.

The water is obtained from two wells located in the courtyard.

The crude oil is then transferred to the refinery which decreases the acidity to 1-1.5%, removes smell by cooperation. The oil with acidity higher than 25% is used for soap manufacture. The refined edible oil is sold on Tripoli markets.

The average working period is 4-5 months and during the peak periods 120 men are employed.

In a day the factory can manufacture 6,000 kilos olives (6 metric tons) and 7-8% oil by weight extracted. About 0.75-1% of oil remains in sansa but the dry matter is only used for combustion.

The factory produces on average 500 tons of sulphur oil but in 1957/8 the total rose to 1,000 tons.

It is interesting to record that in 1930 the proprietor also extracted the oil from castor seeds with a return of 42 quintals oil for 100 quintals processed. Because the working period may deviate widely the extraction of oil from soft seeds has much to recommend it.

Markets and Prices. Olive oil and sansa oil produced in Tripolitania is destined to aliment an internal market by which the annual average consumption is about 3,500 metric tons (increasing at the rate of 29 metric tons), and to a more limited extent an external market which, in principle, is the surplus produced above domestic needs.

Whereas the olive harvest interests the majority of the rural population, their manufacture is carried out by less than 800 mills; the distribution of the oil to markets is the responsibility of a small number of merchants, trading companies and groups of negociants. The exporting of the oil and by-products is mainly in the hands of Consorcio Agrario (an

Italian credit agency) and 61 individual wholesalers who operate on licenses issued by the government. These licenses are released when domestic demands of oil have largely been catered for.

The growth of the internal market has been the overriding factor in oil commerce in the present century. The means by which the oil reaches the consumers are numerous.

Amongst small Libyan farmers there are three methods of marketing the olive crop. The overwhelming majority of the producers still press their own olives or take them to the local oil mill. In good years the surplus may be placed on markets but the greater part of the produce is for domestic consumption.

It is quite common for the olives to be sold to merchants before the harvest to obtain working capital. In this way the merchant becomes responsible for the transport, manufacture and sale of the oil. The olives are very rarely transported to local markets and then sold to merchants and mill owners.

These three systems have evolved due to

(a) an interest in the crop rather than the price,

(b) hardship forced in poor crop years,

(c) uncertainty of crop until harvested,

(d) difficulties of transport and storage.

The pre-sale of the crop always operates however to the advantage of the merchant.

But these systems are changing. The growth of the cooperative oil mills, the advantage of higher oil yields and the sale of oil at wholesale prices is attracting the small producer.

Amongst Italian collective farms there is a much greater degree of cooperative action although there are significant exceptions. Many farmers at Breviglieri for example sell their crop and oil to merchants rather than the cooperative mill. This they do because prices are better during low producing years.

The greater part of Italian oil production is, however, taken by Consorcio Agrario, either from the cooperative oil mills or from those established on the private concessions. This agency thus becomes responsible for the transportation and sale of the oil. In order to avoid the taxes on commercial transactions several of the large Italian private concessions control the whole industry from cultivation, manufacturing to retail marketing. One farmer interviewed at Garribulli reported that he owned nearly 20 small shops in Tripoli through which he disposed of his olive oil.

There are several advantages of the Italian system of marketing. In the first place, because of the higher productive capacity of the mills and the intervention of Consorcio, the oil is transferred quickly from producer to consumer. This method also cuts out the exploitation of the producer by the middleman. On the other hand the Libyan system doesn't benefit the producer as he doesn't experience the movement of prices. Because there are several concerned in the marketing of olive oil the margins of profit for the wholesaler are high and the gap between the income of the producer and retailer is widened.

Internal distribution of olives, oil and other products is done primarily through small shopkeepers and local village markets. Most of the smaller villages have only one market a week but the towns of the coast and Jebel generally have 2-3 market days a week. The small markets serve primarily to exchange goods between Arabs specialising in different productive fields of agriculture and craft industries. In this typically primitive marketing system products frequently pass through the hands of many dealers. Each must have a margin. Obviously marketing margins under this system are high and a relatively large percentage of the population are traders and merchants instead of being producers.

It is interesting to compare these systems with the more developed markets of Tunisia. The greater part of the olive crop is transported to mills where it is bought from the farmers by specialist wholesalers. They sell oil to the retailers at market prices. The whole business is much more simple and efficient with the producer benefiting from favourable market movements.

One of the impediments to the improvement of Libyan olive oil with respect to external market requirements, is the lack of discrimination on the part of buyers between oil of varying qualities. Some price differentiation does exist between sansa oil and olive oil.

Table 63

Average selling prices of 1 kilogram of oil on Tripoli markets.

	Edible Oil	Inedible
1953/4	£L0.150	£L0.140
1954/5	£L0.190	£L0.150
1955/6	£L0.290	£L0.200
1956/7	£ 0.240	£L0.210
1957/8	£ 0.100	£L0.150

Usually the edible oil commands a higher price. There is therefore little incentive to carry out improvement in the techniques of olive cultivation and manufacture whilst there remains no price support and recognition of superior quality oils. Oils of different qualities and from diverse regions are mixed and ungraded.

The prices for olive oil and the more important dryland crops - wheat and barley - have fluctuated widely since 1946*. Wheat prices are considerably lower than in 1946 (Table 64)

Table 64.

Index of wholesale prices on the Tripoli market.

	1946	1947	1948	1949	1950	1957	1958
Wheat	100	100	169	90	82	79	75
Barley	100	237	197	146	78	116	117
Olive Oil	100	110	126	100	63	112	78

and only the droughts of 1947 and 1948 have halted the decline

* Earliest date for which continuous figures are available.

in prices of olive oil after the war.

Fluctuations in the prices of agricultural products have less effect upon production than is common in the more advanced countries (whose production is primarily for sale) but they are still felt. The fluctuations in prices reflect the size of the crop and the demands of the domestic markets. The Government by controlling the issue of export and import licences is trying to maintain a degree of price stabilisation but with the achievement of independence, the initiation of development programmes and the extensive work being carried on in connection with oil exploration, the cost of living has tended to rise so that the relatively high wholesale index for 1957 reflects rather the effects of inflation than a poor crop year. The Government, through Consorcio, has purchased oil on the local market when supplies have been plentiful and later resold or exported this surplus. Apart from these cases, the local price of olive oil and the by-products has been primarily the result of the interplay of demand and supply facgors in the local market. They have been closely related to world prices only when the product was easily exported and export permitted. Even then export prices have only approached prices on the local market because of the tariff free quotas allowed on the Italian market. Because of the low quality of the oil the ordinary export prices to open markets would be well below domestic prices. Because of the influence of rainfall on production the government can hardly be accredited or critized for any appreciable influence on production and prices. In this respect the ability to carry over stocks from year to year would bring about the most significant move towards stabilization of production and prices.

Tripoli and Cussabat are by far the largest markets for olive oil. They are followed by Homs, Zuara, Garian and Misurata.

During 1957 the movement of the market prices closely reflected the production of olive oil and its availability.

Table 65a

1957 - Average Prices in Municipal Markets in Tripolitania. (in millèmes)

	J	F	M	A	M	J	J	A	S	O	N	D
Tripoli	230	232	236	260	202	192	222	208	193	170	166	156
Suk el Giuma	255	255	255	252	250	230	242	235	230	175	167	152
Tagiura	235	232	235	225	220	220	220	250	220	190	172	150
Azizia	240	245	242	247	244	247	255	230	263	219	202	182
Zavia	250	265	268	250	270	267	237	237	217	177	167	170
Sorman	255	272	270	250	252	270	-	200	205	170	167	170
Sabratha	280	275	280	270	275	270	252	250	242	217	195	185
Zanzur	255	265	245	255	250	235	225	232	255	170	175	162
Zuara	265	267	256	267	251	260	237	250	233	210	185	170
Garian	230	227	230	235	227	227	210	190	192	197	185	157
Jeffren	230	225	207	205	190	185	195	195	195	190	170	135
Nalut	240	200	220	240	210	215	240	190	200	195	217	205
Misurata	232	235	242	255	227	210	220	220	211	195	180	145
Homs	210	220	251	216	215	190	197	191	180	152	153	151
Cussabat	210	215	225	217	205	180	197	193	195	170	155	150
Zliten	220	225	242	257	232	185	210	192	190	170	162	156
Tarhuna	245	245	-	247	255	215	220	220	217	205	164	187
Sirte	275	235	-	-	-	-	-	-	-	-	-	190
	Av. 242	Av. 240	Av. 244	Av. 244	Av. 233	Av. 223	Av. 293	Av. 216	Av. 214	Av. 186	Av. 170	Av. 165

Prices were high during the early part of the year and declined towards the summer months. They were lowest in autumn and early winter when the main harvest and pressing is carried out. It is quite obvious that although supplies of oil in late winter and early spring are diminishing and result in the rises of prices, large quantities of the oil is held back for the lean summer months when a relatively high price can be obtained.

Prices not only move in the opposite direction to production from year to year but also regionally (Table 66 Appendix). However the prices fluctuate less. The difference in the times of harvest between the Jebel and coastal areas is well brought out. The largest quantities of olive oil come on to the market at Cussabat much later in December than at Tripoli. The Tripoli market appears much steadier than the one at Cussabat. This feature is presumably related to the much greater hinterland of the former town and its greater facilities for storing olive oil. (Table 65b Appendix)

In order to lessen these wide price fluctuations and repair the unbalance between export prices and those of local markets production of olive oil must be stabilised and the quality of the oil must be raised. Only an increase in export prices relative to domestic prices can stimulate the improvement of olive cultivation and oil manufacture.

trade. At the present international trade is only about half the peak volume of 270,000 metric tons traded annually in the 1930's (table 67) Appendix . In recent years it has averaged 110,000 tons annually. About 70% of world exports of olive oil during the period 1950-53 came from Spain and France and their dependent possessions (including Tunisia).

The main reason for the decline in trade has been the promotion of a self sufficiency policy and reduction of imports by the United States and Argentina. In 1924-28 these two countries accounted for about 90% of total imports but only about 40 in 1950-53. An additional factor has been not only the increased production of oil in the Mediterranean itself and a decrease in the proportion of Italian and Greek exports, but also the increased production, substitution and consumption of other seed oils. For example since the second world war Spain has become an importer of soft oils, soyabean and cotton seed in scarce years, in order to maintain domestic fat consumption and traditional exports of olive oil. The substitution of olive oil by soft oils has been allowed to some extent by the wide fluctuations in supplies and prices (table 68) Appendix . Trade controls in postwar years have also effected the volume of olive oil entering international trade. [72]

The increase in volume of North African exports has to some extent offset the restriction of trade in the northern Mediterranean countries. Tunisia now relies on export markets to the tune of about 40% of total production each year.(70)

Only about 7% of the trade of the largest Mediterranean producers is with non-European countries. Trade with the dollar currency area represented 28% of the total volume of exports. These dollar earnings are of major importance to Spain, Portugal and France but they have become limited in recent years. (Table 68)

The greatest market for olive oil lies in the sphere of food consumption and the largest demand is traditionally in the Mediterranean basin. Lower grade oils have their uses in soap manufacture as lubricants, medical goods and textile and leather industries. But because of the high price of the olive oil relative to other soft oils the latter are easily substituted. Consequently the markets for these lower grade oils are obviously concentrated in the industrial countries of Europe.

The brief survey above of trade in olive oil supplies the background to the important question facing Tripolitania olive growers. Can exports of olive oil be expanded? As regards the exportation of olive oil Tripolitania is a young and inexperienced country. Her trading links in any sphere and with countries other than Italy are limited.

The general volume of trade is declining and markets are less easy to command in the face of trade controls and the import of cheaper substitute soft oils. Two types of markets exist abroad for Tripolitania

(1) Markets of consumption

(2) " " transformation.

The second group of markets receive lower grade olive oil than the first, refines and exports it. Italy and France are the main markets for this type of trade. At present the oil industry of Tripolitania is destined to serve as an industrial annexe to the industries of Italy in particular. The inexperience and immaturity of the export trade is emphasised by the fact that the exporters themselves have a multitude of interests of which oil is one.

The home market consumes on average 9/10ths of the olive oil production so that only in good rainfall years is there a surplus to export. But as we have seen (p.) this surplus is likely to increase as more Italian trees come into production. So that although at the present the exportable surplus is low and variable it can rise to make a substantial contribution to export earnings.

The exportable surplus of Tripolitania accounts for only a very small proportion of world trade. The main exporting countries are Spain and Tunisia who between 1950-53 exported 31% and 27% respectively of total exported oil. It is only in recent years that the country's export trade has expanded (fig. 44). Before 1939 little oil was exported for the growth of population rapidly outpaced olive oil production. The import of olive oil and other soft oils was accordingly high during the years 1936-38. This resulted from the increase in population and also because of an increase in the circulation of capital. More oil was absorbed than local farmers could produce. Notwithstanding the almost total absence of olive harvests there was a continual demand for imported refined oil. The defect was partly made up by the import of oil seeds.

In recent years the volume of trade in Tripolitania has increased and although exports still fluctuate widely according to the season the years of high export far exceed the quantity of oil exported before 1939. This expansion can be attributed in the first place to the increased olive production as a result of Italian plantations maturing, to the abolition of export duties on olive oil, and also to the expansion of the export market. The growing importance of cheaper soft oil imports is well illustrated in fig. 44. Usually imports are highest in years of low production but it is obvious that in 1955/6 the import of soft oils enabled the export of oil even though the olive crop was only mediocre. These soft oils are blended with local oils. Obviously this substitution of olive oil by the soft oils indicates that the improvement in oil mills and techniques and storage facilities is not moving very rapidly.

In good years olive and sansa oil dominate Tripolitania's exports and they cause a marked diminution in the volume of exports. Since 1954 olive and sansa oil have increased their importance as export items from 7.1% of the total exports (esparto 16.6%, peanuts 15.9%) to 12% in 1955 (peanuts 14.8%, esparto 12.5%) and 24.6% in 1957 (peanuts 17.8%, esparto 7.3%). (Table 71.)

Italian colonisation has inevitably effected the sphere of Tripolitania's trade. Even though Libya has achieved independence Italy supplies the greater part of the country's oil import requirements and takes the major part of the surplus production (tables 72 and 73). Although the cornering of the market by Italy is responsible for the limited trading relations of the country it has allowed the export of low grade olive oil in the face of competition from Tunisia and other Mediterranean producers whose industries are well established. This preferential market originated after the war when surplus olive production was difficult to sell because of wartime inflated conditions. Italy subscribed to this compensation trade which allowed up to 2,500 tons annually of Libyan oil to enter the country with a 20% reduction on customs duties. This agreement was ratified by G.A.T.T. Owing to recent negotiations the Italians have agreed to import up to 3,000 tons of Libyan oil each year. But in 1958 the Italian Government compelled Italian importers to buy a certain proportion of seed oil to olive oil. This movement will undoubtedly effect any further overtures from the Libyan Government for the raising of the export quota. Because this quota is exceeded in good crop years the export trade is not working to full capacity.

Table 70

Type of oil.	Uses and Interchangibility of leading vegetable oils.														
	Margarine	Lard	Salad Oils	Sardine Oils	Cooking Oils	Soap	Glycerine	Cosmetics	Medical	Paints & Varnishes	Illuminants	Lubricants	Linoleum	Textiles & Leather	Processing
Groundnuts	X		X		X	X		X			X			X	
Cötton seed	X	X	X		X	X	X		X		X				
Soya bean	X	X	X			X	X			X			X		
Cocoanut	X	X				X		X	X						
Ropeseed						X					X	X			
Olive			X	X		X			X		X	X		X	
Sunflower	X	X	X		X	X				X					
Palm	X	X				X								X	
Palm kernel	X	X				X									
Linseed						X	X			X			X	X	
Sesame	X	X	X		X			X	X		X	X			
Castor						X			X	X	X	X		X	
Tunny										X			X		
(Whale)	X	X				X	X				X			X	

Table 71

Contribution of olive oil exports to the general economy in 1957.

	Exports. (%)
Olive oil	24.6
Groundnuts	17.8
Esparto	7.3
Camels	5.7
Scrap metal	7.0
Hides and skins	4.7
Wool and other hair	4.6
Castor seed	4.5

Table 72

Direction of olive oil exports from Tripolitania in 1957.

Country	Value £L
Italy	1,153,469
Algeria	6
Malta	2,454
Tunisia	4
Total	£L1,155,933

Note: In olive oil exports accounted for 7.1% in 1954, 12% in 1955, and in value of all exports

Since the country's oil is low grade only the markets of transformation can be exploited at present.

Table 73

Export of olive and sansa oil from Tripolitania.
1950/1 - 1956/7.

Year	Olive Oil Amount met. tons.	Olive Oil Value £L.	Sansa oil Amount met. tons.	Sansa oil Value £L.
1950-1	2,907	549,000	640	74,000
1951-2	432	83,000	311	34,000
1952-3	-	-	89	10,000
1953-4	1,433	256,000	373	38,000
1954-5	139	26,000	743	48
1955-6	1,710	41,672	648	9,567
1956-7	-	-	380	6,133

Prospects of the Oil Export Market. Both internal and external geographical conditions affect the prospects of the olive oil export trade in Northern Tripolitania. There is little doubt that the production of olive oil will continue to increase throughout the 1960's at a rate which will allow considerable export in some years. Since irregularity of production stems from a variety of causes, some of which are environmental, this phenomena will continue to handicap the industry and trade. Yet several ways of ameliorating the effects have been suggested. These include the nationalisation of cultural practices, increased planting and the provision of modern oil machinery and adequate oil storage facilities. Under an enlightened government, which has the technical and capital resources of many nations at its command, the spread of better agricultural techniques and capital investment in agricultural services can bring about a gradual raising of agricultural standards amongst a rural population which for the most part is eager to learn and desirous of progress.

The low quality of Tripolitania's oil, in addition to the fact that the country is not a regular exporter, are further impediments to increased exports. Whilst the world markets require high grade oil a balance must continue to be maintained between local and overseas demands until the rural population is educated to the consumption of higher grade oil. This will inevitably delay the country's entrance on to world markets.

On the other hand there are several factors which favour the higher export of oil and by-products. The Government budget is biased towards public and agricultural development. Since 1952 there have been several measures designed to help the olive farmer, the exporter and oil mill owners. The exemption from import duties of agricultural machinery, chemicals and fertilisers, combined with public and private development of water resources, have benefited both Italian and Libyan rural communities, especially in the coastal belt and Jefara. Change is less rapid in the traditionally conservative farming areas of the central and western Jebel. In 1957 the National Bank of Libya was set up. One of its main functions is to supply local farmers with short-term credit. At the same time it can advise on investment and agricultural practice. In order to increase both the quality and quantity of oil in the less accessible areas cooperative oil mills were installed in the Jebel. The price control of oil together with the abolition of export duties on oil are further measures introduced recently to encourage the export of oil and prevent seasonal hoarding of supplies. It is to be hoped that the standardisation of exports of peanuts, citrus and fruit will shortly be extended to the oil industry.

For these reasons it is likely that average olive oil production and the export surplus will increase in the next ten years.

When viewed against the world situation, the favourable economic and political circumstances prevailing in the region, the prospects of increased exports are still good.

The world production of olive oil is declining because of the increased importance of other soft oils. However a U.N. study in 1955 believes that there is no cause for alarm because any degree of economic development of the Mediterranean countries will result in an increase in food consumption.(70) Historically such changes have resulted initially in a higher consumption of fats and oils and less cereals.

It will be some time before Tripolitania can place appreciable quantities of refined oil on export markets.

<u>Conclusion.</u> At present most of the oil designed for export is ungraded and unrefined. In consequence the only markets available are those of Transformation for which the

preferential Italian market exists. Because Italian influence and responsibilities in Libya are declining it is unlikely that the Italian annual import quota of 3,500 metric tons of Libyan oil will be appreciably revised to accommodate greater Libyan surpluses. Although the American community at Wheelers field in Tripoli (17,000 in 1956) have been obliged to accept greater quantities of local agricultural products, vegetables and citrus fruit are in far greater demand than olive oil.(73) In any case Libya must look to more permanent markets abroad.

In this connection Libya has only started, since independence, to expand her diplomatic contacts abroad. Thus she has only a few commercial attachés in neighbouring Mediterranean countries, Central and Northern Europe which are well situated for trade with Libya. In comparison Libya's greatest competitor, Tunisia, has established strong marketing organisations throughout the Mediterranean.(74) Moreover the majority of oil exporting countries belong to G.A.T.T. and are therefore more suitably placed than Libya.

But the commercial status of Libya is changing. During 1957 the Government concluded commercial agreements with Belgium, Denmark, Egypt and Holland.(75) All these countries subsequently agreed to import small quantities of olive and sansa oil. But obviously the distance to European markets and their main requirements for high grade oil will ensure small demands.

Malta offers interesting opportunities. It is close to Tripoli and lies in a route well served by both sea and air transport. Malta produces no oil of her own, although dietary demands are similar to other Mediterranean countries. As well the similarity of currency in the two countries would allow compensation trade with the United Kingdom manufacturing market.

On the basis of the preceding discussion and the author's introduction, at Sfax, to the system of olive growing, manufacture and export, certain recommendations can be made which could increase the productivity of the oil industry, and contribute to the raising of living standards. They are as follows:

(a) Assistance to growers in the form of nurseries, pest-control, pruning campaigns, credit facilities and cheap electric power.

(b) A plan for Jebel - continuance and expansion of soil and water conservation programmes and cooperative schemes.

(c) Production of soft seed oils grown in Libya to supply at accessible prices the local markets whilst remunerative grades of oil are exported.

(d) Compulsory export standards.

(e) Policy of ensuring the quality and regularity of supply of oil to markets.

These measures designed to improve the economic status of olive oil producers must be evaluated as part of an integrated solution for the agrarian and regional economy as a whole.

Conclusion.

In the previous seven chapters the potentialities of Northern Tripolitania, as a region for commercial olive cultivation, have been assessed from physical, human and economical aspects. It only remains to draw together the main conclusions reached. These are summarised at the end of each chapter.

To do this it will be necessary to reiterate the basic questions which have guided the lines of research. These are as follows:-

(1) Can the area devoted to olive cultivation be expanded in view of the environmental factors influencing or controlling the distribution of sedentary agriculture, land use and crop productivity?

(2) Where are the suitable development areas ?

(3) Are the prevailing, political, social and economic circumstances favourable for the expansion of the olive ?

(4) What types of land settlement and systems of arboriculture should be adopted in the future ?

(5) How far can the present systems of olive cultivation be improved ?

(6) Taking into consideration the methods of cultivation, types of oil mills, marketing systems and external market situations, what are the prospects for the establishment of a regular and significant oil export trade ?

The importance of the olive in the agrarian economy of the region has been emphasised repeatedly. Throughout history it has held a position of prime importance as an item of diet and exchangeable product. There are several reasons why new plantations and therefore new rural settlements ought to be planned.

These include:

(a) To prevent wide fluctuations from year to year in oil production.

(b) To fulfil domestic consumption requirements and allow a regular exportable surplus.

(c) Because Libyan trees are in an advanced state of maturity oil production from this sector is likely to diminish. Moreover the political status of the Italian community is not likely to inspire the confidence required for continued tree planting.

(d) To help in a soil and water conservation programme so that existing and potential settled farming areas will not be exposed to the deleterious effect of wind and water erosion.

(e) To help sedentarise and rehabilitate the semi-nomadic elements of the population.

(f) To counteract the declining importance of the olive in irrigated farming areas.

The results of research in chapters 1 - 6 suggest that there are both virgin and extensively used areas into which the olive could be successfully introduced. The scale of new plantation developments would have to be of a more modest nature than those carried out by the Italians, since there are no large potential development areas. In addition the rate of expansion will depend on the speed at which adequately qualified Libyan farm managers can be supplied. The onus is very much on the government.

1. At the present time the rate of expansion of olive cultivation is very gradual. The 'Green belt' is being extended in the Eastern Jefara and the Jebel Tarhuna but these fragmentary developments hardly compensate for the decline in the Western and Central Jebel.

The distribution of the culture is controlled largely by groundwater, morphology, climate and economic systems. In the Eastern Jefara and several high level surfaces of the Jebel the traditional association of nomadic pastoralism has precluded sedentary agriculture.

In such an arid environment groundwater determines the distribution of rural settlement and consequently localises olive cultivation. Only a few orchards are the property of nomads. Three geological formations are important:

(i) Gefarico (Pliocene)
(ii) Miocene
(iii) Quaternary.

They contain aquifers and act as catchment basins. These beds are most continuous in the Jefara and lowlands of Miswatino. However in the Jebel the Miocene beds only occur east of Cussabat, the Gefarico is absent, and the Quaternary is discontinuous as a result of faulting, erosion and the anticline structure. Because the Jebel acts as a watershed water flows away from the best rainfall zones to the Jefara and Ghibla.

A rough computation for the crude water balance shows that in each month except December and January there is a moisture deficit. Taking into account the loss of annual precipitation through evaporation, transpiration and run off the total available moisture amounts to 1,687 million M3. About 100 million M3 only is used each year for irrigation and urban requirements. Thus there appears to be sufficient water for the extension of irrigation although the fraction retrievable by dry farming is probably greater because supplies are very localised. Approximately 1,032 million M3 is located north of the Jebel scarp.

The most prolific yielding wells, and those likely to be increasingly used, are distributed throughout the coastal belt and parts of the adjacent steppe. Water supply in the Jebel is provided mainly by tanks and cisterns, which are not so reliable as wells, but which yield sufficient water for tree planting.

Another source of water, at present underutilised, is surface run off. What is required is the systematic development of watershed basins by the construction of dams in the mountain valley tracts, diversion dams in the Jebel piedmont, terracing of slopes and wadi sides, and the extension of arboriculture on the watersheds and slopes.

The accessibility of groundwater determines the sites for rural settlement. Irrigation water, either from surface or underground sources, is essential for tree crops outside the area enclosed by the 200 mm. isohyet. Even within this zone climatic hazards are so great that the semi-irrigation of the trees is desirable.

There are three sources of groundwater in the region. A shallow water table has been intensively exploited by Libyan farmers to support a small irrigated culture at the coast and as far inland as Suani Ben Adem. More abundant sources have been tapped by the Italians. The yield from these semi-artesian waters in the Jefara is constantly being increased as wind pumps are being replaced by motor pumps and sprinkler distribution systems. Because of the great density of wells there are signs that the area in the vicinity of Bianchi is near the limit of sustained development. On the other hand the development of deepseated artesian aequifers has not proved entirely successful because of the high salinity of the waters. However where the use of the water is controlled and soils are sandy then they prove to be one of the cheapest forms of irrigated agriculture. The value of the artesian waters has been demonstrated at Crispi.

Potential water supply regions are unfortunately outside the zones of highest humidity and rainfall and therefore the cost of irrigated agriculture increases from the coast. Crops, such as the olive, requiring only partial irrigation would help to decrease running costs.

Irrigated agriculture could be extended into two regions:

(1) Sorman-Zanzur, a sandy zone with reasonable quality water at 20 m's depth.

(2) Tripoli-Azizia.

Ultimately costs must be considered. Here, dry farming has a decided advantage for the capital costs of irrigation are high(£44 per ha. on the coast) in contrast to £3.3 per ha. for dryland farms on the Jebel.

In view of the fact that the Dalu, although inexpensive, is adapted only to small areas and shallow acquifers and the cost of electric pumps is high, there is much to be said for developing the cheap artesian water. In areas of depleted water supply dryland crops should be introduced.

The present morphology is a result of tectonic evolution and the remodelling effects of aeolian and fluvial erosion. The main distinction is between the Jefara and Jebel. Topographically the Jefara is the most favourable area for land settlement expansion. The undulating Jefara where it is successfully stabilised, is located in the best rainfall and hydrological zone. In the plain Jefara the poor water supply and skeletal soils are limiting factors. Other negative elements include the superficial calcareous crust zone, the sebkas and Pre-Jebel hills.

Within the Jebel there are several distinctive levels in varying stages of erosion and dessection. Whilst the plains of the Eastern Jebel appear to be approaching maturity the escarpment and the 500-600 metres surface is being intensely eroded. South of the scarp the high plains of El   and Assaba are relatively unaffected by erosion. Only their pastoral associations have precluded the spread of olive cultivation and sedentary agriculture.

Many wadi basins of the Jebel could be more intensively utilised especially the Upper, Middle and Scarp zone basins. Because the Jebel front is being degraded by fluvial erosion systematic development of the catchment areas is essential.

Foremost amongst factors influencing agriculture is rainfall. The Ghibli and temperature extremes do not effect the production of oil with the same frequency as the variability of rainfall, both seasonal and periodic. Every ten years farmers can expect a prolonged drought whilst there are pronounced fluctuations in amount and distribution from year to year.

The olive is now cultivated in the most favourable ecological regions, with the exception of certain areas in the Eastern Jefara, steppe lowlands of Misuratino, the Eastern and Central Jebel. The best region from the point of view of yields and regularity of production from dry farmed olives is the Eastern Jebel. The ultimate limit for the olive is the 24°N but it is plain that in areas of the Semi Desert and the Western Jebel the olive hardly produces an economic crop.

In the author's opinion at least 200,000 ha's are available for the extension of olive cultivation. Less than 50,000 hectares in the steppe zone however could be successfully irrigated. Expansion would be particularly considered in the middle basins of the Northern thalwegs of Jebel Wadis. Rainfall, soils and nearby orchards verify the suitability of these microregions.

At the same time existing plantation areas need to be stabilised. For example, general economic conditions in the Central and Western Jebel require improvement to halt migration to coastal towns. Such a loss of population seriously effects the production of such labour intensive crops as the olive. The new cooperative oil mills at Garian, Jefren and Nalut are a step in the right direction.

The olive is adaptable to a variety of soils and climatic conditions. It thrives best on limestone soil, hill slope sites where true Mediterranean climatic conditions prevail.

Even though there are several transitional Mediterranean climatic types and rainfall is very variable it doesn't seem that average yields and natural oil quality are seriously impaired. Both in quality and average yield per tree the oil of this region compares favourably with Northern Mediterranean producers. Moreover the region benefits from a prolonged cycle of production. Although the tree does best at heights of 3-500 m's it has no altitudinal limits.

At the present time only 66% of all trees are productive, yet nearly 80% of the Libyan trees are in an advanced state of maturity. Thus production will continue to increase but at a diminishing rate.

The limiting factor of summer aridity is accentuated on the coast by the absence of a pronounced summer rest. However on the Jebel low temperatures induce a repose in growth. Only occasionally do frosts injure the trees (10% trees in Jebel each year).

Diseases from insect attacks are a serious problem in the humid coastal areas and especially where irrigation is practised. About 20% of the olives at the coast under irrigation are injured by dacus oleae.

The close correlation between rainfall and the olive crop has already been stressed. Three centres of production stand out where rainfall is high and least variable - Zavia - Tripoli - Suani Ben Adem, Msellata, Garian. Great fluctuations in production result from the fact that over 70% of the olives are dry farmed. Prolonged drought and variable moisture supply can only be alleviated by choosing soils with high storage capacities and infiltration rates or by partial irrigation.

The irregularity of production from dry farmed olives is aggravated by the unsuitability of several Italian olive varieties. Many farmers have either grafted or irrigated the Frantoio in the Jefara with the result that production has been greatly stabilised. Both local and Italian varieties appear well adapted to dry farming in the Jebel but those on the coast should be grafted with the successful Tunisian variety, Chemlali.

Thermal conditions allow a wide range of crops but because rainfalls when it is least needed there is an accent on winter crops. Four types of crop husbandry can be recognised:

(1) Rain watered crops + supplementary irrigation - broad beans, lucerne.
(2) Sown planted at the beginning of the rains - barley.
(3) Crops dependent on soil moisture - olive, almond.
(4) Irrigated crops - groundnuts, tomatoes.

More briefly there are dryland, semi-irrigated and irrigated crops. It is becoming increasingly evident that increased oil production, or even stabilisation, can only be achieved by semi-irrigation of an essentially dryland crop. But since water costs are high and potential water supplies limited the integration of dryland and irrigated agriculture where rainfall is marginal should be the guiding factor in new land settlement schemes. These farms ought to be at least 50 ha's. The large dry farms relying on a single crop are suffering too many economic handicaps and therefore a policy of water development and crop diversification ought to be pursued. In the best rainfall zones, where tree crops can safely be intercultivated, then rationally applied dry farming techniques would be suitable. From all accounts the olive seems to be losing its place on irrigated farms in the coast. Groundnuts and high income citrus fruits are replacing it. Eventually this trend will need to be compensated by increased planting on the dry land outside the oases boundaries. Since these areas experience lower rainfall irrigation developments would be necessary.

3. Agriculture remains the basis of the economy. Therefore it will continue to be subsidised and supported.

The periods of expansion of olive cultivation and sedentary farming have invariably coincided with phases of economic prosperity and political stability. Political emancipation in this century has not brought economic viability even though future oil developments may reduce budget deficits. Rapid extension of land settlement and plantings cannot be envisaged in the immediate future because of the following observations:

(1) Money from oil and increased employment is being invested in luxury goods rather than the land.

(2) Although Italian farms are being intensified and improved extension developments are very unlikely.

(3) Even resettlement schemes are suffering from an uneducated rural population.

(4) Only 40,000 ha's out of 10 million are at the Government's disposal to extend sedentary farming.

Private farms are being laid out in the Eastern Jefara but this extension is balanced by an alarming decline of sedentary agriculture in the Central and Western Jebel.

4. Land settlement schemes should not be planned outside the experience of the Libyan farmer. In the Jebel there should be a great emphasis on cooperative action, although certain adjustments are certainly required. The irrigated saniya per se is too small and fragmented to constitute an economic holding unless water yields can be easily increased. Dry gardens with mixed crops, whether outside the coastal oases or in the wadis and plains of the Jebel, are a most efficient form of cultivation. They are especially valuable in the systematisation of wadis.

The Demographic farm based on irrigated and dryland farming (the proportion varying with rainfall and water supplies) appears to be well adapted to environmental conditions but the large dryland concession, with its dependence on hired labour and single crops, is highly susceptible to weather vaguaries.

Italian farm incomes are considerably higher than those of Libyan farms. For identically managed farms irrigated olives yield an income more than double dry farmed olives. The costs of cultivation are naturally highest on the large estates where olives are irrigated. Whereas the costs of harvest and irrigation vary with the year costs of cultivation and pruning remain fairly constant. This situation has special implications for the small farmer whose liquid assets may be negligible.

The small diversified farm of about 50 ha's would appear to be more adapted to the rigours of climate and the market than the specialised dry farmed holding of over 200 ha's. Libyan peasant agriculture is evolving towards small commercial economies as the traditional social and economic systems break up in the face of new opportunities and stresses.

5. The improvements in existing systems of olive cultivation are bound up with several related problems, the better use of land and water, raising of living standards and a better distribution of population. Appreciable long term increases in oil production can only be obtained by the maturing of new plantations. Technical improvements in olive cultivation (pruning of trees, regular spacing of trees, handpicking harvests, adopting better varieties, use of irrigation water) and improvements in the social and economic organisation of

agriculture will effect oil production more gradually.

Even though the Italians are technically superior to the Libyans the quality and quantity of oil produced could be improved. Italian varieties in the coastal belt need grafting and the practise of associating olives with other tree and field crops should be discontinued when the olive is fully producing. Some progress is being made. Intensification of tree crops is taking place on all Italian demographic farms, and electric pumps and the sprinkler distribution system have allowed the semi-irrigation of the olive in the Jefara.

The efficiency of Libyan tree culture varies regionally. At the coast where more highly valued irrigated crops are cultivated, the olive tends to be neglected. In contrast high standards of olive husbandry are found in the Eastern Jebel. Several factors contribute to the generally low standards of cultivation; (a) there is no price incentive to improve standards; (b) low level education; (c) low rate of capital accumulation; (d) subsistence crop production; (e) fragmentation and dispersal of land.

It is not that the Libyans are loathe to change, for where they have had close contact with Europeans and Italians they readily accept new ideas and techniques. Yet only through government intervention and cooperative action can improvements take place, where Italian influence has been intermittent and on small, uneconomic farms.

Education in rural sciences, field extension posts, credit facilities, the demonstration of soil and water conservation schemes and the piloting of cooperative (tribal) associations can speed up this process of transforming a peasant community into a commercial society.

6. The olive oil industry is represented by a great variety of oil mills capable of processing an average annual olive crop. Although the productive capacity of these mills has kept pace with increased harvests (mainly due to the establishment of medium and large capacity mills by the Italians) there are several notable deficiencies within the industrial structure. These are as follows :

(a) Many Libyan plantations outside the best areas of the coast and Eastern Jebel, and the zones of Italian settlement, are served only by small capacity, antiquated presses which are resorted to mainly in highly productive years. The answer to this maldistribution of mills lies of course in the erection of small, mobile mechanical mills which can be run on a cooperative basis. Three of these mills have recently been erected in the Western Jebel villages.

(b) In productive efficiency, capacity and oil quality the European mills of the Italians are far superior to widely distributed Libyan mills. The present tendency to mix oil from these different mills inevitably lowers the final quality of the oil.

(c) Although four olive refineries have been erected in

Tripoli the country still serves as an industrial annex of Italy where the lowest priced market of transformation exists. This legacy of Italian rule is likely to persist for some time since agreements have been reached on an increased quota.

(d) Production of oil is sufficient in normal years for the domestic market but because of the low storage capacity of the mills (in particular Libyan) a regular export of surplus oil cannot be maintained through the carryover of stocks from one year to the next.

(e) The low quality of Tripolitanian oil is related mainly to methods and time of harvesting and processing, allied to better storage and washing of olives would greatly reduce the acidity of Libyan oil.

The export market for olive oil appears less certain and predictable than the domestic market which can be expected to expand. Unfortunately Tripolitania's efforts to develop her export trade in olive products comes at a time when the volume of world trade is declining, when there is a tendency for substitution of olive oil by cheaper soft oils, and when Tunisia is well established as an exporter of oil from North Africa.

On the other hand there are certain favourable factors. Production of olive products is increasing; the Italians have guaranteed a larger import quota and new trade agreements have been declared in the Mediterranean and Europe. Since 1952 measures have been introduced to help farmers, mill owners and exporters to improve and expand all facets of the olive oil industry in Northern Tripolitania.

It seems likely that, given a stable and enlightened administration, the olive can certainly contribute towards an increased wealth and prosperity of the Libyan people. However in the face of all the difficulties, physical, social and economic, the introduction of new methods of husbandry, together with the extension of sedentary agriculture and the development of an export mentality towards crop production, must inevitably be slow.

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APPENDIX

able 9

AVERAGE CLIMATIC CONDITIONS FOR SELECTED STATIONS

TATION	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
RIPOLI													
ean temp.	12.0	13.3	15.2	18.2	20.6	23.9	25.6	26.3	25.6	22.7	18.1	13.6	14.8
" max.	16.5	17.9	20.1	23.2	25.5	28.6	30.2	30.9	30.3	27.6	23.0	18.3	24.3
" min.	7.6	8.6	10.4	13.1	15.7	19.1	21.1	21.7	20.9	17.8	13.2	8.9	14.8
RH	62	61	60	59	62	63	65	65	63	60	61	62	62
ainfall	76.9	42.9	24.6	9.3	5.3	1.3	0.5	0.8	10.2	35.5	65.9	93.8	348.0
ZIZIA													
ean temp.	11.3	13.0	15.7	19.6	23.1	27.0	28.7	28.8	27.5	23.6	17.7	13.0	20.8
" max.	17.4	19.6	23.0	27.6	31.1	35.6	37.4	37.5	35.8	31.2	24.3	19.3	28.3
" min.	5.1	6.3	8.4	11.5	15.1	18.5	20.0	20.0	19.2	16.1	11.2	6.7	13.2
RH	62	58	54	46	42	37	41	45	49	50	57	60	50
ainfall	47.5	33.2	21.1	9.6	4.6	1.2	0.1	0.1	6.6	16.0	27.1	50.5	217.6
ARIAN													
ean temp.	8.3	10.0	12.7	17.0	20.7	24.7	26.5	26.8	24.1	20.4	15.3	9.9	18.0
" max.	11.8	13.9	17.7	22.7	26.8	31.0	32.6	32.8	29.9	25.4	19.2	13.6	23.1
" min.	4.8	6.1	7.8	11.3	14.6	18.4	20.4	20.7	18.3	15.4	11.3	6.1	12.9
RH	57	54	48	40	36	28	30	31	39	43	53	58	43
ainfall	74.1	51.5	39.9	16.0	12.7	2.1	0.5	0.7	11.4	23.8	39.5	54.0	326.2
USSABAT													
ean temp.	11.0	12.0	14.9	17.7	21.0	24.7	26.3	26.7	25.4	22.1	17.5	12.7	19.3
" max.	15.5	16.9	20.7	24.2	27.5	31.9	33.4	33.7	32.0	28.3	22.3	17.1	28.3
" min.	6.5	7.2	9.1	11.2	14.1	17.0	19.2	19.7	18.9	15.9	12.7	8.3	13.4
RH	70	68	59	49	46	42	41	49	53	54	60	63	55
ainfall	80.6	56.2	37.7	14.7	5.0	1.3	0.0	1.7	9.2	28.8	38.1	55.6	328.9

ENI ULID

ean temp.	11.5	13.0	15.7	19.7	23.1	27.6	29.4	29.0	26.8	22.8	17.6	12.8	20.7
" max.	17.2	19.0	22.5	27.4	31.5	36.1	37.7	36.9	34.0	29.0	23.7	18.6	27.8
" min.	5.8	7.0	8.9	11.9	14.7	19.0	21.0	21.0	19.7	16.6	11.5	6.9	13.7
RH	64	61	57	48	43	35	30	40	48	54	60	65	51
ainfall	11.1	7.9	10.2	3.0	5.0	0.5	1.0	0.0	6.1	7.9	6.3	6.6	65.6

APPENDIX

e 22a

SCHEDULE OF WATER COST ON THREE ITALIAN SETTLEMENTS

Supplied by U. MARRONI. OFFICIAL RECORDS E.N.T.E. Tripoli.

lement	No. of farms.	Average size hectares	Average total cost farm	First capital cost of water installations per farm	Maintenance and mining cost	Water supplied per day in cub. metres	Irrigated area hectare
				(1)	(2)	(3)	
iglieri	168	50	2,200	166	6	5	Small garden
etti	49	30	2,811	667	67	200	3
pi	370	10	2,000	444	33	200	10 (3 ha. each year)

s:

Water installations comprise the following:
(a) Breviglieri - water supplied by a central aqueduct delivering about 500 litres per farm daily.
(b) Olivetti - a borehole, tank for water storage, electric pump and 3 hectares developed for irrigation on each farm.
(c) Crispi - artesian wells - each serving 20-30 farms, system of pipes and canals over entire 10 ha's of each farm. Initial installation cost excludes cost of wells which were borne by government.

The running and maintenance costs are calculated on the basis of proportioned interest on capital invested and a proportional share of maintenance, running and amortization costs.

At Breviglieri a daily allowance of 500 litres per farm for small garden and domestic requirements.

At Olivetti 200 m3 daily are enough to irrigate 3 ha's of intensive crops in spring and early summer.

At Crispi 200 m3 sufficient to irrigate 3 ha's of intensive summer and spring crops, but because of saline water irrigated area has to be alternated from year to year on each farm.

Table 22b. **Water Costs**

Cost of water per hectare - calculated on basis of whole farm.	Breviglieri	Olivetti	Crispi
	£	£	£
Capital cost of water per hectare	3.3	22.2	44.4*
Capital outlay for supply of 1 cub. metre of water per annum	.9	.009	.006*
Maintenance and running costs per hectare per annum	.12	2.2	3.3
Amount of water per hectare per annum	3.7	2,433	7,300
Running costs per cub. metre	8	.21	.11
Total cost per hectare of settlement farm	44	94	200*

* excluding cost of artesian wells.

APPENDIX

1953. Census of TREE CROPS

	OLIVE			PALM			CITRUS						
ince	Productive number	Unproductive number	Total	Productive number	Unproductive number	Total	Orange	Tangerine	Lemon	Apples	Total number	Vine	Almonds
oli & West	591,890	886,287	1,478177	654,467	101,643	756,110	319,000	53,100	64,000	4,500	440,600	4,281,150	1,078,706
ern	437,436	451,935	889371	555,582	139,384	694,966	2,000	500	800		3,300	6,285,519	407,308
ral	170,859	69,186	240045	63,745	43,262	107,005	-	-	-			10,223	7,990
l	1,200,185	1,407408	2,607593	1,273,794	284,289	1,558,081	321,000	53,600	64,800	4,500	443,900	10,576,892	1,494,004

APPENDIX

AGRICULTURAL PRODUCTION IN TRIPOLITANIA (M. TONS) 1935-1949.

Statistics from Agricultural Dept., 20/3/1950.

	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
t	8,700	1,200	6,500	13,500	5,000	3,000	6,000	4,000	6,000	7,000	8,000	6,046	1,046	2,400	8,000
ey+	41,000	3,000	32,000	42,017	16,000	11,000	9,760	13,560	28,600	74,000	79,000	75,000	1,800	21,000	135,000
*	? 102	-	102	642	300	400	400	500	300	240	390	250	200	-	500
e*	28	105	-	-	200	300	400	500	400	550	480	560	640	700	800
*	-	-	3,845	-	7,000	8,500	10,000	9,000	4,000	5,000	7,000	6,500	5,000	6,000	10,000
n															
toes*	500	600	800	500	1,000	1,000	3,000	4,000	2,000	5,000	8,000	9,000	10,000	9,000	10,000
toes*	657	-	1,462	-	2,000	2,500	3,000	2,500	1,800	3,000	1,000	3,500	3,500	4,000	4,000
e															
es*	-	-	5,073	1,000	1,500	1,500	2,000	2,000	1,000	1,200	1,500	1,000	2,000	1,500	5,000
Grapes+	2,500	-	-	9,000	9,000	7,500	10,500	7,500	1,500	4,500	5,000	5,000	5,000	5,000	-
+	-	-	3,000	6,500	6,000	5,000	7,000	5,000	1,000	3,000	3,500	3,880	3,790	2,000	3,000
es+	-	-	250	19,700	5,000	9,000	12,000	25,000	10,000	20,000	13,000	5,500	6,500	10,000	50,000
e oil	900	2,300	37	2,700	720	1,480	1,700	3,040	1,080	2,670	1,800	616	936	1,500	8,000
ns *	-	-	669	-	500	600	600	650	500	600	700	710	750	500	-
ges*	-	-	1,370	-	800	1,100	1,500	2,000	1,250	1,600	1,400	2,800	3,150	1,300	5,500
erines*	-	-	246	-	200	300	400	350	250	300	400	500	600	800	-
nds +	-	-	159	600	500	800	1,000	500	245	534	600	534	615	400	1,500
ous fruit*	-	-	822	-	1,000	8,700	900	1,100	500	900	1,000	1,100	11,000	900	2,000
cco															
poly*	636	788	908	714	1,200	899	542	136	66	223	952	1,408	441	272	-
cco (ATI)*	94	12	215	229	244	18	80	33	56	56	60	34	-	-	-
a+	-	250	180	70	190	150	200	200	50	40	25	30	20	25	100
	-	-	-	15,823	1,100	10,000	12,000	14,000	2,000	5,000	7,000	8,000	600	500	15,000
s*	25,000	27,000	37,000	36,000	22,000	40,000	41,000	42,000	12,000	22,000	29,000	15,000	15,000	35,000	30,000
ndnuts*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,200
rto	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Irrigated
\+ Dry farmed

APPENDIX

AGRICULTURAL PRODUCTION 1950-1953.
(Metric tons)

Wheat	Barley	Oil	Almonds	Wine	Dates	Tobacco	Orange	Cereals	Tangerine	Lemon	Prachi
8,000	85,000	7,000	1,500	3,100	20,000	862	3,500	1,200	700	600	1,920
6,200	53,700	5,000	2,000	3,520	675	1,920	4,100	1,200	1,030	700	1,200
7,323	74,650	1,000	2,500	1,400	30,200	499	1,600	700	110	320	4,620
1,317	11,572	6,000	2,500	3,000	35,000	7,100	3,000	500	500	300	5,000

APPENDIX

TABLE A27.

Distribution of Olive Trees by Province (1954-55)

Western Province.

Indigenous Trees Productive 1957.			Italian Demographic Prod.	Non.Prod.	Total	Italian Concessions Total(1937)
El Assa	1,333	Olivetti	21,102	7,471	28,523(INPS)	181,159
Regdaline	6,821	"			30,316(ENTE)	60,211
Zuara	9,940	Bianchi	4,666	27,603	32,269	89,965
El Agelat	956	Hascian	2,206	3,220	5,426	14,881
Sabratha	13,020	Giordani	1,648	21,172	22,820	
Zavia	47,970	Micca	1,346	16,899	28,245	
Maamura	1,227					
Zanzur	25,349					
	114,216		30,968	76,365	147,599	346,216

Total 625,815.

Tripoli Province

Indigenous Trees		Italian Demographic	Italian Concessions Azizia	
Total (1931)		15,691 - Fonduk Togar	100,000	Azizia
Tagiura	1,361		135,323	Mellaha
Tripoli	53,669		126,728	Sidi Mesri-Cueroc
Gurgi	2,246		116,466	Tagiura
Gargaresch	406		34,463	Gurgi-Gargaresch
	57,782		157,698	B. Geran.El Maia
			152,841	Suani Ben Adam
			129,941	C.Benito, S. el Sebt.
		15,691	853,460	

Total 926,933.

Northern Province

Indigenous Trees			Italian Demographic		Italian Concessions	
		Prod.				
Zaviet Maghuib		2,698	Crispi	59,400	89,349	Garabulli
	Prod.	Total				
Zarrugh	6,258	7,433	Garabaldi	67,000	35,000	Volpi
Zliten Wast	15,320	24,052	Gioda	25,000	45,000	Valdagne
Zliten Guma	19,285	24,000	C. Verde	710	70,911 ?	Tarhuna
Zliten Fuatic	22,234	29,680	Corradini		240,360	
Tarhuna	19,699		Tazzoli	18,272	(9,169 prod.)	
			Marconi	17,983	(143 prod.)	
				240,240		

G. Chiar	66,299
Sciogran	44,000
Cussabot	114,000
Msellata	156,644
Elamamra	7,500
Homs	14,612
Beni Ulid	12,000
	519,919

Total 1,000,519 (55% prod.)

Central Province

Indigenous trees				Italian Demographic		Italian Concessions	
Azizia 1,022							
	Prod.	Total		Prod.	Total	Prod.	Total.
Garian	51,318	87,993					
Beni Daud	6,854	12,054		8,294	28,257		2,900
Beni Nser	7,234	11,484		8,294	28,257		2,900
B.Khalifa	10,718	16,514					
Al G	9,031	17,531					
Assaba	2,729	12,029	69,612				
Chicha	14,703	18,553	88,165				
Orban	37	787					
Mizda	12	37					
Haraba		15,552					
Giado		40,291					
Rodjeban		16,963					
Zintan		15,727					
Rianina		28,161					
Jefren		37,014					
Cabao		10,587					
Haraba		8,891					
Nalut		6,919					
		248,103					
Total		280,482					

Table 57.

Fluctuations in the production of olive oil for selected Mediterranean countries in metric tons. 1930/31 0 1952/53.

Country	30/31	31/32	32/33	33/34	34/35	35/36	36/37	37/38	38/39	39/40	40/41	41/42
SPAIN	115	351	349	310	313	440	390	380	320	209	285	383
ITALY	138	244	223	170	223	238	154	272	178	320	154	203
TUNISIA	22	35	60	66	60	66				82	17	27
TRIPOLITANIA	0.5	2.5	.8	1.5	2.8	.9	2.3	-	2.7	.8	1.6	1.8

Country	42/43	43/44	44/45	45/46	46/47	47/48	48/49	49/50	50/51	51/52	52/53
SPAIN	237	414	275	189	388	543	149	388	172	605	305
ITALY	181	131	153	97	131	257	105	189	180	372	199
TUNISIA	38	46	65	9	15	11	33	118	46	47	39
TRIPOLITANIA	3.4	1.2	3.3	1.8	.6	.9	1.5	8.0	6.5	5.0	1.0

Table 65b

Quantities sold and average prices of oil at Tripoli and Cussabat in 1957.

	J	F	M	A	M	J	J	A	S	O	N	D
Tripoli												
Q	10000	13000	13000	11000	13500	17000	28000	38000	38000	27000	27000	36000
P	230	232	236	260	202	192	222	208	193	170	166	156
Cussabat												
Q	49000	35000	12900	9000	11300	24000	55000	10000	18000	17400	130400	298400
P	210	215	225	217	205	180	197	193	195	170	155	150

Q = quantity - litres. P = Price in millemes.

Table 66

Quantities of Olive Oil sold in Municipal Markets, in litres, 1957

	D	J	F	M	A	M	J	J	A	S	O	N
Tripoli	36000	10000	13000	13000	15000	13500	17000	28000	38000	38000	27000	27000
Suk el Guna	5000	650	750	650	800	850	750	900	1400	1100	1100	2500
Tagiura	1000	400	500	600	708	500	400	500	400	600	700	1000
Azizia	420	400	600	250	400	350	200	300	300	300	220	700
Zavia	6000	700	350	500	350	800	350	400	500	2700	4000	7200
Sorman	400	500	400	500	130	300	400	-	200	250	350	700
Sabratha	1800	1200	1500	1500	1450	1150	1400	950	950	1300	1500	1200
Zanzur	670	450	390	750	650	450	370	320	300	350	300	400
Zuara	16000	6000	2700	4500	4900	10000	900	6500	6000	9000	8000	1200
Garian	10500	2600	2700	2700	3500	3100	2900	2200	5000	4900	4500	4500
Jefren	1500	1960	3800	2320	3600	3960	2600	4100	6500	1680	4000	2800
Nalut	280	-	450	100	90	100	250	100	80	50	180	290
Misurata	18559	18474	5866	5697	6470	5385	6980	9385	9242	5707	10100	14533
Homs	20000	13000	5000	4000	2400	3800	10300	4700	4000	4000	4200	18000
Cussabat	298400	49000	35000	12900	9000	11300	24000	55000	19000	18000	17400	130400
Zliten	5000	5500	3500	3000	11000	1700	500	900	5000	700	700	1000
Tarhuna	5000	170	230	180	240	250	330	250	320	450	220	2500
Sirte	800	1000	300									240
Total	427329	112004	77036	53147	60688	58445	69630	114505	97192	89087	84470	216163

Statistics showing regional differences in time of harvest, quality of oil, importance of oil.

APPENDIX

Table 67. OLIVE OIL: EXPORTS AND IMPORTS BY COUNTRY, ANNUAL AVERAGE 1924-281 1929-33, 1934-38 and 1950-53.

Country	1924-28		1929-33		1934-38		1950-53	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
	Thousand mec. tons		Thousand mec. tons		Thousand mec. tons		Thousand mec. tons	
EXPORTS								
Spain and its territories	73.8	42	71.6	31	51.9	29	37.0	31
Italy	39.9	23	58.9	26	21.4	12	11.2	9
Greece	10.1	6	15.6	7	10.9	6	3.7	3
French North Africa	(31.2)	(18)	(55.5)	(23)	(57.7)	(32)	(46.7)	(39)
Algeria	12.9	8	14.5	6	15.5	9	12.0	10
Morocco	1.8	1	0.6		3.5	2	2.0	2
Tunisia	16.5	9	38.4	17	38.7	21	32.7	27
Portugal	2.5	1	2.8	1	4.4	2	8.5	7
Turkey	2.8	2	11.0	5	4.6	3	1.1	1
Syria	1.5	1	2.4	1	6.5	4	0.2	-
Lebanon							0.5	-
France	6.6	4	10.1	4	14.8	8	7.0	6
Libya	0.2		-		-		2.2	2
Yugoslavia			0.1		0.5		-	
Other countries	6.0	3	4.0	2	7.0	4	3.0	2
World total	175	100	230	100	180	100	120	100
IMPORTS								
Spain and its territories			3.5	1	8.2	4	15.0	12
Italy	10.1	5	52.5	20	26.5	14	18.0	14
Greece	-	-	-	-	-	-	-	-
French North Africa	(1.0)	-	(1.4)	(1)	(1.5)	(1)	(4.8	(4)
Algeria	-	-	0.2	-	0.7	-	2.8	2
Morocco	-	-	1.1	-	0.8	-	1.6	1
Tunisia	1.0	-	0.1	-	0.1	-	0.4	-
Portugal	2.9	2	4.4	2	3.6	2	1.1	1
Turkey	-	-	-	-	-	-	-	-
Syria	-	-	-	-	-	-	1.1	1
Lebanon	-	-	-	-	-	-	0.2	-

United States	57.5	30	62.8	24	44.5	24	25.7	20
Brazil	5.6	3	5.1	2	4.5	2	7.2	6
Cuba	7.5	4	6.8	3	6.0	3	3.9	3
Argentina	38.9	21	45.2	17	18.1	10	-	-
Germany	1.1	-	2.1	1	4.0	2	1.4	1
Norway	3.2	2	3.2	1	2.9	2	1.3	1
Switzerland	4.5	3	6.3	2	6.3	3	1.5	1
United Kingdom	8.7	5	10.4	4	-	5	2.8	2
Canada	1.7	1	2.4	1	2.0	1	0.7	1
Mexico	1.0	-	1.3	-	1.3	-	0.8	1
Chili	6.6	3	2.0	1	1.1	-	-	-
Uruguay	5.8	3	6.5	-	3.4	2	0.5	-
Israel	1.0		1.2		1.0		-	-
Egypt	1.2	2	1.8	2	2.9	3	1.9	1
Australia	0.6		1.0		1.4		1.0	1
Other countries	12.0	6	12.0	5	9.0	5	8.0	6
World total	190	100	260	100	190	100	130	100

1. Partly estimated.
2. Western Germany only.

Table 68.

PRICES OF OLIVE, GROUNDNUT AND SOYBEAN OILS, SPECIFIED MARKETS 1950-1955.

	Olive Oil			Groundnut oil	Soybean oil
	North African 1/ drums f.o.b.	Spanish drums f.o.b.	Imported edible, drums, N.Y.	Indian c.i.f. Europe	U.S. crude f.o.b.
	U.S. dollars per metric ton				
1950					
January-March	473	700	750	395	292
April-June	485	538	639	400	296
July-September	687	1 537	813	433	331
October-December	778	2 700	889	442	388
1951					
January-March	986	938	1,012	572	479
April-June	927	1,037	922	596	467
July-September	835	1,036	780	507	368
October-December	691		664	497	331
1952					
January-March	690	610	661	419	276
April-June	634	620	614	352	251
July-September	716	620	660	359	283
October-December	741	620	689	354	286
1953					
January-March	755	615	742	379	312
April-June	850	653	797	394	314
July-September	833	700	772	391	266
October-December	681	634	732	403	323
1954					
January-March	593	601	679	432	337
April-June	602	601	646	406	344
July-September	597	601	643	343	339
October-December	623	601	684	309	294
1955					
January-March	586	601	690	279	297
April-June	644	601	682	274	285

1. Average for July.
2. Average for Nov.-Dec.
3. Including the import duty $6\frac{1}{2}$ cents per lb.
4. Average April-May.
5. South African drums, c and f.
6. From March 1955: Tunisian, 1 percent, drums, f.o.b.

Table 69. APPENDIX

Direction of International Olive Oil trade by volume: Average 1950-1953.
(Thousand metric tons)

Country	Spain	Italy	Portugal	Greece	Tunisia	Algeria	Morocco	France	Total
Italy	0.01	-	1.26	1.95	5.16	0.99	0.54	1.19	11.10
France	0.54	0.07	0.01	-	17.15	0.65+	1.02	-	25.44
Algeria	-	-	-	-	1.25	-	0.05	0.15+	1.43
French Morocco	-	-	-	-	1.19	0.34	-	-	1.53
Tunisia	-	-	-	-	-	0.34	-	-	0.34
Portugal	0.25	0.02	-	-	0.53	0.04	-	0.02	0.86
Yugoslavia	-	0.02	-	0.16	0.01	-	-	0.04	0.23
Egypt	0.01	0.10	-	0.33	0.08	0.51	0.01	0.06	1.10
Lebanon	-	-	-	-	-	0.01	0.01	-	0.02
Syria	-	0.02	0.02	-	-	-	-	-	0.04
Spanish Territories	14.00	-	-	-	-	-	-	-	14.00
Tangier	0.72	-	-	-	-	0.01	-	-	0.73
Other	-	0.04	0.01	-	-	0.02	-	-	0.07
Total Mediterranean area and Spanish Africa.	15.53	0.27	1.30	2.44	25.37	8.91	1.61	1.46	56.89
U.S.A.	12.76	5.84	1.83	0.43	2.50	1.28	0.03	1.18	25.85
Canada	0.12	0.29	-	-	0.04	0.01	-	0.01	0.47
Cuba	2.80	0.02	0.02	-	0.01	0.63	-	0.13	3.61
Mexico	0.46	0.43	0.06	-	-	-	-	-	0.95
Venezuela	0.27	0.26	0.04	-	-	-	-	-	0.57
Columbia	0.04	0.05	-	-	-	-	-	-	0.09
Ecuador	0.01	0.07	-	-	-	-	-	-	0.08
Other	0.58	0.07	-	-	-	-	0.01	0.01	0.67
Total dollar area	17.04	7.03	1.95	0.43	2.55	1.92	0.04	1.33	32.29

United Kingdom	0.65	0.11	0.50	0.02	0.14	0.22	0.03	0.07	1.74
Germany (Western)	0.04	0.26	0.52	0.04	1.02	0.20	-	0.15	2.23
Switzerland	0.98	0.62	0.08	-	0.01	-	0.01	0.03	1.73
Austria	0.02	0.30	0.01	0.14	-	-	-	0.02	0.49
Belgium-Luxembourg	0.04	0.04	-	-	0.11	0.01	-	0.04	0.24
Other	0.83	0.04	0.15	0.14	0.52	0.17	0.01	0.03	1.79
Total non-producing European countries	2.56	1.37	1.26	0.24	1.80	0.60	0.05	0.34	8.22
Brazil	1.26	1.26	1.68	0.07	0.73	0.15	0.04	1.98	7.17
Other Latin America	0.17	0.22	0.03	-	-	0.01	-	0.09	0.52
Portuguese Territories	-	-	2.19	-	-	-	-	-	2.19
French Territories (Excl. N. Africa)	-	-	-	-	-	0.28	-	0.44	0.72
Australia	0.21	0.35	-	-	0.03	0.04	-	0.46	1.09
China	-	0.16	-	-	-	-	-	-	0.16
Other and unknown destinations	0.21	0.54	0.05	0.48	2.24	0.10	0.21	0.94	4.77
Total all other	1.85	2.53	3.95	0.55	3.00	0.58	0.25	3.91	16.62
TOTAL	37.00	11.20	8.46	3.66	32.72	12.01	1.95	7.03	114.0

Source: Official trade returns. Trade of exporting countries listed represented approximately 95 percent of gross world exports 1950-1953.