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THE AGRICULTURAL DEVELOPMENT OF THE MIDDLE EAST

BY

B. A. KEEN, D.Sc., F.R.S.

A Report to the Director General
Middle East Supply Centre
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No. 2. Middle East Science, by DR. E. B. WORTHINGTON. *Price,* 7*s.* 6*d.* net.

No. 3. Rural Education and Welfare in the Middle East, by DR. H. B. ALLEN. *Price,* 1*s.* 6*d.* net.

No. 4. Animal Industry in the Middle East, by DR. N. C. WRIGHT. *In preparation.*

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FOREWORD

By DR. K. A. H. MURRAY, *formerly Director of Food in the Middle East Supply Centre.*

THE purpose of the Middle East Supply Centre, established by the British Government in 1941, and made into a joint Anglo-American agency in 1942, was to ensure that the civil population in the Middle East countries was provided with those supplies which were essential for their livelihood in war-time. At the same time it was necessary, in view of limitations of shipping, port capacity, and internal transportation, to see that imports were kept as low as possible. Imports into the principal Middle East countries were reduced from over 6 million tons a year in pre-War years to about 1½ million tons a year by 1944, thus providing transport and quay space for the vast supplies of war materials for the desert campaign in North Africa and for aid to Russia through the Persian Gulf.

One of the greatest potential savings in tonnage lay in increased food production in the Middle Eastern countries themselves, and a Food and Agriculture Division of the Centre, staffed by British and American experts, was set up to advise on means and ways to achieve this. Many short-term measures, such as changes in cropping and the importation and controlled distribution of fertilizers and agricultural machinery, were adopted by the various Governments and Administrations, but the need for additional expert study was soon evident if the more fundamental scientific problems were to be tackled. In 1943 the British and American Governments agreed to the appointment of a Scientific Advisory Mission to the Centre.

The first members of the Mission were Dr. B. A. Keen, F.R.S., Assistant Director of Rothamsted Agricultural Experimental Station, and Dr. E. B. Worthington, Director of the Freshwater Biological Association, the former being asked to examine some of the factors limiting agricultural production in the Middle East, and the latter a number of other scientific problems, particularly those bearing on land, water, climatic, and human resources. At a later date, Dr. Allen, of the Near East Foundation, was appointed to the Mission to advise on rural education. Finally, Dr. N. C. Wright, Director of the Hannah Dairy Research Institute, was requested to survey some of the major problems of live-stock production.

From the short-term point of view the work of the Mission had a direct bearing on the immediate war-time problems of supply and production facing the Centre, and part of the time of its members was necessarily devoted to advising the Centre, and sometimes the Administrations of the Middle East countries, on current problems. Nevertheless, much of the ground covered by their survey involved fundamental questions of longer-term importance. Indeed, one of the main underlying objects in securing the appointment of the Mission was the desire—strongly felt in a number of quarters—to obtain a comprehensive and objective appreciation of some of the main scientific and technical problems facing the Middle East region. Although of course a considerable amount of work had been done in the past in various parts of this field, no such regional survey had previously been made or even attempted. The Mission was composed of men each distinguished in their own branches of science, yet without previous specialized knowledge of the area concerned. It was felt that an appreciation of this kind could not but be of lasting value.

The material which the members of the Mission gathered and the views which they have formed are contained in their reports presented to the Director-General of the Centre. The end of the war, and of the Centre itself, came before the final reports were ready for publication. But the value of such surveys clearly does not end with the war; the question of food supplies and nutrition, for example, is in the forefront of post-war world problems, and in the Middle East as elsewhere there are many difficulties to be overcome if standards of living are to be improved or even maintained at their present levels. In response to many requests from both within and without the Middle East it has therefore been decided to make the Reports of the Scientific Advisory Mission available to the public.

While these Reports are published with the agreement of His Majesty's Government and of the Government of the United States, as the Governments formerly responsible for the Middle East Supply Centre, they represent the individual observations and opinions of the authors and do not necessarily reflect the attitude of the two Governments; nor do the Governments accept responsibility for them. Nevertheless the Reports are published in the hope and expectation that they may stimulate further scientific research and discussion, and may prove of value not only to all who are concerned for the well-being and future development of the Middle East, but also to those in other parts of the world where similar problems have to be met.

Both Governments, however, desire to express their gratitude to the members of the Mission for their invaluable work, to the British and American Institutions which made their services available for this task, and to many individuals and Governmental bodies in the Middle East without whose interest and co-operation these surveys could not have been carried to a successful conclusion.

Dr. Keen's wide experience and knowledge of agriculture and agricultural research, not only in Britain but in other parts of the world where conditions were more similar to those in the Middle East, were a great practical benefit to the Centre in its work, and were welcomed by many persons whose normal contacts with institutions in other parts of the world had been broken by the War. His reputation will also ensure that the views which he puts forward in this Report are given due consideration, as they concern some of the most vital questions. The Middle East is predominantly an agricultural region, and will be so for a long time to come; with exceptions, it is not an inherently fertile area and, again, cannot be made so in a short time. Yet it is an area where the population is increasing rapidly and consequently there is a grave danger in a fall of standards of living unless early action is taken to remedy the factors which prevent an increase in food production. Dr. Keen has selected some of the considerations which he deems to be the most important and outlined them, country by country. His observations on the technical problems of soil erosion, plant nutrition, tillage, live-stock production, and the like, will be helpful not only to the Middle East but also in other agricultural regions. Even more valuable is the emphasis which he places on the need for examination of the factors underlying the organization of farming as it is practised to-day, particularly the problems of the systems of land tenure, with their economic, legal, religious, and other aspects. The obstacles to agricultural progress recall in many ways those which characterized the feudal system prevailing in Britain some 500 years ago, such as the uneconomic subdivision of farms into units too small to provide an adequate living, the distribution of each holding into widely separated strips and fragments, insecurity of tenure, and the extreme difficulties of live-stock improvement with common grazing.

These handicaps are not unrecognized in the Middle East, and Dr. Keen describes some of the most interesting experiments in farming reorganization which are being tried at the present time. Some, such as the Jewish settlements in Palestine, have already been discussed widely; others, such as those in the Sudan, are regrettably less well known and yet probably of wider significance.

Finally, the Report emphasizes, as does that of Dr. Worthington, the similarity of so many of the technical and social problems confronting the Middle East Governments, stressing the need for greater consultation and co-operation in research and in education. The numbers of trained personnel are limited as well as the money for agricultural research; both must be used, therefore, with the greatest economy. Dr. Keen's proposals for a scientific and non-political Middle East Council of Agriculture and his indication of the type of work which it would sponsor have an infinite significance for the well-being of the rural areas of the Middle East. They are an early sign-post on the road to better farming and thence to better health and happier living.

On behalf of the former Middle East Supply Centre and its staff, I would like to express our deep sense of gratitude to Dr. Keen for his assistance in our work. He spared no effort, often under rather trying conditions, in finding the answer to many of our questions; his personal contacts with administrators and agriculturists in the different countries created an asset which it would be difficult to overestimate. We offer him our sincere thanks.

K. A. H. MURRAY

LINCOLN COLLEGE
OXFORD
December 1945.

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My best thanks are due to the Governments and Administrations of the territories visited and to the Middle East Supply Centre, Cairo, for the special facilities freely afforded me; and to the many persons —far too numerous to be mentioned individually—who, although heavily burdened with urgent war-time responsibilities, nevertheless found time to give me invaluable assistance.

*

INTRODUCTION

This Report forms part of a survey within the terms of reference drawn up for a Scientific Advisory Mission. The purpose of the Mission was (*a*) to examine the principal scientific problems in the Middle East, irrespective of political boundaries; (*b*) to examine the principal scientific and technical resources (including personnel and facilities for both research and education); (*c*) to make recommendations for the development of the scientific and technical resources and for the establishment of the necessary organization in the Middle East and elsewhere to ensure the fullest practicable service of relevant scientific and technical information and advice. The Report below is concerned with agricultural problems, and with some of the closely associated subjects, primarily educational and rural. It is intended to be reasonably complete in itself, but to be read in conjunction with the other Reports in this series, referred to in the Preface, as there are numerous points of contact between them.

The Middle East was the cradle of civilization, because settled or arable agriculture began there. The region with which this Report deals consists of fourteen countries with a population of perhaps seventy million, and extends from Cyprus in the north to the Sudan in the south, and from Persia in the east to Tripolitania in the west. Its climate ranges between the extremes of rainless desert and copiously watered hill forests. It displays all stages of agricultural development from the immemorial nomadic pastoral to the most advanced irrigation farming: and in irrigation itself there exist all shades of engineering and agricultural efficiency and inefficiency. The rural population density varies from intense to sparse. The systems of land ownership and tenure, and the problems—economic, agricultural, and sociological—to which they give rise, are of great complexity.

But in spite of these wide diversities the territories have many common characteristics, and hence many common problems. In this sense, at least, the Middle East is essentially a unit. Over much of the area the season is divided into a hot rainless period and a rainy one, in which the precipitation may or may not be fully adequate for crops. This weather distribution has led to the use of a system of agriculture in which 'mixed' farming (the combination of arable and animal husbandry) has had little or no place. Farming is predominantly of the peasant type. The majority of the peasants work under some form of tenancy, usually on a share basis. With some obvious exceptions, the Departments of Agriculture, and the help they can supply to the peasants, are rudimentary; education—especially rural education—is very backward, and village welfare and amenities scarcely exist.

The advantages of attacking this core of common problems—a few of which are listed above—on a regional basis would possibly have remained of academic interest only but for the overriding necessities of the war.

The war-time problems that have been dealt with on a regional basis will not disappear with the war; many of them will be accentuated by post-war conditions. In addition, the Permanent Organizations envisaged by the Hot Springs Conference will work on the basis of regional organizations.

These considerations point to the desirability of a survey of the scientific and technical problems in Middle East agriculture and in subjects closely related to it; and, without reducing in any way the opportunities and the responsibilities of the separate Governments for the advancement of agriculture within their territories, they also stress the mutual advantages to be gained by the co-ordinated exchange of experiences and by integrated attack on common problems.

The arrangement of this Report and the treatment adopted have been influenced by the above considerations and by the experience gained in visiting the territories. In all essentials the complex of the social organization and the system of agriculture in the Middle East is like the one that endured so long in western Europe and still exists in India. Two centuries or so ago a number of circumstances combined to produce a rapid evolution in western Europe and Great Britain, with profound changes in agriculture and the rural social structure. To-day the Middle East stands on the verge of the same situation, with the one big difference that past experiences and scientific aid are now available to ease the strain of the transition.

Early in this inquiry it became evident that to deal with the problems primarily from their scientific and technical aspects—vital though these are—would give insufficient emphasis to the real situation. It was necessary first to discuss this and its implications, which is done in Chapters II and III. The main scientific and technical problems are dealt with in Chapter IV, and examples are drawn from a number of territories. The task of surveying the scientific and technical problems was greatly facilitated by the work of the Imperial Agricultural Bureaux, whose abstract bulletins and frequent Technical Communications provide a continuous and up-to-date picture of the situation. In these circumstances an annotated survey would have resembled a 'still' from a film and would have had the same restricted value. Therefore, in Chapter IV attention has been concentrated on certain problems of basic importance to Middle East agriculture on which further research and technological work is clearly required. The first section of Chapter V discusses the problems of each territory in turn, but to avoid too much repetition a problem that has already been used for purposes of illustration in an earlier chapter is not, in general, referred to again in Chapter V. The arrangement imposes on a reader, who is primarily interested in one territory, the task of glancing through the complete Report; it is hoped that this may not be entirely a disadvantage. The second section of Chapter V deals with certain aspects that concern the Middle East as a whole. As Chapter VI is to a considerable extent a summary of the complete Report, no separate summary has been written.

With the exception of Plate 14, the illustrations are from photographs taken by the author.

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THE AGRICULTURAL DEVELOPMENT OF THE MIDDLE EAST

CHAPTER I

Outline of Middle East Agriculture by Territories

In general, the climate of the Middle East, which dominates the agricultural utilization, is of the Mediterranean type. The great bulk of the rain falls in the winter months November–March, and the summer period, May–October, is practically rainless except in the summer rainfall areas, e.g. the Sudan and Ethiopia. Cyprus, north Palestine, much of Syria, Iraq, and Persia are representative areas having enough winter rainfall for winter crops, with possibly summer crops after a winter of fallow.

In other areas the Mediterranean type of climate is modified into very low or practically rainless conditions, on the one hand, to copious and reasonably well-distributed rainfall on the other. Thus Egypt and the Sinai desert are nearly rainless, and the Negeb area of south Palestine has a sparse winter rainfall, so that the crop fails in perhaps two years out of five. Lebanon, north Persia between the Elburz mountains and the Caspian, and Ethiopia have a much higher and, on the whole, a better distributed rainfall, so that a wide variety of winter and summer crops is possible.

Hot winds, such as the khamsin in Egypt and Palestine and the ghibli in Tripolitania, sand-storms, and dust-storms such as the Sudan haboob, are liable to produce wind erosion of the surface soil and to cause great damage to crops, especially in those areas where afforestation and the provision of shelter-belts of trees or bushes for the crops and orchards has been neglected.[1]

Superimposed on these broad groupings, there exist wide local modifications of farming methods due to topography, soil type, the use of irrigation, and the opportunity of supplying internal or external markets with specialized crops.

Apart from small- and large-scale developments of irrigation, Middle East agriculture is essentially a subsistence system, based on grain or bread crops, with long periods and large areas of fallow. The great majority of the cultivators farm small areas which are usually subdivided into scattered strips. Thus there exists the situation—paradoxical in present-day conditions—of small holdings which can thrive best under an intensive system of farming coupled with a full development of co-operative societies (as in Denmark), being farmed under the extensive methods that characterized the ancient two-field systems of Europe.

Live-stock belonging to the cultivators also exist under a system of extensive farming. Little or no fodder can be grown for them; they get what they can from the stubbles and stalks of the arable crops, the weeds on both arable and fallow land, and the indifferent and over-grazed herbage of the common land and the rough hill pasture. But probably the greater numbers of the live-stock are held by nomads who trek considerable distances with them, from plain to hill, or riverside to uplands, following the succession of herbage and water-supplies. Both nomadic and settled stock have developed hardiness so that they can live in climates and nutritional

[1] See Dr. E. B. Worthington's *Report on Middle East Science*, chapters iv–vii, for an annotated account of climate and water-supply problems.

conditions that would be impossible for the highly developed milk and meat breeds of western Europe.

The impact of these general and special factors on the agricultural systems of each country will be evident in the summarized accounts below. All detail has been purposely omitted, even though it has in most cases considerable local significance.

(a) CYPRUS

The broad central plain—the Mesaoria—is bounded to the north and south by mountain ranges, rising respectively to 3,000 and 6,000 feet. Between each range and the sea there is a narrow coastal plain. The climate is typically Mediterranean. Rain falls mostly in the winter months and varies from under 15 inches in the Mesaoria to over 25 inches in the higher parts of the southern mountains, and the mountains become covered with snow. The summer is long and hot and the winter is mild. There are no major irrigation works, but numerous local schemes exist, from springs and wells and the diversion of spate water. Active and successful efforts are in progress for improving and increasing the number of such schemes. Several systems of crop husbandry exist.

(i) Un-irrigated cereal growing. This is, in effect, the ancient 'two-field' system; it is still used in a wide area of the Middle East, particularly in the Arab regions. Cereals are sown in the autumn, wheat on the better land and barley on the poorer. About two-thirds of the other half of the land is left in fallow and one-third is devoted to a vetch crop in the season between the cereal crops. The land gets the small amount of dung left by flocks grazing on the stubbles and fallow; some artificial fertilizer is now used on the cereals.

(ii) Irrigated arable. Two crops a year are grown: cereals in the winter, and irrigated crops in the summer. Irrigation is either from flood or from underground water; in the latter case irrigations during growth are possible. Crops grown on flood irrigation include cotton, sesame, cowpeas, and water melons. Hemp, haricot beans, tobacco, vegetables, and potatoes are raised under the other method. The system makes efficient use of the land and more manure is now used than formerly.

(iii) Hill farming. Cereal growing as in (i) is supplementary to olive and carob trees. The fields are small and scattered.

(iv) Horticulture and fruit. Citrus is grown in the plains and some of the lower valley lands. In the hills deciduous fruit plantations are extending. Figs and nuts are grown in many places. Vines are concentrated mainly on the south side of the southern range, often on very steep slopes, and un-terraced, except where there is abundance of stone, e.g. the calcareous soils.

(v) Animal husbandry. 'Mixed' farming does not exist. The hot dry summer makes grazing very difficult and the cost of irrigated fodder crops prohibitive. Beef and milk cattle are, therefore, practically unknown except that near the large towns some dairying is practised. In these conditions cattle are used for working the farm, and animal husbandry is confined to flocks of sheep and goats, which roam over the fallows, the village pastures, and waste lands. Animal food is scarce, and the shepherds are often in conflict with the farmers and the Government because of the depredations of their flocks among crops and afforested areas.

(b) PALESTINE

The country is small; the north-to-south length is only 160 miles, and the average width is 55 miles. The central hill range, running roughly from north to south, is

in two sections. The northern part, extending from Nazareth to the anti-Lebanon mountains of Syria, is mainly basaltic; the southern part, from Mt. Carmel eastwards to Nablus and thence southwards towards Beersheba, is limestone. The north and south parts are separated by the plain of Esdraelon, which has a heavy but fertile soil. The coastal plain is about 20 miles wide, with a narrow portion at Haifa. South of Haifa sandy soils predominate, with a fringe of heavier soil to the south and east. North of Haifa there is much heavy clay and marshy land.

East of the central range is the deep and narrow Jordan valley, at the northern end of which is the heavy clay and large marsh area of Lake Hula.

The climate is typically Mediterranean. The amount of winter rainfall, however, decreases rapidly from north to south. In the coastal plain this decrease is from about 20 inches to 10 inches, in the Jordan valley from 20 inches to 2 inches, and 35 inches to 25 inches in the central range. The annual variation is considerable, from about half to nearly double the average. The water-supply is inadequate, and there are few suitable rock foundations for dams to impound water. Underground sources seem to be limited, and are often too deep for economical use, and some of them are saline.

The agriculture is of great interest, primarily because of the developments made by the Jewish colonists, which are discussed separately below (Chap. III, 1, *d*, *e*, *f*). The Arab system of husbandry varies. The simplest is found in the area of very limited rainfall south of Beersheba and Gaza, where barley alternates with fallow. Yields are low, and although the area here under barley represents about 70 per cent. of the total Palestine area under this crop, it contributed in 1935 and 1936 only 30 per cent. and 15 per cent. respectively of the total production.[1]

The most general system of agriculture, however, is a two-year rotation. The winter crop of wheat or barley is rotated with a winter leguminous crop, or with a summer crop (in the succeeding, not the same, year) such as dura (millet) or sesame. A three-year rotation is also used: a cereal, a legume, and a summer crop. These rotations suffer from the obvious defect of not providing animal fodder for the whole year, and from lack of manure. Such supplies as accumulate near the villages seem either to be left unused or else sold for use in the citrus plantations. Arab live-stock are managed in the traditional way, either as nomadic flocks or pastured on the stubbles and land not under arable.

The Jewish agricultural systems now differ greatly from the Arab ones. They have undergone progressive development in which three phases can be broadly distinguished. The first was in effect the standard Arab system; the second was the development of mixed farming on un-irrigated land; and the third was the development of various types of mixed farming on irrigated land, coupled with a study of irrigation technique. Simultaneously there has been the development of the citrus industry in the coastal plain. In 1939 about 75,000 acres were under citrus, about a third of which is not yet (1943) in full bearing. About half the citrus area is owned by Jews and the remainder by Arabs. Olives are grown generally over the central and northern areas. The industry is almost entirely in Arab hands, and its financial value is equal to that of the citrus area.

(c) SYRIA AND THE LEBANON

The topography is essentially a mountainous western strip, close to the coast, and an undulating plateau to the east, which runs down to the Tigris–Euphrates basin.

[1] Chapter IV, 'Agriculture' (by M. Brown) in *Economic Organisation of Palestine*, published by the American University, Beirut.

Lebanon occupies the southern portion of the mountains, which here consist of the two parallel ranges, the Lebanon, and the anti-Lebanon to the east, separated by the 3,000-foot high plain of the Bekaa valley. Most of Syria is made up of undulating table-land.

The climate is Mediterranean and, because of the topography, the amount of the winter rain decreases rapidly from Lebanon to Syria. Lebanon is thus, in general, better supplied with rainfall, rivers, and springs than Syria, but the latter has two large rivers, the Orontes and the Euphrates, whose water-supply is as yet only partly exploited. But because of the long dry summer only crops of low water requirement, such as millet, and deep-rooting trees and bushes, such as olives and vines, can be grown without irrigation. With irrigation a full range of crops is possible, as in the narrow coastal strip of Lebanon, where produce varying from cereals to bananas is grown. The mountains grow vines and temperate fruits, and in the northern foothills the well-known Latakia tobacco. The Bekaa valley grows winter cereals and pulses and good summer crops of potatoes and vegetables in the irrigated sections.

Syrian agriculture is primarily cereal production, and the immense 'fields' cultivated in long strips by communal villages are a characteristic feature. The rotation is wheat, fallow, lentils, or vetch. Two other areas are important because of their special features. The first is the north-east corner, the area of the Djezira between the Tigris and the Euphrates. This is fertile land with ample winter rain for wheat and was formerly one of Rome's granaries; now only relatively small areas of it are farmed. The second area is the Damascus oasis, where the waters of the Barada and of the Awaj to the south of it, which would otherwise disappear in the desert to the east, have been for many hundreds of years used for irrigation. Proceeding outwards from Damascus there is a well-marked sequence of land utilization: dairies; olive and fruit plantations intercropped with vegetables and cereals; vines; cereals; desert.

Nomadic sheep and goats provide the bulk of the meat and milk, especially in Syria, but in Lebanon and the Damascus oasis milk cattle are important. The Beiruti and the Damascus cattle can in fact be counted as definite breeds.

(d) TRANSJORDAN

The western boundary of Transjordan is the Jordan valley. From the steep and indented escarpment the land slopes away to the north and east to the Syrian and Saudi Arabian desert.

The rainfall comes in the winter from the Mediterranean winds which deposit most of their moisture in the passage over Palestine. They are cooled as they rise up the eastern escarpment of the Jordan valley and so deposit further moisture, the bulk of which falls along a narrow belt to the east of the cliffs. The rainfall in this area shows the same decrease from north to south as is seen in Palestine. Farther eastwards the rainfall becomes negligible.

The farming system follows this rainfall pattern. In the higher rainfall areas the usual winter and summer crops are grown, the latter with the aid of small irrigation works. Vines and olives occupy the steeper slopes. Dry-farming is necessarily practised in the low rainfall areas, and is pushed eastwards to the fringe of the desert, where there can be small hope of getting a crop.

Sheep and goats are the principal live-stock. There are few cattle, mainly scrub ones in the Jordan valley. The plough oxen are imported, gelded, mostly from Syria.

(e) IRAQ

The north-west to south-east valley of the Tigris and Euphrates forms the long axis of Iraq. The northern portion contains rolling upland country and the mountains of the north-east. The remainder and larger part is a flat plain only slightly above sea-level.

Over the greater part of the country the climate is of the extreme continental type: very cold winters and hot summers, with dust-storms especially in the central and southern area. The rainfall distribution is the Mediterranean type, but the quantity is reduced, as much of the rain is caught by the Palestine hills. The rain zone in Iraq corresponds roughly with the higher-lying northern area. Here rain-cultivation and dry-farming are practised, with fruit and summer vegetables, under irrigation. The rest of the country depends almost entirely on irrigation.

Only about a quarter of the total land area is under cultivation, and nearly half of this is in the relatively small northern area. Here crops of cereals and legumes and some oil seeds are sown to grow in the winter rains. The summer crops grown under irrigation in the valleys include a wide variety of vegetables, and a considerable area of rice, as well as deciduous fruits and nuts.

The central and south areas show wide variations in the efficiency of irrigation. Suitable land for irrigation is in excess of actual or potential water available, and there is no pressure of population on the land. As a result, extensive methods of farming are widely used. Some two-thirds of the cultivable area lies fallow each year. Much of the land is liable to deterioration under irrigation, unless it is more skilfully managed than is at present the case. Over-irrigation is general, and as there are no main drainage works, incipient alkali conditions rapidly appear. The cultivator, therefore, practises a kind of shifting cultivation, moving to a fresh area when the first becomes bad and leaving it to recover if it can. One consequence of this primitive system, especially in the lower reaches of the rivers, is that excess irrigation water, and seepage waters, find their way into shallow depressions and give rise to marsh and swamp conditions.

The crops are the typical ones: cereals, legumes, and some oil seeds in the winter; in the summer, sesame, giant millet, maize, and a little cotton.

In the southern portion of the country there are important areas of intensive irrigation where adequate drainage exists on account of the tides (see Chap. III, 1, *h*). The best known and most important is the date-grove area, a narrow strip about 120 miles by 3 miles, along the Shatt el Arab. The groves vary from large estates to small-holdings. Manures are liberally used, and there is much interplanting with fruit, vegetables, cereals, and lucerne. A small fruit area along the Diyala river, near Bagdad, produces citrus with winter crops of temperate vegetables and fruit. The fringes of the marsh areas mentioned above are utilized for rice-growing.

Live-stock have an important part in the general economy of the country. Cattle belong mainly to the settled cultivators of the northern and the irrigated areas, although there are large herds in Kurdish ownership in the north-east. Arabs in the marshlands area specialize in buffalo-breeding. The animals are distributed along the riverain area. The majority of the sheep and goats are in mixed flocks in the possession of nomads or semi-nomads, and move from the desert winter pastures to the riverain areas for the summer.

(f) PERSIA

The bulk of the country consists of a great central plateau, a westward continuation of the central Asian table-land. The plateau is about 4,000 feet high and is traversed in places by minor mountain ranges running generally in a north-west to south-east direction, parallel with the Zagros mountains which form the western and southern boundaries of the plateau. The northern boundary is formed by the high Elburz range, north of which are foothills fringing the narrow Caspian coastal plain. To the south of the Zagros mountains, at the head of the Persian Gulf, lies another plain and the valley of the river Karun.

The climate of the central plateau displays both continental and semi-arid conditions; the rainfall in the north-west area is 10 inches, and the amount progressively decreases towards the south-east. The area between the Elburz mountains and the Caspian Sea has abundant rainfall mostly in the autumn and winter, with spring and summer showers, and a relatively mild climate. The area around the Persian Gulf experiences hot and oppressive summers and mild winters, with a scanty winter rainfall.

Except for the Elburz–Caspian section, water is scanty and not infrequently too salt for irrigation. In the central plateau there are large salt marshes and lakes fed by small rivers and, as would be expected, large areas of the central plateau soils are salty. The Karun valley is fertile, but much of the soil in the plain is salty.

Only about 10–15 per cent. of the total land area is under cultivation. A further 20–30 per cent. could be cultivated if irrigation were available. About 15 per cent. is grazing-land and 15 per cent. is in forest. No less than 30 per cent. must be classed as desert and waste.

Wheat and barley are the predominant crops. Paddy rice is grown in the well-watered Caspian littoral. Pulses, oil seeds, and cotton are also widely grown. Vegetables in wide variety are also grown, especially near urban centres. In recent years attempts have been made to become self-supporting in tea and sugar. The tea plantations are in the Caspian littoral, and sugar-beet is grown on the plateau. The production is by peasants and on the peasant scale, in contrast to the processing operations which are done in large modern factories (see Chap. II, *c*). Previously, sugar-cane was grown in the Caspian area and the Karun river valley, and the possibility of reviving it in the latter area is being explored.

Many kinds of fruits and nuts are produced, some in considerable quantities for export. The production is mainly centred around the foothills of the mountains.

As in Iraq, the normal system of peasant cultivation, except in the Caspian littoral, is to leave a considerable proportion of the land in fallow, because the water-supply is limited, and also for it to recover fertility.

Live-stock are held both by settled and nomadic peoples. Sheep are by far the most important, and with about half their number of goats form the main supply of meat and milk, and provide the local and export trades with wool and skins. Cattle are of little importance except as draught oxen.

(g) EGYPT

Agriculturally, Egypt is the narrow strip bordering the Nile, which is highly cultivated in estates and small-holdings and densely populated. Rainfall is insignificant, and the country depends exclusively on an irrigation system which for size and efficiency of construction and management is unique. A change of great importance

is the progressive conversion of 'basin' irrigation land to perennial irrigation. Under the former and older system the land had a summer fallow, but under perennial irrigation it grows crops in this period. The cropping capacity of the land has been increased as a result, but some doubts have been expressed whether the fertility of the land will remain at its original level (see Chap. IV, *b*). Wheat and other bread crops and a wide range of vegetable crops are grown, but by far the most important crop is high-quality cotton, whose value represents, normally, about three-quarters of Egypt's export trade. Other crops exported are onions, sugar, and rice, this last being grown largely in the Delta; sugar-cane for sugar production is grown in Upper Egypt, but a certain amount of cane for eating is grown in the Delta. Citrus plantations and vines are increasing in area.

In Egypt live-stock have been integrated with arable farming to a much greater extent than elsewhere in the Middle East, through the medium of Egyptian clover or berseem (*Trifolium alexandrinum*) as a crop in the rotation. It grows luxuriantly and gives several cuttings in a season. It is grazed direct or as green cut-fodder or as hay. Although the large urban population has led to the development of dairy cows the fellah relies mainly on the buffalo for his milk-supply.

(h) THE SUDAN

This immense country of one million square miles has very variable conditions, from desert in the north through Acacia-grasslands to the broad-leaved savannah and forest in the extreme south.

Except for the Red Sea coastal strip rains fall in the summer; they increase gradually in amount and duration from nothing in the north to 60 inches in the south, where the beginning of the equatorial type of distribution is evident. Everywhere there is a pronounced dry season.

The soil types show a corresponding succession from south to north. In the extreme south-west tropical red and yellow loams have been formed from the Basement Complex granites and gneisses and more particularly the overlying upraised lateritic ironstone of pre-Miocene days. Soils and climate are suitable for a variety of tropical crops including American cotton, Robusta coffee, and oil palm, provided suitable cultural conditions can be devised to overcome, for perennial crops especially, the effects of the pronounced dry season of about three months. Present crops include cassava (both bitter and sweet), bananas, sweet potato, finger millet, maize, and ground-nuts. The tsetse-fly reigns supreme in this and the succeeding unpopulated and less dissected ironstone plateau. Farther north are the grasslands and swamps of the flood plain which on the east side of the river extend much farther south, and which are the home of the large cattle-owning Dinka and Nuer tribes who also cultivate dura and simsim (sesame).

The granite and gneiss rocks of the Nuba mountains area of south Kordofan produce alkaline soil types because of the lower rainfall and higher temperatures as compared with south Equatoria. Appreciable areas east of the Nile from Equatoria to Kassala and fringing the grasslands and swamps are also of the same type. Annual crops, particularly dura, but also much simsim and ground-nuts, are grown. In the Nuba mountains cultivation of rain-grown American cotton had reached large proportions at the advent of the war.

The vast flood plain of the Nile and its tributaries is a heavy cracking clay with some higher sandy ridges, both alluvial deposits from the rivers.

Northern Kordofan, northern Kassala, and Northern Province are mainly desert,

but Kordofan has extensive areas of commercially very important gum forest on the red Kordofan sands. In the Red Sea hills area the soils are skeletal.

On the extensive flood plains or deltas of the Gash (near Kassala) and Baraka (near Tokar) Egyptian-type cotton is grown on the annual floods.

In the north the ancient system of husbandry, apart from rain-grown dura where conditions permitted, was riverain cultivation of various crops on the saturated land left by the receding Nile flood-water, and by primitive irrigation. In recent years there has been a great development of modern irrigation, largely centred in the Gezira between the Blue and White Niles, but also extending along the White Nile from Kosti to Jebel Aulia and northwards along the main Nile. The waters of the Gash have also been trained.

Cotton is by far the most important crop, providing directly or indirectly the major part of the Government revenue. Other crops in the rotation are dura and lubia, the latter providing leguminous fodder for animals. Wheat, pulses, and small quantities of other crops and of vegetables are also grown, particularly in Northern Province. As a war-time measure wheat has been extended to the Gezira and White Nile areas.

In a large area south and south-east of the Gezira 'harig' cultivation is practised. This is a controlled burning of grass in the early rains, to kill both the young and old grass and weeds, followed by planting to dura. After one or more crops of dura the land is allowed to revert to grass. The system is well suited to the nomad tribes who trek north in July and August when the biting-flies make life difficult for their animals, and who harvest the crop on their return in January and February.

In the southern Sudan primitive native agriculture, with its shifting cultivation, is general.

Cattle, sheep, and goats are managed mainly by pastoral and nomadic methods.

(i) ERITREA

Running northwards up the middle of the country, and sloping gradually to the north, is a spur of the Ethiopian table-land. In the southern portion of Eritrea it forms a mountainous plateau 7–8,000 feet high; in the north the plateau and hills are about 4,500 feet high. Westwards of this central spur there lies an arid plain which continues into the Sudan to the west. Eastwards of the central ridge there is a steep escarpment to the narrow coastal plain of the Red Sea. The north and south plateaux are cold and rather dry. The rainfall is about 20 inches and occurs mostly in the summer months, May–September. The western plain also has a summer rainfall of about 12 inches. The coastal plain, however, has a winter rainfall which varies from only 6 inches in the coastal areas to 30 inches on the steep escarpment and foothills.

The agricultural practices in these four divisions are largely conditioned by the topography and climate. The south plateau of the central ridge is predominantly settled agriculture. The production is insufficient for local needs for several reasons: much of the land is of poor fertility; the fertile black soil area is comparatively densely settled; the people are warlike and agriculture does not appeal to them; there is also some shortage of grazing-land.

The north plateau is occupied by nomad pastoralists, who migrate seasonally to the eastern plain and its foothills. The eastern plain is inhabited mainly by nomads owning cattle, sheep, goats, and camels. In the southern portion of the eastern plain

the goats and camels often migrate deep into Ethiopia. In the foothills the higher rainfall allows a certain amount of rain-cultivation to be done.

The western plain contains a potentially rich agricultural district which is not fully exploited, partly because of the lack of perennial water, but mainly owing to the nomadic habits of the tribesmen. Settled agriculture is being developed largely by Sudanese and West African immigrants.

(j) ETHIOPIA

The country has a very complicated topography, and the great bulk of the land lies high. A rough division is possible into a highland temperate zone, with a lower and non-mountainous area surrounding the central massif. Meteorological data are very scanty. In general, rainfall is plentiful—over 40 inches per annum in the areas higher than 6,500 feet. Most of the rain falls from June to September, but there are also the 'little rains' in March and April. Springs and wells are plentiful. Even on the border of French Somaliland there is said to be ample water at 20–40 feet.

There are three main types of soil: (*a*) rich black soil of the valleys and wide plains, of basaltic origin; (*b*) red and brown soils, often sandy and rocky and usually carrying woody vegetation; (*c*) grey and red soil, largely composed of quartz and mica-grit, from crystalline granite rocks and of poor fertility.

As a whole the country is of high fertility, and the distribution of the rainfall and variations in altitude make it suitable for a great variety of crops and for animal pasturage. The standard of peasant cultivation is high. Besides the usual cereal and bread crops, oil seeds and legumes, most European vegetables and fruit do well. Fibre crops, such as cotton, and the fruitless banana (*Musa ensete*) are grown, and coffee is important in a number of districts.

Apart from the common diseases the conditions for stock are good. They are better, in fact, than the appearance of the animals and their management would suggest. Although on the high plateaux pastures are good and mixed farming is perfectly feasible, the farmers here give first place to arable husbandry; whereas in the low plains of Danakil and Somali, where conditions are less suitable for stock, cattle are almost the sole resource of the people. The cattle are mostly Zebu in type, and their characteristics vary in different parts of the country. There is the usual distinction between the cattle of the settled tribes, where work ability is prized, and the nomad tribes, whose interests are milk, meat, and hides. Hides and skins are an important export, in spite of the low standard of preparation. Sheep do well, especially at the higher altitudes. It is indicative of the lack of information on the country that authorities differ as to whether goats exist in large or relatively small numbers. Poultry and bees are widely kept.

Although the agricultural conditions of the country are excellent, the difficulties of communications and transport are considerable, and it is doubtful whether economic exportation of staple food crops would be possible. 'Plantation' crops, such as coffee—already exported in quantity—and possibly drug plants are, however, likely openings.

(k) THE ADEN PROTECTORATE

The Protectorate is in a summer rainfall zone. The north-east monsoon provides rain in the period March–May. This is followed by a hot dry month before the July–September rains of the south-west monsoon. Coastal areas may get local rain in the winter from storms in the Indian Ocean.

The rainfall is capricious in amount and distribution and, except in the western areas, is insufficient, and must be supplemented where possible by flood- or well-irrigation.

The limitations imposed by the rainfall conditions and by the topography, which is partly mountainous and partly a high arid table-land intersected by deep wadis, have been skilfully dealt with. Quite steep mountain slopes are terraced and the small parcels of land are cultivated by hand. Lower down, where the terraces are larger, much care is taken to lead into them the run-off water from the adjoining bare slopes and hill-sides, and the cultivation practices, which are those appropriate to dry-land farming, reach a high level of efficiency.[1]

Below these high areas special importance attaches to irrigation from flood-water coming down the wadis, as the normal rainfall alone is insufficient. Silt-laden water is deflected at speed by brushwood and stone deflectors into channels and thence to the bunded flat areas. It is a system of basin irrigation, complicated by a progressive rise of the terraces due to silt deposition, which necessitates moving the deflector sites correspondingly higher upstream. In the lower reaches of some of the wadis another type of irrigation is practised. Big earth dams are built across the wadi in the dry season, to bank up the water, which is then led as a moving sheet over as wide an area as possible. The aim of the cultivator is that water shall stand on the land for forty-eight hours. Then, if the dam has not already broken, it is deliberately breached to let the surplus water down to the next dam, where the process is repeated.

Wherever possible, underground water is used for well-irrigation throughout the Protectorate, and at places, including along the coast, small supplies of perennial water are available.

In the western part of the Protectorate sorghum is an important crop. After a good flood-irrigation a second and quite good ratoon crop is obtained. Sesame is another important crop, and cowpeas and gram are often interplanted in sorghum.

Vegetables are grown on the well-water, and any permanent water is utilized for tropical fruits, as in the Lahej area, and for coffee in the Yafa mountains. Potatoes have recently (1939) been introduced in the highland area. The live-stock include the Red Amiri cattle, which are a good milk and work type, goats, and sheep.

The eastern part of the Protectorate is poorer, agriculturally, than the western. It is steppe country and has a more pastoral outlook. But it has an exceedingly interesting development of arable agriculture in the little known Hadhramaut, where the floors of the extensive wadis are cultivated partly on flood- and partly on well-water. The soil is generally sandy (although the upper wadis may be heavier), and all available supplies of house refuse, vegetable wastes, and human excreta are used as manure. The agricultural system centres round the wells. There are about fifty date-trees per well, on about 2 acres of land, and two crops of sorghum planted in March and August–September. Numerous subsidiary crops are grown, including various millets, vegetables, and lucerne; a few are interplanted in the sorghum. As much wheat as possible is sown. The flood-irrigation is controlled and directed by masonry and earth dams. Floods are erratic in time and amount, so the area of crops sown on flood is correspondingly variable. This intensive arable system, which has developed in an unfavourable area, is bound up with the pressure

[1] An excellent description is given in *Dry Farming Methods in Aden Protectorate*, B. J. Hartley. Middle East Agricultural Development Conference (Agricultural Report No. 6, M.E.S.C., Cairo, 1944).

of population which necessitates growing the maximum of human food and the minimum of animal fodder. A further handicap is the progressive development of saline conditions in the lower reaches of the wadi, which leads to the abandonment of wells and of areas formerly flood irrigated, owing to deterioration of the soil.

(1) TRIPOLITANIA AND CYRENAICA (LIBYA)

These two territories have similar topography and climate. There is a coastal plain, much wider in Tripolitania than in Cyrenaica, where, except in the Barqa area adjoining Benghazi, it is hardly more than a narrow coastal belt. To the south of the plain, and presenting a steep escarpment to it along most of its length, is the Jebel, a range of hills which merge into an inland plateau with a gradual southward slope to the desert.

The Mediterranean depressions of the winter months pass too far north and bring little rain. But a moderate amount of rain is given between November and April by local moist sea winds by their ascent up the hill and plateau edges. It is erratic in amount and the distribution both in space and time is very variable. In these circumstances the average annual amounts have little meaning. A further factor of importance is the ghibli, a hot desiccating wind from the south, that comes in the spring and summer, and often causes great damage to crops and vegetation.

Although the topography and climate are similar in Tripolitania and Cyrenaica, the soils are different; in Tripolitania they are light and sandy, but in Cyrenaica they are much heavier, and in the broad peninsula between Benghazi and Derna (which constitutes the main part of the agricultural area) they consist mainly of a heavy red loam.

The typical vegetation régime of both territories is steppe; the cover is much denser in Cyrenaica, and parts of the northern slopes of the Jebel in this territory carry good woodland and trees. In Cyrenaica, too, there is remarkably little evidence of erosion, and it is clear, from the evidence presented by numerous recent excavations and trenches that have retained their original shape for two or three years, that the soil possesses an inherent resistance to erosion.

The agriculture of Tripolitania is closely conditioned by the rainfall. Along the coastal belt there are large areas of date palms which are intercropped on a two-year rotation of crop–fallow, with vegetables and cereals. The farmers are Arabs, who have become settled agriculturists and have reached a commendable technical level. The fields are well tended, and the texture and fertility of the light soil have been greatly improved by manuring with finely divided compost of animal, vegetable, and household residues.

In the coastal plain footing on to the Jebel, good quality barley is grown in seasons of favourable rainfall; in poor seasons the meagre growth, if any, is used as animal fodder. On the slopes of the Jebel and the plateau there are numbers of very ancient olive-trees still in bearing. Around groups of these, and often around single trees, the land is sloped and bunded so that the surface run-off water from the adjacent areas is led to the roots, thus augmenting the moisture supply. Barley is also grown as in the coastal plain, especially in depressions and wadi beds where run-off water will accumulate in favourable seasons.

Live-stock are kept mostly under the traditional semi-nomadic system. Sheep and goats predominate.

This picture of traditional Arab cultivation, augmented by a small amount of irrigation for vegetables, ground-nuts, &c., where shallow wells could be sunk and

worked by animal power, has been altered in a number of places since the Italian occupation. The area under olives has been greatly increased, and almonds and vines, which also do well in the local conditions, have been planted extensively. More irrigation water has been obtained both from artesian bores and wells, and used for citrus plantations, vegetables, and fodder crops. Extensive areas of sand-dunes were anchored and afforested. Much of the development is recent and incomplete owing to the war. An early phase, in which areas often thousands of acres in extent were granted as concessions to individuals, was followed by the so-called demographic colonization, the settlement in prepared colonies of peasant farmers and their families from Italy. This development is discussed in detail in Chapter III, 1, *i*.

The agriculture of Cyrenaica as practised by the Arab tribes has both arable and pastoral aspects. The narrow coastal belt is extensively ploughed for barley, and suitable areas grow market-garden and orchard produce under irrigation water from wells and running spring water. Dates are also grown, especially around Derna, but they do not do so well as those in the Tripolitanian coastal belt, where the atmosphere is less humid. In the Barce plain and the extensive plateau barley is also sown in a wide variety of places, depending on the date and amount of the rainfall, and the harvest extends over the period May–August. This spread fits in well with the rhythmic semi-nomadic movement of the stock, mostly goats and sheep, southward from the plateau in December for the grazing and back in May. The main lambing season is in November, and the fresh grass and warmer conditions of the south suit both sheep and lambs.

Before the war there was an extensive trade of sheep on the hoof to the Egyptian markets, over the period when grass was growing on the southern pasture belt. And, in favourable seasons, there was a surplus of barley available for export.

As in Tripolitania, extensive changes were envisaged by Italian colonization in this self-sufficient system combining semi-nomadic pastoralism with shifting arable agriculture. This is discussed in Chapter III, 1, *i*, but two points are suitably mentioned in the present chapter. The first is the evidence, provided by the extensive old Greek and Roman settlements on the Jebel plateau and slopes, that the area formerly sustained an extensive agricultural population. The second is the very large Barce plain of some 30,000 acres, free of bushes, which has been used during the war for large-scale mechanized cereal growing.

CHAPTER II

The Obstacles to Agricultural Improvement

As we have seen (Chap. I), agriculture in the Middle East is mostly a peasant and extensive system, such as was swept away in other countries because of its definite limitations. But it must be remembered that although the system inevitably has a low subsistence level it is for that reason less affected by the crests and troughs of economic waves. The more intensified a system becomes the more delicate, in general, is its economic balance. The four-course system with separate self-contained farms carved by the enclosures from the three-field system of England was an intensification that produced larger crops, adequate fodder for stock throughout the year, and at the same time raised the level of soil fertility. In its basic form it consisted of two cereal crops, wheat and barley, and two fodder crops, clover and

turnips. It solved, by hay and turnips, the problem of winter food for cattle; and the larger quantities of manure and the residues of the clover increased the yield of the cereal crops. Its financial stability rested on its sales of wheat, meat, and milk for the rapidly growing population of industrialized Britain. If ever any system looked secure, both technically and economically, it was this one which, in the middle of the last century, was known as the 'golden age of English farming'. And yet its two main financial props were demolished, in time, by the importation of wheat and meat from the New World and Australasia.

In the Middle East the improvement of agriculture is beset by even greater problems than the English improvers had to solve. On the social side, there are a number of related problems—all, unfortunately, fundamentally involved in the system of agriculture—arising from the system of land tenure and the social organization. On the technical side there is the over-riding influence of the climate, with its long, hot, dry season, and the many problems inherent in 'strip' and fragmented systems of farming. On the economic side, it seems unlikely, from the geological and economic information so far available, that there will be any great industrial developments, whose workers would provide expanding markets for the products of an intensified agriculture.

SOCIAL FACTORS: THE FEUDAL SYSTEM

Land tenure is based on a complicated and ancient system, and only its agricultural implications need be examined here. The social structure resembles the feudal system but, with few exceptions, those who have absolute or hereditary titles to any considerable area of land are, to all intents, absentee landlords. This seems to be often true even for tribal leaders who live with their people: their contribution to the husbandry of their tribe consists in levying a contribution in cash, or more usually in kind, on the products, without giving in return any effective leadership and guidance in agricultural matters. In the more settled areas a similar position exists. The landlord is a receiver of rent in cash or kind; he may even sell the right of collecting the rent to the highest bidder with obvious consequences to his unfortunate tenants; consciously, or unconsciously, he is in effect an exploiter of the land and his tenants. It is hardly necessary to point out that the blame for this disastrous state of affairs rests not with the individual landlord but with an age-old social system in which a sense of responsibility for the well-being of the land and its workers did not develop. The question whether the system could survive if this sense of responsibility were grafted on to it is in some respects outside the scope of this Report. But there can be no question whatever of the urgent necessity of attempting the operation, for history shows that if the problem of the absentee landlord is allowed to drift, it is liable to be solved by an agrarian revolution. The matter is discussed separately later (Chap. III, 3, *a*).

But not all the land is in the possession of large landlords; there are a number of peasant proprietors. In Egypt the 1933 figures showed that, although 39 per cent. of the agricultural land was held in estates of over 50 acres by 0·6 per cent. of the total number of landowners, no less than two-thirds of the landowners held, on an average, only two-fifths of an acre each.[1] Such minute holdings could hardly be economically sound, even if devoted to intensive vegetable and fruit production and aided by strong co-operative societies for marketing the produce, which is not the case. The consequence is that throughout the Middle East this class is in the grip of the money-lender. Although they own their land they have not the means

[1] From a paper prepared in the Research Branch of the British Foreign Office.

to improve it and are no better off than the small tenants of the large landlord who hold only an annual lease. The problems of raising the agricultural level and the well-being of these two classes—the small tenant and the small proprietor—are sufficiently similar to be treated together; this is done in Chapter III, 3, *b*.

TECHNICAL FACTORS

The technical disadvantages of the medieval system of farming are so well known as to need only brief mention here. The climate introduces a further difficulty because of the hot dry summer. Summer crops are, of course, grown in wide areas, but the moisture needed for their growth must be conserved in the soil from the previous winter's rainfall, and therefore during that period the land must lie fallow. Conversely, land that has grown winter crops must lie fallow in the ensuing summer. Hence a dry-farming system must be practised, except where irrigation water can be made available. However, just as with the social problems outlined in the preceding section, the biggest technical difficulties to improvement are a consequence of the system of land tenure. This system produces 'strip' farming and fragmentation of holdings. Particularly striking examples of strip farming are to be seen on the broad plain of north-east Syria, where some of the strips are only a few feet wide but up to a mile long. In itself, strip cultivation is only an inconvenience in a peasant agriculture whose economics is based on human and animal labour, although in its disregard of the topography and the slope of the land it may be, and often is, a potent contributory factor to soil erosion. The weakness of strip farming arises from the underlying system of which it forms a necessary part. In this system a tenant's holding is fragmented into a number of strips that vary both in time and place. Although it originated in the laudable desire to give him his fair share of good and poor land, it has the great objection that he has no real inducement to improve a holding that automatically passes to someone else after a season or so. He cannot grow a different crop from that on the adjoining strips, because it would be difficult or impossible to enter the strip to harvest and remove the produce, and after the general harvest the whole area is thrown open to grazing. The standard remedy which is usually applied to this state of affairs is individual ownership together with consolidation of holdings. The process is long and complicated. Where villagers have achieved individual in place of communal ownership their holdings are, in general, still fragmented; no agreement could be reached as to what area of poor land was equivalent to a given area of good land, so the villagers preferred to have their appropriate share in each class of land. Consolidation of this form of individual ownership into compact farms has to face the same difficulty, to which must be added those arising from uncertainty of boundaries, absence of legal titles, and the long delay and expense of the numerous appeals against the awards.

Even when settlement is eventually reached, there are further difficulties. The laws of inheritance and the freedom of the owner to sell the whole or part of his land lead, almost inevitably, to refragmentation of the consolidated holdings. Even without this complication, a number of the holdings will be too small (and in some cases too large) to be run as an economic unit. Families on such smallholdings will normally live below the poverty line unless they can get part-time employment on other farms or in town and village industries.

The problems of consolidation are thus formidable. They become almost insuperable in cases where the land is owned by one group of persons, the water rights by another group, and trees (e.g. date palms in Northern Province, the Sudan)

by yet a third, and where the laws of inheritance apply to each class of ownership. An individual may own one-fifth of a date-tree which is on someone else's land, one-seventh of another, which is on his own land; some of the part-owners may be local cultivators and the remainder residents in a distant town. This is the *reductio ad absurdum* of private ownership. Some alternative way to the laborious and unsatisfactory method of consolidation is needed, and it must fulfil two conditions: the rights of the existing owners must be recognized (the ultimate alternative to this is an agrarian revolution); the new holdings must be an economic size, and their future fragmentation or division must be controlled. In the next chapter this problem and a feasible solution are examined in detail. As long as the present difficulties remain, the many improvements that agricultural science has to offer must in great part remain unfulfilled. Thus, much better varieties of dates are available than those growing in the Sudan area quoted in the example above. But to replace an existing tree by a better one would first require agreement among all the part-owners, and no Government could justify the expense, time, and trouble that would be needed to obtain it. Analogous difficulties prevent the general introduction of many other improvements, even though they are of self-evident value and have been proved successful in similar soil and climatic conditions elsewhere.

INDUSTRY AND AGRICULTURE

Geological examination, although incomplete, shows that extensive mineral deposits suitable for industrial use are unlikely to be found. However, the large supplies of oil can provide a cheap source of power for the development of industries that can cater for an internal market. The main market for the more varied and higher-priced crops produced by an intensified system of farming must be found among the industrial and commercial workers in the towns; and, in turn, they produce and supply the consumer goods that will be called for by the higher cash income of the farmer.

The Jewish settlement in Palestine provides a large-scale experimental attempt to marry agriculture and industry. Beginning with the standard Arab system of agriculture, they have developed more intensive methods, and by 1939 the approximate position was as follows:

	Area, in 100 acres	*Value of production in £P.1,000*	*Value per acre £P.*
Arabs			
Citrus	366	1,600	43·7
Other produce . . .	15,383	2,998	1·95
Jews			
Citrus	383	2,400	62·7
Other produce . . .	1,100	900	8·2

The table shows that, excluding the citrus area, which is about equally divided between Jews and Arabs, the Jewish area has been made four times as productive per acre as the Arab area, but it must be remembered that a good proportion of the Jewish holdings are situated on the better-class land. At present Jewish agriculture gives gainful employment to about 15·4 per cent.[1] of the Jewish population, and the standard of the agricultural life is high. The system aims at high productivity and a high percentage of protective foods, coupled with the purchase of any balance of

[1] This was the figure obtained in a special investigation made in the middle of 1942 by the Statistical Dept. of the Jewish Agency. The aim is to raise the percentage to at least 20, and perhaps up to 25.

energy-producing foods needed. The key to the problem is the marketing of the protective foods, and for this an urban consuming population engaged in industries is needed. So far the only established Jewish industries are the agricultural one of citrus production for export and the extraction of chemicals from the Dead Sea. Because heavy industries can find no place in Palestine special attention is being given to lighter industries in which raw material is needed in small quantities presenting no transport problems and in which Jewish technical and artistic abilities will find scope. Diamond-cutting has become important, but this may not last when the Dutch centres are restored. A useful 'fashion' and dress industry is developing for the richer social centres, such as Egypt; and there are possibilities in the manufacture of scientific and surgical instruments, fine chemicals, false teeth, &c. The Sieff Institute for Industrial Research is actively exploring the possibilities of industrial development.

Agricultural intensification will itself promote the development of ancillary industries. Some crops require grading and various forms of processing before being marketed. Others, of which fibres and vegetable oil are obvious examples, are the raw material of many industries.

There has been one marked development in Persia of much significance: factories and equipment for processing various agricultural products have been installed on a considerable scale. They are large, modern, and efficient, and many are State-owned and operated. The most important are the group of factories for extracting sugar from sugar-beet. Sugar-beet is a relatively new crop in the country. Reliable figures for the yield of beet per acre are difficult to obtain, but the sugar content is stated to be about 15 per cent. Under the impetus of the late Shah it was grown on a very large scale, for the total capacity of the factories was designed to make Persia practically self-supporting in sugar. The factories are State-owned and operated. The State also owns seven modern wheat-cleaning and fumigating plants, whose product is superior to the village-cleaned article for milling. Of the dozen large flour-mills, two are State-owned. Among other State-owned and operated factories are canneries for meat, fruit, and vegetable products; the efficient tobacco and nicotine-sulphate factory of the tobacco monopoly; glycerine and vegetable-oil refineries; cotton ginning, jute, silk, and tea plants; and a factory for arsenical insecticides. No other comparable country in the Middle East possesses this range of large-scale modern equipment in the processing and ancillary industries of agriculture. Provided they are kept within the economic limitations of the particular crop, these developments are all to the good; agriculture is the industry of food production and, like any other industry, it can benefit by utilizing the resources of our modern economy. But agriculture is more than the industry of food production; it is also a way of life; and the unsatisfactory conditions of the primary producer have been shown up in even greater contrast by the developments just mentioned. The main task in Persia now—as in so much of the Middle East—is to balance these advances by a corresponding improvement in the standards of living for the agricultural population. As will be shown later in this Report, a combination of technical and sociological advances must be effected if the difficult task is to be accomplished.

But, although industrial and agricultural development should proceed together in any long-term programme, there are cogent reasons why, in the immediate future, special concentration should be given to the agricultural problems. The standard of subsistence is low, as already mentioned; but owing to the continuing high birth-rate and the marked decline in infant mortality and the death-rate, due to the

introduction of even rudimentary medical and health services, the population is rapidly increasing, particularly in Egypt, already densely populated, and in Palestine, where pressure on the land has also been increased by Jewish immigration. To varying degrees the same process may be expected throughout the other Middle East countries.[1] The combination of a rapidly increasing population with a system of agriculture capable of giving only a low subsistence level presages double disaster, for the already dangerously low living-standard would be further reduced, and the damage to the soil would be increased in the attempt to get more crops and keep more animals under the old methods. This is a compelling argument for giving special attention now to agricultural improvement, particularly in those countries where rural population density is already high. Further reasons arise from the post-war consequences of war conditions. In the Middle East, as elsewhere, the war actually improved the lot of the primary producer by creating a strong market for his produce and by absorbing much surplus labour from rural areas. Careful and far-sighted planning will be needed if this improvement is to be preserved after the war.

CHAPTER III

Methods of Raising Agricultural Standards

There are two main problems to consider. The first is how far, and by what means, improvements can be made in the existing system without altering its essential agricultural and social structure. The second is whether there are opportunities for developing better structures, and, if so, what form they should take. The division into two problems is a very real one, for although, on a long-range view, the first is included in the second, it is not expedient to introduce a new system in an area where the old one operates until it is ripe for an evolutionary change. The evolutionary process, however, is helped by an adjacent successful experiment. It is an ever-present demonstration to those living under the old system of what is possible under a new one. It is a large-scale utilization of a well-known fact: the habit of farmers the world over to 'look over the hedge' to see what their more successful neighbour is doing and how he does it, and then to copy it.

In practice, it is simpler to try new systems in areas that are relatively undeveloped and unoccupied, or in areas where, after the existing structure has disintegrated into chaos, a stable and authoritative administration takes over, as happened with the Anglo-Egyptian occupation of the Sudan. A number of undeveloped and lightly populated regions exist in the Middle East where conditions are reasonably suitable for developing new systems either at once or after appropriate reclamation measures. In Egypt the intense pressure on the land has already led to the draining of portions of the shallow Delta lakes, and work on further parts is in hand. In Syria there is a very big area in the north-east, running up to the Djezira, where more agricultural population could be carried than at present; the Euphrates valley offers considerable areas suitable for irrigation; the large marsh area, el Ghab, in the Orontes valley south of Jisr ech Chorhour, could be reclaimed and irrigated. The southern and central regions of both Iraq and Persia and various areas in the Sudan provide opportunities for closer settlement. In addition there is a considerable number of smaller areas such as the following: in Transjordan,

[1] See Dr. E. B. Worthington's *Report on Middle East Science*, chapter xv.

the region west of Ma'an, and Ghor Safi south of the Dead Sea; in Palestine, the marsh area of Lake Hula; in Cyprus, the Syrianokhori marsh near Morphu; in Cyrenaica, the Barce plain. These lists are not exhaustive but typical of the large and small areas available for development. Although only agricultural development is considered in this Report, the desirability of introducing inland fisheries in some of these areas, either as an alternative to, or in conjunction with, an improved agriculture, must be borne in mind (see Dr. E. B. Worthington's *Report on Middle East Science*, chapter xi).

An important addition to the regions already mentioned is made by the areas of State Domains and Waqf lands to be found in practically every Middle East territory. At present, with very rare exceptions, these are leased to an individual who offers an acceptable rental and who either farms them himself or sub-leases to smaller tenants; in either case they are almost invariably farmed on the traditional methods. State Domains and Waqf lands are usually free from the complexities of ownership and land tenure outlined in the preceding chapter, so it should be possible to use some of these areas for the trial of various schemes of agricultural development on a relatively small scale, and thus to gain valuable experience for the development of larger areas.

The two problems of developing new systems and improving the existing system are examined in turn below. The development of new systems is taken first, and is followed by a discussion of the lessons from these experiments.

(1) DEVELOPING NEW SYSTEMS

Fortunately, a number of large-scale agricultural developments already exist in the Middle East, and much valuable guidance for the future can be obtained from them. Below, a brief description and examination is given of the following:

Sudan: the Sudan Plantations Syndicate; the Government's Alternative Livelihood Schemes; the Gash Board.
Palestine: the Jewish agricultural settlements; the citrus industry; private farming.
Iraq: the Latifiyah Estates; the date industry.
Libya (Tripolitania and Cyrenaica): the Italian colonization.
Cyprus: the Co-operative Societies.

(a) The Sudan Plantations Syndicate, the Sudan Gezira.[1] The Gezira is the great triangle of flat land of five million acres lying between the Blue and White Niles. Its northern apex is Khartoum. The Gezira Scheme now covers one million acres, and is irrigated from the Sennar dam. It is operated on a share-farming system by a triple partnership of Government, Tenant Cultivators, and the Sudan Plantations Syndicate, whose basic shares are, respectively, 40 per cent., 40 per cent., and 20 per cent.

The rights of the original landowners of the area are protected. The Government has the power to rent their land from them for 40 years at 10 piastres (about 2*s.* 6*d.*) per acre, but the owners and their nominees have prior right to tenancies which are in single units of 40 acres. Provisions exist to prevent the fragmentation of holdings and sale to merchants or absentee landlords. The Government meets

[1] *Note.* This discussion of the Syndicate's activities was written before the Government announcement that the concession would not be renewed after its expiry in 1950. As the account is largely factual, and as termination of the concession at some date in the future was always envisaged, it has not seemed necessary to alter the text.

the capital, interest, and maintenance costs of the Sennar dam, canals, and drains, except certain short lengths at the head that are the responsibility of the Syndicate. The Government also maintains the Sudan Irrigation Department and meets the cost of the 10 piastres per acre rental paid to the original landowners. The Syndicate develops and levels the land, and provides control pipes in water-courses and lateral field channels, but recovers the cost from the tenant up to fixed maxima; it undertakes the management of the area, the supervision of the farming operations, collection, storing, and marketing of the cotton crop, which crop is the foundation of the whole venture. Other activities of the Syndicate are dealt with in the discussion below. The tenant has to maintain the water-courses and laterals, and meet his proportionate share of expenses considered to be common to the three partners, such as sacks, ginning, transport, and marketing, and he contributes also to the Tenants' Reserve Fund. Recently the cost of items such as the control of crop disease and certain agricultural operations that research has shown advisable, which would normally be the tenant's responsibility, have been shared in the standard proportions by the three partners. In addition to his share of the cotton-crop proceeds, the tenant's other crops—usually dura, for grain, and lubia, a leguminous fodder—are free of all claims. The present rotation is an 'open' one, i.e. it includes a proportion of fallow, as this has been found necessary to ensure a good cotton crop. The open rotation also gives a good dura crop, which is necessary for the contentment of the cultivators.

The heavy cultivation operations needed to prepare the land for cotton are done by the Syndicate with power implements and the cost is charged to the tenant. The eradication by deep cultivation of patches of Seid or nut-grass (*Cyperus rotundus* L.)—a pernicious tuberous weed—is also done by the Syndicate. The cost of this is charged to the General Tenant Account and is thus shared by all tenants instead of being met only by those on whose holdings the weed appears; it can be regarded as a kind of insurance premium that each tenant pays to meet the contingency of nut-grass infestation. The maintenance of seed quality, and the replacement of existing types by the better ones produced by research, is undertaken by the Syndicate. They have a staff of Inspectors who are responsible for the routine running of their areas. In the early years of the scheme urgent agricultural problems fully occupied their time, but in the later years the Inspectors have been able to help the tenants towards various corporate activities aimed at a fuller rural life.

The area under cotton reached before the war a steady level of about 200,000 acres. Its stability and the financial return to the three partners depend on the cotton yield and price obtained, and there have been anxious periods on both counts. But, on the whole, there has been a steady advance in prosperity. The satisfactory financial position of the Sudan is largely due to the revenues from the Gezira Scheme; before the war it contributed 25 per cent. of the gross revenue. The Government has, therefore, been able to finance improvements in other parts of the Sudan. The Gezira Scheme has also improved the food position of the country. Before the scheme began the five million acres of the Gezira produced yearly about 130,000 tons of rain-grown dura. Now, on the one million irrigated acres, about 65,000 tons of dura are obtained off about 100,000 acres.

The tenant has benefited considerably. He has security of tenure; skilled advice and guidance is available; the stranglehold of the money-lender and the merchants is lessened, for he can get cash advances on simple terms from the Syndicate, and the marketing of the cotton is done for him; and there is the vital point that it is

to his own interest to improve his holding. It has been shown that the average net profit of a tenant on the eve of the war amounted to about £40 per holding, plus his food crop; he is unquestionably much better off than a tenant on a private holding.

One point of special interest in its bearing on the position of women in the Sudanese problems of social emergence is that a number of the tenancies are held by widows of former tenants. This is not a new practice of the Syndicate, and experience shows that a number of the women tenants are quite successful.

Four criticisms have been made on the Gezira Scheme; it is founded on an export cash crop requiring extra labour at picking time and subject to world-market vicissitudes, and is thus necessarily an unbalanced system of agriculture in which livestock have not their rightful place; secondly, personal financial gain by the tenants has bulked too largely and their social life and welfare and communal responsibility have not progressed; thirdly, the Syndicate cannot overlook the fact that it has to earn interest on its capital for its shareholders; and fourthly, developments based on foreign capital may tend towards insufficient attention being given to the welfare of the people. The first two criticisms are, in some measure, corollaries of the last two.

(b) The Alternative Livelihood Schemes, the Sudan. The construction of the Jebel Aulia dam on the White Nile, to provide Egypt with extra water, has caused a riverain tract to be inundated by the waters of the reservoir. Some 70,000 families, living under tribal organization, could no longer practise their traditional livelihood. Their system of agriculture was to move inland with their animals when the rains broke and to sow rain-grown crops. After harvest they returned and grew crops on the moist land exposed by the falling river. Some of the compensation money paid by Egypt has been used to provide fresh centres for these people. Areas were selected in, and adjoining, the Gezira, above the reservoir level, and all had to be irrigated. The oldest, dating from 1936, is at Abd el Magid, and obtains water by a branch canal connected at El Qurash to the system served by the Sennar dam on the Blue Nile. By the beginning of 1944, 45,000 acres had been settled, and 35,000 more will be taken in. Nearly 2,000 families are on the settled area and a further 800 are on the temporary wheat-growing scheme, a war-time measure put in on the outlying areas. Other settlements are at Umm Garr, Ed Dueim, Fetisa, on the White Nile and pump-irrigated from that river. Umm Garr, the youngest scheme, dates from 1942.

The basic problem of the Alternative Livelihood Schemes is to turn semi-nomad tribesmen into settled cultivators practising an entirely new system of farming in a different area and environment from their traditional one, while maintaining the best features of a tribal organization and developing the corporate life of compact village groups. It is a joint agricultural and social task. The agricultural system is modelled closely on the Gezira Scheme, with cotton as the foundation crop, although it seems that in the initial stages of the scheme it was hoped that cotton would be less prominent. The rotation adopted is 'closer', i.e. less fallow, than in the Syndicate area, so the yield of the dura crop, which is important for the cultivators' contentment, may not be so large. The main administrative difference is that the Government itself undertakes the duties performed by the Syndicate in the Gezira Scheme and executes them through native agencies—described below—that are being developed by experience for this purpose. The tenants' share of the gross profits on cotton is 40 per cent., and the Government's 60 per cent., and the tenants' other crops are untaxed.

No large-scale cultivation machinery is used. Instead, groups of tenants have been encouraged to form co-operative societies for ploughing. Each society owns strong ploughing bulls and employs whole-time ploughmen; the tenants contribute in cash and in kind to a treasurer who is one of their number. On the technical side, the ploughing co-operative shows good promise of success; its value on the social side is in the encouragement it gives to further forms of co-operation.

As already mentioned, the development of a social and community spirit receives special attention in this scheme. The aim is to build on the basis of tribal discipline a society that is able to govern its internal affairs through the agency of elected representatives. Courts of discipline, tax collection, &c., have been regularized on the normal basis of tribal heads and district representatives, but there is an Administrative Sheikh for each village, elected by the inhabitants, who controls the discipline and tax collection and presides over the Village Council. An important development is the appointment of an elected Agricultural Sheikh for each thirty holdings. His duties resemble in some ways those of an estate agent, and he is the intermediary between the tenants and the Government Agricultural Officer, who acts as Adviser. The Agricultural Sheikhs together form a Court, which has powers to try cases of agricultural misdemeanour and to inflict fines, that are paid into the Tenants' Share Account. The Court meets the Adviser weekly to review the past week's operations and the next week's duties. The Adviser, accompanied by the Sheikh, inspects each group of holdings weekly to see that the tenants' work is correctly done and that the Sheikh is carrying out his supervisory duties.

There is a cess of 1 piastre per bag of cotton—the tenant paying 40 per cent. and the Government 60 per cent.—which is set aside as a Tenants' Welfare Fund. The fund has a local committee of management and is used for activities outside the normal scope of the Government. Suggestions come from tenants and include requests for wireless sets, a club house, adult education, child welfare, purchase of stud stock, &c.

The Alternative Livelihood Schemes, although young, have much promise of success. Applications for holdings greatly exceed the number available. Evictions average only 2 per cent. per annum. And, although the venture is much younger than the Sudan Plantations Syndicate, there are already two cases of a widow of a tenant being granted the vacant tenancy, and managing very well.

Three comments on agricultural aspects may be made. (*a*) The financial success of the scheme rests on cotton, just as the scheme operated by the Syndicate does. (*b*) Although the aim of the scheme is a cash crop (cotton) allied to mixed farming, the position of stock is not very different from that in the Syndicate's area, where, until recently, no special encouragement of mixed farming was attempted. The Alternative Livelihood tenants were animal owners and they brought their herds with them. The average is 10 goats, 3 cows, 6 sheep, 1 donkey, and 1 camel per family. Grading up and selection is necessary, but hardly possible under individual ownership, but a co-operatively owned herd, under a trained herdsman, on the lines of the successful co-operative ploughing scheme would be likely to succeed. (*c*) The development of the farming system could not have proceeded as rapidly and smoothly as it has but for the fact that much experience and technical knowledge was already available from the results of the Sudan Plantations Syndicate and of the collaboration between the Syndicate and the Sudan Government Gezira Research Farm at Wad Medani.

There are a number of other matters of interest. The scheme envisages less

direct supervision than in the Sudan Plantations Syndicate area, and it is to be expected that in the early stages the standard of husbandry will be lower, and that problems such as that of the absentee tenant may arise. The Syndicate canals are designed for day watering only, whereas the canals in the scheme area permit of both day and night watering. The latter requires more supervision, and a higher standard of integrity and communal spirit on the part of the tenant; otherwise, damage and disputes will occur.[1] The villages in the scheme are situated for the most part on the respective farming areas, which is sound in principle, but it is more important that they should be on the higher ground, even if that is some distance away, to reduce the risk of collapse in the rains. Finally, the Welfare Fund, that forms a prominent part of the scheme, is likely to have more useful outlets in a large than a small village.

(c) The Gash Board, Sudan. The Gash Delta is in the Kassala Province and lies in an area in the eastern Sudan, north of Kassala and adjoining the Eritrean frontier. It consists of alluvial soil deposited by the Gash, which rises, as the Mareb, south of Asmara in Eritrea. The Mareb is a flood river, the flow reaching Kassala between 20 June and 10 July and lasting, on the average, for three months. The flood is highly charged with silt, and care has to be taken to carry the bulk of it on to the irrigated land to avoid rapid silting-up of the canals. The method used is sheet irrigation, the land being divided into suitable parcels by low banks and fed by the field watering channels, or misqua. The soil varies from an alluvial silt to a black cotton soil. It is a rich soil, and the Gash-grown dura had formerly a great reputation in the Arabian markets. Cotton is now the main crop.

The present policy is to irrigate annually about 35,000 acres of land for cotton. The irrigated areas are divided into two blocks, one of which is irrigated 15–30 days before the other in order to spread the labour of sowing and cultivating over a wider period. One heavy watering only is given before sowing. Flooded land in excess of the area for cotton, and land that has had only a light watering, is used for dura or for grazing. In addition, the cultivator may have an area for rain-grown dura. He may grow 1 acre of dura for each 5 acres of cotton. The dura is his own property, and is free of all taxes or charges. The rainy season is from May to September. The average fall at Kassala is about 13 inches. The bulk of the fall coincides with the flood period of July–September. The rains during the flood period are liable to complicate irrigation control, besides encouraging the growth of weeds and delaying the cleaning of the irrigated land.

During the flooding of each area careful maps are made of the spread of the water and, on the basis of the final map, allotment of areas is made to the cultivators. The normal unit is 5 acres, but capable cultivators will receive up to 50 acres. Allotment is on a tribal basis, sheikhs and sub-sheikhs being given a block which they divide out among their tribe. Satisfactory tenants are assured of continuity of tenure. Weed growth is heavy and a rotation of cotton–fallow–fallow has to be used, instead of cotton–fallow, as originally proposed. Owing to the soil fertility and the deep penetration of the irrigation water, the cotton plants grow to a height of 6 feet (2 metres) or more; the optimum spacing is about 39×43 inches ($1{\cdot}0 \times 1{\cdot}1$ metres), which is considerably more than that used in the Gezira. The quality of the cotton lint is excellent, and diseases and pests do not present serious problems. Leaf curl has been noted from 1928–9 onwards, especially on Sakel cotton. Pink bollworm, thrips, and cotton aphis also occur, but blackarm is never

[1] It has even been said of one Middle East country that more murders are due to disputes over night watering than to any other single cause.

severe. Occasionally crickets and grasshoppers attack the cotton seedlings, and resowing is necessary. Smut and the stem-borer attack dura, which may also suffer from locusts and birds. Advantage is taken of this comparative freedom from diseases by using isolated areas in the Gash for the bulk multiplication of the cotton types sown in the Gezira.

From the viewpoint of the present Report, much interest attaches to the history of the development of cotton-growing in the Gash area. In 1923 the Kassala Cotton Company was formed and a 40-years' agreement with the Sudan Government was signed. The Government, who owned the land, undertook to compensate the tribesmen for existing cultivation rights, to arrange alternative grazing-areas, and to maintain watering rights at the wells in the concession area. The Company undertook to provide a staff for instruction and supervision, and to allot tenancies to applicants approved by the Government, with preference for local people. A cess of a halfpenny per pound on all lint cotton was set aside, and one-half of this sum was available for financing schemes, jointly approved by Government and the Company, for the general benefit of the tenants. Division of the profits on the cotton sales, after appropriate deductions, was fixed at 50 per cent. for the tenant, and 50 per cent. divided as follows between the Government and the Company:

	Government	*Company*
Cotton crop up to 40,000 kantars .	20	30
The next 20,000 kantars . . .	25	25
All additional cotton	30	20

(a kantar is approximately 99 lb. or 45 kilos.)

After four years the agreement was terminated and the Company transferred its activities to a new concession in the Gezira. It appears that they were disappointed with the prospects in the Gash, partly because better cultivators than the local people, who were mostly hillmen, were available, whereas the Government view was that development should be done primarily in the interests of the local inhabitants.

The situation was closely examined by the Government, who decided to run the area themselves. They accepted the principle that development of the area in the interests of the local people could not be on a sound basis unless the undertaking was run on commercial lines for the purpose of making profits, and that, therefore, the success or failure of those responsible for its management was to be judged by the showings of a properly prepared profit and loss account. The device adopted was to set up a Board, with capital subscribed entirely by the Government, and with its accounts kept in ordinary commercial form and isolated from the rest of the Government accounts. The Board is composed of three *ex-officio* directors: the Director of the Department of Agriculture and Forests (who acts as Managing Director of the Board), the Director of the Irrigation Department, and the Governor of Kassala Province. The Resident Manager and the Irrigation Engineer are seconded from the staffs of the Agricultural and Irrigation Departments. The Government acts as banker to the Board, so that certain proposals, e.g. capital expenditure exceeding £500 from Reserves, require the approval of the Financial Secretary to the Government. But, in general, the affairs of the Board, including the sale of spot cotton and future contracts, are controlled by the Managing Director in accordance with the policy approved by the Board and the Financial Secretary. The Board's percentages of the net profits are the same as those to which the Company had been entitled.

The arrangement has worked exceedingly well, and the Board now looks after the interests of about 7,000 tenants. Some 70 per cent. of the area is still farmed by the indigenous tribes, who were recently pastoral but are becoming successful settlers. Riverain people, mainly seekers of fortune from the Nile valley, occupy 5 per cent. of the holdings; technically, this group is the best, as its members work hard and are adaptable. The remaining 25 per cent. is in the hands of West Africans, who are industrious and seldom resort to hired labour. These people are mostly from Northern Nigeria, and have reached the Sudan along the pilgrim route to Mecca.

The progress made is reflected by the history of the original halfpenny in the pound cess. This was divided into two equal portions: the tenants' equalization and reserve fund, and the Gash Board reserve fund. The former is used in the direct interest of the tenants. Its main purpose is for equalization, to be carried forward from one year to the next so that, in bad years, something can be added to the tenant's return, thus avoiding (unless a succession of bad seasons should render it essential) changes in the statutory tenant's-share percentage. The use of the equalization fund for levelling out these oscillations is an important contribution to the stability of the whole scheme, for all experience goes to show that the progress of tenants who are still in the stage of agricultural and social tutelage is as adversely affected by doing too well for a time as by not doing well enough. By 1943 the tenants' equalization fund had accumulated £100,000 in reserves, which the Board considers adequate. Money in excess of this is now devoted to suitable welfare objects approved by the Board. A local Consultative Committee has been set up, part of whose duties is to recommend proposals to the Board.

The Gash Board reserve fund is also in a sound financial position. Part of its reserves are to be transferred to Capital Account. The effect will be to increase the Government revenues; hitherto these have not been commensurate with the reasonable taxable potentialities of the area.

Two comments relevant to the present Report can be made on the venture. In the first place, it is obvious that the scheme would be impracticable—or worse—in any country not possessing a Civil Service with high traditions of integrity in addition to the necessary technical qualifications. Granted this, the second point follows naturally; it is that situations are certain to arise when the Government will have to weigh political considerations against commercial advantage, and it is imperative that the commercial interest should be properly and adequately presented. The scheme provides for this, for the Resident Manager, although working in close touch with the Governor of Kassala Province, is directly responsible to the Director of Agriculture in his capacity as Managing Director of the Board. Therefore if any differences of opinion arise the Government can make its decision with both sides of the case before it.

(d) The Jewish Agricultural Settlements, Palestine. In what follows attention will be confined as far as possible to the purely agricultural aspects. The political ones are excluded, and so are the sociological ones except in so far as they bear directly on the technical and economic problems of the agriculture.

The historical development of the settlements from cereal growing to mixed farming was very briefly summarized in Chapter I. In 1937 the various types of settlements covered 95,000 acres, occupied by some 10,000 families, or 34,000 individuals. The settlements vary considerably in their systems of agriculture and in their economic and sociological organization. For these reasons, coupled with

the magnitude of the experiment, much valuable experience[1] has been accumulated which could be used to guide developments elsewhere in the Middle East. The experiment has been well documented, especially its later stages, but the exposition and discussion are not always objective: nor could a wholly dispassionate and impartial treatment always be expected, by the nature of the case.

The Jewish agricultural system and the sociological framework of their colonies are closely connected. The land belongs to the Jewish National Fund and is leased to settlers on hereditary perpetual lease under special conditions. Jewish agricultural settlements are of two main types, collective and small-holdings. The former vary in size from a small collective group (Kvutza) to a large one (Kibutz), for 40–200 families who, as a single group, run one large farm or, more accurately, an estate, whose social and economic structure resembles that of the Russian communal farm (Kolkoz). The latter type, the small-holdings, are essentially co-operative settlements; each family independently runs its own farm, with a well-developed co-operative system for its products and requirements. In this class there is the moshava, a group of independent farmers (see section *f*, below) and the moshav, a colony of the Agricultural Workers' Association. The objects of this Association are briefly discussed at the end of the present section.

A very important point bearing on the development of the colonization is that the Jewish authorities rejected the idea that the standard of living of the colonists should be that dictated by the economics of the farming system at any given time. Instead, they fixed a satisfactory minimum standard and endeavoured to evolve a farming system that would sustain it and that could be worked without hired outside labour.

The original agricultural system, which followed the Arab practice, was based on a winter cereal. Later there were marked advances towards mixed farming. However, for technical reasons, cereals are important and inevitable crops in many parts of Palestine (and therefore, for climatic reasons, in much of the Middle East). The reasons are that winter pulses as an alternative to cereals are associated with low yields and low prices; and summer crops are risky, because if the winter season has been wet the land will be very weedy, and if dry, the crops will be poor. Cereals have, in fact, continued as part of the Jewish farming rotation, where they now represent 11 per cent. of the farm income, as against over 50 per cent. in the Arab system. The yields have also been increased, by improved varieties, the use of manures, &c.; compared with the Arab average of 5·6 cwt. of wheat and 4·7 cwt. of barley per acre, they are respectively 8·8 cwt. and 12·3 cwt. Of more significance is the method of cultivation. Cereals lend themselves easily to mechanized sowing and harvesting and, especially on the collective settlements, these methods have been adopted, with an appreciable economy in the amount of human labour needed for this crop. At first sight this would seem to conflict with the Jewish policy of settling the maximum number of workers on the land, but the explanation is simple. Although for technical reasons cereals cannot easily be avoided, they represent a small proportion of the farm income; more labour is needed and more profit is given by other crops. Hence, wheat is grown everywhere by the cheapest available

[1] The Jewish Agency has published two most informative and detailed publications: *Planned Mixed Farming*, by I. Elazari-Volcani, the Director of the Agricultural Research Station at Rehovot (Palestine Publishing Co., 1938), and *Economic Survey of Palestine*, by D. Horowitz and Rita Henden (Economic Research Institute, Tel Aviv, 1938).

method: mechanization in the Jewish agriculture, and cheap human and animal labour in the Arab system. The contrast in methods is brought out in the following table:[1]

	Per cwt. of wheat		
	Working days		*Other expenses*
	Human	*Animal*	*£P.*
Jews	0·3	0·1	0·59
Arabs	2·8	2·9	0·12

The move from wheat towards diversification—still on non-irrigated land—faced, as its main problem, the raising of the soil fertility. Artificial fertilizers were used, and attention was given to improving dairy cows to increase the milk yield and to obtain more organic manure for raising the yield of the fodder crops that would be required. Native cows, specially those from the Beirut and Damascus areas, already used by the Arabs for dairying, were crossed with imported Friesian bulls. This cross is now the standard in the Jewish settlements. Subsidiary experiments were made with poultry, leading to the adoption of the pure White Leghorn, and with fruit, especially the olive, almond, and wine grape, but without full success. Nor was any satisfactory solution found for the basic problem of fodder crops. It was still necessary for the farms to supplement their fodder by purchase from outside. Throughout this period of non-irrigated development the unit area for the labour of one family was around 25 acres.

Subsequently, irrigation farming was introduced and the unit area per family was reduced to 5–8 acres. The wider freedom of cropping possible on irrigated land was fully exploited: irrigated fodder; diversified rotations, to level out the peak demands for water and labour; the production of surplus milk, eggs, vegetables, and fruit for sale. Methods of irrigation were also examined, and overhead (or spray) watering finally adopted as standard (Chap. IV, *d*).

The farms themselves were also diversified. Three main types were evolved. The type differing most from the original system is a combination of dairy, poultry, vegetables, and fruit, with a minimum of field crops; in order, these contribute to the cash income approximately 45 per cent., 13 per cent., 15 per cent., 20 per cent., and 7 per cent. There are two other types, one primarily arable with a variety of legumes, oil seeds, and cereals, and the other, in which these crops are grown between trees such as olives and carobs that are suited to wide spacing.

In addition to these types, there are others in which there is both unirrigated and irrigated land, and the unirrigated fruit-farms in the hills, growing grapes, olives, and deciduous fruits.

The maintenance of satisfactory living standards in the settlements, and the avoidance of hired labour, focus special attention on the economic aspects. The pioneering nature of the experiment and the lack of previous agricultural knowledge in most of the settlers inevitably meant high capital and running expenditures. Thus the cost of rearing a cow to the time of her first calving at the age of about 2½ years was nearly £63 in 1927, and the cost of producing milk, exclusive of interest on capital, was about 1*s.* 9*d.* per gallon on the farm.[2] In 1928 attention was drawn to this in a report made to the Empire Marketing Board by visiting experts, for the costs were double those of countries exporting dairy produce. Since 1927, although better quality cross-bred stock with higher food requirements have become general, the extension of irrigated fodder and reduction in concentrates, com-

[1] *Economic Survey of Palestine*, Horowitz and Hinden.
[2] *The Dairy Industry as a Basis for Colonization in Palestine*, I. Elazari-Volcani, 1928.

bined with more efficient use of labour, have reduced the costs appreciably: figures supplied by the Rehovot Experiment Station show that the cost of rearing a cow had been brought down to £41 in 1938. This is an encouraging achievement, and it can be assumed that comparable reductions have been made in other branches of the industry. It should stimulate further efforts to close the gap completely, for in the long run the standard of living of any agricultural community cannot exceed the capacity of the agricultural system to sustain it.

Reference was made above to the Agricultural Workers' Association. This is not, as its name might imply to British readers, a trade union of agricultural labourers. Originally it was an organization for the early colonists, most of whom were without previous agricultural experience. Its functions have extended since then, and besides the activities outlined below, the Association is able to ascertain and express the views of the colonists to the Jewish authorities. It now has branches in some 150 centres, half of which are in co-operative settlements. It deals through a central elected executive with settlement questions embracing arbitration, wages, and technical matters including courses of agricultural instruction; it negotiates with the Jewish authorities for new settlements, particularly on land and budget questions. Its other activities are considerable. Tneuva, its distributive co-operative, deals with over 60 per cent. of the total Jewish output. It has also a supply co-operative, a mutual insurance company, and it runs a cattle insurance fund jointly with the Jewish Farmers' Federation, which is a body that looks after the interests of the independent or private farmers (section *f*, below).

(e) The Citrus Industry, Palestine. Palestine citrus has experienced in full measure the vicissitudes that often fall on monoculture crops grown for the export market. In the initial stages the article has either an intrinsic luxury value or a scarcity value; in both cases capital is attracted, the area under cultivation rapidly increases, and the luxury of yesterday becomes the bulk-supply of to-day. Larger quantities have to be disposed of at a lower price if a profit is still to be made, which calls for the special development of marketing, grading, advertising, and other co-operative organizations at a time when, for various reasons, many growers oppose these necessary developments. The market may become over-saturated, due to restrictions such as quotas and tariffs, or to genuine over-production. There is a lag of about seven years before the newly planted citrus-trees come into fairly full bearing and, by then, economic conditions have usually changed appreciably. This situation especially affected Palestine because of the rapid expansion of the area under citrus: in 1938 half the area had not yet come into full bearing. In the war years that followed there was an increased crop at a time when ships to export it were practically unobtainable. Palestine citrus has had to meet these hazards as well as internal difficulties. It is of interest to note that the political and racial troubles culminating in the racial disturbances in the years before the war did not prevent Arab and Jew co-operation with the Government in the arrangements for export marketing: over this period the citrus exports were fully maintained.

There are a number of special technical problems. The marketing season for the Jaffa (Shamouti) orange—the main type—begins in October and lasts for barely four months, because after that period the fruit deteriorates. There is a further period of two months during which Valencias can be exported, but by May fruit-fly infestation has come in and summer export is precluded. The full season, therefore, is about six months. Although co-operative marketing from the Jewish plantations is very well organized, the produce of the Arab plantations—which supply about half the fruit—was handled prior to the war by a considerable number

of dealers and middlemen; as late as 1938 there was not a single Arab co-operative society. This lack of uniformity of method in dealing with a single export crop has been a severe handicap to the industry. It has not mattered so much for fruit sold in the country for local consumption, but the internal market can absorb only a small fraction of the crop; the bulk must be exported, and the short shipping-season for this market is apt to cause a glut which can only be mitigated if the crop is handled as a whole. During the war the Government has been able to introduce measures that have much improved the situation, and it is to be hoped that the experience so gained will be utilized by the industry in its post-war arrangements.

By 1943 war-time difficulties had reduced the citrus area from 75,000 to 68,000 acres[1]—the bulk under Jaffa oranges, about one-tenth under grapefruit, and less than 2,000 acres under lemons. A survey of the coastal plain shows that if water supplies are adequate and economic conditions are suitable, an area of 125,000 acres would grow citrus: 85,000 acres of oranges on the light soil and 40,000 acres of grapefruit on the heavier soil, on which, contrary to earlier belief, it grows quite well. But this would seem to be a disproportionately high area under grapefruit, which is a luxury article with a rather restricted market.

The fact that the Palestine citrus industry has survived throughout all its troubles strongly suggests that it has a permanent place in the agricultural system of the Middle East. Certain marginal plantations will, no doubt, be eliminated and other land brought in before stability is achieved, and citrus by-products and processing industries will develop as an integral part of the industry.

The question of the maximum economic area cannot be answered until post-war market conditions become definable. Just before the war there was considerable evidence to suggest that the area then under citrus had reached the optimum.

(f) Private Farming, Palestine. It has been convenient to deal separately above with the agricultural aspects of the farm colonies and with the citrus industry. The creation and development of the farm colonies has been one of the important activities of the Jewish Agency in their task of settling, in Palestine, immigrants with no previous agricultural experience who, particularly in recent years, were permitted to bring little if any money with them to start their new life. But the agricultural development of Palestine and the growth of the citrus industry have been due in a considerable degree to private individuals who brought capital with them for the purchase and development of their own holdings. Of the citrus area in Jewish hands over 80 per cent. belongs to private farmers, and their activities in general agriculture, especially since the outbreak of the war, are shown in the following table:[2]

	1939	*1942*
Number of farms	1,880	3,470
Cattle	5,950	8,775
Goats (pure bred)	290	1,990
Poultry	160,000	390,000
Vegetables (acres)	1,025	1,375
Potatoes ,,	150	1,575
Cereals ,,	18,750	26,500

As private farmers they use hired labour—both Arab and Jew—unlike the collective and co-operative colonies. The great majority of the farmers belong to the Jewish Farmers' Federation, founded in 1923, whose membership in 1943

[1] *Statistical Abstract of Palestine*, 1943, 7th. edn. (Government Press, Jerusalem, 1943).
[2] Supplied by the Jewish Farmers' Federation.

was approximately 4,000. The Federation has built up co-operative societies to serve its members. Marketing and supplies are handled by the Farmers' Company in Palestine Limited, citrus by the Citrus Marketing Corporation, wines by the Rishon Co-operative Society, and a long-term credit organization—the Farmers' Mortgage Corporation—was established before the Government-guaranteed organization was set up. Advisory, cultural, and educational activities have been developed. In 1935 the Federation established a secondary school with an agricultural bias at Pardess Hanna near Haifa. Up to 1943 it was the only one of the four Jewish secondary schools whose passing-out standard in academic education was accepted by the Hebrew University as equivalent to its matriculation and was thus the only school from which students could be admitted to the Agricultural College of the University at Rehovot. On the advisory side the Federation is giving special attention to the means for diversification of agriculture to improve the economic position of the smaller citrus groves.

It is apparent that the Jewish Farmers' Federation represents an unusual development of co-operative activities among independent farmers having adequate capital resources, a class that, in general, does not readily take to this type of organization.

(g) The Latifiyah Estates, Iraq. This Company purchased 60,000 acres from the Government in 1928, and has leased a further 10,000 acres. The estate, which was desert land, is 26 miles from Bagdad, and lies between the Tigris and Euphrates rivers. All told, 60,000 acres are now watered from flow or pump irrigation: the remaining 10,000 acres are for various reasons uncultivable. The cost of canal construction was paid by the Company.

The cropping system is based on half the land being fallow each year—the standard Iraqi practice (Chap. I, *e*). The winter crops are cereals, with barley predominating; the summer crops are sesame, millet, and some cotton (largely replaced by food crops during the war). Unlike Egypt, the flood season comes in April–May, i.e. at the harvesting time of the winter crops, and the low-water period comes when the summer crops need irrigation. The acreage of summer crops is, therefore, restricted—it is about one-sixth the winter crop area—and there is no present possibility of increasing it, as the available water is needed for the rice crop in the Delta.

The purpose of the fallow is to reduce the danger of deterioration in the absence of drainage, and to rest the land so that it may recover in fertility. Fertilizers are too costly for use, so a leguminous crop, green gram, is often sown on the wheat and barley stubbles.

The main live-stock, except for working-animals, is sheep, but the numbers are limited because of feeding and grazing difficulties.

From the viewpoint of the present section an important aspect of the Latifiyah scheme is the change in policy since the early stages of development. Originally it was managed on 'plantation' lines: direct extensive cultivation with machinery, and the employment of daily wage-earners. But machinery and resources were inadequate, and the workers, who were unused to a daily wage, were apathetic and required too much supervision. A system of tenant farming was therefore introduced with much more satisfactory results. The unit is 20 acres for winter crops, plus a maximum of 5 acres for summer crops. The head of a family group may take a number of units for the families under his control, but they are registered as partners in the lease, and the danger of the absentee landlord is met by the provision

that the head of the group must reside on his area. The Company offers certain services to the tenants, such as threshing by machinery and power cultivation. Rent is taken in kind and is about 50 per cent., the exact figure depending on the type of land, the irrigation facilities, and services rendered.

(h) The Date Industry, Iraq. This is an old-established industry, practised along the narrow strip of land bordering the Shatt el Arab in southern Iraq. The water is obtained by tidal irrigation running directly into the ditches from the Shatt el Arab on the flood tide. The lower level of the ebb tide provides the necessary fall for an adequate drainage of the irrigated land. The dates produced in this area have a deserved reputation for quality, and command the world export market. There is a considerable number of varieties, and there is a relation between the various export markets and the varieties. Although there is little published information on date culture, a considerable fund of empirical knowledge and experience exists. The groves vary from large estates to small-holdings. The best groves are well run, and advantage is taken of the protection against sun and wind given by the trees to intercrop with cereals, vegetables, and even with citrus. A tree lasts, on the average, for 20–30 years. They are felled when they grow above the general canopy level, as then the fruit ripens too quickly. Fresh trees to replace the old ones come from offshoots. Pollination is by hand; pollen dust, or more usually a stalk of male flowers, is placed within each bunch of female flowers. One male tree is grown for every 20–30 females.

The total number of trees in the 350 square miles of the date-grove area along the Shatt el Arab is about six millions, and the average yield is 1 cwt. per tree.

Collection of the produce, grading, packing in different forms for various export markets, fumigation, and marketing are largely in the efficient hands of two big trading concerns under British management.

(i) The Italian Developments, Tripolitania and Cyrenaica (Libya). Although the settlements in Libya were primarily, in recent years, an expression of Fascist policy and politics, the agricultural and economic aspects of the attempt by the Italians to develop the area merit an objective examination.

The first stage began around 1920 by the granting of concessions of land, some of a large area, to individual Italians who had, or could command, capital for development. A brief description of one of the largest—Jung's concession near Sidi Gibrik, about 8 miles south of Barce, Cyrenaica—will serve to show the general pattern. It has 6,000 acres of land with grazing rights over a further 50,000 acres, and it carried 10,000 sheep and goats and 2,000 cattle and horses. Some 50,000 almond- and 5,000 olive-trees were planted. Large covered cisterns were constructed or renovated throughout the estate to collect run-off water from adjacent slopes, for watering the stock. Both soft wheat (Capelli) and hard wheat (probably Mofrai) and also barley were grown, on the usual two-year rotation of crop–fallow. Fertilizers—cyanamide and phosphates—were used, but the effect on the yields is unknown as some of the estate records are missing. The buildings consist of a modest house for the manager, extensive farm-buildings including a large workshop, and five small houses, each with a small vineyard, and presumably intended for small-holder colonists who would also act as part-time foremen.

Some other concessions, such as Cremonini's at Cerasola near Barce, were laid down to peaches and grapes and irrigated vegetables. Yet others, such as Calo's at Gasr Chear, midway between Tripoli and Homs, and Volpi's near Misurata in

Tripoli, include wine-making in their activities. Thus, Calo's 7,500-acre concession has two-thirds of its area planted with almonds, olives, and vines; the wine factory contains thirty-six large concrete vats. There is also an irrigated citrus area, surrounded by tamarisk wind-breaks. The rest of the concession is down to wheat and barley, grown by Arab cultivators on a half-share basis.

From the technical and economic aspects, these estates were quite sound. Almonds, olives, and vines do well, the arable land was under a suitable rotation, and arrangements for live-stock were satisfactory. They are, of course, examples of the so-called 'plantation' type of development in which agriculture is regarded primarily as the industry of food production; the conception of agriculture as a way of life takes second place or may not enter at all.

Before dealing with the Italian colonies a description may be given of a privately controlled scheme intermediate between them and the individual concessions discussed above. The moving spirit was Count Marzotto, a wealthy Italian industrialist, who formed a society (Società Anonima 'La Valdagno') with a capital of 15 million lire (£160,000). A concession of about 4,500 acres was taken at 'La Valdagno' near Homs in Tripolitania and settlement began in 1938. It was laid out for 33 colonists' holdings each of 27½ acres, and included 1,000 acres of vines and olives, about half of which is irrigated, and run under the direct management of the Society. The colonists share no part in them but can be employed and paid to tend them. In addition to the area under vines and olives, about 600 acres have been planted with trees—eucalyptus, acacia, and pine—with the object of providing timber for sale and fuel for the colony. A communal centre, with buildings ranging from a hospital to an electric power-station, forms part of the scheme, but these, as well as 10 of the 33 homesteads for the colonists, had not been completed when the war stopped further work. Agriculturally, however, the estate is fully developed: the 23 holdings are being farmed by the colonists, and the remaining 10 by the Society direct.

Each holding has 2½ acres of olives and 1¼ acres of vines. Arable crops occupy about 12 acres. Wheat and barley are grown as winter crops, and in summer, tobacco, ground-nuts, millet, and maize. Lucerne is a prominent feature of the rotation. Each year 2½ acres are sown for a three-year ley, so that, in any one year 7½ acres are under this crop. There is also 2½ acres of fallow each year. A typical rotation is:

1st year,	Lucerne	6th year,	Tobacco
2nd „	„	7th „	Barley or wheat
3rd „	„	8th „	Ground-nuts
4th „	Wheat or barley	9th „	Maize or millet.
5th „	Fallow		

The arable cropping depends largely on irrigation, for which a simple and efficient scheme was worked out by the first manager. A canal is used for the primary supply only; thereafter the water goes by covered pipes along the short side only of the irrigation squares, whose dimensions are about 100 × 50 yards. Experience has shown that the irrigation water can be led from one square to adjoining ones without danger of soil wash or other ill effects. Thus, economy in land and costs has been secured.

The farm-buildings include a cow-byre, storehouse, manure and silage pits. The number of live-stock per holding varies from 4 to 10 cattle, with a horse, poultry, and rabbits; sheep and goats are not kept, nor, up to the present, pigs.

The well-tended farms, on an area that previously was rough grazing-land, show that on the technical side the enterprise has been unquestionably successful. The homesteads are larger and better than the usual run of colonists' houses. They are built on each side of the main avenue which, with its lines of flowering trees and the colourful gardens of the houses, is exceedingly attractive. The obvious contentment of the colonists suggests that the venture is also sound financially; it is known that they—and therefore the Society—made good profits in 1943 and 1944, but a longer period under more normal economic conditions will be needed to settle this point.

The colonists work under a simple contract. Their first year is probationary, during which they are paid a wage and receive a one-fifth share of the produce they grow. Thereafter they work on a half-share basis. The Society receives half of all produce and pays half of their expenses, including electricity, water, live-stock, and tools. They do not acquire any rights to the land nor to permanent improvements. They may leave, and the Society may give notice to leave or may evict. Since 1938 there have been four evictions, but no families have given notice to leave, and there is a long waiting-list of applications to join.

This interesting experiment brings out two useful points. The first is that much of the success depends on the resident manager, especially in the early stages (the colony was fortunate in this respect); the second is that ultimate ownership of the holding is not an essential feature of successful small-scale farming.

However, the scheme of the Italian Government for colonization, pursued with great vigour from 1932 onwards, provided for ownership of the holdings by the settlers. The Government purchased the land, erected the range of central buildings—church, school, shops, administration, &c.—and provided money for roads and wells. Control and development into colonies then devolved on one or other of two societies: Ente della Colonizzazione della Libia, or Istituto Nazionale Fascista della Providenza Sociale, the latter being a privately owned insurance company which undertook the work as a business investment. The societies cleared the land, built the colonists' houses and farm-buildings, laid out the farms, provided the stock and equipment, and developed the water-supply. The ideal aimed at was to have everything ready, even to house furniture and food in the larder, for the colonists and their families when they arrived.

The financial arrangements for the colonists were more elaborate in the case of Ente colonies than in the Istituto schemes. In the latter the colonist became immediately the titular owner of his holding. Istituto bore all the costs of development which were debited against the colonist; it also disposed of his entire produce and credited him with the net value. The Ente scheme provided for three phases. In the probationary period of one or two years all produce was the property of Ente and the colonist was paid a living wage. In the second, or crop-sharing period, development expenses were still borne by Ente, but the crop was shared equally, the value of the share of Ente was credited against the colonist's debts. In the third or purchasing, phase, which was expected to last for 25–30 years, the colonist sold his crops and paid all the expenses, and also paid a fixed cash sum annually to Ente until his indebtedness was cleared.

Within each settlement the farms are uniform in area, but vary considerably from one settlement to another. They range from 25 acres, all irrigated, to 62 acres of which 12 are irrigated, and 75–150 acres for dry land farming. The number of farms in a colony ranges from 20 to nearly 300.

Although the scheme was intended for the settlement of Italians in Libya, three or four small colonies were prepared for Arabs, laid out to the same general plan, with a mosque included in the central buildings.

Altogether about 2,000 holdings in some 18 colonies, and occupying 145,000 acres, of which 16,000 acres were irrigated, were established in Tripolitania from 1935 onwards. In Cyrenaica there were about 1,700 small-holdings. Four settlements were well established, but a large proportion of the holdings were on the Barce plain and were not ready for occupation when the war broke out.

Because of its history and associations the Libyan settlement has aroused undue praise and criticism. Before dealing with these it is as well to put its agricultural achievements into a proper perspective. All told, about 250,000 acres were developed or prepared for development, only a small proportion of which was irrigated; whereas in the Sudan Gezira the combined area of the Sudan Plantation Syndicate and the Kassala Cotton Company extends to one million acres of which 800,000 are irrigated. Criticisms based on political aspects do not fall for discussion in this Report. But it is necessary to point out that the admittedly unsatisfactory conditions of many of the settlements is largely due to the haste with which they were set up and colonized in 1938 and 1939, in the attempt to meet the orders of the Italian Government for a greatly increased rate of settlement. There were other adverse factors: there was an unnecessary number of minor official posts; most of the better-class land was already in the possession of private concessions; the farming policy was dictated more by the needs of metropolitan Italy than by considerations of what was most suitable for the local soil and climate. Again, problems of water-supply would probably have become increasingly serious. In some cases artesian water from 1,000-foot bores had been tapped and used, as in the Crispi settlement, south of Misurata. In other settlements a water-table which varies in depth from 60 to 120 feet and which, although not fully mapped, appears to be extensive, had been reached by wells. But there are signs of decreasing supply and, in places, the water is becoming saline. The cost of irrigation is also heavy. Thus, at the Olivetti settlement about 30 miles west of Tripoli, where 72 acres of the 75-acre holdings are irrigated by electric pumping, electricity is supplied at a special uneconomic rate of 2 liras per kilowatt (about one penny per kilowatt at the present rate of exchange). The present economic charge would be nearer 9 liras per kilowatt, and, as it is, it costs the settler 20,000 lire (about £40) per annum. In Cyrenaica the acute problem of domestic water-supply for the settlements had caused the Government to begin a scheme for a pipe-line from a source at Einmara, near Giovanni Berta, about midway between Cirene and Derna. Besides the cost of the pumping-station, a number of booster stations were needed at intervals along the pipe-line because of the distances involved; in view of the limited market the scheme must have been quite uneconomic.

Nevertheless, in its original conception, the colonization scheme had some commendable features. It is a 'demographic' settlement, as the family and not the individual is the unit. Hired outside labour was forbidden, because the farm was designed for operation as a family unit. The immigrants were of peasant stock, and had to be healthy, of good character, and literate. Before the hurried mass immigration of 1938 and 1939, some care was taken to place settlers in areas where the farming system bore some resemblance to the one they knew, and instruction was given in the modifications required. The provision of a centre for the community, with educational, welfare, and other facilities smoothed the difficulties of transition, and provided a focus for a communal and civic outlook appropriate

to the new conditions. Although the scheme was devised for the purposes of immigration to another country, the features mentioned should be generally applicable to any new settlement within a country by its own nationals.

(j) Co-operative Societies, Cyprus. The development of co-operative societies by communities of peasant farmers for obtaining credit facilities for the sale of their products and the purchasing of household and farm requirements is hardly feasible unless the peasants own their farms or hold them under a tenancy agreement such as the one used in the Sudan Alternative Livelihood Scheme. This is not the case over most of the Middle East, where crop-sharing agreements between landlord and tenant prevail. But in Cyprus where, in general, the working farmer owns his small-holding there has been a sturdy growth of the co-operative movement, which besides its general relevance has two special lessons for Middle East conditions. The first is that the extreme fragmentation of most of the Cyprus holdings has not prevented—although it has undoubtedly hindered—the movement; the second is that some form of co-operative organization might well be considered as part of any closer settlement plans for existing large holdings at present in private, Government, or charitable (Waqf) possession.

Co-operatives began in Cyprus in 1916, but up to 1934 their main activity was the issue of long-term loans contracted from the Agricultural Bank, and they did little more than act as lending and collecting agents. In 1935 the Government's Department of Co-operation reorganized the societies to give more scope to collective supplying and marketing, the encouragement of thrift, and the granting of short-term credits. In 1937 the Co-operative Central Bank was founded, with the societies as members, for whom it provides the facilities just mentioned. After the war it is proposed to establish a Co-operative Wholesale Society to take over the supply of goods to the member societies, when the Co-operative Central Bank will confine itself to the financial side. A start has already been made, in conjunction with the Government Transport and Marketing Department, in the more difficult problem of grading, packing, and marketing perishable fruits and vegetables through the medium of marketing societies. Appropriate organizations—some of which already exist in embryo—will also be developed for some of the bulk and the specialized products. Among the former are carobs, olive oil, and cereals, and among the latter, wines, raisins, tobacco, and cotton.

In the special conditions due to the war, the societies have gained much experience, as they have been used by the Government as agents and bankers for bulk purchasing of various kinds of farm produce, as well as for the distribution of household and farm requirements, including rationed goods. The growth of the movement from 1934 onwards—the year before the societies were reorganized—is shown in the following table:

	31 December			
	1934	*1938*	*1940*	*1943*
Number of societies	324	353	343	362
Number of members	16,053	24,079	31,286	45,000
Number of societies with deposits	45	123	262	330
Savings deposits	£5,231	£21,600	£52,458	£85,000
Total deposits	£19,972	£80,105	£122,480	£380,000
Reserve funds	£23,446	£41,186	£55,477	£100,000
Co-operative Central Bank:				
Number of member societies	..	112	190	257
Deposits by member societies	..	£14,000	£22,000	£329,000
Reserve fund	..	£158	£2,385	£24,000
Value of goods supplied to societies	..	£10,400	£40,000	£150,000

As stated at the beginning of this section, ownership of the holding—or a suitable tenancy agreement—is a necessary prelude to the full development of co-operative societies to give both credit and marketing facilities. In the Middle East these conditions are not, in general, present, with the exception of Cyprus where the farmers are predominantly peasant farmers, and Palestine, where co-operation is strong both in the Jewish colonies and among the private capitalist farmers. But in at least two other areas, Lebanon and Egypt, there are appreciable numbers of small owner-farmers who could benefit from co-operation. Official or private initiative, however, is needed for the early stages; so far this has not been given except in one village near Beirut where the conditions for private initiative existed and where a promising start has been made.

Although ownership of the land, or a suitable tenancy agreement, is an almost essential condition for the development of credit societies, it is not so important in co-operation for marketing. Indian experience shows that such societies can operate successfully among tenant farmers, provided they have some stability of tenure, which can be achieved by legislation for regulating the increase of rentals and for safeguarding them from eviction save under defined and reasonable conditions.

(2) THE LESSONS FROM EXISTING LARGE-SCALE DEVELOPMENTS

The schemes discussed above vary widely in structure and organization, for most of them were devised independently to suit particular environmental, economic, and human circumstances that also vary from one area to another. Within this range of schemes it should be possible to find one—or a combination of features from more than one—that is most likely to suit the conditions in a new area where development is projected.

But the most significant point is that nearly all of them possess one feature in common. Whether the scheme is based on a monoculture crop (citrus, dates) or a basic cash crop in a rotation (cotton) or on general arable farming (Latafiyah estate), certain activities essential for the success of the individual farmer are done by an organization adapted to perform these special functions. This arrangement explicitly recognizes the fact that there is much more in the industry of agriculture than the successful growing of crops and raising of stock, fundamental though these obviously are. The other factors include marketing the products to the best advantage; grading, inspection, publicity, and propaganda; the introduction of better cultural methods, improved varieties, and even new kinds of crops and better stock; and they can include what may be termed reverse services, such as cash advances at times of peak expenditure, low-interest loans for development, and the supply at favourable prices made possible by bulk purchase, of farm and farm-house requisites and consumer goods. Not all these functions are—or need be—carried out by the special organizations. Some are more within the province of the Government, others can be performed by co-operative societies composed of the farmers themselves; the precise allocation depends on factors such as the ability of the Government in its particular stage of development to provide the proper administrative organization and experienced personnel, and the level so far reached by the rural community in the practice of husbandry and the management of corporate activities of all kinds.

But, no matter how these activities are divided out, whether they are performed entirely by independent middlemen or by any form of corporate organization, they must be financed. They represent a certain proportion of the total capital that must

be provided and, either directly from gross receipts, or indirectly from taxes (or by a combination of these), the interest on that capital has to be found. Without entering into detailed analyses, it would seem that the capital required for these services should not exceed 20 per cent. of the total. Thus in the Syndicate area of the Sudan, where the Syndicate undertakes the duties, its share is 20 per cent. And in the Alternative Livelihood area, where they are performed by the Government, 20 per cent. is added to the Government's share. The figures for the Jewish colonies in Palestine also appear to confirm the proportion of 20 per cent.

In a number of the Middle East countries the stage of development is such that the experience, capital, and qualified men for such developments are not at present available. They must come mainly from outside. The provision of such assistance can no longer be left to the chance interplay of forces: it must be controlled and systematic. Above all, it must be motivated by the spirit of the Sudan Alternative Livelihood Scheme: the desire to promote a better life, prosperous in its material affairs, and with a developed social organization founded on the best of its indigenous features.

For these reasons it is suggested that a proportion of the capital needed for a development scheme should be provided by forming a Public Utility Corporation which, with the Government and the farmers, would form, in effect, a tripartite organization for agricultural development. It is not the function of the present Report to enter into the technical details of this proposal, but only to outline the general principles and the advantages. It should remove the suggestion of exploitation, for the rate of interest on its capital would not exceed a fixed modest maximum, and earnings surplus to this amount would be used for the general benefit of the farmers. It would be a means of using credit balances that a number of Middle East territories have accumulated in other countries, and of employing private capital within the territories. The Corporation would undertake, in addition to its commercial work and management, to develop certain aspects of the welfare requirements alluded to at the end of the preceding paragraph. These would be agreed upon in consultation with the Government for they would naturally depend on a variety of circumstances. The experiences of the Sudan Alternative Livelihood Scheme and of the Jewish Colonies should be useful guides in this connexion. The Corporation might also, in some circumstances, undertake the responsibility for certain scientific and developmental work after reviewing the position with the Government. The contract with the Corporation would run for a fixed time, so that a periodical review of the terms could be made.

There are four further advantages in the proposal outlined above. The first is that a Corporation would be pursuing a long-range policy covering its contract period, which should have a steadying effect on agricultural policy. This might be a valuable feature in any territory where the machinery of popular government is still under construction.

The second is that the Corporation could, as part of its contract, train nationals of the country in the technical and administrative duties, progressively devolving responsibility on them, with the object of handing over completely at the earliest possible moment, as is contemplated in the Sudan Alternative Livelihood Scheme. In this connexion much interest attaches to the suggestion made on 7 February 1945 by the Secretary of State for the Colonies during the debate on the second reading of the Colonial Development and Welfare Bill. He suggested that Colonial Development Companies, run perhaps by the Colonial Governments, could provide the managerial experience and some of the capital for the difficult initial period of

development, and gradually pass over these responsibilities as development proceeded.

The third is that it would be a suitable method for the settlement of semi-nomadic groups who already practise a simple form of arable agriculture; this was the case, for example, with the riverain people who were settled under the Sudan Alternative Livelihood Scheme.

The fourth advantage is of great importance: it would ease the exceedingly difficult problem of revising land settlements and land tenures which is, beyond question, the greatest obstacle to any permanent improvement in the Middle East (Chap. II, *b*). Where revision has been attempted a more or less unsatisfactory compromise is inevitable, especially if there is any considerable proportion of small landowners; and, after the temporary improvement, there is usually a decline towards the old conditions. Under a Public Utility Corporation scheme it would be relatively simple to deal with the rights of existing landowners. As we have seen (Chap. II, *a*) the large landowners, with few exceptions, are interested in their land mainly as a source of income. The Government or Corporation would by purchase or by long lease—preferably the latter—take over control of a certain area of land and the landowner would receive a fixed and guaranteed rate of interest. Uncertainties arising from undefined boundaries and rival claims to ownership, which in the normal procedure of land settlement can only be finally resolved after the completion of a cadastral survey and the legal establishment of absolute title, would present no difficulty under the alternative scheme. The area of disputed land involved would rarely be more than an insignificant proportion of the land being taken over. The extra cost of a satisfactory *ad hoc* financial settlement for such marginal or disputed areas would be correspondingly slight—far less than that of the legal proceedings accompanying land settlement—and the arrangement would recognize only a reputed ownership and thus confer no title to the land in question. The small landowner, who would usually be farming his own holding, would be treated in the same way as the large landowner, and in addition would be given prior right to a tenancy of the reconstituted holdings laid out by the Corporation. In the tenancy agreement provision would be made for compensation for any approved permanent improvements made by the tenant to his holding, when the tenancy was terminated for any reason.

At the beginning of this chapter it was pointed out that the new system should be started, in general, in undeveloped and lightly populated areas. The complement of tenants for the scheme would be made up by suitable applicants from adjoining areas. The attraction that the Public Utility Corporation Scheme could offer the inhabitants in such an area would be a transfer to another area specially prepared to receive them, with indivisable leased holdings of economic size, technical guidance in any modifications of farming methods, together with the other advantages of the Corporation scheme already discussed. The vacated area would come into the possession of the Government as a consequence of the exchange, and be put in order with the Corporation for settlers from yet another area. It is not to be expected that resettlement can ever be an easy problem. Reluctance to leave a familiar environment and the sense of personal attachment to a particular piece of land are inherent in the cultivator's outlook the world over, and often the more deplorable his condition the more loath he is to be uprooted. But, the strong family, group, and tribal loyalties of the Middle East offer the possibility of group settlement, in which common ties and common descent will help to reduce the strangeness and the initial difficulties in the new life. India affords a good example

in this connexion, for there the problem was even more formidable. Yet the Punjab colonies bear witness to what can be done.[1]

It will clearly be to the mutual advantage of the Middle East territories if the common nature of their agricultural problems is kept in mind in planning these developments. While the individual territory will rightly envisage the work of the Corporation within its own area primarily from the viewpoint of its own agricultural advancement, the Corporation will need to take a wider view, and to see each problem against the background of the whole Middle East region. This would be desirable in any case, and it will be essential in view of the creation by the United Nations of a permanent organization for dealing with food and agricultural problems on a regional basis. Hence, the Public Utility Corporations should have some machinery, such as an association or federation, for discussing common problems.

The above discussion has been confined mostly to the agricultural aspects and the social problems of a rural population. Its purpose was to bring out the fundamental fact that a new organization is needed because the existing one is incompatible with present-day conditions, and to suggest that a Public Utility Corporation would meet the case. The proposal needs closer examination than is feasible in the present Report, for, besides the agricultural aspects discussed, there are obvious financial, administrative, and legal questions. The suggestion might well be brought to the notice of the Governments of those Middle East territories in which the conditions offer most scope for the inquiry, together with an offer of expert assistance for making the examination.

(3) IMPROVING THE EXISTING SYSTEM

In the preceding sections reasons were given why any new and better system of agriculture should as a general rule be introduced first in relatively undeveloped and unoccupied areas. But the greater part of the population is concerned in, and a very considerable area of the land is occupied by, the practice of firmly entrenched systems of agriculture. The simplest is the nomadic pastoral system, in which flocks and herds follow the flush of vegetation and their owners live almost exclusively on animal products. A variant of this system is seen in Libya, where there is a seasonal movement of stock to the markets of Egypt during the period when vegetation grows in the hinterland; and in northern Iraq from whence large numbers of stock move through Syria to the Palestine and other Middle East markets. In the semi-nomadic system the animals move within relatively short and well-defined regions and their owners usually sow with food grains an area of ground *en route* and harvest it on the return journey; examples of this practice are seen in the Sudan and Eritrea. The system of settled agriculture which is, in effect, the medieval system of western Europe has already been discussed in Chapter II, *a* and *b*; it is a dry-land system of farming, and good examples of it are seen in north-east Syria, the Arab sections of Palestine, and parts of Cyprus. Finally, there are limited areas, such as the coastal belt of Libya, the Damascus oasis, and the Aden Protectorate where some form of irrigation agriculture is practised. With the exception of the last type, the problem of agricultural improvement is, in general, twofold: firstly, the introduction of changes, mostly minor in character, that can be absorbed without too much difficulty and which, in the aggregate, may

[1] Valuable details of the procedure are given in *Triennial Review of Irrigation in India, 1918–21*. P.W.D. Government of India (Superintendent of Government Printing, Calcutta, 1922).

produce a substantial improvement; and secondly, and with special reference to the settled system, to foster all those factors that will assist in an evolutionary change.

It is only necessary to give in this chapter brief mention of typical examples of the various minor changes that are feasible, because they are discussed in more detail under their scientific aspects in Chapter IV and under their territorial aspects in Chapter V, 1, *d*. In most of the Middle East territories the Departments of Agriculture are already engaged in this work as far as their varying resources permit. The majority of the territories have developed combined demonstration and nursery stations which supply, at low cost, improved varieties and new plants to the farmers. This has been most successful with trees and bushes: olives, carobs, various nuts, vines, fruits, and suitable trees for village fuel. And, as a direct result of war conditions, seeds of suitable varieties of vegetables are sown at these stations and the seedling plants sold for transplanting. Some progress has also been made with the introduction of better varieties of the standard farm crops. A main difficulty here, in addition to the technical one of keeping cross-pollinated varieties free from contamination, is the peasants' custom of retaining for seed purposes a portion of the crop rather than to purchase his seed. Arrangements for exchanging an equivalent quantity of his seed for the new variety are cumbersome to make, and by no means free from abuse. Often in practice, after a season or two, the crops are an indeterminate mixture of the new and old varieties.

There would appear still to be considerable opportunities for improvement in live-stock and live-stock products within the framework of the existing agricultural system. Striking work has already been done by the Veterinary Departments and Institutes in the elimination and control of diseases, but this has not been entirely an unmixed blessing because it has increased the animal population and thus intensified the problem of providing enough animal fodder. Further attention might now be given to an improvement in the animals themselves. Without a too elaborate and expensive organization it should be possible to build foundation herds and flocks from indigenous animals and to provide from them a steady supply of better-class sires for use in selected districts. This method has been adopted in Bulgaria[1] with much success, for draught and transport animals as well as for the usual farm stock, and to a lesser extent in Cyprus. However, little advantage would be gained unless the males in the flocks and herds were castrated. If the experience in the 'beef' cattle area in the Sudan is any guide, there are no insuperable difficulties in persuading and educating the farmers to introduce this measure. In animal products, which are an important item in the Middle East export trade, skins and hides are usually badly prepared. There is scope for the introduction of simple changes that would appreciably raise the quality. In poultry, encouraging progress has been made in selling young chicks of improved breeds to replace the baladi fowl, and this branch of work could be further extended.

The methods needed to foster the process of evolutionary change are all, in essence, educational. Among the problems are (*a*) to develop among the larger landowners the sense of their responsibilities to the land and its workers, (*b*) to cultivate among the tenants and peasant proprietors a desire to improve the lot of themselves and their families, (*c*) to evolve a type of education for rural children that will fit them to live in and profit by a rural environment, (*d*) to train teachers for rural schools, and members for the Agricultural Department, who will be able to evoke and guide the move towards rural improvement.

[1] *Report (1939) to British Foreign Office and Bulgarian Government on the intensification of Bulgarian agriculture*, B. A. Keen.

(a) For **the landowner class** the most hopeful method is to awaken the coming generation. It should be possible to provide a suitable curriculum at an educational centre in the Middle East, specially designed for the sons of landowners. The course would include instruction on the technical side of agriculture but would correspond more with the Estate Management syllabus in Britain, appropriately modified for Middle East conditions. But, as the absence of a sense of responsibility for the well-being of the land and its workers is a direct consequence of an ancient social system (Chap. II, *a*), the inculcation of new moral values among students reared in a different tradition will need skilful handling. It is fortunate, therefore, that some useful experience has already been gained in this very subject by the American University of Beirut and its associated Institute of Rural Life.[1] The enlightened and sympathetic approach made by the University to many Middle East educational problems has earned a deserved reputation and influence. Its students are drawn from many Middle East countries and from a number of different sects and classes of the community. Many Government officials were educated there. The advice and help of the University authorities should be sought in any development of this proposal.

(b) The tenant and the peasant proprietor can, as pointed out in Chapter II, be treated together in the present connexion. They present an even more difficult problem than the landlord class. They are imprisoned within the walls of their own agricultural system; year by year their numbers grow, but the walls remain. Many live on or below the border-line of adequate nutrition and begin and end their lives in debt. The peasant proprietor has neither the means nor the knowledge to improve his holding, and the tenant has no inducement to do so. Education and propaganda are liable to be ignored or misinterpreted by an illiterate adult population. But they will generally listen to a villager, one whom they recognize and accept as a member of their own class, and here lies perhaps the only feasible method of approach while present conditions remain. Where this method has been tried, the results have been encouraging. In the Sudan the Sudanese medical assistants have brought about considerable improvements in village health and hygiene because the villagers accepted readily from them simple treatments and methods that the assistants had learned in a restricted and simple, but carefully thought out, training. Periodical refresher courses are arranged so that village improvement proceeds step by step. A further example, more or less accidental, comes from the Nuba mountain area of the Sudan. The customary inspection visits by British entomologists have had to be given up, for war reasons, during the past three years. The Sudanese staff, before being themselves taken away for locust control teams, were able to train local Nuba field men to do the work, and there has been no loss of efficiency.

The American organization known as the Near East Foundation, which has successfully worked in the Middle East and the Balkans for the past twenty years on a programme of village welfare and agricultural improvement, also employs the same principle. When a project is agreed upon by the Government and the representative of the Foundation, it is operated, under supervision, by men and women who are themselves villagers in outlook and background.

The selection and training of suitable people for work among the peasant and tenant farmer types is discussed under the fourth of the present headings.

[1] *The Institute of Rural Life at Beirut*, Bayard Dodge. Appendix I, Middle East Agricultural Development Conference (Agricultural Report No. 6, M.E.S.C., Cairo, 1944).

(c) Rural Education. As with the landlord class, so with the peasants: education of the children offers the surest hope for creating the conditions in which an active desire for improvements will arise. It is not necessary here to enter the controversy how far vocational training for an agricultural life should dominate the educational organization and the curriculum. Instead, three examples of educational experiments in Palestine, Cyprus, and the Sudan will be discussed that have, from the viewpoint of this Report, a great deal of agricultural value.

The Palestine Department of Education has for a number of years encouraged the schools to develop school gardens, worked by the scholars under the supervision of a member of the staff. The scheme began in the Moslem and Christian Arab schools; later it was introduced by the Jews into their schools. The progress made in schools under direct Government control can be measured by the increase in the budget for this work; £30 in 1928 and over £3,000 in 1943. In their full development the gardens contain flowers, fruit, and vegetables, small sections of farm crops, bees, and poultry. One class lesson and three practical periods per week are given to the work which includes, in suitable districts, training in grafting and budding. Seedlings and young trees are raised and sold to the boys and their parents, and an elementary system of costing is used in fixing the selling-prices of mature products. A number of the school gardens run poultry-houses on improved lines, using no costly materials or methods. This is, of course, a vital condition in all sections of the scheme: an attempt to introduce similar methods in the schools of another country produced antagonism—which is even worse than indifference—among the parents. The reason was that in a misguided enthusiasm, hen-houses were erected costing as much as a fellah's yearly income.

There can be no question as to the direct and indirect value of this endeavour. There is nothing stereotyped about it. The gardens vary in scope, according to the size of the school and the natural difficulties of the district. But even in small rural schools, with only one or two teachers, good gardens exist and are relatively of as much value to the class as those at larger urban schools, which may have their own irrigation system, flower-beds, lawns, and shade-trees. Its effect on the children is obvious, and the experiment has run long enough to show that the good results are not all forgotten in adult life. Interest has been aroused among the adults and some villages have provided, at their own cost, extra land for extending the gardens. Where the teacher has the right training and personality he can employ the school garden with considerable effect among the neighbouring cultivators and give them useful advice and guidance. The risk of occasional misunderstandings and perhaps jealousies between the teacher and the local officer of the Agricultural Department can largely be avoided if the two Departments foster friendly collaboration at all levels, for the work is one in which they are both concerned.

The second example comes from Cyprus; it deals not with school gardens, which are also being actively developed, but with the development of Rural Central Schools for farmers' sons who undertake to return to their villages at the end of the course. Eight such schools are projected, one in each of the typical farming districts, and one is already in operation. The guiding principle is that everything connected with the school and the training are founded on the environmental characteristics of the particular district but with improvements that are within the power of the farmers to adopt. The farm and school buildings are made of local material and in local style, but with simple and desirable improvements. The boys live, not in one large hostel, but in small houses resembling their own and better equipped in various simple ways. The houses themselves are set back from the

road, along which shade-trees are planted, and the land between the houses and the road carries vegetables and flowers. The system of husbandry is the local one, done on the local scale, with local resources, but with a variety of improvements in crops, stock, implements, and methods. The progress of this experiment in Cyprus should be carefully followed by other Governments in the Middle East, and especially by their Agricultural and Educational Departments. It deserves attention not only for its intrinsic merits but because the conclusions could be generally applied, for the reason that Cyprus displays on a scale small enough to serve as an experiment, and yet large enough to be practical, most of the conditions and problems found in the Middle East.

The third example is a part of a very important experiment that is being made at Bakht er Ruda, Blue Nile Province, the Sudan, to work out the system of education best adapted to Sudanese needs. Elementary, 'central', and teacher training are all included, and a rural agricultural secondary school is in process of formation. This last will have a rural bias but will not give a full-scale agricultural training; it is intended to round-off the education of country boys not proceeding to full secondary education. The curriculum will include some novel ideas, on which judgement can be reserved until results are available. The guiding principle throughout the whole experiment is to foster civic consciousness in every possible way. The section that falls for mention here is the Young Farmers' Club. It is based on the scheme that has had considerable success in Great Britain and the United States, except that no lectures or discussions are held. Its purpose is mainly economic and partly civic. There are about seventy-five members drawn from those who are training for teachers. About half come from farming families. Their farm work is done in small groups each of which has an area of land amounting to three-quarters of an acre per person, farmed on a rotation of cotton, cereals, legume, fallow. An important feature is that each member is given a cash advance to serve as working capital for his holding, which he must account for and repay. Hence he learns that agriculture, like any other industry, needs both working capital and some skill in using it. An elected committee runs the club and deals with the accounts of each group so that, in effect, the venture is a co-operative one. Suitable members of the teaching staff are available if needed, for consultation, but their help is confined to suggestions and supplying information on points of fact. The balancing of pros and cons, and the taking of decisions, must rest with the committee.

Although the example just discussed refers to the training of teachers, which is considered in the next section, it is given here because, in a simpler form, it could be used for the pupils in rural schools as a means of extending the usefulness of the school gardens as a preparation for an agricultural life.

Above, the problems of the landlord, peasant, and rural education have been discussed in their bearing on the process of evolutionary change in the agricultural system. It remains to consider the fourth factor on which they largely depend: the training of rural teachers and assistants in the Agricultural Department. Both these questions have, of necessity, already been touched on in the above three sections.

(d) Rural Leaders. There are two essentials. Those selected for training should have the rural outlook. In present Middle East conditions the bulk of the candidates could come from villages, so this condition could be generally satisfied; it is desirable that a certain proportion should be drawn from urban areas, and these candidates should be carefully selected.

The second essential is that the environment during the technical training, and the training itself, should be such that the rural outlook is not weakened or lost but actually enhanced during this period. This essential requirement is found in the Sudan organization at Bakht er Ruda, referred to in the preceding section. It is also fully present in the Cyprus scheme. The Teachers' Training College at Morphu is in rural surroundings, and adjoins the experiment station of the Department of Agriculture and the Rural Central School where, as described in the preceding section, the local environment is stressed. All the student teachers get some agricultural instruction in their two-year college course, after which selected students go for a third year to the Rural Central School; during this year they cover the bulk of the two-year curriculum of the school.

Unfortunately most other Middle East countries are not, as yet, working on this policy. Often the training centre is near, or perhaps even in, a city. The buildings are large and provide facilities and amenities unknown in the countryside. The farm is large and run on modern lines, with farm-buildings, implements, and live-stock to correspond. There are good laboratories well stocked with modern apparatus and chemicals. There may be a hundred, or many more, students in residence, with all the corporate and social activities that that implies. It is understandable if, after a year or so back in the country, the young teacher and agricultural assistant compare their conditions unfavourably with those of their urban colleagues. The teacher has, possibly, a mud building for a school, in poor repair, with little equipment and a meagre budget. The extra attendance that he managed to secure by persuading the parents has dwindled to normal. He feels acutely the lack of educated friends and the primitive conditions of his own house. The agricultural assistant has found the peasants' conservatism too strong for him, and is realizing that much of what he learned at the training-centre is of no interest to the farmers, even if they could be brought to understand it. It is not surprising that the teacher seeks a transfer to an urban school, and the agricultural assistant to his head-quarters office, with their better conditions, prospects, and salary. Many of those that fail to escape sink from disillusionment into apathy. Relatively few retain their enthusiasm and their sense of vocation. The device, often adopted, of providing part or the whole of the cost of training in return for an undertaking to serve for a specified period of years in a rural district is no solution of the problem. Indeed, it often accentuates it, by giving the young graduate a feeling that advantage was taken of his financial circumstances.

This situation is not peculiar to the Middle East. The 'white collar' mentality affects every country in the world. But it is specially troublesome to deal with in non-industrial countries whose economic life rests on an extensive rather than an intensive system of agriculture, as is the case with the greater portion of the Middle East. National income is low and there is little money for agricultural and educational development. The capital cost and cost per head for training is less in a large central institution than in a number of smaller scattered ones.

If the two essentials mentioned above are to be fulfilled there must be a change of values between urban and rural conditions. This cannot be achieved easily or quickly. A consistent long-term policy is necessary, one that utilizes all possible small advances in preference to big changes. The Sudan and Cyprus experiments, already discussed, are examples of some of the means by which the policy can be carried out. There is a rural environment and a strong agricultural bias to the training, and many other details, too numerous to mention here, all directed to the same end.

A further important example of this method of approach is given by the law for the agricultural reform in the villages recently adopted by Egypt. The country will be divided in accordance with local variations into a number of units which, when the scheme is in full operation, will number about 400, with an average area of 15,000 acres. Each unit will have a model demonstration farm, under a resident agronomist, where the results of the work carried out by the Ministry of Agriculture's crop research stations will be tested and shown; and a veterinary centre for disease prevention, the improvement of animal husbandry, the control of abattoirs, and the conversion of animal waste products to fertilizers.

The key part of the scheme is a Council of Agriculture for each unit, charged with a variety of duties, especially those, already discussed in this section, that make for improved standards in agriculture and rural welfare. The Council has machinery, including a link with the local agricultural inspectorate of the Ministry of Agriculture, for interpreting the Ministry's policy to the farmers, and for passing back to the Ministry the views and needs of the area.

CHAPTER IV

Scientific and Technical Problems

(a) SOILS: CONSTITUTION AND CLASSIFICATION

The general principles of soil classification are now well understood. The effects of climate, natural vegetation, and geological origin on the type of soil have been worked out, and under the auspices of the International Society of Soil Science soil zones and types have been mapped over a good deal of the world. In many respects this classification is to the soil scientist what a herbarium is to the botanist. It enables him to recognize similarities and differences in the effects of weathering processes on soil properties and behaviour, and thus not to be misled by superficial resemblances or distinctions.[1] Combined with his knowledge of the physical and chemical factors that operate in the process of soil formation it may enable him to advise on the suitability of a given soil type for a new system of agriculture, e.g. a change from dry-land farming to irrigation. A modified system of soil classification in which special attention is given to agronomic and agricultural aspects has been found very useful in the Sudan. (See Chap. V, 1, *b*.)

So far little research has been done on the effects of soil-forming processes under Middle East conditions, except on Palestine soils.[2] The question whether this type of work should be given more attention needs careful consideration. As an end in itself, a complete classification is, of course, desirable. But the overriding need in the Middle East is agricultural improvement, as rapid as may be, and a marked increase in soil classification studies could only be justified at this stage if without it agricultural improvement would be held up or proceed on wrong lines. Such is not the case. There is no rigid relation between soil types and systems of agriculture. A fund of scientific and empirical knowledge already exists as to the most suitable type of agriculture in given conditions. In the circumstances the study of fundamental problems of soil formation and classification in the Middle East could well be left,

[1] For further information see: *Soil Conditions and Plant Growth*, E. J. Russell (Longmans), and *Soils: Their Constitution and Classification*, G. W. Robinson (Murby).

[2] *The Soils of Palestine*, A. Reifenberg (Murby). The discussion is applicable to a wider area of the Mediterranean littoral than Palestine.

as it is at present, to the Universities. The work on Palestine soils was made possible by the Hebrew University, Jerusalem, and extension to other areas should be effected on this analogy. A small central fund would be needed and an advisory committee.

The aspects of soil science of most immediate urgency in relation to agricultural development are the chemical and physical behaviour towards irrigation. The selection of suitable areas, bringing them into suitable condition, and maintaining this condition afterwards, are all problems for the soil expert. The unfortunate history of the Khuzistan Development Scheme in Southern Persia[1] is not unique; numerous other examples exist throughout the world of costly reclamation schemes that have failed because expert knowledge on the soil problems either did not exist or was not utilized.

In general, the soils of the Middle East potentially suitable for irrigation development have been formed under arid or semi-arid conditions and are liable to show undesirable saline characteristics due to the presence of sodium salts, usually chloride or sulphate, which have become concentrated either in the process of soil formation from the parent material, or been brought in by a rise in the underground and saline water-table. Geological examination is needed to distinguish the factors. Not infrequently irrigated areas show deterioration owing to saline conditions after a few years' use, because the level of a saline underground water-table has been raised from a safe position owing to over-lavish irrigation, or inadequate provisions for drainage, or both. Examples are also known of deterioration through the use of irrigation water containing too high a concentration of sodium salts.

It is important to realize that the absence of visible signs of salt accumulation in the upper layers is no guarantee that the soil is unaffected. A relatively small amount of sodium salts in the soil moisture will lead to a replacement of calcium by sodium in the absorbing complex of the soil, which will then possess the intractable characteristics of a 'sodium-clay' soil. Such soils are sticky and waterlogged when wet, and dry to a dense hard crust at intermediate moisture contents and fail to assume the crumb-like structure necessary for satisfactory plant growth.

Field and laboratory methods for specifying the soil condition have been devised by soil experts. The field tests involve, in addition to measurements of the position of any water-table, a close study of the soil section as shown by a vertical cut or profile; in the laboratory the nature of the salts is determined and the condition of the soil-absorbing complex in the soil is measured by physical and chemical methods. The results give guidance as to the most suitable areas for development, suitable methods of reclamation, and prevention of deterioration. It is not always possible to give absolute answers without some preliminary small-scale trials, but in such cases the previous examination enables these trials to be considerably narrowed.

A small but useful example of this method of procedure is afforded by the reclamation of certain lower Jordan valley soils under the auspices of the Rehovot Experimental Station. The soils were very saline and contained some 10 per cent. of salt, mostly sodium chloride. They were clays and clay loams, and analysis of the absorbing complex showed that it contained sufficient calcium to possess a favourable physical structure that would permit of free drainage and the production of a suitable tilth under cultivation. Provision of artificial drainage was, therefore, unnecessary, and it was possible to decide with some confidence to flood the surface and wash the injurious sodium salts towards the underground water-table which was

[1] *Some Difficulties in Land Reclamation—an example from Southern Persia*, G. L. Bailey. Middle East Agricultural Development Conference (Agricultural Report No. 6, M.E.S.C., Cairo, 1944).

ascertained to be deep below the surface. The minimum quantity of water required and the duration of flooding were worked out from trials on a small plot in a typical area, and the downward movement of the salt was traced by measurements. The soil, when washed, possessed the good structure predicted from the laboratory results, and satisfactory growth and yields of crops were obtained.

A larger-scale example of the great value of expert soil examination is afforded by the Sudan Gezira. A systematic soil survey and laboratory examination preceded the irrigation development, and showed that the soils were exceedingly heavy clays, alkaline in reaction, and containing soluble salts. The salt content in the top 2 feet was slight and consisted mainly of sodium carbonate and bicarbonate. Below this the amount sharply increased and consisted mainly of sodium sulphate and gypsum. It was clear from this examination that the soils would present special irrigation problems, especially as further tests showed that water penetrated very slowly. The conventional remedy of the irrigation engineer for these conditions is the installation of under-drainage coupled with gypsum applications to change the sodium-clay complex to a calcium one and thus improve the permeability and physical condition of the soil. This was, in fact, urged as an immediate necessity by outside experts who pointed out that the natural underground water-table was 50 feet deep and that yields had recently dropped alarmingly—a circumstantial sign of soil deterioration. There is little doubt that but for the knowledge available to the Sudan soil experts, the very expensive system of filter-joint tile-drains, that was recommended, would have been installed. They were convinced, from their studies of the soil before and after irrigation, that soil deterioration even if occurring, which was very doubtful, was not rapid. This opinion was based on the small addition of salts from the good quality irrigation water and on experimental determinations of the water movement and salt composition and movement in the soil under irrigation. Laboratory and field experiments showed that even if under-drainage were installed little or no water would reach the drains, nor would any noticeable improvement in soil permeability be brought about. The sudden drop in yields was to be ascribed, therefore, not to the absence of a drainage system, but to unfavourable seasons and to lack of experience in suitable methods of soil management and in the choice of crop rotations for the peculiar conditions. The subsequent history of the area has amply confirmed the correctness of this view.

The two examples given above have been chosen to show two contrasting cases of the value of expert soil advice on irrigation problems. The first case was a recommendation that the expenditure of reclaiming an area would be justified by the results. The second was a recommendation that prevented the expenditure of a heavy capital sum.

In the Middle East there are great possibilities of irrigation development; and there are large areas of more or less saline soils, especially in Iraq and Persia. Therefore there is a real need, reinforced by the warning of the Khuzistan experience, for the territories most concerned in irrigation development to follow the example set by Egypt and the Sudan whose agricultural organization includes a Soils Department staffed by research workers and technologists.

(b) SOIL ORGANIC MATTER

For many years it has been generally stated and assumed that the basic defect of tropical and sub-tropical systems of native agriculture is their inability to maintain the organic matter content of the soil at a proper level. The poor yields of crops and the ravages of erosion are both ascribed to the lack of organic matter. By the nature of

the case these criticisms originated with those familiar with a temperate climate system of agriculture and they are based on the traditions of that system, and on the assumption that these traditions must be universally true. The advances of agricultural research have supported some of these traditions, have demolished others, and have confirmed the practice but denied the traditional explanation of yet others. The decision as to the best future structure of Middle East agriculture depends so much on the question whether the organic matter content of the soil should be increased that it would be folly to rely for the answer on tradition alone—no matter how convincing it seems: all the more so, as the matter is eminently one for the objective scientific examination. Although much work has been done on the status of soil organic matter in temperate agriculture, there has been until recently very little examination of the problem under climatic conditions similar to the Middle East.

The three main effects of organic matter brought out by past work are due to (1) its content and availability of plant nutrients, principally compounds of nitrogen, phosphorus, and potash; (2) its influence on the activities of the soil micro-organic population; and (3) the improvement in the physical structure of the soil. All these are the results of the complicated biochemical and biological reactions occurring as the organic material progressively decomposes to humus. Already a number of facts are available to show that important differences exist between temperate and Middle East conditions. The effects of organic matter seem much more ephemeral than in temperate climates, owing possibly to the much quicker rate of decomposition and the smaller equilibrium content of the end-product in the soil.

A valuable study on these points has been made in Egypt[1] on basin and perennial irrigated soils. The former is the older system, now fast disappearing in favour of perennial irrigation. Basin land lies fallow in the summer (the sharaki period) and thus bears a closer resemblance to the rain-cultivated soils of the Middle East, which also lie fallow in the dry period. The depth distribution of the organic matter falls off less rapidly in basin than in perennial irrigated land. The inference that this points to steady loss of soil organic matter under perennial irrigation, and therefore to an eventual decline in fertility and soil structure, is not borne out by a full examination of the figures, because the upper layers of the perennially irrigated soil are becoming richer in organic matter, as a result of the agricultural system under which the land is farmed; on the whole it is no poorer and may be even richer in inherent fertility.

Chemical examination of the soil organic matter shows that decomposition is very rapid and very advanced, so that it exists mainly as end products. The greater percentage (70–90 per cent.) is lignin and resistant proteins which undergo little or no further change. The remainder consists mostly of proteins that will decompose and thus provide a steady supply of soluble nitrogen compounds for plant growth. The cellulosic substances which bulk so largely in fresh organic matter, and whose progressive decomposition products account for much of the 'humus' effect in temperate conditions, have a very brief existence, and therefore an ephemeral effect at best, in Middle East conditions.

The rapid disappearance of organic matter and the small total nitrogen content of the soil do not necessarily mean that yields could be heavily increased by additions of organic or artificial nitrogen: there is enough to provide most and sometimes all of the nitrogen required for full crops. This effect has been traced by measuring the so-called 'available' nitrogen made up of the reserve in the decomposable proteins, and the soluble ammoniacal and nitrate compounds. At the end of the dry and hot

[1] *Organic Content of Soils of the Middle East*, D. S. Gracie. Middle East Agricultural Development Conference (Agricultural Report No. 6, M.E.S.C., Cairo, 1944).

sharaki or fallow period the available nitrogen is greater than at the beginning of the fallow. The increase is mainly in ammoniacal nitrogen, not nitrate, because bacterial activity ceases in the dry soil. When remoistening by rain or irrigation water takes place, there is a rapid biological conversion to nitrate. It is this mobilization of reserve nitrogen as nitrate that accounts for the effect of the resting period in restoring the fertility of the soil.

Work in Cyprus has brought out another interesting difference from temperate climate conditions in the residual (second-year) manurial effect of organic material. Artificial manures were compared with various organic manures containing equivalent amounts of nitrogen, phosphorus, and potash. The increases in yield were the same. But the residual effects on the next crop, wheat, which was unmanured, were striking: there was a larger yield on the plots that had had artificial manures in the previous season. This result is the opposite to that found in temperate climates. A suggested explanation is that in this low rainfall area, loss of artificials by leaching does not take place, and that the high temperature in summer and the dryness of the soil cause the organic matter to decompose more than the nitrogen artificial. In some other places the nitrogen in organics does not produce an increase in yield: thus, in Nigeria, the effect on yield was traced to the phosphorus content of the manure. The decomposition of organic material in the soil is essentially an oxidation and, in Middle East conditions, much of its content of nitrogenous plant nutrients may be lost as gaseous products. Unless some system of husbandry can be devised in which the crops can utilize a good proportion of the nitrogenous material, the advocacy of increased organic manuring as a means of increasing fertility is hardly justified. Indeed, a good case could be made out for the peasants' custom—so generally condemned—of using dung for fuel: if so small a proportion of its nitrogenous value is obtained by plants, owing to the rapid oxidation and disappearance in the soil, is it not better to use the heat of oxidation for domestic purposes than to lose it uselessly in the soil? And, as to the potash and phosphorus value of the dung, these mineral ingredients will remain in the ash, so the incorporation of this with the soil will be as effective as applying the raw dung.

There can be little doubt, assuming investigations and experiments show the desirability of stepping-up the soil organic matter content, that considerable quantities will be needed, in view of the rapid decomposition and low equilibrium value in Middle East conditions. The amounts are far beyond what the indigenous system of agriculture could supply, even if none of the dung were used for fuel. This is true also for more advanced systems. Thus, calculations have been made by the Palestine Agricultural Department for Jewish Settlements in the plain of Esdraelon, whose system is grain and farm crops, with a small area of vegetables, and intensive fodder crops for the stock. The calculations show that the grain and farm crops area got farmyard manure only once in 20–30 years and the theoretical limit in the ideal case is only once in 12 years. This is because most of the available manure is put on to the vegetable and intensive fodder land. It has been suggested that a possible method of improvement is an adaptation of the 'temporary ley' that was widely practised in British agriculture under the urge of war. It would be necessary to find a grass or other fodder plant that would survive the dry summer and grow away with the first flush of rain (section *j*, this chapter). The stock would be turned on to this so that the land would receive a few months' 'stock' nitrogen. After a few years it would be ploughed up and another area similarly treated. To keep up the quantity of stall manure used for the vegetable and intensive fodder area to the same amount, extra stock would be needed. The extra keep for them would be provided in part by the grazing and, in part, by

the enhanced yield of fodder crops due to the extra dung. The introduction of the temporary ley would reduce the grain and farm-crop area, but this would be compensated by the higher fertility due to the ploughed-up ley. This illustration is given not so much as a possible method of raising soil fertility by increasing the organic matter content, but as an indication of the somewhat elaborate changes in husbandry that would be involved; and, therefore, as a reminder of how desirable it is to explore, by research and technological investigations, the degree of truth underlying the basic assumption that an augmentation of soil organic matter is both desirable and possible. Useful information on the technological side would probably be obtained from a comparison of the conditions on the Lebanon coastal belt with those elsewhere. In this coastal belt there are areas of intensive irrigated market gardening, with numerous fruit-trees that provide effective shade to the soil in hot weather. The winter season is cool and comparable to Europe. Thus, in this area the effects of organic matter might be expected to resemble those produced in western Europe.

The assumptions made, on western experience, of the supposed effect organic matter would produce in Middle East conditions, cover not only soil fertility but also resistance to erosion. In temperate climates, organic matter causes the individual soil particles to aggregate into little crumbs or compound particles. The effect of such a structure in helping percolation and resisting wind and water erosion is self-evident. What is not self-evident is the extent to which a similar structure is formed by organic matter in tropical and sub-tropical soils; this question needs further research. Some most suggestive results[1] have been obtained in this connexion in Uganda, and the work should be repeated in typical soil and climatic conditions in the Middle East. It has been shown that additions of farmyard manure have a fertilizing value only; there is no marked improvement in the soil structure. On the other hand, a marked improvement in structure is produced when the land is laid down to grass. Thus, for anti-erosion measures on farmland a temporary ley is needed: the vegetation provides mechanical protection, its roots anchor the soil; when the land is ploughed up for arable, it possesses the desirable crumb structure. The work has also shown that some grasses, notably elephant grass (*Pennisetum purpureum*), are much more potent than others in producing a good soil structure. The reasons for this merit scientific examination.

It will be clear from the above that the role of organic matter in Middle East agriculture is an urgent subject for fundamental research and technological investigations. The relative importance of its manurial and soil structure effects needs examination, for each of the three modes of application: farmyard manure; 'green manures' and ploughed-in temporary leys; composts. The last of these has received considerable publicity in India, not only from its agricultural aspects but also as a contribution to village and town hygiene by utilizing all vegetable refuse. The manurial value of town refuse has been the subject of much study in industrial countries where various processes have been introduced for controlling the fermentation to produce a suitable compost. So far as the agricultural value, as distinct from the public health aspects, is concerned, it remains to be seen what it is in Middle East conditions. At the Mikveh Israel farm, untreated town refuse from Tel Aviv was said to have given good results on heavy soil. The conclusion is based on simple observation trials, not controlled experiments, and the material, which was unsorted, contains a high proportion of old cans and cut metal waste that should be removed. A modern equipment for treating town

[1] '*Grass Covers in relation to Soil Structure*', W. S. Martin, 1944. Emp. J. Expt. Agric. **12**, 22–32.

refuse is now installed at Beirut, and adequate field experiments to test its value should be made. In Cyprus tests have been made of a composted town refuse in comparison with farmyard manure and artificials. Analysis of the materials showed that the compost was poorer in nitrogen, potash, and phosphate than the farmyard manure. The yield results showed that to be equally effective the amount of compost had to be double that of farmyard compost (farmyard manure composted with chopped straw) and seven times that of sheep manure. These amounts are very roughly in the same proportion as the amount of nutrients contained in the manures, so the compost cannot be regarded as a very valuable fertilizer when the cost of preparation and transport of the bulky quantities required are taken into account. The emphasis falls, therefore, more on the hygienic aspects of disposing of the waste products of towns rather than on the agricultural value of these products. If, as experience elsewhere seems to show, treated town-refuse composts are low-grade fertilizers, they cannot be sold at fancy prices but must go for less than the cost of production, and the loss must be considered as a legitimate charge on the health and amenity services of the municipality. Naturally the cost of production will be kept as low as possible. In this connexion it may be asked if there is not, at times, some over-elaboration in the requirements of the Public Health authorities relating to the destruction of pathogenic organisms during the fermentation and preparation of the refuse. The cycle of changes, and indeed some of the organisms, are a normal feature of agricultural and garden soils.

In the research work on manurial values of organic matter it is desirable to study under Middle East conditions the activities of the nitrogen-fixing groups of soil organisms in relation to the composition of the organic matter supplied; and also to explore the claims—not yet confirmed elsewhere—of Indian workers that a chemical photosynthesis of nitrogen compounds occurs when carbonaceous material is added to soil and is of more importance than fixation by biological processes.

Further information on the subject of organic matter will be found in Appendix I.

Soil Burning. The deliberate firing of vegetation as a means of clearing land for a period of arable agriculture, or for the encouragement of young growth for animal fodder, is practised in a number of places in the Middle East. Attention has been drawn to its undesirable consequences, especially in the greater liability to erosion of the fired area. It is possible, however, that the practice has some benefit on the fertility of heavy soil in certain conditions in addition to its known value in the control of some insect-borne animal diseases. A series of experiments over a number of years has been made on the irrigated soil at the Gezira Research Farm, Wad Medani, the Sudan. The top 2 inches of the surface soil was removed and put into alternate layers with cotton sticks; the heaps were fired and afterwards spread back on the area. A marked increase in yield of cotton was obtained, equivalent, in one experiment, to that given by a dressing of 200 lb. of sulphate of ammonia per acre to unfired soil. Subsequent experiments were made to trace the cause of the effect. Part of the reason is physical. This heavy soil cracks in the dry fallow period and surface soil finds its way into the cracks. The fired material, being coarser than the original soil, facilitates lateral water penetration from the cracks to the lower layers. In addition, the fired soil that remains on the surface breaks the force of the rain, whose beating action on unshielded soil produces a surface impermeable to water. It was found that a similar result could be obtained by a mulch of vegetable trash. The physical effect, however, does not completely explain the increase in fertility; there seems to be a definite manurial benefit—direct or indirect—as well. Firing must reduce the organic matter content in the burnt soil, and the nitrogenous effect of a

certain amount of charred cotton stalks cannot be great. The number of the nitrogen-fixing group of soil micro-organisms is greatly increased in the soil over which the fired soil is spread, which is, probably, a consequence of the better environmental conditions resulting from the physical cause already mentioned.

Burning of the black soil of basaltic origin in the arable areas of Ethiopia is extensively practised, but inquiries failed to elicit any traditional reasons.

The matter is worth exploring further.

(c) SOIL TILLAGE

The cultivation implements and methods used in Eastern and Middle Eastern agriculture have, like the alleged neglect of organic manuring, been generally criticized by Western agriculturists. The nail-plough which merely scratches the soil was compared unfavourably with the Western type, which works deeper, inverts the furrow slice, and leaves no untilled ridge between the successive furrows. The lack of subsidiary tillage implements such as cultivators, hoes, and harrows, for all of which the Western farmer finds employment in producing and maintaining a tilth, was also the subject of adverse comments. To-day, however, criticism would not be so positive, for some of the traditions on which the art of soil cultivation leans have failed before the test of scientific examination. This examination forms an example of the best method of applying science to agriculture: fundamental research, followed by technological exploration. In this case the research dealt with the physical factors underlying the movement and distribution of water in soil. When the laws were elucidated—which involved, incidentally, the removal of some current hypotheses—the technological stage was obviously the study, for various soils and climatic conditions, of the extent to which cultivation operations did exercise a control of soil moisture; and, as a corollary, the extent to which crop yields were influenced by these operations. It is sufficient to say in this Report that extensive work in England and the United States has shown that moisture control and crop yields are considerably less influenced by cultivations than was hitherto supposed, but that weed control, especially in the early stages of crop growth, appears to be of even more importance than past traditions would suggest.[1]

It remains to be seen whether the same results occur in Middle East agriculture, particularly in irrigation areas, where the moisture régime is different from non-irrigation conditions. An extensive programme of work on cultivation, which includes a study of particularly interesting weed effects, is being conducted throughout the Sudan Gezira irrigated area by the Gezira Research Farm, Wad Medani. The importance of clean weeding in the early growth stages of the cotton crop has been amply shown; if omitted, the early growth is checked, and the yield may be reduced by nearly one-third. A very interesting result deals with the resting period. It is the custom for land due for cotton in the rotation to be rested the previous year during which weeds grow, ripen, and dry off at the end of the rains. The weed growth dries out the soil and thus encourages deep and extensive cracking which, in this heavy and impervious soil, is considered an important means of securing a good tilth and of maintaining aeration. The effect of cutting these weeds during their periods of rapid growth was tested in a large number of experiments throughout the Gezira. The average increase in the yield of cotton in the following

[1] A summary of this work will be found in *Soil Physics: Theory and Practice*, B. A. Keen, 1942: the Cantor Lectures of the Royal Society of Arts. (Royal Society of Arts, John Adam Street, Adelphi, London, W.C. 2.)

year was 7 per cent., the value of which was considerably more than the cost of hoeing the weeds. It would appear that yields could generally be increased by hoeing the land during the resting period. Long-term experiments will be needed to see whether the effect of soil-cracking is less than hitherto supposed, or whether an occasional year of weed growth on the fallow should be included in the rotation.

There is much scope for investigations on tillage and tillage implements throughout the Middle East, as very little work has been done so far, except in the Sudan. An early decision about the scope and role of power-drawn implements is of great importance. The urgent need for more food crops in the war was met by bringing in tractors, mostly of the high-power variety, and big blocks of land were ploughed, some under direct Government control and others by large landowners and contractors to whom tractors were allotted. As a war-time measure, the innovation was amply justified, for, owing to the shortage of labour, these areas could not have been cultivated by any other means. This inadvertent demonstration of the power of modern agricultural machinery has not been missed by many landowners; throughout the Middle East there is a strong desire to own these machines and, in most cases, the possession of war-time sterling or dollar balances to pay for them. The demand is there, and with the return of the factories to industrial production the supply will be quickly available from overseas. This situation cannot be regarded with equanimity. Middle East Governments would be well advised to retain for the present the control of these machines, and any allocated to private landowners should be under some form of hire, to be used only under agreed conditions. More experience is needed of the effect of these labour-saving machines on the sociological structure of the countryside, especially in view of the return to agriculture of those now in army and war industries; and more information is needed on the technical side of tillage to avoid errors that might well have serious results.

The technical aspects will be studied by the Palestine Government in the Negeb area. The experiment is designed to test tractor cultivation against the age-old native method both in its effects, if any, on yield and on the soil, with special reference to erosion. Work on deep ploughing has also been done at Mikveh Israel. Ploughing to a depth of 10 inches on the dry soil in the summer and again after the rains has been compared with the normal baladi or native system. The ploughing is done for the maize crop, in a maize, wheat, vetch rotation; it increases the maize yield, and, to a lesser extent, the two following crops. The soil is heavy, flat, and low lying, and the effect is almost certainly that of facilitating the penetration of rain and providing a greater pore-space for its absorption. This is borne out by the effect of harrowing the soil surface after ploughing, which produces a reduction of yield, presumably because the fine surface inhibits the penetration of rain. In Cyprus experiments are now in hand to compare mouldboard and local nail-ploughs, and also on modern and local methods for preparing a seed-bed. Analogous experiments should be set in hand in other territories where the extension of tractor cultivation is contemplated.

Power implements already have, of course, a definite function in Middle East agriculture, for example, the Sudan Plantations Syndicate and the communal Jewish settlements. They would also be used by the Public Utility Corporations and in the reconditioning of areas being prepared for resettlement (Chap. III, 2). The essential feature here is that they would be operated by skilled workers, and be under the control of qualified executives, with knowledge based on experimental results.

It has been suggested that the difficulty of providing in non-irrigated areas enough fodder for the animals (sections *f* and *j*, this chapter) might be circumvented by using small power units instead of work animals. Although supplies of cheap oil fuel would be available from the Middle East wells, the possibility is a limited one in present conditions. It might be feasible on compact holdings and the smaller estates where the size of the undertaking would permit the economic and technical requirements to be met. For the bulk of the cultivators' holdings, however, the handicaps of fragmentation, and the fact that work animals must perform many duties besides cultivation, rule out the suggestion. It can be regarded as one of the technical improvements that would become feasible after reorganization along the lines discussed in the previous chapter had been put into effect.

(d) SOIL MOISTURE

Where irrigation is impossible soil moisture is the most important limiting factor in Middle East agriculture. Water is lost by evaporation from the loose layer produced in preparing a seed-bed, and the deeper the layer the more water will be lost. Until recently it was generally believed that this loose layer served as a mulch which prevented the moisture in the lower undisturbed layers from rising upwards and being lost by evaporation, but recent researches have discounted the magnitude of this effect.[1] It appears that upward movement is very slow and over limited distances, so that the main cause of loss is by a progressive drying out downwards. The practical value of a mulch is that it discourages the formation of deep cracks up which moisture from the lower depths could readily escape in the form of water vapour. It may well be that the shallow cultivation of the native system of tillage keeps to a minimum the inevitable losses of water in the preparation of a seed-bed. No systematic experiments seem to have been made so far on soil moisture content under native methods of tillage and under deep and shallow power cultivation. These studies could very usefully be made as part of the tractor cultivation experiments discussed in the preceding section on soil tillage.

The soil moisture conditions in irrigation present a different set of problems. Paradoxically, one of the usual problems is not to conserve water but to get rid of it: many if not most of the irrigation areas in the world would deteriorate through waterlogging, and the development of alkaline or saline conditions, unless efficient drainage exists, and where the natural drainage is inadequate, artificial drainage is needed. The Sudan Gezira is an interesting exception. As civil and mechanical engineering developed much earlier than soil science, the great majority of irrigation schemes have been conceived and constructed primarily as engineering problems. In many cases a costly and compromise drainage system has had to be constructed at a later date. Areas of land have been included that a previous soil examination would have excluded as unsuitable. It is not generally appreciated that the land area occupied by field, collecting, and main drains is usually between 5 and 10 per cent. of the total, and falls little short of the corresponding area of minor and major irrigation canals, and that the costs of construction, cleaning, and maintenance are roughly similar. There are strong financial reasons, therefore, for ensuring that the drainage system is the minimum consistent with efficiency. To achieve this, more knowledge is needed on the factors governing soil-water movement, to replace some of the empirical rules that have to be used at present. A number of researches on the permeability of soil to water in varying conditions

[1] B. A. Keen, 1942. *Soil Physics: Theory and Practice.* The Cantor Lectures of the Royal Society of Arts, London.

have been made, but the subject is by no means completely covered. The Physical Department of the Egyptian P.W.D. has produced valuable results and so has the Irrigation Research Laboratory, Lahore, India; and, more recently, the Hydraulic Laboratory of the Hebrew Technical Institute, Haifa, Palestine, has instituted some very promising researches, facilities for the extension of which should certainly be provided. They deal with the theoretical and experimental study of percolation in soils, the pressure variation in underground water movement, and with the apparently simple but exceedingly baffling problem of assessing evaporation losses from large water surfaces.

Meanwhile important practical developments in substituting open by closed, or pipe, drains are under trial in Egypt. Main drains must, of course, continue as open ones, because covered channels for such large volumes of water would be too costly. But piping for the intermediate and field drains offers some advantages. The soil over them can be cropped and the drains, being buried, do not have to conform with property boundaries: both factors are of some importance in view of the dense agricultural settlement of Egypt and the high rental value of the land. A point of general importance is that evaporation losses from open-drain surfaces are avoided: the significance of this is that owing to the low salt-content of its soil and water Egypt is fortunately able to use some drainage water from higher levels as irrigation water lower down, by pumping it into irrigation canals. For these reasons the extension of covered drainage in Egypt should be favourably considered, and close attention given to the technical problems. Among these are the best type of material to use for the pipes, the prevention of silting up, and the best methods of clearing the drains, and the reduction of the cost of the installation and maintenance. At present the cost is £12. 15*s*. per acre, which is equivalent to perhaps £7 in normal times. It is true that in the area in question, which is intensively cultivated, this figure represents only about the cash equivalent of one year's rental, but all additional capital expenditure in periods when the economic régime is artificially high should be carefully watched.

There are many problems connected with the 'duty of water', i.e. the amount of water needed to produce one unit of crop, that need further investigation. Irrigation farming is in essence the art of securing the largest positive difference between the cost of the water and the value of the resulting crop, consistent with the technological requirement that the amounts of water used shall be well inside the limits of excess and deficit that lead to soil deterioration. The universal and natural tendency of irrigation farmers is to use as much water as they can get, so in practice the investigations are directed to the more economical use of water. One interesting development is the use of overhead or spray irrigation now widely adopted in the Jewish colonies. It has some definite technical advantages. The land need not be so carefully levelled as in channel irrigation and, as field channels are not needed, the whole area can be cropped. The water is more evenly and more gently distributed for most of it reaches the ground by dropping from the foliage; in consequence the deterioration of soil tilth, due to periods of flooding with standing water, is partly avoided. The cost of the pumps and piping needed for this system has been considerably reduced and the ease of manipulation much improved. It is claimed that the system has a better water duty, i.e. uses less water, than the older furrow systems. It is desirable that fuller publicity should be given to the experimental results on which the claim is based, because considerable evaporation losses would be expected from a fine spray projected into hot dry air, especially on windy days. As would perhaps be expected, overhead irrigation may have

disadvantages for certain crops, e.g. tomatoes, where the spread of fungus diseases would be assisted by the wet foliage.

Duty of water figures vary so much for different crops, and for different varieties of the same crop, that the fullest possible information about them is desirable for practical advisory purposes, as well as for the plant-breeder. In fact very little information is available, partly for the reason that the figure cannot be measured in any simple way. Thus, even for the same plant variety and the same total quantity of water, the duty of water value will depend on the choice of time intervals for irrigating and the fraction of the total quantity of water given at each irrigation. The possible combinations of these two factors are so numerous, to say nothing of those introduced by soil and seasonal differences, that a complete specification of duty of water for all conditions would be impossible. But there is clearly scope for a technological investigation here, co-ordinated and working to a common plan, to obtain results spread at intervals over the main range of variation of the more important factors; these results, in tabular or graphical form, could be used with reasonable accuracy by interpolation, for inferring values within the main intervals chosen. Information of this kind will be specially helpful in places such as parts of Iraq and Persia, where there is more land suitable for irrigation than the potential water-supply could irrigate and where the most efficient use of water is therefore of particular importance.

(e) SOIL EROSION

In recent years soil erosion in many parts of the world has become 'front-page' news.[1] This is especially the case in the United States, where the full resources of the Government have been thrown into remedial and counter measures. Erosion is widespread throughout the Middle East. In assessing its danger and devising counter-measures it must be remembered that the prime causes are climatic and geological and therefore beyond man's control. In the dry season the soil bakes hard and cracks. In the wet season there are often torrential rains and floods, which carve gullies and deposit at lower levels the great quantities of silt carried in suspension. Here it may cover fertile land and block existing natural drainage flows. Again, the bed of a river flowing through a plain becomes gradually raised by silt deposition, until it is above the level of the land, and eventually it breaks its bank and takes a new course. It may be kept in its course by artificial raising of the banks (as in the case of the Mississippi, whose water level is now at or above ground-surface level over wide stretches), but the price of removing immediate danger is the threat of a greater future one. Similarly the construction of dams to hold up flood water defeats its purpose if the reservoir quickly becomes filled up with silt deposited by the impounded water.

The conclusion is that all constructional works should be conceived not as means of preventing erosion, but of controlling it as far as it is possible and desirable to do so. Both topographical considerations and the physical and chemical characteristics of the soil itself need to be taken into careful account. Unfortunately, little is yet known about the relations between soil characteristics and the degree of resistance to erosion; it is a subject to which research should be directed. Two contrasting examples may be given to illustrate the general problem, one from Cyprus and the other from Ethiopia.

[1] For a detailed account see G. V. Jacks and R. O. Whyte (1939), *The Rape of the Earth: a World Survey of Soil Erosion* (Faber & Faber, London). See also Dr. E. B. Worthington's *Report on Middle East Science*, chapter ix.

The main agricultural area of Cyprus is the large flat Mesaoria plain lying between the north and south mountain ranges. It has been formed by erosion of the impervious clay and calcareous shales which, as tumbled hummocks, still remain at the foot of the mountains, although near the mountains the hummock topography gives place to the higher peneplain, which is well cultivated with orchards and trees. The soil of these hummocks and the low-level plain derived from them is very prone to erosion. Gullies 3–4 feet deep form in the plain, and the steep slopes of the hummocks crumble and break away in large pieces. Little can be done to anchor the hummock slopes by herbage cover because of the effect of the hot dry summer. On the plain itself, broad terracing with slight bunds and a gently sloping bank to the terrace below would check the rate of water-flow and reduce the tendency to gullying. But in all probability the erosion process is here inevitable and can at best be mitigated.

In Ethiopia there are large areas of black soil of basaltic origin which is quite resistant to erosion. On the steeper slopes which have been terraced for agriculture, cultivation can be done up to a foot or so from the edge of the terrace, and it is not even necessary to support the vertical face of soil with a stone wall.

Apart from actual constructional measures for the prevention or control of erosion, a good deal can be done to reduce it, by modifying certain practices in arable and animal husbandry. Ploughing along the horizontal contours of sloping land should be done wherever possible. In Cyprus a publicity campaign on this point has been launched and has met with considerable success. In Palestine the Mt. Tabor (Jewish) Kadoorie Agricultural School ploughs its sloping fields on the contour and, by doing so, has checked the back-gullying of a nearby wadi into its land. In Ethiopia contour ploughing of sloping land is general. The land is left in a rough cloddy condition to encourage rapid absorption of rain water, and to reduce the amount of silt carried away by the run-off water. In addition, a system of surface-furrow drains a few yards apart is drawn, at about half the maximum slope of the land, to serve the double purpose of checking the velocity of the run-off and of giving it a further opportunity of percolating into the soil.

The efficiency of contour ploughing obviously depends on its completeness. The land-tenure system of the Middle East with its fragmented holdings, and with strips often running up the maximum slope of the land makes its general adoption difficult. But where land settlement is being revised, the exchange of parcels of land and the revision of boundaries will afford opportunities for grouping the holdings in relation to topography; and in the settlement and development of new areas it should be a fundamental point.

Tractor cultivation of large areas of spare or unused land was introduced as a war measure to increase the total production of foodstuffs. By the nature of the case power implements will be used only in large flat or gently undulating areas, e.g. plains and wide valleys, where the kinds of erosion are most likely to be sheet-erosion and, possibly, wind-erosion. These power-drawn implements cultivate deeper and may produce a different type of tilth from that given by the nail-plough. If tractor cultivation is to continue after the war, it will be important to know whether these two differences are likely to increase erosion or not.

It is not easy to devise precise experimental measurements to express the degree of erosion, and the experimental specification of degrees of soil tilth is even more elusive. But in the present instance qualitative observations would suffice, for the skilled user of power implements develops a good empirical knowledge of the

influence of design and adjustment on the type of tilth produced. There should be no insuperable difficulty in securing by power methods a tilth that is at least as resistant to erosion as that obtained by the peasants' implements (section *c*, above).

It is said that the maintenance in good order of existing terraces has been much neglected in recent years and that in consequence there has been much unnecessary erosion. It is true that instances of this can often be seen, and they are not all due to the inevitable neglect following on social and political disturbances and lack of security of life and property. At the same time there are plenty of examples of well-maintained terracing and of fresh and satisfactory constructions. The question is one whose answer is inevitably coloured by the inquirer's own views: if he has formed the opinion that terracing is becoming more neglected he will notice all the examples supporting his contention. The matter could only be conclusively settled by a detailed and objective survey repeated at intervals.

But the most definite and general accusation is that the destruction of forests for fuel and the uncontrolled grazing of both grass and forest areas by goats have steadily increased to the stage of imminent disaster in wide areas. It is urged, and with truth, that the effects are rapidly cumulative. A tree-covered slope presents a double barrier to the force of rain: the trees themselves, and the layer of absorbent soil and litter under them. Remove the trees and the soil will be quickly washed away leaving rocky slopes down which rapid torrents will run to erode the lower lands. Water that previously sunk into the land and replenished the underground supplies is now lost as run-off. The same sequence applies to the effects of grazing and browsing. Reafforestation becomes impossible because the young seedling trees are destroyed by the goats. In these circumstances there has arisen a strong official opinion on the necessity for restrictive legislation to bar grazing completely in certain forests and areas scheduled for reafforestation, and to control by comprehensive grazing laws the numbers of animals—and shepherds—on other grazing-lands. Legislation in these directions has probably gone farthest in Cyprus. Goats have been excluded from certain forest areas and the goatherds have been given alternative employment as forest guards, &c., and are said to be well content with the change. The sheep and goats of the lower lands present a more difficult problem, further complicated by a perennial conflict of interests between the shepherds and the settled farmers. Among the laws aimed at controlling this antipathy and at making the farming and village system more self-sufficient are the following:

The Rural Constables law for the redress of damage done to village arable lands by grazing, if the shepherd responsible for it is known. The law is seldom invoked owing to the fear of reprisals by the culprit.

The Malicious Injuries law, to supplement the above; it applies to damage by animals whose owner or owners cannot be identified. Damage is assessed and the value is levied on the animal-owning community in the neighbourhood.

The Licensing of Shepherds law, which limits the size of the flock and the number of shepherds.

The Goat law, by which a village can, by a majority ballot, exclude all but tethered goats from its area.

The Tree Planting of Village Areas law. The purpose is to encourage the planting of trees in areas adjacent to the village and thus to discourage the undesirable and illegal entry into forest areas for fuel. The village can, by a majority vote, set aside up to 20 per cent. of its area for tree planting. When such an area is declared, no animals are allowed in, except in transit.

It is evident that the attitude of the conservative and struggling peasant farmer to these laws will be less approving than that of, say, the forester. While he may, after discussion, approve of the intentions, he is, for all practical purposes, in the grip of a farming and social system that necessitates the continuance of the very practices that the reformers deplore. For example, the few goats he keeps for his meagre milk-supply are their own foragers. Their replacement by tethered goats would give the peasant and his family much extra work in searching for, collecting, and storing fodder, and to grow a special fodder crop is not only difficult in the existing farming system, but it reduces the area available for human foodstuffs. And, in any case, varieties of goats suited for tethering have been bred for milk yield and therefore need better fodder than the free-ranging baladi goat. (See, further, section (*j*) on Live-stock and Fodder below.)

Other examples could be given to illustrate the essential point that it is not often possible to detach one problem, such as erosion, and deal with it separately; the problems are interlocked in a social and agricultural system which, in spite of its basic simplicity, has many technical complexities. The system may, indeed, have got into a vicious circle, but it is a complete circle, and must be dealt with as such. A possible way is to associate the heads (or representatives) of the various Government Departments, and other interests concerned, into a body where technical proposals made by one Department can be examined from the viewpoint of the others. This method has already been adopted for certain limited purposes by some Middle East territories. Thus, Soil Conservation Committees have been formed in Cyprus, Palestine, and the Sudan with encouraging results. There are strong arguments for similar bodies in most if not all of the territories. The composition and constitution would vary to suit the special circumstances of the territory and the framework of its government. It is clear that each body would gain if some central machinery were also set up for the interchange of experiences and discussion of methods, and that the association would be of special value in dealing with a problem that was cut into two artificial halves by a political frontier.

(f) PLANT NUTRITION AND PLANT GROWTH

The general principles of plant nutrition have been elucidated by the work of plant physiologists and soil scientists. The subject is very complex and, in consequence, the applications to field conditions often present puzzling problems, and analogies drawn from field experiments in temperate climates may be quite misleading.

Plants require for their nutrition a supply of nitrogenous potassic and phosphatic salts in soluble form, together with calcium and silicon compounds and a variety of other elements some of which are needed in minute amounts but are nevertheless essential for normal growth. These latter are usually referred to as the 'minor elements' and, throughout the world, cases are accumulating of obscure so-called 'physiological diseases', or failure to respond to manuring, being traced to the deficiency of some minor element. Physical research into the spectra of elements has led to the development of a rapid and simple spectrographic method of identifying the presence or absence of any element in a given sample and, if present, of assessing its amount even though exceedingly minute. The technique has found numerous industrial applications and is now also used in agricultural laboratories for the routine examination of soil and plant samples in which minor element deficiencies are suspected. The Sieff Institute at Rehovot in Palestine possesses the apparatus, which although simple to use, is costly. As minor element problems

are only occasionally met with in agriculture, the simplest procedure for the Middle East would be a direct arrangement for examination of samples by the Sieff Institute.

By far the greater bulk of plant-nutrition problems are those concerned with nitrogen, potash, and phosphate. The standard method of attacking these problems is to ascertain by field experiments on various crops the effects of nitrogen, potash, and phosphate, alone and in combination, on the crop yield, and to analyse the soil for its contents of 'available' nutrients. Approximate balance-sheets for the different nutrients can thus be drawn up and used in recommending the combinations and quantities of fertilizers needed in the particular circumstances. The method has had considerable success in Great Britain, Europe, and the United States, particularly since the developments of statistical theory have been widely adopted in designing the layout of the field experiments and the examination of their results. But the complexity of field conditions is such as to make quantitative results impossible. The line of advance lies in developing those studies that will help in giving more precision to what must be, in essence, qualitative recommendations. For this purpose straightforward manurial trials need to be accompanied by investigations in plant physiology, and in husbandry[1] or crop management.[1]

The plant physiology work deals with the uptake of nutrients and their translocation within the plant in relation to developmental characters and the degree of dependence of crop yield and crop quality on these factors. The crop management (or agronomy) factors include the cultural treatment of the land, the effects of varying the crop rotation, the form in which the plant nutrients are applied whether organic, or artificials, in various alternative compounds.

Within the Middle East the developments just mentioned have been adopted to a noteworthy degree in the Sudan, in Egypt, and at the Mikveh Israel Station in Palestine. A few instances of the types of problem that arise may be given.

The citrus growers of Palestine use the more costly imported potassium sulphate in preference to the chloride which is produced at the Dead Sea factory. Their reason is the fear of getting excess of chloride content in these soils, for the irrigation water is, naturally, not free from chlorides, and they are aware of its bad effects on foliage and fruit. Analyses of the quantities involved show, however, that the amount in the manure is small in relation to the normal concentration and that no such danger is to be apprehended, except in bad cultural conditions on heavy soil, in which case other and more obvious dangers will have already arisen. In reality, the problem is whether, in concentrations below those causing visible damage, the chloride affects, more than the sulphate, some of the rather elusive quality factors in the fruit, and there is no easy method of solving it. At the Mikveh Israel Station an impressive long-range experiment on a group of associated problems is in progress. A set of lysimeters is in use so that drainage water from single trees, each manured in a different way, can be collected and analysed; numerous tree development and fruit characters are chemically analysed or measured. The results are compared with those under natural conditions in an experimental citrus grove. It is not feasible to summarize here the numerous interim results of this extensive work, whose prime purpose is to elucidate scientific facts; but already a number of conclusions of a practical nature have been drawn which would probably have not emerged from direct field trials alone. The great importance of phosphate in tree growth and fruit quality and the need for manurial additions of

[1] Neither of these terms is very precise, and unfortunately no word exists to describe this group of problems, although their existence is well known to agricultural scientists. The nearest word is agronomy, in the sense that the Americans use it.

this nutrient in the lighter soils have been clearly shown. Over a considerable period artificial fertilizers have proved equal to organic manures.

From the extensive Egyptian work two illustrative results can be selected, relating to the effects of nitrogenous fertilizers on wheat and cotton. The response of wheat to nitrogen additions is more marked the lower the inherent fertility of the soil: on high fertility land the additional nitrogenous dressing produces less marked increment of yield. Cotton, however, behaves in the opposite manner. A larger increment of yield from added nitrogen is obtained when a good yield will be secured in any case without additional manure. The reason was found in the special dependence of cotton yield on the water supply to the roots (which depends on the physical condition of the soil) and on the seasonal condition; the effect of nitrogen is not marked unless these two primary factors have operated favourably. This result well illustrates the importance of linking up manurial experiments with physiological and agronomic investigations, as mentioned above. The physiological characteristics of the cotton plant confer a peculiar importance on the choice of the sowing date in Egyptian conditions. With warm springs—the rule in Upper Egypt—early sowing is possible, and nitrogenous manuring produces an increase in yield. But in the Delta the spring may be warm or cold, and the nitrogen effect will vary accordingly. The effect of nitrogen is also influenced by other agronomic factors, such as the variety, water-supply, and the spacing distance of the plants, and these factors may interact with one another, i.e. the joint effect of two factors may be less or more than the sum of their separate effects. Modern statistical methods have made it feasible to design field experiments in which these factors and their interactions can be studied. The value of such studies needs no emphasis, for, in agricultural practice, a variety of factors is necessarily present. Over the period 1934–7 an admirable series of investigations were made in Egypt on these lines.[1] The work, concerned mainly with cotton, cleared up much confusion in manurial practices. Different varieties of cotton were found to show marked differences in their response to manuring, and it was possible to give recommendations for the optimum dosage for the main varieties. Closer spacing (originally adopted to counteract the loss due to Pink Bollworm) was shown to increase the yields, and response to manuring, thus confirming the conclusion of the Department of Agriculture. (See also section *i*, below).

But it is in the Sudan, at the Gezira Research Farm, Wad Medani, that the greatest development of modern field experiment technique is to be found. The scope of the work is indicated by the total number of separate plots in the various experiments: 2,702 in the season 1942–3. They cover the three important crops cotton, dura, and lubia, their manurial and cultural factors, and full use is made of parallel studies in crop development in the interpretation of the effects. To give one instance, it was found that leaf growth and nitrogen absorption are severely checked by internal factors in the plant at the time of boll development, so, at this stage, the soil nitrogen-supply is of no importance. Absorption is resumed after the first flush of bolls has matured. It is clear that the cultural practices should aim at securing extensive early growth to obtain a large plant before boll production begins, and therefore that the efficiency of nitrogen-manuring depends on the extent to which it raises the concentration of soil nitrogen during the early growth. With this con-

[1] *Experiments in Egypt on the Interaction of Factors in Crop Growth*, by F. Crowther, A. Tomforde, and A. Mahmoud. Bull. 1–8 of the Joint Research Scheme by the Royal Agricultural Society of Egypt, Imperial Chemical Industries, Ltd., and I. G. Farb. Aktiengesellschaft (1934–7). Also issued by the Royal Agricultural Society of Egypt, as Technical Bulletins Nos. 22, 24, 25, 26, 28, 30, 31, 32.

clusion in mind a manurial experiment can be designed and the results interpreted to provide reliable guidance for the cultivator. Perhaps the most striking example of the use made by Wad Medani of modern technique is in the design of field experiments to compare various crop rotations for the Gezira soil. The peculiar soil conditions have already been touched on in the sections dealing with soil problems (sections *a*, *b*, *d*, above). Early results obtained by the Syndicate showed that these conditions caused the cotton crop to be markedly influenced by the sequence of the other crops and fallows and they tried a number of rotations before adopting the present one. The Wad Medani experiments are designed to discover the best rotations to suit the various parts of the Gezira within the already known limitations that frequent fallows are necessary; that dura in the rotation reduces the cotton yield; that cotton should not occupy the same land more often than once in three years at most; and that lubia, although a legume, is not much better than a fallow in its effect on cotton yield. On the basis of all this work the most suitable rotations of cotton, dura, lubia, and fallow can be specified for varying agronomic and economic conditions that may arise in the future. As an instance, the regenerative effect of a fallow that the rotation utilizes is feasible so long as ample land is available; but if land values rise, and a less 'open' rotation becomes necessary, the experimental results have already shown that much of the fallow could be replaced by lubia without detriment to the cotton yields.

The examples given above have come from irrigation agriculture. The higher the economic level of the farming system the more important becomes the solution of its problems by research and technological investigations, for its stability rests very often on relatively small increases in yield or decreases in production costs. The same is not true of the native systems of agriculture with their lower economic level and relative insensitiveness to economic conditions. No attention has been given to the question of artificial manuring in dry farming, for until recently the system would have been unable to sustain the cost. Organic manures and the effects of tillage practices, both of which are discussed elsewhere in this Report, have been considered the main plant-nutrition problems in this system of agriculture. These two problems will always be important, but the question of using artificial manures now presses for decision. Their cost has been heavily reduced, and there is a vast potential market for them in India and China as well as the Middle East. In dry-farming areas many peasants believe that organic manures in more than small doses will 'dry-up' the plant, i.e. the moisture is used up by vigorous vegetative growth so that little grain comes to maturity. If the belief is well-founded it would apply with equal or greater force to artificial manures. The overriding limiting factor in dry-farming is moisture, and the problem is complicated by the erratic seasonal distribution and the variable amount of the rain. It is very probable that in years of good and well-distributed rain an appreciable yield increase would result. But in poor rainfall years, artificials might cause a greater reduction of yield than has been shown by the Indian experiments[1] to occur with organic manures in such years. Long-term experiments would be needed to show whether, on balance, the use of artificials has economic justification. Very useful guidance and economy of effort would be obtained in these experiments by utilizing the general methods of inquiry that have been worked out in the Indian investigations just referred to.

In the more developed systems the problems are legion, and the emphasis shifts quickly from one group to another; so much so that recommendations from outside

[1] *Dry Farming in India*, W. V. Kanitkar, 1944. Imperial Council of Agricultural Research, Scientific Monograph No. 15 (Delhi: Manager of Publications).

may prove ephemeral, if indeed they do not state what is already obvious to those on the spot. The current work and programmes of the Sudan and Egypt admirably cover the scientific and technical problems of their areas in so far as the limitations of staff permit. The work of the two Jewish stations in Palestine is, of necessity, less extensive; citrus problems claim the main attention, especially at Mikveh Israel, but at Rehovot agricultural problems are included in the programme.

Elsewhere in the Middle East, little attention has been given so far to plant nutrition problems. If, as is to be hoped, extensive irrigation developments take place, this omission will have to be quickly remedied. Much of the irrigation will be sited on soils where salt problems will arise, and where the permissible salt-content of the irrigation water will need attention, as in Iraq and Persia. Studies should be made on the effect of salts on the normal processes of plant nutrition and the best manurial treatments to counteract the adverse effects. It is well known that adequately manured plants can withstand higher concentrations of salts, and under the generally adopted but somewhat inapt name of 'antagonism' this inhibiting or blanketing action of nutrients has been examined in a number of laboratories, and especially in the United States. With that information available, together with the basic results from the Sudan and Egypt, plant-nutrition studies in fresh irrigation areas can be directed with some confidence towards the local problems. By the very nature of agriculture a delay is to be expected between the emergence of a problem and the remedy. The delay can be reduced, or even avoided altogether, if the fundamental knowledge necessary for the solution already exists. This is the justification, if any be needed, for the association of plant physiological and agronomy studies with field experiments on plant nutrition as exemplified by the Egyptian and Sudan organizations, and the results they have already achieved. The principle, of course, applies generally to all aspects of agriculture, and not only to highly developed irrigation farming systems. The simple non-irrigation husbandry system contains important agronomy problems that have not yet received proper investigation, such as the methods of tillage and choice of implements discussed in earlier sections of this chapter. Attention should also be directed to the fairly widespread native practice, common in both dry-land and irrigation husbandry, of growing mixed crops in the same field instead of using a rotation. The practice may be regarded as equivalent to a rotation so far as spreading the risks of failure is concerned, but it may be important to know whether the various advantages commonly attributed to a rotation are also given by a mixed crop. One further problem is of sufficient technical interest to merit separate discussion, immediately below.

Effect of Legumes on the Succeeding Wheat Crop. One curious problem meriting further investigation is the poor wheat yield after a good legume crop grown on for seed. This was observed both in Cyprus and Palestine and may well be general in similar areas. It is, of course, the reverse of experience in western Europe. It is significant that an analogous phenomenon is well known to the peasant farmers of Bulgaria,[1] where auxiliary irrigation of peanuts to increase their yield has the effect of reducing the yield of the wheat crop that follows. Typical figures are:

Irrigated peanuts, 16 cwt. per acre; wheat, 5·5 cwt. per acre.
Unirrigated ,, 6–8 ,, ,, ,, ; ,, 10·5 ,, ,, ,,

The reason is not clear. It can hardly be a moisture effect, as depletion of water by the larger peanut crop is offset by the irrigation itself. The larger supply of

[1] *Report (1939) to British Foreign Office and Bulgarian Government on the Intensification of Bulgarian Agriculture*, B. A. Keen.

decomposable nodule material from the irrigated peanuts should result in a greater nitrogen supply for the following wheat crop. Washing out of nitrates by rain before the wheat was established should affect both irrigated and unirrigated soil. It may be that supplies of other plant foods than nitrogen are heavily drawn on by the larger peanut crop on the irrigated areas. Whatever the reason, the peanuts shrewdly exploit the peculiarity by giving or withholding irrigation to peasants according to the probable prices for wheat and peanuts.

The Cyprus trials were laid out on modern statistical principles for the design of field experiments to compare the following four rotations:

(*a*) wheat–wheat
(*b*) wheat–bare fallow
(*c*) wheat–vetch (*Vicia sativa*) ploughed in for green manure
(*d*) „ „ „ „ taken for seed.

The results for five rotations are available, and the comparison of interest in the present connexion is that between rotations (*b*) and (*d*):

Yields of wheat in cwt. per acre

Year	*After bare fallow*	*After vetch taken for seed*
1936	1·35	1·07
1938	7·55	5·15
1940	0·86	0·97
1942	6·38	5·7
1944	2·90	2·36
Mean	3·81	3·06

Except for 1940, when the yields were very low, this table shows that wheat after vetch gives less yield than after fallow.

Similar results have been observed by the Palestine Department of Agriculture, and two reasons have been suggested by the Acre Experiment Station: (*a*) the open stand of the legume encourages a heavy weed infestation in the succeeding wheat crop, and (*b*) volunteer legumes in the wheat are unavoidable. As a result both weeds and legumes will compete with the growing wheat for moisture and nutrients. One would expect, however, that a heavy legume crop would reduce the influence of the first reason and increase that of the second, and vice versa with a poor legume crop, and hence competition with the wheat would be much the same whatever the legume yield had been.

More scientific work is needed on the problem. Among points for study are the moisture status of the soil, and the available nutrients in the two cases. Biological processes, particularly the activities of the nitrogen-fixing soil organisms, and the effect of the legume on the nitrogen status of the soil may be rather different from those shown in western European conditions. The availability of the mineral nutrients also needs study, especially phosphate, in the neutral or alkaline soils characteristic of this region.

(g) PLANT IMPROVEMENT

The breeding and selection, on genetical principles, of plant varieties with better yield and quality characteristics than the indigenous ones, and the introduction of varieties existing in other parts of the world, are the methods of improvement for agricultural crops. We may also include the introduction of plants not indigenous to the area in question. As in the case of plant nutrition the bulk of the work in the Middle East on plant improvement has been given to irrigated crops, and particularly

to cotton. The Egyptian work and, later, the Sudan investigations are well-known classical examples. With cotton, the quality factors are of vital importance, for it is the raw material for a great industry with its own research and technological organizations; in consequence their specifications become steadily more precise and exacting. The plant-breeder has, therefore, to consider not only such agricultural factors as yield and disease resistance in his work, but he must maintain and even improve those quality factors that the cotton industry requires and, in the long run, these are of controlling importance. In the early stages of the Egyptian work it was necessary to send bulk samples to England for spinning and other tests, which was not only expensive and time-consuming in itself but a severe limitation on the breeding-work, where the ideal would be tests that were feasible and reliable on the cotton from a single plant. This ideal has been approached by the development of a Cotton Spinning Laboratory in Cairo by the Egyptian Cotton Research Board. The temperature and humidity of the laboratory are automatically controlled; cleansing, carding, and spinning are done on standard machines, specially modified to handle small samples. The weight of sample needed for the standard tests, such as breaking-strain, fibre-length distribution, and fibre-weight has been reduced to about 2 oz. (60 grammes) instead of the 5 lb. (2·2 kilos) sample formerly required. The fact that only a few plants of each type are now needed to provide a sample is a great convenience to the plant-breeder, especially in the early stages of an investigation. The ability to make many tests on small samples of the numerous cotton strains already in commerce enables the laboratory results to be compared with the valuations of the expert cotton buyers. The results show that these experts are in effect buying almost entirely on the fibre-strength of a sample, so much so, that the Laboratory can closely predict the price of a new variety before it gets on to the market, by using the strength-price curve they have constructed from the results of their many trials.

This work admirably brings out the importance of ensuring that the plant-breeder has the fullest possible information on the quality factors required by the industry that purchases the crop. In a number of industries the purchase price is fixed by valuers who, by long experience, have developed an expert skill in judgement, based more on subjective visual, tactile, or taste impressions than on objective scientific tests. The plant-breeder cannot be expected to possess this ability, and he will be working largely in the dark or, at best, find his progress slowed up, unless he has available some objective criterion of judgement that will short-circuit some of the factors entering into the expert valuation as, for example, in cotton where fibre-strength is a very important factor, and malting barley, where a low nitrogen-content accompanies a high valuation. Other instances no doubt exist.

It is the task of Departments of Agriculture to give the plant-breeder this help, either from the appropriate other scientific departments or by ensuring suitable contacts with the purchasing and processing industries.

Frequently an improvement in some desired quality is accompanied by a decreased resistance to pests and diseases and the plant-breeder's work is complicated by the problem of conferring immunity, if possible, or resistance, to the improved varieties, so as to avoid or reduce the expense of plant protection measures. The Sudan provides a good example. At present the three dangers to the cotton crop are in order of importance: blackarm, a bacterial disease; leaf curl, a virus infection; and jassid, an insect pest. Each one presents some complicated and interesting problems. Blackarm infection may occur through the seed, or through secondary infection of the tissues of the growing plant, so that, for the growing plant tissue-

resistance is important. Some Asiatic types are immune, but the majority of New World types are susceptible in varying degrees. Genetical examination has shown that resistance depends on the presence of three factors, whose absence is shown by characteristic symptoms in the plant. The investigation has been helped by transferring a gene that confers a red tinge in the plant to mark or 'tag' resistant strains, to provide an easy visual guide for certain aspects of the field work. The study of leaf-curl resistance was hindered at first by the spasmodic and irregular incidence of the disease over the experimental area containing the plants under test. This was overcome by surrounding each test plant with four susceptible ones. Breeding-work for resistance to jassid attack has been helped by the observation that hairy plants are less attacked, and progress is being made in transferring the factor for hairiness to non-hairy but otherwise desirable strains.

The importance of cotton has called into existence the research and technological organizations, some of whose work is outlined above. But there remain other crops, that are not 'cash crops' like cotton, and yet are the backbone of the agricultural system over most of the Middle East. In the case of Egypt and the Sudan the existing organizations are available for the work. In Egypt attention is given to wheat, for example, and the Sudan has work on dura in progress. Elsewhere the work is confined to varietal tests of baladi and imported varieties, and it is sometimes carried out on an extensive scale. At the Karaj Station (Persia) some 1,500 wheat varieties are on trial, and promising ones are multiplied up on the black earth at Kamalabad; varieties of the annual castor are being tested for use on the plateau as an oil-seed crop to supplement the perennial castor grown in the south. In Iraq well-organized variety trials of cereals, linseed, and cotton are in progress, which are carried forward to the large plot stage (100 square metres in area) on the extensive land of the Experiment Station, and to the bulk replication stage on Government-owned farms. Some degree of success has been reached in two important wheat requirements for Iraq: early maturity, and rust resistance. But in a number of the other territories the scale of work is considerably less. Taking the Middle East as a whole, more attention to the improvement of the standard crops, cereals, pulses, oil seeds, and fodder crops is needed.

Reference was made above to the need for the plant-breeder to have full preliminary information on the quality factors required by industry in cash crops. In the case of food and fodder crops he must take into account the agronomic practices of the cultivators. Thus, with bread grains it is not simply a question of producing a higher-yielding variety; in great areas the yield of the stalks and leaves are equally important for they are the main fodder-supply for the work animals. Even such matters as the depth and density of sowing the seed must be taken into account. A heavy seeding-rate is usual over wide areas of dry-land and irrigation farming, and the most likely reason, apart from insurance against poor germination, is that the close stand of plants discourages tillering which is especially undesirable in dry-land farming conditions. An automatic selection of non-tillering types may well have been effected by the practice of close seeding, and there is evidence from India[1] that the sorghum in dry-land areas does not usually tiller. Again, a plant-breeding station cannot run the risk of losing its material by drought, and is therefore unable to test fully the response of apparently improved varieties under the extreme vagaries of rainfall characteristic of dry-farming areas.

The weakest link at present is the end one: small test stations throughout the

[1] *Dry Farming in India*, W. V. Kanitkar, 1944. Imperial Council of Agricultural Research, Scientific Monograph No. 15 (Delhi: Manager of Publications).

territory where a final choice could be made from among a few varieties generally suitable for the conditions of the district. One obvious reason for the lack of such stations is the difficulty of selecting representative sites in the absence of the information provided by a broad survey of farming systems and results in relation to soil and climatic variations (Chap. V, (*a*)).

With fruits, nuts, and to some extent, vegetables, the position is more encouraging. Nursery stations and gardens have been established and young vines, olives, deciduous fruits, nuts are raised and sold at low charge in considerable quantities. A good deal of quiet work is being done in the selection of suitable root stocks and scions, both indigenous and imported; American varieties of vines immune to phylloxera have been introduced, the available range of temperate and sub-tropical fruits is being extended. It is not clear, however, that full advantage is being taken by every territory of the knowledge and help already available in selecting the most suitable varieties for given conditions, and in the numerous technical problems of successful fruit growing. The root-boring beetle *Capnodis* is known to be a danger unless resistant stocks can be found. An observation in Ethiopia points to another problem of some interest. On the high plateau near Addis Ababa, where a wide variety of crops, including temperate fruits, can be grown with ease, raspberries will not fruit: the plant grows luxuriously but in the form of a rosette of shoots a few inches high instead of the normal canes. Dormancy problems deserve further attention, they may well be the cause of some obscure difficulties in fruit growing. At the Rehovot Station in Palestine, delayed foliation in the spring has been investigated; the branches are long and bare with a rosette of leaves near the top. It is possible that the winter temperature is generally above the minimum needed to break the dormancy at the normal time. However, it has been observed that the winter oil spraying does break the dormancy. The reason is not yet known, but may be found in the effect of a small amount of some accelerator incidentally present in the oil, coupled with physical penetration of the oil itself, as light oil produces better results than heavy. Further practical trials have been carried out, in co-operation with the Shell Company, on various sprays and added chemicals. So far, the best results have been given by di-nitro-cresol, the substance that excessively stimulates human metabolism. Spraying two weeks before bud-opening is better than two months before; but the fruit that does form on the earlier sprayed (or even non-sprayed) trees ripens much earlier and will come in for the higher prices of the early market. At the Shibin el Kom Agricultural Institute, Egypt, work has been begun on the dormancy of soft and stone fruits. The normal practice is to withhold water in the winter so that the trees shall rest. Yet in European winter conditions the trees get much water at this time, so the effect of winter irrigation will be tried. It will be of interest to see if the treatment succeeds and, if so, whether the effect is due to the lowering of soil temperature due to irrigation. Potatoes—an expanding crop in the Middle East—are among other plants in which dormancy problems exist, as two crops a year are grown in a number of areas. The rapid so-called degeneration may be due more to the short period between lifting the seed and its replanting than to the increasing incidence of virus or other diseases. The Cyprus work has shown that where cold storage is available for keeping the seed for use as the next crop but one, the results were better than those given by using growth accelerators such as ethylene.

In Bulgaria—where the soil and climatic conditions resemble much of the Middle East—the part of their agricultural intensification programme concerned with fruit received invaluable aid from two British centres—the Horticultural

Research Station and the Imperial Bureau of Fruit Production, both at East Malling, Kent. Similar help is available for other countries.

The movement towards fruit production has everything to recommend it. With proper terracing and cultural conditions—on which more demonstration work is desirable—the hilly and sloping land is, of course, much less liable to erosion under orchards than under arable agriculture, and the free ranging of animals. It is a desirable diversification of the agriculture, which directly employs more workers per acre than normal agriculture and gives further employment in various processing industries, of which wines are an obvious example, especially in Palestine and Cyprus. In this latter connexion, it is worth pointing out that it is more advantageous to develop types of wine natural to the soil and climate of the country than to simulate universally known types from other regions.

The Palestine citrus industry presents some special plant improvement problems. The season is short, and the reputation of the industry has been built up on one variety, the Jaffa. The desirability of widening the range of varieties in view of changing market conditions was mentioned in the Stockdale Report of 1935.[1] Top-working of existing groves to other varieties is now being seriously considered, as the present abnormal conditions which prevent marketing of the bulk of the crop provide an opportunity for the change. The Rehovot Station is already investigating some of the technical problems, and the Mikveh Israel Station has accumulated over many years a mass of cultural and performance information on the large number of citrus varieties established in its observation groves. This information should be invaluable to the industry.

(h) SEED PRODUCTION

Once an improved variety has been obtained, stocks of seed have to be multiplied, for sale or distribution to farmers, and steps must be taken to prevent deterioration and contamination in successive seasons after the seed has entered the market. In the Middle East there exist the extremes of close and efficient control, and no control at all. The first is illustrated by cotton seed in Egypt and the Sudan; the second by the widespread peasant practice of the saving of a portion of a crop for next year's seed, or of casual purchase from some small dealer.

The Egyptian system for cotton exercises control without any interference with the normal agricultural and commercial activities connected with the crop. At the research centre fresh propagations are made each year of the pure-bred nucleus stocks of all the standard and new varieties. This is carefully done, with the standard precautions, so that year by year the nucleus stock of any variety becomes more homogeneous. The normal stages of multiplication—cages, plots, Government seed farms, seed-growing under contract on big farms—occupy several years. The yearly renewal at the initial stage means that the multiplied stocks get purer each year, which would not be the case if renewal seeds came from the bulk-propagation level. The Government pedigree seed produced in the multiplication scheme is sufficient to plant about one-tenth of the whole area, and it enters the market at that stage, and thereafter is left to free commercial handling. Two generations suffice to produce enough seed for the remaining nine-tenths of the cotton area. The central organization continues to produce a bulk of new seed of the fresh variety, which is used to replace, under a system of examination, parcels of seed in the

[1] *Report on Visit to Palestine and Trans-Jordan.* Colonial Advisory Council Paper No. 247: 1935, Colonial Office, London.

commercial stocks that have become contaminated through cross-fertilization. The Egyptian cotton yield and quality, and hence the cultivators' receipts, have been greatly raised since this system has been in operation.[1] The cotton crop is of such importance to the Egyptian cultivator that he needs little persuasion to adopt a better variety. Thanks to the close help the Cotton Spinning Laboratory tests give to the plant-breeding work, there is every certainty, before a new variety even enters the renewal system, that it will prove advantageous to the cultivator.

The special circumstances of cotton have made feasible a closer and less irksome control for the benefit of the cultivator and the industry than would be possible with other crops. Nevertheless the general principles must be followed in the case of other seeds and crops where more than an immediate local market is involved. Before the war there was no important seed production industry, other than cotton, in the Middle East. During the war M.E.S.C. and the territories themselves have of necessity organized local production of seeds to meet a threatening situation, and the question has already arisen whether the Middle East could and should take some share in the industry of seed production for export as part of its peace-time agriculture. The seeds industry is a complicated one in both its commercial and technical ramifications, and isolated efforts to enter it would be of little use. The opportunities that arose owing to the extreme disruption of the industry in Europe are not likely to survive of their own accord in the post-war reorganization of production. If Middle East areas are to have any place therein, it will be secured only by organized action based on the suitability of the areas in question and technical efficiency. There is no doubt that suitable Middle East areas exist for agricultural and horticultural seed production. The Mediterranean littoral areas closely resemble southern Italy and France where the industry is well established, and war-time experience in Palestine has shown its suitability; Cyprus, Syria, and Lebanon have analogous conditions, and some commercial production has already been done in Iraq. The technical aspects present more difficulties. Seed multiplication by farmers under contract with seeds firms is a skilled business. Government legislation and control for seed testing, inspection, and certification are required. Seed multiplication is only one aspect. For example, the production of pure line seeds for introduction elsewhere requires contacts with Government experiment stations, variety trials, and other co-ordinated activities.

The situation appears to be one where common action is needed to avoid misdirected efforts. It might be an appropriate activity for an organization on the lines of the Public Utility Corporations proposed in Chap. III, 2. Among its duties would be to act as a contract-placing authority for overseas firms, to allot the contracts to the most suitable places, and to handle the disposal of the products. It would help Government Departments to secure uniformity in controls and legislation, disseminate trade and technical information, and foster new developments by co-operation with agricultural experiment stations. The organization, although envisaged above from the viewpoint of seed exports, would have considerable scope in relation to seed requirements within the Middle East. In spite of the efforts of the agricultural experiment stations in some of the territories it cannot be pretended that the benefit to the farmers' crops has been commensurate with the work put into the production of new varieties and better seeds of the standard agricultural

[1] For further details of the system see *The Practical Applications of Agricultural Research* by W. L. Balls (in the Proceedings of the Conference on Agricultural Development, M.E.S.C. Agricultural Report No. 6, Cairo, 1944), and *The Cottons of Egypt*, by H. A. Hancock, Egypt Ministry of Agriculture Technical Bulletin No. 235.

and horticultural crops. The reasons are simple. There is the peasant custom of saving part of certain of his crop for next year's seed which unavoidably leads, even with self-fertilized crops, to deterioration and contamination. And, secondly, the preservation of seed quality on the farm depends on the technical knowledge and efficiency of the commercial seed dealers, to whom a Government must hand over at some point in the chain of distribution from experiment station to farm. The entry of a competent organization into the seed trade would have a salutary effect both directly, through its own efforts, and indirectly, by setting a high standard to which private dealers would have to aspire if they wished to remain in the business.

(i) PLANT PESTS AND DISEASES

The Middle East has its full share of plant pests and diseases, and the problem of control is intensified by the differing levels so far reached by Government organization in the various countries. Thus Egypt, Palestine, Cyprus, and the Sudan have plant inspection and quarantine organizations, backed by technical and research laboratories for plant pathological and entomological problems. In other territories these organizations are often less developed and in others they are almost absent.

In general there are two classes of problems: those that cover a wide region embracing a number of territories, and those that, for environmental reasons, or, more often, because of the concentration of a particular crop in a relatively small area, have an intensive local significance. The locust is typical of the former and the pink bollworm on Egyptian cotton of the latter.

The basis of any method of control or prevention is, of course, a knowledge of the life-history of the disease or pest, which must be worked out under the local conditions. In the main, control by insecticides and fungicides is only possible for valuable 'cash-crops' such as oranges. In the normal systems of agriculture it is economically impossible, and other means must be explored: varieties that are resistant, or that mature before the disease reaches peak incidence; change of sowing or planting dates; a change in the rotation; reduction of alternative host plants—often weeds; cultural practices of this kind may reduce the trouble to manageable dimensions. A good example is given by the pink bollworm in Egypt. Its depredations were countered by spacing the cotton at closer intervals, the effects of which on the number and date of opening of the bolls had already been studied in another connexion.

In the case of insect pests there are occasional possibilities of biological control, by breeding and releasing quantities of a parasite. In Palestine the mealy bug which attacks citrus is being controlled by a parasite obtained from Japan.

Associated with life-history studies of diseases and pests there should be an examination of the ecological relationships. The Plant Pathology Division of the Rehovot Experiment Station has paid special attention to this question and has elucidated a number of examples of its importance in control methods. Although many of the pathogenic fungi are specific to certain host plants, the distribution of the fungi and host plants is not necessarily the same. The 'scab' on oranges and Panama disease of bananas, serious in tropical countries, have not developed in Palestine. This is not because the organisms have not been introduced, but because the combination of high temperature and humidity essential for their development does not occur in Palestine. The Sclerotinia brown rot of deciduous fruit trees, a temperate climate trouble, is also absent, because the temperature during the growing-season of the trees is too high for its development. Another group of

diseases, the powdery mildews, that affect tomatoes among other crops, are specially liable to develop in dry conditions, and therefore to cause serious losses in the Middle East.

Ecological knowledge of this kind can be used practically in a number of ways, apart from its use in instructing farmers. Some root rots are not amenable to control, but if their ecological limitations are known, areas outside these can be specified as suitable for growing the susceptible crops. The timing of spraying operations can be regulated or even omitted with safety at certain seasons, by applying the results from ecological studies of fruit and leaf diseases. Quarantine regulations, and arrangements for exchanging plant material with other countries, can be properly drawn up and unnecessarily rigorous regulations removed. Normally these regulations play for safety and prohibit the import of all plant material from countries in which diseases not present in the importing country are reported to occur.

Evidently the ecological studies must be done on a regional basis by co-operation between workers in the countries of the region, which would have the further advantages that the general pathological observations made in each country could be pooled, and specialists could be kept in touch with the research programmes in other territories. The main difficulty in the full development of any scheme on these lines is the fact that a number of the territories have, at present, incomplete or even rudimentary plant pathological services. But in recent years the advantage or rather the essential necessity of common action, has been shown by the development of the international organization for dealing with the locust. Other plant pests and diseases may be less spectacular in their manifestations, but not in the aggregate damage they cause. Rust and smuts on cereals are prevalent in many areas. The Sunn pest (*Eurygaster entegriceps*), a sucking-bug attacking cereals, especially wheat, which causes trouble in south Russia, is known also in Persia and Iraq. A wide variety of diseases of vegetables and fruit are reported from those countries where staff is available to examine economic plant diseases,[1] and there is every reason to believe that a similar situation exists elsewhere. When one remembers that a corresponding range of disease and pest problems occurs in the stored or processed crops, the case for co-ordination of effort and exchange of experiences becomes unanswerable. The form which this could best take is dealt with below (Chap. V, 2, *a*).

(j) LIVE-STOCK AND FODDER

The problems fall into three groups: the cure and prevention of diseases; improvement by breeding and selection; and the supply of a more adequate and nutritious animal fodder.

Most progress has been made in disease prevention and cure. The production and use of vaccines and serums is perhaps the best organized of any Middle East agricultural activity. Several of the territories have large-scale institutes and veterinary staffs fully occupied in this work. It is significant that the first (and only) agricultural laboratory to be started in Ethiopia since conditions became more settled was the Veterinary, Vaccine and Serum Institute at Addis Ababa. In comparison with the second and third problems, research and technological work on animal diseases and their control is very well catered for in the Middle East. There is indeed some danger in this lack of balance if it leads, as it is said to have done in certain areas, to a marked increase in numbers and hence to overstocking

[1] See, for example, *List of Economic Plant Diseases in the Anglo-Egyptian Sudan*, A. S Boughey. Sudan Government, 1942.

which, in turn, intensifies the problem of building up a balanced agricultural system in which live-stock will be adequately fed. Although Colonel Joyce in his recent report on agriculture in Ethiopia even recommends the withdrawal for a time of cattle-disease control measures because of the special conditions of that country, the requirement for redressing any lack of balance in the Middle East as a whole is obviously to increase the work on stock improvement and nutrition.

Stock improvement is being attempted in a number of the territories. With cattle, work has been concentrated mainly on crossing with various European types, particularly where increased milk-supply was being aimed at. The Jewish colonies have adopted the Friesian, and Friesian–Damascus or Beirut crosses for dairy purposes. In Persia, the Animal Husbandry Institute at Haidarabad has imported bulls from breeds selected by a former French Director. Some resemble the dual-purpose Brown Swiss, and were said to be Simmenthaler and Tarantaise. This Institute is contemplating the ambitious programme of increasing milk, beef, and work within the same 'breed'. In Egypt there is a full programme. Two native types can be distinguished: draught, known as Minufi, and a fairly distinct dairy type known as Damietta, after the old port on the eastern arm of the Nile Delta, and having some European affinities. The draught type is being improved by selection, but this method is said not to be fruitful with the Damietta. In consequence, crossing with Friesian, Shorthorn, Jersey, and Simmenthaler is now being done, and the aim is to build up a new breed with seven-eighths imported and one-eighth indigenous blood for dairy farms near towns. The Simmenthaler, having draught qualities, is also being crossed with the draught Minufi. In Palestine and Cyprus, besides Guernseys, Devons, and Shorthorns, Kerrys have been tried. This last breed, although presumably better for crossing with the native cows than the much heavier bulls of the other breeds, has been more successful in the pure state; this is so both for the pedigree ones used in Palestine and the commercial Irish ones favoured by Cyprus.

There are two environmental conditions in the Middle East that may affect European breeds. Firstly, their metabolism may be upset by the climatic conditions. In South Africa and the southern part of the U.S.A., work on the effects of temperature on European breeds has shown the desirability of keeping them in the shade or under cover from about 9 a.m. Secondly, various workers have suggested that the digestive powers of high-grade or pure-bred European animals are less than those of native cattle, and if this is so it would be a further handicap in introducing European blood. However, French[1] has recently queried the belief, and has pointed out that many other factors are involved besides nutrition.

Little work is being done in the Middle East on the grading-up of native cattle. Some Middle East types may be worthy of trial in habitats where the environment is somewhat better than their own. In Eritrea a beginning has already been made: Red Amiri cattle have been imported for trial and up-grading in the upland plateau. A further possibility is to try the effect of bulls from improved herds now existing in countries more comparable to the Middle East than western Europe, e.g. India. As satisfactory types become evolved, artificial insemination could be used to increase the numbers more rapidly.

An indication of what can be done in improving milk yields of native cows is given by the farm of Madame Arfa, near Tehran. The cows were selected locally, and the herd was graded up by drafting in the best calves produced. The present bull

[1] *The Composition and Nutritive Values of Tanganyika Feeding Stuffs*, M. H. French, 1943. East Africa Agric. J., **8**, 126–32.

was bred on the farm from a deep milking mother. The present average daily yield at the peak of lactation is about 2½ gallons (11 litres); individual cows have given nearly 5. There has been little disease: piroplasmosis and foot-and-mouth each once. The buildings are native, with improvements well within the power of any go-ahead farmer. A similar experiment in the Sudan has shown that the type of cattle inhabiting the riverain and nomadic areas of the north and central Sudan is intrinsically good, and needs only management and feeding to produce excellent milk yields. In the winter of 1940–1 the School of Agriculture had to buy cattle quickly, for a military hospital, with few opportunities of picking and choosing. About 75 per cent. were culled to leave, in 1944, a herd of 30 cows whose average yield exceeded 390 gallons (1,770 litres) in 40 weeks, with one cow giving nearly 5 gallons (22 litres) daily at the peak, and likely to reach more than 750 gallons (3,400) litres. These figures are the same as those for the Tehran herd, and suggest that similar results might be expected from other native types in the Middle East. Naturally the full practical application of the results is possible only for the few dairy herds serving the towns, but it has been suggested that if a selection of bull calves from the herd were turned over to nomads, with the object of using the survivors after, say, four years as stud bulls, some degree of inherent hardiness combined with improved milk yields might be expected to follow. Analogous considerations apply to cattle for draught—the most important quality in the Middle East system of farming. It is encouraging to note that good progress is being made in grading-up the buffalo, which, in Egypt, is more important than the cow for milk and draught purposes.

With sheep and goats the problem is the threefold one: milk, wool, and meat; and some progress is being made in a number of the territories. The Cyprus experiments on the introduction of Merino blood showed that, with their conditions and breeds, wool improvement could not be obtained without some sacrifice of milk yield, and the latter is more important than wool quality in that country. But both Palestine and Cyprus have given attention to the grading-up of native breeds. Cyprus has had good results with a fat-tailed breed, with special reference to milk and wool, and rams from their flock are distributed to suitable areas. Palestine has graded-up a flock of Awassi sheep, after experiencing poor results with crossing by Merino, Dorset, and Scottish Blackface. In Persia, wool improvement is being effected with Merinos, and they are working towards seven-eighths Merino blood. In Egypt some interesting work is in hand with Rahmani and Ausimi sheep. Rahmani is a large, reddish wool, and coarse-fleshed animal; the Ausimi is small, white wool, with better flesh. A first cross is being tested for better and more flesh, with hybrid vigour. The production of Persian lamb pelts is being studied in Persia, where they are working with Karakol sheep and the Qum breeds of Astrakhan sheep; and in Palestine, where good pelts are obtained, by crossing Awassi sheep with Astrakhan rams. Goats have received less attention than sheep, probably because the official attitude to the baladi goat is often one of disapproval. And yet the Cyprus work indicates that the baladi goat gives more milk per lactation than sheep do: 180 pints (101 litres) as against 124 (74 litres). The difficulties of replacing the baladi goat by a suitable tethered breed have already been mentioned (section *e*, above), but where that is feasible the Cyprus results suggest that the Saanen (Swiss), a breed probably of Syrian origin, is preferable to the Maltese.

Pigs are, for obvious reasons, of limited importance in the Middle East, but there are possibilities of development in suitable areas for supplying the relatively small Middle East market and for exporting pig products to suitable world markets. The work that has been done so far is, as would be expected, under European initia-

tive: in Cyprus (whose pig population is high in comparison with other Middle East countries), in Eritrea and Libia under the Italian régime, and in Palestine. In Cyprus, the Large Black does very well and is the predominant breed; Palestine is experimenting on the cross of Large and Middle Whites with the native pig. In Eritrea the Agricultural Department of the British Military Administration took over the Italian stock and has greatly increased the pig population around the towns; considerable ingenuity has been displayed in finding suitable rations. These include vegetable refuse from the farms, some rationed bran, soya-bean meal from captured German ship cargoes, and the ground-up shavings of the exceedingly hard dom palm nut (vegetable ivory) obtained from a local button factory; the analysis of the ground shavings is:

Dry matter 87·75 per cent.

Total nitrogenous substance	3·10
Albuminoids	2·65
Ether extract	trace
Fibre	68·25
Non-nitrogenous extract	19·31
Ash	9·34

Horses, donkeys, mules, and camels are of prime importance for farm and pack transport, and are also used to a limited extent on the farm itself. A certain amount of breeding-work is being done in supplying good quality sires on loan or purchase to suitably selected districts.

In small stock by far the most importance attaches to poultry and eggs. The baladi fowl, small sized, and producing a limited number of small eggs, is a characteristic feature throughout the Middle East, and the eggs provide a small supplement to a diet that is notoriously low in protein. The considerable attention given to fowls by the Jewish settlements may have stimulated work elsewhere in the Middle East, but whatever the reasons, poultry and egg improvement are now receiving a good deal of attention. The Jews have adopted the White Leghorn for the great majority of their settlements. Elsewhere other breeds are under trial, notably New Hampshire, Light Sussex, and the Australorp (a Black Orpington from Australia). Attention is also being given to native types. In Egypt, the Fayoumi, which is a passable breed, is being improved by selection, and an indeterminate white type of baladi—which probably came from an earlier introduction of White Leghorn—is being crossed with pedigree White Leghorn. Palestine has shown the considerable possibilities that exist in straightforward up-grading of the baladi fowl. In twelve years they have obtained the following results:

Number of eggs per annum, increased from 80 to 169
egg weight „ „ 40 to 55 grammes (1·4 to 1·9 oz.)
body weight „ „ 1·2 to 1·77 kilos (2·6 to 3·9 lb.)

However, it must be remembered that the baladi fowl does not lay eggs in the winter, whereas the imported breeds do.

The relative ease of working and handling poultry on a large scale have led to a useful development in the supply of birds to farmers and to some war-time extensions. Thus in Palestine the Government has two large hatcheries at Jerusalem and Acre to produce day-old chicks. In the season May–June 1943, 500,000 chicks were sold. Production from the Government poultry farms would be insufficient to meet this number, which is made up by purchase of baladi eggs, although the risk of accepting infertile or stale eggs has to be taken. These amount in fact to 50 per cent. The danger of introducing disease into the experimental and pedigree

stocks housed near by was reduced as far as possible by keeping the hatchery separate and employing separate staffs. Unfortunately, some of the collected baladi eggs came from areas affected by fowl plague, and the disease has been introduced by the day-old chicks to other areas. The risk that this would happen was considered a justifiable one to take because of the war-time urgency for increasing the meat and egg supply. The scheme is a useful illustration of what could be done with proper precautions in peace-time to distribute better-class birds throughout the Middle East. With the removal of urgent war-time considerations it would be possible to buy-in hatching eggs only from areas selected for their freedom from disease, and thus indirectly to reduce the disease incidence in other areas by supplying them with disease-free chicks.

The third main problem, the production of more adequate and nutritious animal foods, is undoubtedly the most difficult one. As already pointed out (Chaps. I and II), the climatic conditions, the system of agriculture, and the social organization all combine to create a kind of passive resistance to changes. But the scope for animal improvement is severely limited unless the fodder position can be correspondingly improved. This problem has several aspects: pastoral, settled agriculture without irrigation, and irrigation farming. In each of these aspects useful information could be procured and species of fodder plants secured for test from other parts of the world where the conditions are roughly similar to those of the Middle East, e.g. South Africa, India, Australia, and the drier southern and western areas of the United States. Attention should also be given to the indigenous vegetation in the Middle East pastoral and semi-pastoral areas, as little or nothing is yet known about the nutritive values. A survey of species and trials of their feeding-values is needed similar to the extensive work conducted in India by the Imperial Veterinary Research Institute at Mukteswar, U.P., India. The possibilities of introducing other and better types of grazing grasses should also be explored on lines analogous to those developed in South Africa, Tanganyika, &c., for the improvement of veld grazing and, equally important, the best methods of grazing with stock. An illuminating example of this latter point comes from the central province of Tanganyika.[1] Five comparable plots, all recently planted with Cynodon grass, were employed, two being grazed by goats, two by zebu oxen, and one left ungrazed. Groups of 2 oxen and 14 goats were used, these being considered to have approximately equal food intakes, and the total amount of grazing allowed to each group was identical. At the end of four years of heavy grazing the cattle plots had become open thicket with poor grazing, bare ground that invited erosion and yet with cover sufficient for the needs of tsetse flies. The plots grazed by goats, however, were still grassland capable of providing grazing for any class of stock and unsuitable for tsetse. Investigations are now planned to ascertain whether or not goats may with advantage be introduced into schemes of rotational grazing originally designed for cattle.

In view of the many charges against the goat on the score of erosion and forest damage, the implications of this experiment should not be overlooked. In the non-irrigated arable areas the difficulty of making any marked changes for the better must be frankly faced, especially where small fragmented holdings are the rule. As long as these conditions exist the farmer can grow only an insignificant area of fodder crops, and the basic difficulty of summer keep for the animals must remain.

In the irrigated areas there is, of course, much greater scope. The classical example

[1] Staples, R. R., Hornby, H. E., and Hornby, R. M., 1942. *A Study of the Comparative Effects of Goats and Cattle on Mixed Grass-bush Pasture*'. East Africa Agric. J., **8**, 62–70.

is undoubtedly the introduction of berseem (*Trifolium alexandrinum*) into Egyptian irrigation agriculture, and it is unfortunate that this crop has not been so successful elsewhere and that up to the present nothing comparable has been found for other areas. Lucerne has, on the whole, been disappointing, which is surprising in view of its deep-rooting habit. But it is a tricky crop to establish, especially in its early stages, and it may well be that further field studies of cultural details are necessary.

As part of their policy of dairy and mixed farming the Jewish settlements have experimented extensively on a wide variety of fodder crops in the rotation, and their published results are available. The Rehovot Experiment Station has tested a number of rotations and now has under trial the following six-course, with overhead irrigation:

	Winter	*Summer*
1st year	Barley (grain, or green fodder if needed)	..
2nd ,,	Berseem	Cowpeas
3rd ,,	Horsebeans	Sunflowers; soya beans
4th ,,	Oats	Soya beans; maize
5th ,,	Peas	Green maize; sunflowers
6th ,,	Vetches for hay	..

It is stated that 15 acres under this rotation will provide fodder for some 20 cows.

The Mikveh Israel Station has a simpler rotation under trial that receives only two (channel) irrigations in four years:

	Winter	*Summer*
1st year,	irrigated	Berseem; fodder oats	Green maize
2nd ,,	non-irrigated	Wheat	..
3rd ,,	,, ,,	Mixed vetch and oats for hay	..
4th ,,	irrigated	Vegetables	Vegetables

Both rotations have berseem only once in the course, to reduce the danger of nematode attack, and of cut-worms (*Euxoa* (*Agrotis*) *ypsilon* Rott.) which are troublesome at times, as they are in Egypt. The rotations have one interesting difference. The Rehovot one has no mixed fodder crop as Mikveh Israel has; the reason given —apart from the biblical edict against the practice (Lev. xix. 19)—was that they obtained less total yield from the mixed than from the separate crop.

At the Acre Experiment Station, Palestine, the idea of 'dynamic' pastures has been cleverly exploited, i.e. a 'seeds' mixture with different grasses becoming successively dominant as the ley period progresses, combined with rotational irrigating and grazing of the plots. After a study of the behaviour of various grasses, alone and in mixtures, an extensive trial was made of the following mixture:

Lucerne (*Medicago sativa*)	22·0 lb. per acre
Sudan grass (*Sorghum Sudanese*)	4·4 ,, ,,
Rhodes grass (*Chloris Gayana*)	2·6 ,, ,,
Paspalum grass (*Paspalum dilatatum*) . . .	4·0 ,, ,,

The mixture is sown in the spring or, with Sudan grass omitted, in the autumn. Sudan grass provides the bulk of the grazing at first and then disappears in favour of lucerne. The main reason for its inclusion is that the lucerne is not so quickly destroyed by grazing or weed competition as in a pure stand. It is possible that if a heavy seeding of lucerne is used, Sudan grass can be omitted in the spring sowings also; this would be an advantage, as its nutritional value is less than lucerne, and the latter in a heavy stand can resist grazing reasonably well and not be choked by weeds. Later, Rhodes grass and Paspalum become dominant, the former especially

so on light and well-drained soils and the latter on heavy soils or low-lying damp patches. Both are included in the mixture for that reason, and also because Paspalum, although giving less bulk than Rhodes grass and having a rather undesirable tufty nature, is somewhat more palatable. In addition to the usual management features connected with rotational irrigation and grazing, rank grass and herbage growing away from stock is mown and removed for hay or litter. The Acre experimental plots are arranged to show all the stages in the rotation, and they show in striking fashion the very heavy yields, especially of Rhodes grass. A number of feeding trials show that a cow of 10 cwt. (500 kilograms), with 10 hours' grazing daily, gets her maintenance ration, plus a production ration, for 2 gallons (8·5 litres) of milk. Milk production in excess of this needs appropriate concentrates.

After 3–4 years the pastures are eaten down hard—mules and donkeys are good for this—and ploughed in. The area can be reseeded to pasture, or arable crops taken. All weeds are completely choked out by the dense growth of the pasture.

The principle of this experiment is one that should be taken up in other irrigation areas of the Middle East, and especially in areas scheduled for settlement after irrigation development, where the information would save much valuable time in devising suitable rotations for the incoming settlers.

The above brief survey should suffice to show that, under the climatic and present farming conditions of the Middle East, live-stock and fodder problems are of peculiar importance in any programme of agricultural development, and the need for an early examination by experts is incontestable. An interim recommendation to this effect was made and accepted. The examination is now in progress and will form the subject of a separate report in this series.

CHAPTER V

The Supply and Development of Agricultural Information and Advice

In the preceding sections the method of approach was through a consideration of various specific problems with illustrative examples drawn from appropriate territories. It now remains to look at the whole range of problems from the viewpoint of each territory in turn, and finally from the viewpoint of the Middle East as a whole.

(1) THE SEPARATE TERRITORIES

It is unnecessary to repeat for each territory all its main scientific and technical problems. In most cases their existence is only too well known to the respective Governments, and a number of them have been used above as illustrations in this report. Attention will be directed rather to matters concerned with the general agricultural policy and programme of each territory, the departmental organizations, and the supply and training of staff. Not only do these questions fall within the terms of reference, but the authorities in several territories specially asked for them to be dealt with. Some of these problems are common to practically every territory, and so can usefully be discussed on that basis. This is done immediately below.

(a) Agricultural Statistics and Surveys. Almost without exception there is a lack of reliable agricultural statistics and even of the more general, but equally

essential, broad surveys of the existing systems of farming in relation to soil types, weather conditions, and the peasant economy. Without these broad surveys it is most difficult to get a properly balanced picture of the agriculture of a country, and to draw up satisfactory plans of agricultural improvement. Countries where peasant agriculture predominates admittedly present many special difficulties in survey and enumeration. Government income is inadequate to provide the full organization; holdings are small; a proportion of the crops is used for food by the cultivators; dealings in kind are more important than cash transactions; herds and flocks may migrate. Some of the problems in collecting and interpreting the data were presented and discussed at a conference held by M.E.S.C. in 1943.[1] In the course of its work the Centre has also accumulated some useful information, some in the form of answers to questionnaires and some which is incidental to certain special investigations, e.g. land tenure, now in progress. The American University at Beirut has sponsored a number of economic studies in which the investigation of agricultural systems is included. The Jewish Economics Research Institutes have made some extensive investigations. Further material could also be abstracted from the official statistics of crops grown mainly for export, e.g. cotton, oranges, and dates. Thus, certain basic material, and useful indirect information for filling gaps, already exist to supplement the field survey work. It is to be hoped that the Governments will initiate—or accelerate, as the case may be—this important work. It would be to the advantage of each country if the surveys are made on an agreed common basis. Where some preliminary training of the survey personnel is needed, this should also be done on a common basis. In the inquiry full use should be made of the technique that has been developed in the statistical theory of small samples. As pointed out in the section on Plant Nutrition (Chap. IV, *f*), it has been widely adopted for agricultural experiments. It can equally well be applied in other and most diverse fields of inquiry, with the advantages of economy of effort and increased precision in the results. It has already been used by the Government Statistician, Palestine.

(b) Irrigation. In the earlier days of irrigation an irrigation scheme was regarded mainly as an engineering problem concerned with the best means of controlling and delivering water to the area of land commanded by the flow. So many cases have occurred of unsuitable land being included and of deterioration of initially fertile land after a few years to show beyond doubt how essential it is for soil experts to be closely associated with any scheme from the first stages of its inception. The following quotation from an official United States publication[2] is to the point:

'The plans for an irrigation enterprise should include the survey of the soils and classification of the lands[3] as well as an investigation of the available irrigation water and the means of conserving it and conveying it to the land. Furthermore, experience has shown that after irrigation has become established, re-examinations of the soil should be made from time to time to determine the trend of changes that may occur in the root zone in consequence of inadequate subsoil drainage or the accumulation of soluble salts. Such examinations of the soil of irrigated lands require special methods not only for the field work but also for reporting the findings. While definite progress has been made by soil scientists in the development of such methods, much may still be done to place this work on a sounder and more acceptable basis. The problem, however, is not so much to develop methods as to make practical application

[1] Conference on Statistics. M.E.S.C., Cairo, 1943.

[2] U.S. Department of Agriculture. Year Book of Agriculture, 1938 (*Soils and Men*), pp. 706–7.

[3] This subject is more fully discussed in the articles *Soil Maps and Their Use*, p. 1002, and *Irrigation in the United States*, p. 693, in the same Year Book.

of methods already developed. Meanwhile the work of constructing and operating irrigation projects goes on. Avoidable mistakes are made and there are many failures. Questions are raised as to the permanence of irrigation agriculture because of uncertainties as to the causes of trouble. These are the reasons for emphasizing the need of careful, detailed soil surveys and land classification prior to the development of projects and the development and use of acceptable methods for ascertaining and reporting the conditions in irrigated soils.'

The Union of South Africa pays special attention to the initial selection of the land. A field unit with scientific equipment designed for a travelling laboratory makes a survey in which nine or ten soil factors are examined and mapped. The data are reduced ultimately to one map, on which several classes of land are delimited in order of their suitability for irrigation: this becomes the master map on which the Irrigation Department bases its construction plans.

In the Sudan Gezira a system of soil sampling and examination has been in use since the early days of the irrigation scheme: it has been modified and improved by experience. Owing to the uniform flat topography of the region samples are taken at regular intervals, over the area concerned, to a depth of 10 feet at 1-foot intervals. During the sampling notes are made at each interval of features likely to have an agricultural or agronomic significance; these include moisture, root penetration, extent of cracks, friability, calcium carbonate nodules, gypsum crystals, termite holes, and general remarks. In the laboratory, the principal measurements are percentage of clay, pH, total exchangeable sodium plus soluble sodium; these figures are used for giving precision to and resolving doubtful points in the field assessment. On this basis the best new areas for irrigation can be delimited with considerable precision, thus avoiding expensive mistakes and making the best use of the available water. A parallel investigation has been made on areas already irrigated for the purpose of correlating cotton yields with the soil factors given above. Further uses of the method are also being explored at the Gezira Research Farm, Wad Medani.

In the Middle East there will be developments of irrigation, some on a considerable scale. It is imperative that the Governments concerned should arrange for their Irrigation Departments to be in possession of expert soil classification maps, analogous to those used in the Sudan and South Africa, before construction plans are worked out. Further, the behaviour of the soil after irrigation has begun should be closely followed by soil experts, so that troubles may be detected and dealt with in their incipient stages. In general this calls for a closer association than usually exists between Agricultural and Irrigation Departments, which may have to be implemented by a readjustment of their respective responsibility and authority. In some territories experts are not available and recourse must be had to special contract, or to loan from another territory. Where some organization such as a Public Utility Corporation takes part in the scheme, it would provide the expert help, and this would, of course, be one of the conditions in the agreement.

In addition to the soil problems discussed above, on which, in general, irrigation engineers need more knowledge—or expert assistance—there are a number of hydrological problems, some of which have been discussed in the section on soil moisture (Chap. IV, *d*). Great changes in our understanding of the water-régime from the soil surface to the underground water-table have been made in recent years by physical studies especially in Great Britain at the Rothamsted Experimental Station, in India at the Irrigation Research Laboratory, Lahore, and in the United States of America at the Federal and some State laboratories. It cannot be said

that this knowledge has yet become incorporated into the training of irrigation engineers. The problem of doing so is not an easy one: in addition there are other matters of importance in water-supply, set out in chapters v and vi of Dr. E. B. Worthington's *Report on Middle East Science*. One possibility worth examination by the British Commonwealth and by the United States of America is to create graduate schools of hydrological engineering, with adequate facilities for post-graduate work: the matter is of more than Middle East interest, for it specially concerns the United States of America and India and many other territories.

(c) The Veterinary Services. As the problems of animal improvement are now under separate expert survey, it will suffice in the present report to draw attention to the following points. The fact that crop and animal husbandry are not so closely interlocked in the Middle East systems of agriculture as in temperate climate systems tends to produce a certain difference of outlook between the veterinarian and the agriculturist. This difference is not necessarily reduced, and may, indeed, be accentuated when, as is often the case, the veterinary service forms part of the Department of Agriculture. Fodder problems are of self-evident importance, and this implies a close association of the agriculturist in a programme of stock improvement. Again, the serious difficulties in the way of a development of mixed farming call for co-ordinated and not independent attack if they are to be overcome.

(d) Special Problems of Each Territory. CYPRUS. A progressive and well-balanced programme of investigation is in hand, but work is handicapped by lack of staff.

In animal husbandry and related problems further staff would permit more attention to the following important matters:

Animal diseases. The serious epidemic diseases have, as elsewhere, been brought under control, but considerable losses occur from other causes. Helminth and insect parasites are at present causing severe losses, and poultry diseases of various kinds are also serious. An appreciable increase in trained local staff—from three, which is quite insufficient, to eight—is suggested.

Fodder and pasture. A survey of indigenous grazing herbage is required, accompanied by feeding-trials and attempts to improve the stand. Work is also needed on fodder crops in green and hay conditions.

Animal products. The local standards of cheese, ham, &c., could be improved, and local processing industries developed. For this it would be necessary to bring in an expert.

In crop husbandry, no special additional suggestions need to be made, but additional staff would permit more attention to the following important matters:

Water requirements. Efficient development of water resources is now being made, but available supplies are limited. The most efficient and economical use needs to be worked out by suitable experiments in typical areas.

Rotations, manuring, and cultivations. Further experimental information is needed on possible improvements within the power of the peasant farmer to adopt.

Vegetables. These are varied and abundant in winter and spring but relatively scarce in summer. Household-scale dehydration experiments for carrying over the winter surplus to the summer are in progress. The possibilities of small-scale canning, both for home use and for local markets, might be explored, as an alternative or additional method. Before the war the Bulgarian Government had intro-

duced this method with considerable success into their peasant agriculture, and a visit to that country, on the return of more normal conditions, to inspect their methods would be advisable.

The underlying problems in Cyprus are, however, the supply and training of junior departmental officers, and the development of agricultural education and the advisory service. Whatever the reasons for the closing of the Agricultural School some ten years ago, the effects are now being severely felt, and early action must be taken to provide a remedy. Departmental training of recruits, such as the veterinary service has had to adopt, is no solution. The position is complicated, because training in England would be disproportionately expensive and not really suitable for juniors whose prime requirement is a thorough practical instruction in a system of agriculture resembling that of their own country. The solution is to restore agricultural training within Cyprus, or to rely on instruction available in Middle East institutions, either existing or contemplated. The latter presents language difficulties for Greek- and Turkish-speaking students, for it is probable that Arabic would be used as well as English. Given a supply of trained juniors it would be possible to arrange refresher courses for them and to select the outstanding ones for higher training overseas. For Cyprus the annual intake of trained students to the Department would be relatively small, even if the need for a larger number of advisory or 'extension' staff is taken into account. If it is decided that the intake would not justify setting up a special institution and if training elsewhere in the Middle East were impracticable, there remains the possibility of using the Teacher Training College as a source of supply, under arrangements similar to those recently introduced at the Kadoorie Agricultural School, Tulkarm, Palestine (p. 82). Some addition to the scheme would be needed, both in the curriculum and period of attendance, and it would be most important to ensure that such additions did not distort the policy of the Education Department in carrying to fruition this admirable scheme of rural education.

PALESTINE. There is little to add, on matters of agricultural improvement, to the full report[1] prepared in 1935 by the Agricultural Adviser to the Secretary of State for the Colonies.

Unfortunately progress in Palestine has suffered a check of nearly ten years due to the disturbances, and the war: not only were the staff and sub-stations reduced for reasons of economy, but the experimental and development work was further hindered by loss or damage. In spite of these difficulties, progress has been made, noticeably so in the last one or two years.

Palestine organization for agricultural investigation presents special features because of the existence of a parallel Jewish organization staffed by able investigators and advisory specialists. Certain of the scientific departments of the Hebrew University have agricultural research problems in hand: the Rehovot Experiment Station is engaged, both in research and technology, on problems in the various agricultural systems developed for the Jewish Settlements, and in citrus culture; Mikveh Israel also has an extensive programme of investigation. In practice, the Government has taken note of the Jewish agricultural work while paying special attention to the problems of the Arab cultivators. It has utilized the services of Rehovot as far as feasible, by grants to cover certain investigations of general importance to Palestine which could more suitably be done at Rehovot than

[1] *Report on a Visit to Palestine and Trans-Jordan*, F. A. Stockdale. Colonial Advisory Council Paper No. 247, 1935. Colonial Office, London.

elsewhere. It cannot be said that this arrangement has been very satisfactory. Experience has shown that it could be a useful supplement to, but not a substitute for, the Government's research and technological work.

At present the Government has an experiment station at Acre, and various sub-stations that are engaged mainly in the multiplication and distribution of better tree and plant varieties, while the sub-station at Beersheba is now developing dry-farming cultivation studies. The distribution and programme of the sub-stations are satisfactory, although more are needed to cover the different conditions. But it is questionable whether Acre is the best place for the one experiment station. It is in the limited marshy region of the northern coastal plain, whereas much of the Arab agricultural activities are in the upland and hill regions and the dry-farming area of the Negeb. It is suitable for irrigation studies, but unfortunately the well-water rests on saline water, and there are signs that the irrigation water is becoming contaminated; if this work is to continue, a fresh supply will have to be found. The question of an alternative, or preferably an additional experiment station, should be carefully examined. In the latter event there would be a main experiment station, and a subsidiary one administered and controlled from the main station.

An increase of personnel is undoubtedly required. The Palestinian Assistants at Acre are all doing good work, and the investigations on 'dynamic pastures' discussed above (Chap. IV, *j*) are most creditable. But there are at least four directions in which more work is urgently needed, for each of which a qualified investigator with trained assistant staff would have to be appointed:

(*a*) the improvement of food crops, especially cereals—including oats, a new crop —and maize;
(*b*) the further development of work on grasses and legumes for pastures and irrigated green fodder, and oil crops of various kinds;
(*c*) the agricultural aspects of 'hill ecology';
(*d*) a soils section for the soil and crop work in connexion with fertility, irrigation, feeding-values, &c.

These lines of work, with those already in progress, would form a coherent experimental programme. The best means of directing the programme has been under consideration for some time by the Government. One proposal is to appoint a Chief Scientific Officer in the Department of Agriculture, who would be responsible for the Government investigations and their co-ordination with the work delegated to Rehovot and elsewhere. The proposal is an improvement on the present situation, but it attaches too much importance to co-ordination and too little to investigation. The former is only useful in proportion to the efficiency of the latter. No experiment station can be really effective without a resident Director with personal experience in conducting research. Periodical visits by a Chief Scientific Officer would be no substitute, even in a country of short distances like Palestine, for the quality of research work depends as much on the immediate discussion of a new line of thought suggested by an unexpected result—or arising of its own accord—as on the most careful planning and co-ordination of a programme of work. What is required is the combination of flexibility with adherence to the main objectives of a programme. The matter can be put in another way: co-ordination at the level envisaged by the proposal to appoint a Chief Scientific Officer would imply an earlier co-ordination at the experiment station level and, if the latter is properly done, much of the former would become redundant. Liaison with external institutions such as Rehovot and allocation of specific problems to them would

remain the formal responsibility of the Director of Agriculture, who would consult—and in practice be largely guided by—the Director of the experiment station.

Therefore, it is recommended that a Director of the experiment station should be appointed rather than a Chief Scientific Officer. It is likely that the Director would also take charge of one of the subjects of investigation, e.g. one of the four mentioned above.

There is a marked contrast as between Arab and Jew in the facilities for training and supply of the subordinate officers, especially those in direct contact with the farmers. The Jewish community is well provided with facilities for agricultural instruction: the WIZO schools, as at Nahalal (for women only); the Jewish Farmers' Federation School at Pardess Hanna; the large Mikveh Israel school. Recently the Hebrew University has opened a college at Rehovot as part of its new Faculty of Agriculture. On the Arab side there is only the Kadoorie Agricultural School at Tulkarm, which has had so far an unfortunately chequered career. Originally the two Kadoorie schools were expected to produce the future agricultural officers, but experience has shown that the scholars of the one at Mount Tabor are absorbed by the Jewish colonies, while those from Tulkarm are inadequately trained. Further, their entry into the Agricultural Service can only be as occasional replacements, as the Department of Agriculture is fully staffed on its existing (but inadequate) basis. Additional outlets were therefore necessary if a reasonable number of students was to be secured, and so a third-year course was instituted for those who elected to be trained as school teachers, specializing on the school garden and agricultural side. Experience gained under this arrangement showed that it would be improved if the school became the responsibility of the Department of Education, and at the suggestion of the Department of Agriculture the transfer has now been made. The Palestine problem thus closely resembles the Cyprus one, and for the same basic reason: the country is too small to sustain an institution for the exclusive purpose of training a junior agricultural staff, and yet it is the outdoor staff of this class that are in closest contact with the farmers, and on whom, therefore, the possibilities of agricultural improvement really depend.

SYRIA AND THE LEBANON. On a broad generalization, the climate and topography of these two countries make Lebanon more suited to diversified and intensive agriculture than Syria, where normal arable and animal agriculture are standard.

The fruit industry has boomed, partly because of the stimulus given by imports of Californian products in Lebanese markets, and partly owing to intensive Italian salesmanship for trees from Italian nurseries. Although sound work has been done by the Jesuit farm at Bekaa in introducing suitable varieties, the development elsewhere has been somewhat chaotic and the general economy of the industry has been affected. Thus the Italians introduced some unsuitable olive varieties, quick growing, but of poor oil content and susceptible to the Leopard Moth stem-borer; the trees are now having to be reworked to other varieties. Along the coastal belt bananas are increasing and replacing mulberries and cereals. Most of them are planted as a quick cash-crop on land intended for citrus, and the sequence is vegetables, bananas, interplanted with citrus. Bananas provide a very large quantity of food per acre, and the increase in this crop should be encouraged in the present and immediate post-war emergency. The tendency to increase the citrus area should be carefully watched in view of the Palestine experience and the increase in the citrus area in a number of Middle East territories. To secure and hold a place in the export market is a difficult task requiring much skilled organization and

capital. It may well be advisable to discourage any expansion beyond that necessary to supply the internal and immediately adjacent markets.

Vines are an important section of the fruit industry, the main area being around Bekaa. In view of the incidence of phylloxera, more attention needs to be paid to the replacement of susceptible root-stocks by resistant American varieties.

It is apparent that one of Lebanon's important problems is the development of the fruit industry on orderly lines, to include the organization of grading and marketing and the development of co-operatives.

The reduction in the mulberry area, due largely to Japanese competition, has been temporarily arrested by the war-time boom in silk for military use. Before the war there was no grading of the reeled silk, which went at a cheap price to the Lyons market. As a war-time measure the British Ministry of Supply provided expert help for the factories, and experiments are in hand with an autumn crop, and other forms of mulberry plantation, to increase the yield of silk per acre and to lower the cost of production. There are good grounds for hoping that the industry may survive and even increase in Lebanon. The competition of artificial silk is more apparent than real, as the two commodities cater for different markets; the world consumption of silk has, in fact, greatly increased since the invention of artificial silk.

Potato-growing has appreciably increased under the impetus of war conditions, but virus and other diseases—including a bacterial wilt that was severe in 1943—have appeared. Lebanon is reasonably well suited to potato-growing, and the crop is now likely to remain as an article in the Middle East diet. More attention should therefore be given to the problems of disease prevention and control.

Vegetable growing is well established, and there are possibilities in seed production provided the development is made along the lines recommended above (Chap. IV, *h*).

It is surprising that so few cultivators have adopted simple poultry improvement measures. The Institute of Rural Life (American University) has changed the stock in a number of villages and finds that Leghorns do well even in baladi conditions. A further attempt should be made to get the improvements introduced.

Most of the Syrian problems are concerned with the ordinary farm crops and animals, as the farming is largely of the traditional Middle East type. They embrace therefore the range of problems already discussed in this Report: improved varieties and new arable crops to give more proteins and fat in the diet; animal fodders; animal improvement; raising the market standard of animals and animal products; grazing and erosion difficulties.

Syria is relatively lightly populated, so problems of extending dry-farming towards the desert area do not yet arise. Undoubtedly the most important problem in Syria, both in its local and general significance, is the development of the fertile Djezira in the north-east of the country. This is one of the districts where new methods can be instituted to serve as one of the patterns for the agricultural rehabilitation of the Middle East (Chap. III, 2). Already, as a war-time measure, large areas of the Djezira have been used for mechanized cereal production, with large-scale implements. The most serious consideration is now urgently needed if this area is to become the centre of a rational system of agriculture.[1]

[1] For a discussion of suitable systems see *Large Scale Farming in the Northern Djezira of Syria*, C. R. S. Wheeler. Conference on Agricultural Development (Agricultural Report No. 6. M.E.S.C., Cairo, 1944).

There is no full-scale agricultural experiment station in the Lebanon or in Syria, but there are about ten nursery gardens, mostly in Syria, for the supply of young fruit-trees and similar material, and, at one or two, some limited tests of cereal varieties. Although these gardens are doing useful work, some of the more progressive farmers possess good private nurseries that are ahead of the Governments' efforts, especially in fruit and vegetables. The establishment of an experiment station for Lebanon and for Syria is such an obvious need as to require only formal recommendation in this Report. It is doubtful whether adequately qualified men are available, and early steps should be taken to provide them. They should have had a basic training in science such as is given at the American University, Beirut, followed by a specialist training in some branch of agricultural science or pure science, and this under present circumstances must be obtained abroad.

There is little provision for agricultural education or the training of candidates for posts in the agricultural service. In Syria the Selamieh Secondary School has been reopened as an agricultural school for farmers' sons. In Lebanon the International College at Beirut has a course, necessarily mainly theoretical in the absence of an experimental farm, and the Department of Education has started a course attached to the Arts and Crafts School in Beirut; here again there is no experimental farm, and the intention is to make it a training course for teachers and thus gradually to remedy the absence of agricultural education in the elementary schools. The few agricultural assistants and advisers have mostly been trained in French schools, e.g. Algiers, to a not very high standard.

It is apparent that much more than this will be needed if the Departments of Agriculture and Education are to have any real influence in agricultural and rural development. One immediate step should be the transfer of the agricultural course of the Department of Education from Beirut (a city environment is most unsuitable) to a more rural area where it is in proximity to and associated with a Department of Agriculture nursery or experiment station; if the projected experiment station in the Baalbek region materializes, this would be a much more suitable place, as it is a natural centre for various types of farming. A further possibility is to utilize the early Palestine experience in the development of school gardens and the training of instructors. If the output of teachers from the agricultural course is alone relied on, development will be much slower than it should be.

TRANSJORDAN. The signs of population pressure on the land are taking shape, but are not yet serious. They have been reduced for a period at any rate by an admirably simple and efficient system of land settlement, which has been speeded up with financial assistance from the Colonial Development Fund. This has produced, of course, a marked improvement in land maintenance and utilization. But the old problem of succession still remains even though it may be disguised by inheritance of shares rather than actual fragmentation of holdings; as it is, there is a tendency for holdings to get smaller.

There are two possibilities of further development: development of irrigation farming in the Ghor Safi near the southern end of the Dead Sea, and the development on a dry-farming basis of the area west of Ma'an. The former is complicated by existing water concessions made to industrial undertakings in Palestine, but by lining the canals water losses have been much reduced and there is a surplus available for irrigating extra land. On the Palestine side of the Jordan irrigation is developing, not only at the older established area of Jericho, but in places where the salt-content problem has been overcome (Chap. IV, *a*). Although these troubles

are not likely to be so serious on the Transjordan side, it would be desirable to watch for them and to draw on the Palestine experiences. Development of the dry-farming area could very usefully be made as an experiment in land settlement. One suggestion that has much to recommend it is to induce the younger sons of sheikhs and a selected group of villagers to go as units, of which the younger sons would become the new sheikhs. A necessary condition would be the surrender of all rights of ownership on their present holdings, to resist the natural tendency to drift back during the occasional set-backs inseparable from dry-farming, especially in the earlier years. The inducements would include a generous parcel of land which would necessitate some co-operative provision for its adequate cultivation. Animal cultivation would mean fodder problems, so tractor implements should be employed. It is assumed that an official supervisor would be in charge of the settlement and the mechanical cultivation should be his responsibility. As already noted in this Report, there is a general desire to own tractors and a belief—still to be proved—that the deeper cultivations will give better yields. The results of the Palestine experiment on tractor and baladi cultivation should therefore be carefully watched and supplemented by local experiments on the relevant issues.

In matters of general improvement there is still room for an extension of olive-growing, for wide areas are suitable, and the extensive destruction of trees in the war of 1914–18 has by no means been yet made good. There is also still much scope for the substitution of phylloxera-resistant vines, and the distribution of young fruit-trees.

Little progress appears to have been made in improving the varieties of the standard arable crops. This was part of the work that the Stockdale Report of 1935 recommended for special study at the proposed experiment station near Amman. For various reasons—not the least one being the absence of a qualified experimental staff—the work now in progress does not fulfil what was intended. Such trials as are being made include various cultivations and rotations, but they are not designed in a suitable manner to give reliable information. Outside help is obviously needed. It should be possible for a visiting expert in field experiment technique to draw up a scheme of experiments on the main agricultural problems which would be within the compass of the available staff and which would necessitate only occasional visits of inspection on his part; the statistical reduction of the results would also be done by him. The adoption of this proposal is recommended, and it is suggested that the extensive experience at the Gezira Research Farm in the Sudan should be utilized in drawing up the scheme.

IRAQ. The development of the central and southern portions presents the chief agricultural problem in Iraq. There is a past history of piecemeal irrigation, and it is only in recent years that systematic development has begun. Many existing small areas will need to be remodelled to fit in with an over-all scheme. As already mentioned (Chap. I, *e*) the area of land suitable for irrigation is greater than can be supplied by the water resources. Deterioration due to absence of drainage and over-lavish irrigation has been met by resting the land and taking in an adjoining area. This is not a defensible policy. There is urgent need for a Soils Department in the Department of Agriculture, to work in the closest association with the Irrigation Department as already discussed (p. 77). The policy should aim at preserving in good heart the areas already irrigated in the older schemes, especially in the central division of the country. The southern portion, with its extensive marsh areas, presents very difficult problems. The area is new and unstable, and there is much

to be said for letting Nature take her course towards stability in this area. Little information exists on the correct use of irrigation water in Iraqi conditions, and early study should be given to duty of water problems.

Owing to the area of land available and the absence of any pressure of population on the land, opportunities exist for the development of arable agriculture along large-scale co-operative lines such as those discussed above (Chap. III, 1, 2). The big operations suitable for machinery, e.g. special ploughing, harvesting, and threshing, could be done on contract for the cultivators by the managing company.

In the northern part of the country there is an established fruit- and tree-growing district, of which the valleys around Shaqlawa near Erbil are typical. The products include walnuts, peaches, apricots, apples, pomegranates, plums; the timbers include poplar, walnut, mulberry, willow, and sycamore. Summer irrigation is given as necessary, for there is plenty of water. The conditions are nearly ideal for fruit, but there is no pretence of an organized industry on modern lines. In the 'orchards' the trees are so close that they grow into one another; there are numerous suckers springing from the roots, there is no pruning, no lopping of dead branches, and the fruit is not culled or graded. But running expenses are negligible in these conditions, and the local Erbil market readily absorbs the products, so the owners see no need to modernize and intensify their holdings. This area, therefore, presents a most interesting problem, which is primarily one of economics and distribution. No costly improvements would be justified unless there is a reasonable chance of entering a wider and more exacting market than the local one. In considering this possibility an important factor is that a good deal of quiet development of fruit and nut supplies is already proceeding in a number of areas throughout Iraq, under the impetus of the Department of Agriculture's Horticultural Station at Zafaraniyeh and, among the nurseries, the pistachio and general one at Mosul, both of which are doing very useful work.

Another problem of special significance in the northern area is the improvement of live-stock. The importance of animals in Iraq's export trade would justify the creation of an Animal Husbandry section, especially as the Veterinary Service is already well developed.

The Agricultural Department has three large farms which are not experimental in the usual sense of that word. The largest, at Abu Guraib, is a 15,000-acre area for commercial crops, dairying and poultry, with an experimental area. There are also a number of nurseries for the distribution of budded fruit-trees, &c. Owing to war conditions a good deal of the time of the agricultural staff has been devoted to commercial crop growing on the Government farms. It is to be hoped that they can be relieved of this activity. It is recommended that the policy of the Government farms be reviewed and that consideration be given to reducing their size to that suitable for agricultural experiment stations. In spite of the difficulties, good work is being done in testing various varieties of arable crops and in multiplying good strains; the observation, row, plot, and farm trials of cereals, linseed, and cotton at Abu Guraib were very well conducted, and with more time and staff it would be possible to extend this work to breeding and selection. The bulk replication of approved varieties for distribution to farmers is done on the Government farm land. This is a necessary activity so long as the present policy is maintained, but it is to be hoped that the work can ultimately be handed over to approved farmers as a commercial proposition.

The supply of staff for the Agricultural Department needs improvement on both

the scientific and advisory levels. At present there are about ten technical officers most of whom have had higher training in California or Texas, where the agricultural problems bear some resemblance to those in Iraq. The desire of the Director of Agriculture to widen the choice of overseas centres for higher training is perfectly sound; the Department would benefit if its technical officers were trained in a variety of places. South Africa—preferably Natal—would be very suitable, and Australia offers definite possibilities. In all probability the soils work would require the engagement on contract of an expert, and steps should be taken now to train abroad a number of Iraqi technical officers to provide the special staff he would need. Similar considerations apply to the development of animal husbandry.

The Supervisor or Assistant class in the Department is recruited almost exclusively from those passing through the Rural Normal School—equivalent to a secondary school—at Abu Guraib. In the past three years the full output of this school has been absorbed, and the intention is to continue this for a number of years. The school comes under the Department of Education, who consult the Director about the curriculum. In view of the special function of the school, it would be well to make a closer liaison, and a joint advisory committee of the two Departments is suggested.

The Ministry of Education, through its Rural Education Department, is making commendable efforts to develop a type of rural education with an agricultural bias. As elsewhere in the Middle East, the difficulties are formidable; and in Iraq they are specially so in the central and southern portions of the country as compared with the north, where more of the population is settled in villages. But if the activities of the Mosul liwa (whose work was briefly inspected) are typical of the country, steady progress is being made.

One feature of the organization, however, should be seriously reconsidered in the light of the views and criticisms about the training of teachers for rural districts already expressed in an earlier section of this Report (Chap. III, 3, *d*); this is the Rural Teachers' Training Centre at Rustamie, close to Baghdad, housing over 800 students. It is unnecessary to repeat the arguments here; it is sufficient to commend for close study the advantages of the system typified by the Sudan and Cyprus methods of approach (Chap. III, 3, *c*).

One unnecessary difficulty that faces the Ministry in its work for agricultural education, whether by school gardens in the village schools or instructional farms in the training colleges, is that any receipts from these activities are claimed as Government revenue by the Finance Department. This produces needless elaboration in the accountancy, and destroys the real value of the schemes. Only a minor alteration in the regulations would be required to give the flexibility needed and to ensure that any profits were put back into the scheme.

PERSIA. One point of some significance must be made at the outset. Many threads—political, racial, sociological, trade—make up the pattern into which nations group themselves. It is far beyond the scope or competence of this Report to enter into the deeper problems that are behind the question whether Persia falls naturally into the Middle East pattern or not. But so far as the agricultural and associated problems dealt with in this Report are concerned, there is no possible room for doubt: in these respects Persia is a typical Middle East country, with as much to contribute to, and as much to gain from, the exchange of experiences as any other of the territories.

In topography and agriculture Persia has some resemblance to Iraq: the northern

portion is better watered than the centre and south, which must rely largely on irrigation, and which present various soil problems arising from saline conditions. The scientific and technical problems are, therefore, generally similar in the two countries.

The development of modern large-scale and efficient factories for processing various agricultural products has already been discussed in Chapter II, *c*, so it is unnecessary to repeat here the implications of that development.

It remains to discuss the organization and policy of the Department of Agriculture. There are two main experiment stations: Haidarabad for animal breeding, and Karaj for arable problems. The work of the former, which is only in the preliminary stages, has been mentioned already (Chap. IV, *j*). The most suitable lines of development will be dealt with in the separate report on live-stock. One general point can be mentioned here: although exact figures are not available there is little doubt that the areas of grazing-land available, coupled with arrangements for collecting and preserving forage for use in the dry season, would enable a larger animal population to be kept. It should be possible to build up a series of herds to demonstrate good management methods in animal husbandry, and it would be preferable for these herds not to be under direct Government control. They should be run under skilled technical and commercial management by some form of concessionary organization so as to be in intimate contact with economic realities (Chap. III, 2).

The services for arable agriculture that radiate from Karaj have progressed much farther than the animal breeding work. The Experiment Station has a chain of some fifteen smaller testing-stations at suitable places whose main tasks are testing the most suitable varieties of seeds for their locality and giving advice on crop management. At present the varieties considered suitable for testing at the substations are chosen mainly on the results of the trials at Karaj. This is not altogether satisfactory, and some measure of decentralization is desirable. Support can therefore be given to the proposal to have three intermediate stations in the Caspian, central plateau, and torrid Gulf areas with the existing smaller places as substations. The present programme of work is generally satisfactory, although more attention could usefully be given to oil seeds.

The work on soils and soil management needs strengthening, as some of the main agricultural problems in central and southern Persia fall in this category. The unfortunate history of the Khuzistan Development Scheme is a cogent example. Many areas in Persia depend extensively on irrigation water brought out from underground supplies by gravitational flow through tunnels to the soil surface. This is known as the 'qanats' system, and its unique and skilful exploitation in the central plateau should not disguise the fact that the system itself and the method of using the water are capable of improvement. Many small qanats run side by side for a long way. The system of lining does not entirely prevent underground erosion and the wide collapse of the overlying ground into the large caverns formed. Experiments should be made on the possible use of the winter flow that at present goes largely to waste and often causes seepage and salt troubles on adjoining land. It would seem feasible, for example, to use it for obtaining a deep saturated zone on land intended for wheat so that less irrigation water would be needed during its growth and a larger area could then be commanded.

Besides being the site of the Experiment Station, Karaj is also the main centre for agricultural instruction. There is an Agricultural College and a secondary

school of two classes. In the secondary school half of the total number of places are allotted by the Ministry of Education to those intending to be primary school teachers. The College provides a three-year course at the end of the secondary school, and has an annual output of about eighty students. Most are absorbed by the Ministry of Agriculture, but a number are now taking managerial posts on estates belonging to the larger landlords. This latter feature is encouraging, for Persia suffers as much as any part of the Middle East from the divorce between the landlord and the land. The College has a good range of Departments, and particularly in Entomology, 'Seed-Breeding', and Botany the equipment is at a very satisfactory level. The standard of scientific and theoretical training appears to be of the level associated with the Agricultural Diploma in England. The practical instruction, however, is weak, especially in field work, but this could easily be remedied. It would be a mistake to reduce the level of the scientific training to make more time for the practical work. The course should, if necessary, be extended and the standard kept to at least its present level. There is much to be said for implementing the suggestion that the College should become the Agricultural Faculty of Tehran University. It should of course still remain under the Ministry of Agriculture, but be recognized by the University as a place of study for their degrees. Under this arrangement the science faculties at Tehran could give the basic instruction in the appropriate pure sciences, after which the students would go to Karaj, where the agricultural aspects of those sciences would be taught at a higher level than is feasible under the present arrangements. This system has been adopted by the Hebrew University, Jerusalem, for the Agricultural College at Rehovot, and an examination by the Persian Government of the arrangement would be a very useful preliminary to framing their own scheme. In addition to the output of men trained to this level there is need for a supply of men with a good practical training for local advisory work. This class, and those intended for rural elementary teachers, require on the agricultural side much the same type of instruction. It would be possible to take over the buildings of the secondary school at Karaj for this purpose, but it would be better to develop the scheme along the lines of the Cyprus and Sudan methods (Chap. III, 3, *c* and *d*) rather than to concentrate too many lines of work at Karaj. This applies with some force to a proposal that has been made to use the adjoining small town of Karaj as a demonstration and training centre for village welfare work, as part of the curriculum of the students. It is unnecessary to enter further in this Report into the problems of improvement of Persian village life and the associated agricultural changes. The general principles have been discussed in earlier sections, and the special problems of Persia have been recently reported on by Dr. Allen of the Near East Foundation. His recommendations are in full accord with those arrived at in the present Report.

EGYPT. Thanks to the work of a succession of first-rate scientists, Egypt has, up to the present, met and solved in good time her numerous agricultural and irrigation problems. The Ministry of Agriculture and the Cotton Research Board have a number of scientific departments for work on soils, crops, and stock, and there is a chain of sub-stations in the Delta and Upper Egypt. The Royal Agricultural Society of Egypt has also taken part in agricultural investigations, especially in connexion with manurial problems of cotton. The Physical Department in the Irrigation Division of the Ministry of Public Works has dealt with some soil moisture and evaporation problems of special importance in irrigation agriculture.

In view of the heavy pressure of population on the land, one problem of special interest at the present time is the reclamation of the salt lakes and swamps in the

Delta and their conversion into farmland. The method closely resembles the Dutch practice of reclamation first to kwelders and then to polders, and as there is considerable traditional experience of the process in Egypt, the work is proceeding rapidly, and no serious technical problems are arising. It has been found that ecological indications are a satisfactory guide of the progress of washing the land free from salt. When the indicator plant—Su'd grass or Galingali (*Cyperus longus*)—appears the land is ready to be put under rice followed by berseem. If the grass is reluctant to appear, extra drains are dug to hasten matters and levelled in later. Recalcitrant areas are chemically analysed to see whether they are specially high in salt, and thus need only extra washing and drainage, or whether they are alkaline soils containing sodium carbonate, in which case treatment with gypsum may be necessary. By the nature of the case, a considerable area is occupied by the third-class or field drains, the bottom of the trench being only 60–80 centimetres below the soil level. It would be well worth while experimenting with tile drains in those areas where the land has been reclaimed for some time so that its physical condition has become stabilized. If they are found satisfactory—and there is no obvious reason why they should not be so—an appreciable area would be added to the land available for cultivation. Drainage in the reclamation areas is one aspect of the general question of covered drainage in Egypt. Its employment in a special area where seepage from canals was causing trouble has already been mentioned (Chap. IV, *d*). The experience on technical and practical problems gained from such experimental areas will be needed before any decision can safely be made to install covered drains as a general measure in Egypt to increase the proportion of cultivated to total area.

A second problem of importance is the work on animal breeding and improvement. An extensive programme ranging from poultry to buffaloes is under way in the Animal Breeding Section of the Ministry of Agriculture. The work also includes various aspects of animal husbandry. The facilities available for the work are reasonably satisfactory, but there is inadequate staff for such a programme. At present the senior officers have too many lines of work going on to be able to give adequate time to them all. The importance of animal husbandry investigations has been stressed in this Report, and if the present programme of the section is to be continued, as it should be, it will be necessary to augment the staff, especially on the animal husbandry side. The nutrition requirements of improved animals are the limiting factor in their adoption by the fellah, who finds difficulty in providing even the low requirements of his present stock inured to hard conditions. Hence nutrition studies and investigations on fodders should figure prominently in the animal husbandry programme.

Training in agricultural science is given at the university level at the Cairo and new Alexandria Universities, and the Agricultural Institute at Shibin el Kom, in the Delta, is in process of being changed from the intermediate to the university level. The field work at the Shibin el Kom Institute seemed to provide a satisfactory blend of instruction and investigation. Besides various typical rotations, there is work in hand on water-table fluctuations, dormancy of fruit-trees, tillage problems, and seed production. This type of training, and the practice of sending suitable people abroad for post-graduate work, should ensure a steady supply of competently trained men for the technical posts in the Ministry of Agriculture.

The provision of suitable men for the advisory and assistant posts, and their training, is the same difficult problem in Egypt as elsewhere in the Middle East, and for the same reasons. The projected development of Rural Centres, already

discussed above (Chap. III, 3, *d*), is an attempt to tackle the problem at its source, and there can be no question of its importance if the lot of the peasant cultivator is to be improved.

THE SUDAN. Considerable discussion of technical and social aspects of the Sudan agricultural activities has already been made in the body of this Report, for in many respects the work there affords valuable guidance both on development policies in other countries and on methods of putting them into effect.

The national economy of the Sudan, like Egypt, is based on cotton. But, unlike Egypt, the Sudan has in addition to its cotton area vast tracts of land that are less developed, including some where a primitive agriculture is practised. From time to time there has been criticism of the Sudan development on the grounds that the economic well-being of the small Gezira area takes much greater precedence over the rest of the Sudan than it should do, so that the reasonable claims of the other regions for developmental expenditure and skilled advisers cannot be met because a disproportionate share of both is allotted to the Gezira. Such criticisms are unsound. In the first place they are based on the contrast between the present conditions in the Gezira and those elsewhere, whereas the only valid comparison is between the present and past Gezira; on the latter basis there can be little grounds for adverse criticism. A further point is that very considerable direct and indirect revenues have been received by the Government from the Gezira Scheme, far more than the undeveloped Gezira could ever have produced. In effect, the Gezira Scheme has provided a subsidy for the general development of the whole country.

The Gezira is, in fact, an illustration of how agricultural progress and rural development can best be made: the progressive selection of areas suitable for an improved agricultural system and the concentration of effort thereon—a point already developed in some detail in Chapter III. A country whose national economy is based entirely on a primitive agriculture can have only a limited national income. If the correspondingly limited technical resources are spread uniformly over the whole area, the scale and density of the services is so attenuated that development is slow and difficult, as experience in India and elsewhere amply shows.

The irrigated Gezira presents its own special range of research and technical problems, but these are covered within the general agricultural policy of the Government. To quote from the 1943–4 research and field experiment programme of the Department of Agriculture and Forests:

'The Sudan is an agricultural and pastoral country and in so far as can be foreseen is likely to remain so. . . . The general policy is to encourage the emergence of a happy, prosperous and well-fed rural population, progressively enjoying the advantages of peaceful progress and permanent agriculture under a Government determined to do its utmost for the welfare of the numerous tribes that go to make up the indigenous population. The emphasis is almost equally upon cash crops, food crops, animal husbandry, rural betterment, and upon the permanence of agriculture.'

Study of the detailed research programme and of the results already obtained in past work shows how well these objects are covered, as far as crops are concerned, within the limit of the scientific resources. In each province the general aim is to develop a system of agriculture suitable to the area, which will give a cash crop to cover taxes and expenses, and an assured food-supply.

In Equatoria Province primitive conditions still exist, and improvement is still in the exploratory stage. Some suitable cash crops—or animal products—have to be found; food crops need to be increased and diversified; erosion and grass and

forest fires are serious. In addition, the usual animal husbandry problems assume special importance. The remoteness of the province from export markets is a serious difficulty, and there is much to be said for a large-scale trial of a proposed policy to make the area nearly self-contained and to market suitable 'exports' in the large Sudan towns to obtain the small amount of money needed for financial self-sufficiency. The scheme would be under the control of a Government Development Board, so that it could be accelerated or slowed up as necessary or, in the event of failure, or unforeseen financial difficulties, it could be abandoned without further loss to the Government. A soil and geological examination, already in progress, is an essential preliminary to secure knowledge about the distribution of economically important types. In areas found suitable, cotton would be the cash crop. A Board-operated ginnery and spinning and weaving mills would be set up. In other suitable areas Robusta coffee could be the export crop, and there are also possibilities in soap-making from cotton seed and palm oil. There would also be a development of internal or self-contained industries, such as the manufacture of jaggery, for which sugar-cane would be the cash crop, and the exchange of dried meat from the cattle areas for food crops from the agricultural areas. Rural betterment, local self-government, and education are an integral part of the scheme. The proposal envisages keeping out—or reducing to the lowest level—all imports that would disturb the narrow balance of the internal economy, e.g. motor transport would be kept to an absolute minimum and would be run on producer gas from charcoal made locally to obviate importing petrol. This is undoubtedly the most difficult part of the scheme, as it tends towards an artificial economic system: a kind of sub-national self-sufficiency. The views of competent economists on the implications of this part of the scheme should be obtained.

With the exception of Darfur Province, which is the least accessible and still awaits the formulation of an agricultural policy, the key problems in the remaining provinces have been ascertained and work on them is in hand. They fall, as already indicated, into problems of the cash crops and the food-crop rotation.

Thus in Upper Nile Province, where the agriculture is on an extensive clay plain under rain cultivation, and where also there are large herds of cattle, cotton is unsatisfactory as a cash crop and may be replaced by sesame; and better rotations of food crops are needed, as the present ones have exhausted the soil. In Kordofan Province the need is for cotton varieties that will give an improvement in the ginning out-turn so that the grower can receive a higher price for his seed cotton. There is also the interesting possibility—taken from the Uganda experience and already tried with encouraging results at Meridi (Equatoria)—that in areas where there is enough rain, cotton and ground-nuts can be grown together without detriment to either. This possibility is important, because ground-nuts provide a valuable protein food. There is also a valuable export in gum grown on the widespread 'Kordofan Sands', and little is known of the relations of soil type and water-supply to this crop. The food-crop problems centre around 'harig' cultivation—the grass–dura succession—and the provision of vegetable protein crops such as soya beans. In Kassala Province cotton is the cash crop in the Gash and Tokar deltas. In contrast to the rest of the Sudan, the plants have excessive vegetative growth, with few bolls, but the cotton is of fine quality; but the general cotton problems resemble those in the Gezira. Another possible cash crop is citrus, to be grown in the region around Kassala town. Trials have shown that the fruit ripens in May–July, and would provide a valuable extension, over the hot weather, of the normal market period (November–March). A nursery is being set up to

provide stocks of good trees for distribution. Harig problems are also important in the province, and there is scope for improving the varieties of dura or millet grown in this system. In Northern Province dates are the main cash crop, but the industry suffers badly because the laws of inheritance apply to the trees: several people may own one tree. In these circumstances it is, in practice, impossible to substitute better varieties for poorer ones, so the Government has recently planted trees which it owns and leases to tenants. Each tenant has the use of 1 acre of dates, shortly to be increased to 2, and he is provided with other land to work as a farm or vegetable garden. This scheme is, in essentials, based on the same plan as the Sudan Plantations Syndicate area and the Alternative Livelihood Scheme: the tenant has the secure leasehold to a compact non-fragmented area. South of the date area citrus production is possible, and observation plot experiments are in hand to ascertain the most suitable varieties. The arable agriculture problems revolve around the improvement of wheat, maize, and dura varieties, and the encouragement of additional food crops such as tomatoes and soya beans. One basic problem in this riverain area arises from the fact that all irrigation water must be lifted from the river. A considerable area is commanded by pump irrigation, and sagias, worked by oxen, are largely used for the smaller holdings; but the production of fodder for them is a serious limitation on the human-food crop area that can be commanded by the small farmer. Some cheap alternative power-lift device would be most useful. The small Khartoum Province presents mainly urban problems owing to the large towns Omdurman and Khartoum. One introduction, due originally to attempts to reduce the dust problem around the town perimeter, seems capable of wider use: this is the South American mesquite which forms a dense thicket 8–10 feet high in 5 years and grows in an average rainfall of only 4 inches. The procedure is to erect fence stockades until some 2 feet of blown sand and dust have accumulated on the clay and then to dry-plant the seedlings. Flour for human consumption can be made from the beans, and the pods from 8 acres will keep one beast for a year. At Shambat, near Khartoum, there is a big natural spread and many isolated trees that have all arisen from one planted there some years ago. The possibility of using this rapidly growing crop, with its human and stock food potentialities, for erosion control in the drier areas is worth full exploration.

In the Blue Nile Province irrigated cotton problems necessarily—and rightly—dominate the situation. It is unnecessary to recapitulate them here, as a number have already been discussed in earlier parts of this Report. Cotton-breeding problems of all kinds are likely to remain pre-eminent, but problems arising from the system of agriculture are equally important in their own sphere. These are bound up with the nature of the soil and the water agreement with Egypt, which defines two periods: mid-July–31 December for maximum rates of offtake from the river, and 1 January–mid-July for a fixed total quantity of stored water. The effect of this agreement is that the Gezira uses the minimum possible water after 1 January and the maximum possible between mid-July and 31 December.[1] The system of cropping in force is devised to make the best use of the supplies in these two periods. The quantity of stored water is a limiting factor, so duty of water problems assume added importance in these circumstances. An allied problem, receiving full attention, is the evolution of the best rotations to provide good cotton yields and adequate and suitable food and fodder crops. The development

[1] More of the Gezira could be irrigated if extra water were available. This could be obtained by the scheme for controlling the out-flow from Lake Tana in Ethiopia (see Dr. E. B. Worthington's *Report on Middle East Science*, chapter v).

of a mixed farming system has not, as already noted, proceeded very far, partly because of the fodder difficulties associated with the minimum water-usage period, but also because of the peculiar water relationships of this soil, to which reference has already been made. The studies of soil and crop behaviour under various watering systems, including full perennial irrigation, while having varying degrees of immediate practical importance, will show whether there is substance in the feeling that perennial irrigation would be deleterious, and will provide essential data for possible future changes; they cannot fail to help in the elucidation of the general soil moisture relationships.

Reference has already been made to the technique of agronomic, physical, and chemical inspection of soil-pit samples (section *b*, above, this chapter), which has had a very considerable degree of success, and which is being used for diagnostic and advisory purposes in other provinces. Important results have also been obtained in the more detailed examination within the Gezira, where the soil and crop behaviour exhibit considerable variations, in contrast to the topographical uniformity. Thus the yield in the central Gezira is depressed by some 20 or 30 per cent. below what might be expected relative to the southern portion; and at the two sub-stations of Wad Medani there is a big response to nitrogenous applications at Turabi in the north, and practically none at Hag Abdalla in the south.

Work on crops other than cotton is now being taken up in greater detail and dura is receiving attention. There is a large number of varieties to investigate. Dwarf milo has good prospects in the Gezira, as it is immune to common smut, and is 10–14 days earlier than feterita, the usual variety, and so saves one watering. Work on rain-grown dura for non-irrigation areas is also under way.

Although largely concerned with Gezira problems, the programme of the Gezira Research Farm, Wad Medani, includes research and technological work of both provincial and country-wide importance. Soil examination is an example, and others may be mentioned. There is an interesting difference in the protein content between irrigated and rain-grown dura. The figures as measured by the nitrogen content are, respectively, about 1·6 and 2·0+, so there is less protein in irrigated dura. The reason is that water is the limiting factor in rain-grown areas, and nitrogen in irrigated areas, although the yields are naturally greater in the latter. The point is of importance where dura is the main food, although a high nitrogen content is probably of more importance for animal than human nutrition. An analogous plant physiological phenomenon of considerable economic importance is shown by cotton: when the number of bolls is low, either through heavy vegetative growth, as in the Gash area, or because of adverse seasonal and other conditions, the lint is of higher quality. A number of results from old and new areas in the Blue and White Nile regions fit into this general picture, but there are puzzling exceptions, and the relationship, on present data, can only be regarded as qualitative. It is clearly a plant physiological problem requiring more research. Another problem of general importance, which occurs in other Middle East countries also, is the infestation of buda (*Striga hermonthica* Linn.), a plant parasite of sorghums and especially bad on dura both irrigated and rain-grown. Indeed, in the Dinka area, where shifting cultivation is practised, the appearance of buda is a sign to move on. Investigation has already shown that the bulk of the parasitism occurs on the sorghum roots in the first four weeks after sowing, and before there is any general appearance of the aerial growth of the buda, and work is in hand on the effect of shade, which seems to increase the infestation in the winter and decrease it in the rainy season (although this may be, in reality, a temperature and moisture

effect), and on the effect of nitrogen manuring in reducing the attack. The breeding of resistant varieties is also being investigated. Experience with the various crop rotations that have been used in the Gezira strongly suggests that heavy infestation accompanies bad or unsuitable farming practices. In the present rotation dura occupies the same ground only once in eight years and there is no trouble with buda, whereas there is heavy infestation on the three-course rotations that are being continued, for experimental reasons, on the Gezira Research Farm.

In a large area of the Sudan crops grown on the harig system are a major source of the food-supply. The main problems here arise from the ecological succession associated with the grass–acacia cycle, and the extent to which control is possible and desirable, either by variation of firing dates or by planting suitable grasses at the end of cultivation, instead of allowing natural regeneration. The field experiments are being conducted at the Rashad and Talodi Experimental Farms in Kordofan Province.

In contrast to the arable agriculture investigations, animal husbandry problems have received little attention until recently, because cotton and food-crop investigations were more urgent. One section of opinion has the view that mixed farming is neither possible nor desirable in the Sudan, for meat can be obtained cheaply from the extensive pastoral areas, milk for the towns can be supplied by nearby dairies, and the cultivator can get his milk and meat from goats and sheep. While there is much scope for sound development along these lines, there is a strong majority view that the contentment and stability of the country also requires a faster progress towards mixed farming in the arable areas, and it is very desirable that more facilities should be provided for extending the work of the Agricultural Section of the Gezira Research Farm further into animal husbandry problems. The section is already building up a herd of dual-purpose cattle and a flock of Butana sheep, and is conducting field experiments on the use of farmyard manure and the growing of fodder crops in the rotations. There are of course special but not insuperable difficulties in the Gezira area. Cotton is the mainstay and provides the bulk of the Government revenue, and there must be full control and supervision of the farming system if the crop is to continue to hold its place in the world market. Lubia, the main fodder, can be, under proper management, first a cleaning and secondly a smother crop. But in present conditions it is liable to be a dirty crop, so an extension of its area to give more fodder might intensify the land-cleaning problems in the cotton break. In addition its leaves shed easily, so much of its food value is lost unless hay-making is carefully done. The Gezira Research Farm has shown that leaf-shedding can be avoided if the cut crop is carted green to the stack; provided the stack is not raised more than 18 inches per day, this thickness will dry out before the next day's layer is put on. The method is suitable for a dairy farm, but is not applicable to the ordinary tenant's farm, as the present rotation does not include enough lubia to provide a surplus for hay.

It is possible that a solution of the problem of mixed farming for the Gezira area will be found by relatively minor changes and improvements, to obtain the maximum benefit from a system of 'fallow' grazing, successional sowing of lubia, and the full use of dura threshings and stalks, and cotton-seed cake. But it would be necessary that these changes should not conflict with the improvements in the crop husbandry system arising from the valuable experiments on rotations, bare fallow, and weed-fallow ('bor').

The universal problem of introducing experimental results into practice is greatly eased by a close co-operation between the Gezira Research Farm and the

Sudan Plantations Syndicate, who arrange for a proper test on each of the numerous blocks into which the area is divided; this network of practical trials is not only an essential preliminary to the adsorption into farm practice, but the results of the trials provide valuable information that can be utilized by the Research Farm in its own work. A striking development in cases where the test involves a major change in the farming system, e.g. a changed rotation or a new crop, is to employ a whole farm as a unit. The tenants on blocks of representative farms try out the new system under guidance, and they receive financial compensation if their receipts suffer.

The past achievements and present programme have been discussed at some length above because they bring out clearly the vital part that has been and is being played by the research and technological organizations in the Department of Agriculture, and because they illustrate a most effective method of introducing the results of investigations into farming practice. So far the Sudan has been fortunate in the high calibre of its agricultural staff, whether permanent officials, contract men, or seconded from organizations such as the Empire Cotton Growing Corporation. They in turn have been given, to a considerable degree, that freedom and flexibility in planning research programmes which is the best guarantee of progress in practical agriculture. Thanks to this combination the Gezira has reached its present position, and the claims of other provinces for more attention must now be met.

The future programme of the Gezira Research Farm at Wad Medani raises very important questions. Unless there is an increase of staff, increased attention to problems of other provinces will necessitate a curtailment of research into Gezira problems. It would be most unwise to do this: the Gezira will require in the future at least as much scientific attention as in the past if it is to maintain its position. There is an unanswerable case for an increase of staff and the establishment of sub-stations if the policy of development in the provinces is to proceed on sound lines.

As the training of junior and assistant officers, and rural education, have been discussed in Chapter III, 3, *d*, only two auxiliary matters need mentioning here. A very useful type of recruit for the Agricultural Service has been coming from the Shambat Agricultural School. Judging from the educational standard it appears that they could be taken to a higher level in agricultural science than the present curriculum permits—sound though that is. The recent reorganization of the Gordon College, Khartoum, with the status of a university college in which the Shambat School becomes the Agricultural Faculty, will ensure this desirable development. The second point, which is related to the educational experiment at Bakht er Ruda, is the creation of simple farm-institute courses designed for rural boys who will go back to the village.

ERITREA. For many years before the war the development of the country was, in effect, subordinated to metropolitan Italy. The Eritrean market had to absorb, first, the exported surplus Italian production; Eritrean production came second. The consequence has been that little or no natural development took place for the benefit of the indigenous population; the small amount that was achieved was mostly in connexion with Italian farm settlements. At the present time the British Military Administration is in control of Eritrea. Its main task, agriculturally, has been to increase local food-supplies, using methods that did not implicitly involve long-range policies as a prerequisite to any improvement. In practice, therefore, the work was mainly confined to items in which some results could be expected in two

years or less, and it has used or revived existing organizations—such as the Italian Office of Colonization and the Farmers' Association—as far as possible. It has obtained marked increases in grain crops. Milk amounting to 450 gallons (2,000 litres) per day on the average has been collected from native nomadic herds, for the use of hospitals and rationed classes, and appreciable quantities of butter and cheese have been produced. All this, including the ingenious conversion of Italian army salvage into hygienic milk containers and the instruction of natives in clean milking procedure, was built up from scratch, as, prior to the occupation, all milk was imported in tins. Some thirteen farms, including the five Government farms, were taken over and fresh vegetables, potatoes, and fruits were grown; seedling fruit-trees, seed potatoes, and suitable vegetable seeds for multiplication were also grown. These farms are now being leased to the Farmers' Association on contract to continue the work. The amount of hay brought in from Government 'prairies' has been greatly increased and the price has been halved. The pig population has grown from 200 in 1941 to 26,000 at the end of 1943, and the quality has improved. In addition, forestry, locust control, game and fishing control have been put on a sound footing and expanded. Progress has been made in growing tomatoes for canning and ketchup, and a factory is already exporting the products. As there are two rainy seasons, the crop can be grown all the year round. These considerable achievements have been made by a very small British staff who have directed a number of released Italians with agricultural experience; they show what can be done with an agriculturally backward population by expert direction from above. But, because the advances are necessarily based on short-range possibilities, they do not include all the major requirements for a balanced raising of agriculture in the country. In arable agriculture the problems already tackled do in fact represent the main lines of technical advance that would fall into a long-term policy. When and if opportunity occurs for the first steps to be taken, the three most promising areas for attention are the escarpment and foothills facing the Red Sea, the south plateau of the western ridge, and the western plain bordering the Sudan, as settled agriculture is practised in all three. The Red Sea escarpment with its European-like winter climate and rainfall, and with some rain in every summer month, is very suitable for coffee and citrus; the south plateau contains areas of fertile black soil with other areas of poorer fertility and is not efficiently farmed even by native standards; the western plain, although lacking water is rich, and presents a problem of some social and political importance in that immigrants from the Sudan and West Africa are developing settled agriculture there, while the indigenous tribesmen are continuing their nomadic way of life.

Animal improvement is another long-range matter. Although water is not too plentiful over the country as a whole, Eritrea is in the main a cattle country, and one of the major possibilities of advance is an improvement in the cattle—which are on the poor side—coupled with the development of suitable systems of animal husbandry.

There are two possibilities worth expert examination. The Barka type of cattle—found mainly on the Sudan side of the country—might be developed in the highlands as a source of milk-supply to the towns. An experimental and demonstration herd under direct Government control by a suitable organization should be the method adopted in the initial stages. The second possibility is a replacement of the poor highland cattle by another breed, such as the Red Amiri cattle from the Yemen and Aden Protectorate (Chap. IV, *j*).

Owing to the past history of the country, agricultural education and advice are as poorly developed as is rural education, and there are the further complications

that a large number of the inhabitants are nomadic, and that where settled agriculture is practised the usual land tenure and fragmentation problems occur. Rural education and the provision of teachers with an agricultural bias can be developed only slowly in such conditions. Meanwhile early attention must be given to the training of suitable men of the agricultural supervisor and inspector class, for in the initial stages the development of agriculture can proceed at a faster rate than rural education. Later it will be possible and desirable to combine to some extent the training of teachers and agricultural supervisors in the manner already done in some of the Middle East countries. Until development has reached the stage where this can be done, the agricultural supervisors will have to be trained in the Department. The essential thing is to select suitable villagers and tribesmen and to give them a short training in a few immediate points arising in the long-range improvement programme for them to put into effect on returning to their districts. At suitable later dates they would be given further instruction in the next points of the programme.

It would appear impracticable for some time to attempt training at the higher levels needed for technical officers in the agricultural service. Eritrea has been under the Italian régime for many years, and the present generation of Eritreans has grown up under a system in which conquerors have ruled a subject people. This system is alien to present-day methods of colonial development and of fostering the emergence of backward peoples. Before Eritreans can be entrusted with the responsibility and authority that are inherent in the performance of duties appertaining to the technical officer grade in an Agricultural Department (and the equivalent grades in other departments of Government) there must be a reorientation of outlook, which cannot come until the leaven of a new system of rural education has had time to work:[1] and this time will not arrive until the children, educated along these lines, have become adults.

In the circumstances, therefore, the Department of Agriculture should consist for some time ahead of one or two experts (brought in from outside) responsible for formulating and developing the policy. They will need one or two assistants who know both English and the vernaculars to whom the work of training the selected villagers can be largely delegated. Thus in essentials the projected organization closely resembles the one set up under the British Military Administration.

ETHIOPIA. The environmental conditions are more favourable for both arable and animal husbandry than elsewhere in the Middle East, but nowhere else are there bigger obstacles in the way of both long-term and immediate improvement. The difficulties are twofold. Transport charges for exports and imports will always be heavy, because of the complicated topography and the long distances to external markets. The ravages of the past few years have deprived the country of almost all its small intelligentsia class, and have produced a large number of unemployed and homeless persons, including many juvenile vagrants.

In these circumstances the concentration of effort must be almost exclusively on social and educational problems: education of juveniles, settlement of unemployed and, where necessary, a minimum of agricultural training. It is fortunate that, as a class, the Ethiopian farmers are good peasant cultivators, for there will be little

[1] This fundamental point is well illustrated by what happened after the British occupation. The use of Italian in the schools was discontinued and education was given, quite rightly, entirely in the vernacular. There were protests by the local elders, who wanted English to be used. 'When the Italians ruled here', they said, 'at least they taught our children Italian.' They firmly believed that the absence of English showed the intention of their new 'rulers' to keep them in greater subservience than the Italian régime did.

opportunity of helping them to higher standards of husbandry until there has been time to train a staff of instructors for work in the field, and to build up a nucleus of technical staff in the Agricultural Section of the Ministry of Commerce and Agriculture. At present there is only one technical unit—the Veterinary Service—which is tackling the difficult task of re-establishing itself on the scanty remnants of the original Italian resources and equipment. Technical departments for animal husbandry, arable agriculture, including vegetables and fruits, must be provided in nucleus before the Department of Agriculture can begin any effective moves towards improvement. These advances must be in the improvement of the existing system of agriculture; the possibilities of developing new systems are remote, until some progress beyond the present level has been secured. Such progress must necessarily be by simple and small stages to begin with, and the means of securing it, by selecting suitable villagers and giving them a short training in certain specific items, and periodic refresher courses, has already been discussed (Chap. III, 3). The most suitable items for the immediate work, and the evolution of the refresher courses, cannot usefully be discussed without the evidence afforded by a survey of existing farming practices. Fortunately a large American mission of technical experts, including agriculturists, toured the country in 1944 and their reports should prove of value in this connexion.

THE ADEN PROTECTORATE. As noted in Chapter I, the technical level of dry-farming in the Protectorate is, in general, commendably high. The possibilities of agricultural improvement rest mainly, therefore, in the increased use of irrigation. The position resembles that in Cyprus, where the aim is that no drop of fresh water shall reach the sea, and where the control and harnessing to useful purposes of spate waters that are erratic in amount and time requires more organized effort than the cultivators themselves can give. This is especially the case in the wadi-floor cultivation in the Hadhramaut, where a recent and severe famine has occurred. The Agricultural Department has made great progress under immense difficulties, reopening wells, repairing existing dams and building new ones, to restore and increase the level of production. The progress to date amply justifies any further expenditure that may be needed. The Agricultural Department has no facilities for examining one very important technical problem, the development of 'brak' or salty soil conditions deleterious to plant growth, that become progressively more noticeable down the course of the main wadi. It is important to ascertain whether the banking-up and raising of the underground water-table by a dam (one function of which is to maintain the water level in the wells above the dam that are sources of irrigation water) favours brak development, and if so, whether the effect can be mitigated or avoided. The problem needs examination in detail on the area together with a series of soil and water analyses, and it is recommended that arrangements be made for a soil expert to investigate and report.

A development of promise is being made by the Government in the Abyan district, about 30 miles east of Aden colony and a few miles inland, in a region where earth dams are built annually across the wadis to divert flood water over the land. In this district feuds and general unrest have resulted in areas going out of cultivation. The Aden Government, having made arrangements by which it acquired certain of the powers and responsibilities of a landlord, has improved the situation and brought back some of the land into cultivation. Other abandoned areas have become infested with 'Sidaa' (*Demostachya bipinnata* L.), and will need deep tractor ploughing for rehabilitation; there has been the usual war-time difficulty in securing tractors and tackle, but the work is now in hand. The intention is to build masonry

dams higher up the wadi, where rock foundations exist, and to lead the water at speed by new canals to the lower reaches. The old earth dams will also be continued to deal with any extra water that may come in years of good flood. The cultivators work on a share-cropping basis with the Government, from whom they can obtain loans either in cash or in kind for their operations. With adequate watering the soil gives very large crops, and it can be intensively cultivated: it is possible in twenty months to obtain two crops of sorghum, with a further ratoon crop off each, and one of sesame. One puzzling problem is the patchy fertility of the soil when it is first taken into crop, or recropped after being abandoned. Rows of the young plants show a great variation in growth over a distance of a few inches. The surface of the soil is irregular, but there is no obvious connexion between the excess or lack of water that would result, and the observed differences in the growth. And as the soil is fine and silty throughout, the variations can hardly be ascribed to local deposits of less fertile soil brought in by the flood. The differences disappear after the field has been cropped for a time, and the high fertility already referred to is reached, so there is no urgent practical reason for a scientific study of the cause.

The Abyan development could, without serious difficulty, bring more land into cultivation than could be managed by the existing population. There are good reasons for encouraging the transfer to this area of some of the Hadramaut cultivators, for their standard of cultivation is high, and the pressure of population is beyond question too great for the inevitably precarious conditions in that area.

TRIPOLITANIA. Because the soils in Tripolitania are mainly light sands, and a devastating hot wind—the 'ghibli'—adds to the normal difficulties of a hot dry season, a limiting factor is imposed on agriculture. The Italians recognized this and made considerable progress in anchoring shifting sand-dunes by vegetation, in providing eucalyptus and tamarisk windbreaks in the concession and colonization areas, and they were beginning afforestation on the hills. The policy should be continued and extended as soon as conditions allow, for the efforts by the Agricultural Department of the British Military Administration to maintain the work and to counteract the results of war-time neglect have been necessarily limited by lack of staff and by the policy of 'care and maintenance' prescribed for occupied enemy territories by International Law.

Water-supply is an equally important limiting factor, and the question whether an intensified agriculture along the Italian colony model can persist cannot be answered until the extent and capacity of the water-tables is proved by examination. Suitable farming systems and crops for irrigation have already been worked out in the colonies. They include the higher-priced vegetables and citrus, protected by windbreaks. The value of lucerne as a crop in the rotation should be stressed. It grows excellently on the light soil and, besides providing high-grade animal fodder, it improves the soil.

Outside the irrigated area, it is known that vines, almonds, and olives do well. A considerable area has already been put down to these crops, not all of which have yet come into bearing. It is probable that considerably larger areas than the present would also be suitable.

The question of cereal-growing needs reconsideration. The soil and climate are unsuitable for these crops to form important parts of an intensified agricultural system such as that practised in the older Italian colonies, although for the technical reasons given in the discussion on the Jewish colonies in Palestine (Chap. III, 1, *d*), they are likely to persist in the rotation. On the other hand, it is quite possible to

produce by dry-farming methods, combined with large-scale modern machinery for cultivating, sowing, and harvesting, a considerable quantity of grain with a minimum use of human labour. As a war-time measure the procedure is amply justified and the British Military Administration, working under many difficulties, were able to produce many hundred tons of wheat in 1943 and 1944 on the Assaba plain some 12 miles south of Tigrinna, which constitutes some of the best dry-farming land in Tripolitania. However, under more normal economic conditions, wheat could hardly be a paying crop and it would be technically less preferable than barley. But barley is already grown fairly extensively by the Arabs, especially along the land at the foot of the Jebel, and it is unlikely that any marked increase in the present production would be advisable. The production of tobacco has already assumed considerable proportions in the Italian colony at Tigrinna, where the crop is handled by an association, the Azienda Tabacchi Italiana. There seems no reason why this specialist crop, which is suited by the soil and climatic conditions, should not continue to form a useful contribution to Tripolitanian exports.

The light soils and the general conditions rule out any large policy of live-stock development. Naturally, in the irrigated sections a normal mixed farming policy should be pursued on the existing basis. The Brown Swiss cattle introduced by the Italians appear to be suitable for first crosses with indigenous cattle. There seem also good reasons why pig-keeping should be increased. It was begun by the Italians, and the British Military Administration have extended it. Some of the colonies have stocks of thriving pigs, not unlike saddlebacks in appearance and build, derived from a cross between the Sicilian, which is black or black and white, and the Callabria from southern Italy. Small live-stock, particularly poultry, would repay increased attention, although, in common with the rest of the Middle East, diseases are at present a serious handicap.

Tripolitania is well served in the matter of experiment stations and substations. The central station, Sidi Mesri, near Tripoli, was set up to serve all Libya, and possesses extensive laboratories and equipment and a good library. All the buildings and contents are intact, although practically none of the Italian scientific staff remained. Judging by the published results the staff had not achieved very much except possibly in sheep-breeding for better quality wool, a line of work which, incidentally, would be of more potential benefit to the semi-nomadic Arabs than to the Italian colonists. If, on the return of more normal conditions, the idea of co-operation in common scientific problems is acted on in the Middle East, the Sidi Mesri station could play a valuable part, for it is the sole station west of Egypt in the Middle East area, and it is well situated to deal with many dry-land farming problems.

Most of the comments above rest on the assumption that cultivators competent to carry out irrigation and modern dry-land farming will be available. Such is the case at present, for the great majority of the Italian colonists either remained on their farms or returned to them after the British occupation. The Arab population falls roughly into two groups: those on the coastal belt, that have become good settled farmers; those that practise a shifting cultivation, typified by barley-growing, combined with a pastoral farming in which sheep and goats predominate. The question of the part the Arabs could play in any immediate and long-range agricultural policy can more suitably be discussed in the next section which deals with Cyrenaica, for in this territory all the Italian colonists left, and the agriculture is now carried on entirely by the indigenous Arab population.

CYRENAICA. The contrast between Cyrenaica with its heavier soil and good vegetative cover and the light sandy soil of Tripolitania has already been pointed out

(Chap. I). The solution of the technical question whether Cyrenaica should remain predominantly under a pastoral system combined with a simple system of shifting cultivation, or be developed along the lines adopted by the Italians, rests ultimately, as in Tripolitania, on the problem of water-supplies, and involves a survey of the underground water-table that is known to exist over extensive areas. Owing to the heavier nature of the top soil in Cyrenaica and its resistance to erosion, there should be a far greater opportunity than in Tripolitania for extending the system of storing run-off water in reservoirs, as practised in Roman times and revived recently in the individual concession areas. The quantity would be insufficient for irrigation on any scale, but would serve as a useful reserve for stock and domestic purposes.

But the complete departure of the Italian colonists and the declaration that Cyrenaica will not return to Italian control has introduced new factors into the question of agricultural development. If it be assumed that no large-scale immigration of technically competent peasant farmers takes place, agriculture will be in the hands of the indigenous Arab population, who are mostly pastoral minded. But there is a small group, analogous to the settled farming Arabs in the date-growing coastal belt of Tripolitania, who farm along the narrow coastal belt of Cyrenaica, making use of the springs from the foot of the hills for irrigation. The standard of work appears to be reasonably good and suggests that with adequate advice it could reach quickly a satisfactory level. The Italians gave some attention to this group and set up two settlement centres for them on the usual lines. There is every reason why irrigation farming in the coastal belt should be increased to the limit of the available water-supply, for the growing of perishable vegetables and fruit. Transport inland up the steep escarpment would hardly be economical, but water transport to Derna should be possible, as a loading pier already exists at Alba (el Fàger). This development, however, would occupy only a small fraction of the population, and special interest therefore attaches to the activity known as the 'Hill Farms scheme' introduced by the British Military Administration. Many of the older Italian settlement farms were fully established, especially those at Luigi Razza, Beda Littora, Luigi Savoia, and Giovanni Berta. Small vineyards formed part of each holding, for supplying the wine factory at Beda, and in many cases there was a small orchard; a number of the sturdy blue-grey Italian draught cattle were also available. Left to themselves, the farms would rapidly return to waste, and this process was being accelerated by the destruction of the vines and young fruit-trees by the wandering herds of goats and sheep. The Hill Farms scheme has a double object. The first was the immediate one of maintaining the farms and their output by means of Arab tenants working under the close control and guidance of a British officer. The second object was perhaps incidental, but on a long-range view should be considered of great importance; it was to see whether the semi-pastoral Arab could develop the aptitude for settled farming. The existence of established and stocked farms, and the practical certainty of making a profit over the next two or three years—a point that did not escape the Arabs—were favourable factors for the scheme; the inability of the British Military Administration to provide more than a very small staff and the minimum of facilities were unfavourable factors that might well have been decisive but for the skill in improvisation and the personality of those responsible. The result has been that, to date, the scheme has been, on balance, a success, for it has demonstrated that with reasonable organization and facilities the pastoral Arab can settle down to agriculture.

In addition to the Hill Farms scheme, the Administration has undertaken another experiment of a different type—large-scale mechanized wheat-growing on the

Barce plain from 1943 onwards. This area of 30,000 acres, partly in private concession and partly laid out for colonist farming, is almost ideal for mechanized cereal production and, in spite of many difficulties, it has been possible to crop 10,000 acres with wheat, and some barley, and to prepare a further 10,000 acres for the ensuing year's crop.

The question whether the Barce wheat scheme should continue beyond the period of urgent necessity for extra wheat-growing in the Middle East depends primarily on the political future of Cyrenaica. But the experiment and the Hill Farms scheme both show that Public Utility Corporations, as outlined in Chapter III, 2, would be suitable organizations for raising the agricultural output of the country and the welfare of its inhabitants.

Whatever agricultural developments take place, stock will continue to occupy a very important place because of the pastoral conditions over so much of the territory. The predominant animals are sheep and goats, but there should be increasing scope for milk cattle and pigs in any development of settled arable agriculture. The general level of the sheep and goats is good both as regards wool, flesh, and hides, but it could be improved and there would be much useful work for an animal husbandry department to do.

(2) THE MIDDLE EAST AS A WHOLE

(a) The Functions of an Agricultural Council. The preceding section has dealt with the separate territories and earlier chapters have discussed the practical and scientific problems of the Middle East as a whole. The present section examines how far it is desirable and feasible to integrate these two aspects by means of some organization to serve not only the individual territories concerned but also to supply their mutual needs. Any such organization must satisfy two basic conditions: it cannot relieve the separate Governments from any part of their responsibility to their own peoples for the well-being of agriculture in their territories; it must fit in with any regional organization for food and agriculture that may be set up by the United Nations.

As already pointed out, each territory has, in varying degrees, gaps in its research, technological, and advisory organization. Scientific and Technical Officers of the territories expressed their belief that a regional organization would help to close these gaps, by recommending the formation of a Middle East Council of Agriculture in a unanimous resolution, passed by Official Delegates to the Conference on Agricultural Development held in February 1944 at Cairo. Up to the present (June 1945) it has not been feasible to implement this resolution, and it is clear that the proposal raises some perplexing problems of administration and inter-territorial relations. Difficult though these problems are, they must be considered as less important than the problems of agricultural development; and in the latter a regional Agricultural Council could be of great service to the territories. It is greatly to be hoped that it will ultimately be found possible to form the Council, and if one serving the whole of the Middle East is not immediately practicable, that as a first step the Arab Federation will create a Council for its adherent territories. Therefore this section of the Report discusses the functions of an Agricultural Council and the means of performing them.

But before considering these functions it is necessary to have clearly in mind the implications of recent developments in agricultural science, and in its organization, that have taken place principally in the United States and the British Commonwealth.

A distinction must be made between fundamental research and technological investigations. The term 'agricultural science' is a convenient general one to cover a very wide range of sciences in their application to agricultural problems, but it is now in some respects a misnomer. It dates from the time when an 'agricultural scientist' was expected to explain almost any agricultural phenomenon and to solve any agricultural problem from his knowledge of physics, chemistry, botany, and other sciences. Normally he had not, and could not have, enough knowledge in even one of these sciences to specialize on fundamental research in the agricultural aspects of that science. This came later. The rapid advances in the pure sciences made specialization more and more necessary if research into fundamentals was to continue. Its bearing on 'agricultural science' was significant, especially in the more developed countries. It was no longer feasible to give a combined agricultural and general science training and to invite the products to do research. Instead it was necessary to select those who had shown ability to do research in some pure science and to invite them to devote their attention to the agricultural aspects of that science. The results of this policy have been very successful. So successful, in fact, that they have intensified the perennial problem of incorporating new knowledge into agricultural practice. It is here that the agricultural technologist comes in. As the work of the agricultural research institutes deals mainly in fundamentals the findings often require a systematic and co-ordinated examination under a variety of external conditions, so that any modifications in their application to different soil, climatic, and agricultural conditions can be worked out, and put into a form that the agricultural adviser or extension agent can use. The sequence research, technology, advice is not rigid, but it is sufficiently general to be the best basis for the formal organization and control of an agricultural service, and for the recruitment into each group of men with the appropriate training, temperament, and outlook.

In the Middle East there are two factors which bear on the above generalization:

(*a*) the majority of the territories could not sustain the cost of a full agricultural service of this kind;

(*b*) many experimental results from other areas, e.g. the U.S.A., India, could be drawn on now for incorporation into Middle East agriculture.

These two factors are clear guidance to the kind of functions that a Middle East Council of Agriculture could perform. Besides keeping itself fully informed of all investigations in the Middle East, it should examine and collate all overseas results having any bearing on Middle East agricultural problems, and bring them to the notice of the territories. It should be able to provide information in answer to specific inquiries from the territories. Such a service would be especially valuable to the smaller and less developed territories in the immediate future years; they would be able to devote a higher proportion of their available funds to staffing their advisory service adequately, because the Council could supply much of the research and technological information which the advisory service requires.

There can be no question that the immediate need of much of the Middle East is an improvement in the advisory service to the peasant. Normally research must be ahead of technology, and that, in turn, in advance of the practical advisory work; the record of advances in Egypt, the Sudan Gezira and, more recently, certain aspects of Jewish agriculture, show what is possible when this sequence is observed. But practically everywhere else in the Middle East the advisory work lags far behind its proper position, even when all allowance is made for the limited scientific work that has been done there. However, as already pointed out, research and technological findings from elsewhere can be pressed into service and the gap reduced. The aim

should be to concentrate largely on small improvements requiring no marked charge in the peasants' outlook. Typical examples are: contour ploughing, where that is feasible; better preparation of hides and skins; improvement of the baladi fowl; the correct cultivation of improved crop varieties; the better use of minor irrigation facilities; simple improvements in stock management. A number of possibilities have been mentioned in various parts of this Report, and many more would emerge from the broad surveys of existing farming systems which, as recommended above (section 1, *a*, this chapter), should be made. The method of approach could well be modelled on that used by the Near East Foundation. The Council would not take any direct part in advisory work in the territories, but it could give invaluable stimulation and indirect assistance in many ways, and for the more backward territories this might well become one of its most important tasks, especially in the initial years.

The task will be facilitated by linking the Council with existing abstract and information organizations in other countries, especially those of the British Commonwealth and the United States. In Great Britain the Imperial Agricultural Bureaux system consists of twelve Bureaux; each Bureau covers one broad section of agricultural science, in which it collects and disseminates information by means of abstract journals, technical communications on specific subjects, and answers to specific inquiries. An example of this last is given in Appendix I, which was prepared by the Bureau of Soil Science in answer to a test inquiry made by the present writer, to show the kind of information the isolated worker or institution with an incomplete library can secure when devising a programme of work. In the United States the Department of Agriculture publishes *Experiment Station Record*, a technical review and abstract journal dealing mainly with home investigations, and the *Bibliography of Agriculture*, a subject catalogue with occasional brief summaries of all material received in the Department library; within the Department, the Office of Foreign Agricultural Relations studies the factors influencing the food-supply and needs of foreign countries, such as competition, trade barriers, production and marketing, and developments abroad likely to affect American agriculture.

These British and American publications are available to purchasers in foreign countries. But the link that the Council would need to make should be closer than acting as a central agency for the publications, many of which are not specifically written for Middle East conditions. The Bureaux organization, for example, is, by its constitution, concerned officially only with Palestine, Cyprus, Aden, and the Sudan. Unofficial contacts exist with the other Middle East countries, for they are to the advantage of the Bureaux in facilitating their work and making it as complete as possible. An extension of these contacts to put these countries on the same footing as the others would be advantageous to the Middle East as a whole. As an example of this, the problem of getting information on general husbandry and farming systems can be cited. Practical problems of improvement in the Middle East system of agriculture have been stressed throughout this Report as the immediate necessity of the area, and the one to which the Council should give first attention. At present no central source of information exists on general husbandry and farming systems. The Bureaux organization has hitherto spread these problems among the existing Bureaux in accordance with their specific interests, but experience has shown that this does not entirely meet the case and it is now contemplating the addition of a Bureau of Agricultural Husbandry.[1] The value of such a Bureau both to the general Bureaux organization and its clients in the

[1] *Report on the Imperial Agricultural Bureaux.* H.M. Stationery Office, 1943.

Middle East will depend considerably on the closeness of its relations with the Council, because the problems of management in a farming system can never be put in such precise terms as, say, one in plant genetics or soil chemistry: it would be the intermediary function of the Council to give the correct emphasis and perspective that comes from close local knowledge, to the material submitted to and received from the Bureaux. It is desirable to stress the importance of this intermediary function especially in the agronomy aspects of every system of husbandry. Examples are afforded by the problems of soil tillage (Chap. IV, *c*), and the effect of legumes on the following wheat crop (Chap. IV, *f*).

It should therefore be an early duty of a regional Council of Agriculture to explore the possibilities of associating itself with suitable overseas organizations, such as the Imperial Bureaux, to their mutual advantage.

The next most important task of the Council should be to encourage investigational work throughout the Middle East. This is more of a long-range programme of stimulating research and technological work and would be best carried out by enlisting the help of existing institutions, where it is constitutionally possible. The emphasis should be on regional or sub-regional problems, so as to make the best use of the limited number of institutions. The Council would, of course, have no executive or jurisdictional functions in relation to the institutions. Its task would be to enlist their help, and to provide facilities of various kinds for the proposed work, and for the co-ordination and dissemination of the results. Here again close association with the overseas organizations, such as the Bureaux, will be of the greatest help in providing information on scientific results obtained elsewhere.

The Middle East institutions that might assist in work of this kind are, of course, few. Apart from the scientific departments of State universities and technical institutes, and research laboratories of the Departments of Agriculture and Irrigation—where these exist—there are only the Royal Agricultural Society of Egypt, the American University at Beirut, and the Jewish organizations: the Rehovot and Mikveh Israel Institutes for agricultural research, the Sieff Industrial Research Institute, the Haifa Technical College, and the Hebrew University. However, for some time to come this range of facilities should be adequate for extra *ad hoc* investigations sponsored by the Council, even allowing for the necessarily limited help that State-controlled institutions can give in outside problems. The problems will fall in both the research and technological divisions. One example of the latter is the investigation of suspected minor element deficiency, the apparatus for which is possessed by the Sieff Institute (Chap. IV, *f*); and of the former, the study of the physiological basis of dormancy (Chap. IV, *g*).

A third important function of the Council, which would be exercised concurrently with the two already discussed, and without which it could not fully carry them out, would be to arrange for periodical conferences on specific problems with each territory acting, in turn, as the host. Two examples will suffice. There is immediate need for a Middle East conference on plant pests and diseases, with the objects of filling gaps in the present work and of introducing some rationalization into the present quarantine regulations. The arguments have already been given above (Chap. IV, *i*). Another matter for early discussion is the agricultural aspects of irrigation which, as already noted, exists in the Middle East in all stages of efficiency and inefficiency: the subjects should include physical and chemical soil factors, the mechanics of water-movement in soil and their bearing on the duty of water, and the choice and management of crop and fodder rotations.

Another direction in which the Council could give useful service to the Middle East would be to act as a local advisory centre in connexion with post-graduate work, temporary exchanges of posts, sabbatical leave, and similar matters. This work would include movements within the Middle East, and abroad. For the latter especially, close relations should be established with the British Council and the Rockefeller Foundation.

The Council could also be of service in the development of plans for new agricultural systems by the Public Utility Corporations. It would help in clarifying the technical and welfare problems likely to be met with in the selected area, and in recommending suitable technical staff.

An incidental necessity to all the above lines of work is to build up an adequate library of publications on Middle East agriculture and related subjects. Much of the technical information already available is scattered in isolated papers in a wide range of scientific journals, most of which are published abroad. What may be the only recent expert article on Ethiopian agriculture appeared in *Der Tropenpflanzer* in 1938—a German publication, seen by few in the Middle East. At the other end of the scale, the extensive research and technological papers dealing with the Sudan have appeared in so many specialist journals that no clear picture of the past achievements and present position is easily available for reference. This situation is being corrected by the Sudan Department of Agriculture; a comprehensive handbook is in preparation, with chapters written by members of the staff, and the treatment is, as far as possible, non-technical. This admirable example of progress reports could well be followed by the other territories, as and when sufficient material accumulates, and a similar periodic survey for the broader background of the Middle East could well be undertaken by the Council. This general situation was recognized by the Conference on Agricultural Development; the publication of a journal on Middle East agriculture was included in their resolutions. A note of caution should be sounded here. Before launching a new journal it is imperative to be certain of its objects, and to know the class of reader it is intended to help. Scientific and technical workers find their medium of publication in the appropriate existing scientific and technical journals, and their difficulty in keeping abreast in their own fields with the work of other people—an acute problem in isolated areas that cannot maintain an extensive library—is greatly eased by the abstract journals, of which those published by the Imperial Agricultural Bureaux are admirable examples. Those concerned more with the advisory and practical side of agriculture are, admittedly, more difficult to cater for, for they have many and varied requirements. Yet other classes are those concerned with administration, the landowners, the educated urban class, and the poorly educated rural dweller. A journal that tried to cater for a number of these groups would defeat its own ends: readers who find only an occasional article to interest them quickly give up the journal. For these reasons, and in view of the necessity to avoid overlapping with publications already issued by the territories, it is recommended that, at first, only leaflets, pamphlets, and booklets should be envisaged, each dealing with a specific subject, aimed at a specific class of readers, and published at the appropriate time, not at the regular intervals so important for a journal. The reception of these publications and the requests arising therefrom would serve to create a demand, and to show clearly whether a regular journal was needed and what its target should be. The procedure would also give guidance on important problems connected with the language of publication, and in particular whether very full abstracts, or short summaries in another language, should be printed. It must be remembered

that this matter will not only bear on the composition of the secretarial and technical staff required for the Council; although intended for Middle East consumption, the publications will circulate abroad and be one of the chief means of informing the recipients of the progress, needs, and difficulties of the Middle East.

One concluding point needs to be stressed. It is self-evident that a regional body such as a Middle East Council of Agriculture would be of great use to the territories, but it cannot reach that position at a bound. It must feel its way from modest beginnings and the performance of simple services, towards the larger aims; its organization must be flexible, so that it can be moulded by experience. Too much planning in the early stages will only produce a castle in the air.

(b) The Question of a Central Agricultural Institute. It was to be expected that the Delegates to the Agricultural Development Conference, being fully aware of the need for much more scientific investigation into Middle East problems, would consider how this could be met. Their resolution on the subject is as follows:

'The Conference requests the Council, when formed, to examine the possibilities of establishing a central Institute of Agricultural Development to supplement the work now being carried on in individual countries and to serve the Middle East as a whole by enabling fullest use to be made of such trained personnel and facilities as are now available.'

It is within the province of the present Report to put forward certain considerations on this proposal. Throughout this Report stress has been laid on the need for more research, and also on the great difficulties facing most of the territories in any attempt to remedy matters. On this count it is clear that the territories could secure, by contributory partnership in a central institution, results beyond their individual resources, and at the same time avoid duplication and overlapping of effort. While that is quite true, the crux of the matter lies in the machinery for the control of the Institution. All experience goes to show that a body with the functions contemplated for a regional Agricultural Council must have no direct connexion with such an Institution. The essential foundation for all Council activities is that they shall be—within the limits of human frailty—impartial and objective. Each Institution must feel that it stands in precisely the same relation to the Council as do all the others, and this cannot be the case if one of them seems to hold a privileged or closer position. Only when States are combined into a close political Federation, as in the U.S.A., can central and State institutions coexist with profit, and even then the problems of co-operation are sometimes difficult. Although the complex political pattern of the Middle East, and the disparities of agricultural progress in different parts of the area, render unlikely the establishment of a regional institution, the creation of one, or more, sub-regional institutions should be well within the organizing ability of the groups of territories concerned. It would be one admirable means of giving practical expression to the growing sentiments of co-operation and feelings of a common destiny, and it would have the further advantage that tangible results might be expected from the effort. An important function of a regional Council should be to encourage the formation of sub-regional Institutes to serve groups of territories having a number of agricultural problems in common.

The territories—or, more probably, groups of territories—should also give early consideration to the possibility of joint action in the training of their agricultural and educational staff whose work lies in immediate contact with the farmers and villagers. Two further resolutions of the Conference are relevant:

'The Conference attaches great importance to the improvement through research and education of agricultural techniques and rural standards of living; increased facilities for the training of personnel are essential.

'In order to ensure the practical application of new knowledge and techniques the Conference stresses the need for the extension of suitable methods of technical education and instruction to the farming community.'

Throughout this Report examples will be found showing the advantages of common action in these directions. The preparation of agricultural statistics and surveys of farming systems (section 1, *a*, this chapter) should be done on an agreed basis, and that implies an agreed form of training for the personnel. The Sudan and Cyprus experiments (Chap. III, 3, *c*) and the rural work of the American organizations—the American University and Institute of Rural Life, and the Near East Foundation—are also relevant to this issue. Many of the territories would find the experience gained there of much assistance to them. Assuming the high probability that a group of contiguous territories would find that their training requirements have much in common, the question of the best form of joint action would arise. Here it may be suggested that—quite apart from language difficulties—the solution is not to set up a sub-regional Institute for the purpose, although something on these lines might well emerge in the future. When the students have acquired their formal classroom instruction in their own territory, they need experience on the ground: survey of an area scheduled for improvement and drawing up the scheme; studies of projects, completed and in progress; examination of others where special difficulties have arisen. These areas would be selected from all the co-operating territories, so that a group of students from one territory would see what is happening in the others. It is unnecessary to stress the lasting value of these wider contacts in broadening the outlook of men whose future work lies in the rural areas, where the parochial viewpoint is, of necessity, so strong. This is the direction in which useful co-operation between contiguous territories could most easily be made, especially in the early period. An integral part of the curriculum for each batch of students should be a demonstration and instruction tour of selected areas in the participating territories, and the programme of study of the visiting students should not be allowed to degenerate to a formal sightseeing tour. On the contrary it must be carefully thought out and varied from year to year, so that it faithfully reflects the gradual change in conditions throughout the region.

CHAPTER VI

Conclusions and Summary of Recommendations

One inescapable conclusion must be drawn from any objective study of Middle East agriculture. The peasant is imprisoned within the walls of his own agricultural system: year by year his numbers grow and the walls remain. The difficulties in attempting to break out are great. Except in areas where irrigation is possible, climatic conditions rule out any system of agriculture like the one now practised in climates with a well-distributed rainfall. The system has necessarily a low economic level, and the Government's income from taxes is insufficient to provide adequate agricultural and education services. There are no large industries to provide a big market for cash crops. (Chaps. I and II.)

Admittedly the system, left to itself, could endure for a long time yet—at a cost: continued soil erosion; periodic removal of surplus humans and stock by famine and pestilence; the maintenance of high death-rates at all ages; and the acceptance of mere existence as a standard of living. But it has not been left to itself, since the days of the first impacts and infiltrations of the modern Western civilization, and the results have been portentous. Great irrigation schemes, with modern knowledge available to avert soil deterioration, have provided large new fertile areas—and the population has rapidly bred up to them. Medical science has eliminated many debilitating diseases and saved great numbers of lives—and intensified the pressure of population on the land. Veterinary science has countered the devastating stock diseases—and now, millions of extra animals compete for the already inadequate and poor fodder. Thus, although the husbandry may be kept going by the resources of modern science, they are often only palliatives, and the price for surmounting a current crisis is the probability of having to meet the same crisis, magnified, in the future. Clearly there is some fundamental difficulty in this system of agriculture which turns the edge of improvements, even though they are of self-evident value and have given highly beneficial results elsewhere. The difficulty is, of course, the trinity of the land-tenure system, the fragmentation of holdings, and strip cultivation. It is not a Middle East problem alone; it exists in India, and it existed in western Europe until enclosures replaced the communal field system by separate and self-contained farms.

No system of agriculture can be progressive unless the holding can be worked as a unit. The size is relatively unimportant, provided it is an economic unit. It may be a collective farm covering thousands of acres, as in the Russian kolkhoz and the Jewish kibutz, or a small-holding linked with others by a co-operative society, as in Denmark. It may be owned or tenanted. It need not cover all branches of agriculture. But it must be a unit. In the Middle East the cultivator's unit, so-called, is often a widely scattered set of pieces, whose position will alter, both in time and space. The fact that little improvement is possible in such conditions is widely known and is one of the main reasons for the attention given to registration of title to land and the consolidation of holdings. This is all to the good, but too much must not be expected of it. When a small plot may be owned by several people, the trees by others, and the water rights by yet others, a reshuffling may produce consolidated holdings, but they cannot all be economic ones. The experience of the Cyprus Government, whose acquisition of a 250-acre area for an experimental farm necessitated negotiations with 600 owners, is not abnormal.[1] Again, so long as the laws of land inheritance, the custom of family division of property, and the unrestricted sale of land endure, land settlement is a Sisyphean task, and the goal—the creation *and preservation* of economic farm *units*—cannot be reached. The longer an equitable solution is deferred, the more likely it is that the peasantry will be driven to the brusque alternative of an agrarian revolution.

It is this situation that confers so much importance on the systems of agriculture discussed in the first part of Chapter III. Although numerous criticisms, some formidable, have been directed towards certain aspects of these developments, they have, at least, produced a cure for the chronic disease of uneconomic farm units. The general principle is that the Government takes over an area of land from the owners, either by purchase or on long lease. The area is then either run by the Government or, more usually, handed over to a suitable organization. In either

[1] Quoted on page 173, *Proceedings of the Conference on Middle East Agricultural Development*, Cairo, 1944.

case the land is redivided, with due regard to topography, &c., into suitable holdings, which are sub-leased to tenants.

The social and economic implications of this arrangement are discussed in Chapters II and III and need only brief mention again. It gives the cultivator two essentials on which rural betterment must be founded: security of tenure, and, with it, the knowledge that it is worth his while to improve his own holding. It deals with the absentee landlord problem (which has arisen from the social system), and it prevents further fragmentation of the land.

It appears that the most suitable organization for implementing the change, and the one that is free from most of the criticisms levelled against the existing large-scale commercial developments discussed in Chapter III, is a tripartite one composed of the Government, the tenants, and a Public Utility Corporation. The Corporation is in fact the keystone of the proposal. It will perform those managerial and middleman services on whose efficiency the success of any system of agriculture depends and which, in view of their commercial nature, are really unsuitable for a government permanently to undertake; but as it is a Public Utility Corporation it will also be training nationals of the country and progressively devolving responsibility on them, with the object of handing over completely at the earliest possible moment. It will take a wide view of its training responsibilities, for they are as much educational as commercial. As its task in one area approaches completion another area would be taken over, where the process would be repeated. In general the sequence would be from sparsely settled to more populous areas, so as to simplify the progressive settlement of each reconditioned district. Resettlement must always be a formidable task, but it will be eased by the circumstance that the present social structure in the Middle East gives more prominence to family and tribal associations than to the sense of a personal attachment to a particular piece of land.

It is reasonable to expect that the operating period of the Corporation in each successive area would become progressively reduced because of its accumulated experience, and the increasing number of trained nationals becoming available.

In the above arguments the economic aspects of the problem have been put in the forefront; whatever the system of agriculture, and the system of money-economy (between the extremes of barter and the gold-standard), they pervade and colour the whole structure: 'The social scene grows out of economic conditions, to much the same extent that political events in their turn grow out of social conditions.'[1]

By the nature of the case, the results from this method of improvement, or for that matter any other, will appear slight and slow when seen against the needs of a complete country, and still more so against the Middle East as a whole: the analogous change in England was not complete a century after it began. For a long time ahead by far the greater part of the population and the land area will be occupied in the existing agricultural system. There can be no radical changes in such a firmly entrenched and climatically restricted system. The only way is to introduce those minor improvements that offer some hope of absorption, and to encourage those factors that will facilitate and hasten the process of evolutionary change. It is not possible to summarize all the numerous minor improvements that may be possible: a number are given at the end of this chapter, which have themselves been summarized from the fuller discussion of Chapter IV; others, referring to particular territories, are given in Chapter V, 1, *d*. The encouragement of evolutionary changes is, of course, a matter of education: the landowner, tenant cultivator,

[1] Trevelyan, *English Social History*.

peasant proprietor, and above all, the children. In Chapter III, 3, these problems are separately considered, and the conclusion is drawn that in the present conditions the main emphasis must lie on the development of rural leaders. Men—and women—drawn from the rural areas, not educated out of their rural outlook, but given a simple training and refresher courses in better agricultural methods, rural education, and welfare.

The responsibility for these advisory services and the training of the staff lies with the individual territories. Their work will be facilitated by free interchange of information and experiences and by adopting a common basis of action wherever feasible. For example, if satisfactory plans for improvement are to be drawn up, the collection of agricultural statistics and the preparation of broad surveys of the existing systems of farming are necessary. These surveys and the training of staff for them could best be done on an agreed common basis. (Chap. V, 1, *a*.)

This is only one instance of the mutual benefits from co-operation, and the need for association has already been recognized by the territories themselves in their proposal to set up a Middle East Council of Agriculture. The proposal can be strongly recommended, not only for its value to each territory, but for the Middle East as a whole. In Chapter V, 2, *a*, the functions of such a Council are examined in some detail both in relation to the individual territories and to the contacts the Council should make, on behalf of the Middle East as a whole, with sources of information in overseas countries. The territories have also considered the possibility of further co-operation in the form of a Central Institute of Agricultural Development. The proposal is examined in Chapter V, 2, *b*, and reasons are advanced to suggest that a Central Institute is not at present feasible, but that sub-regional institutes, to serve groups of territories having similar agricultural problems, are well within the bounds of possibility.

The rest of this chapter consists mainly of a summary of the recommendations relating to scientific and technical problems discussed in Chapter IV. They should be read in conjunction with the discussion and recommendations relating to each territory in turn, set out in Chapter V, 1, *d*.

The survey and mapping of soil types and the study of soil-forming processes have so far been confined largely to Palestine and the Sudan. The Sudan system is of great practical value in its combination of agronomic and scientific criteria (Chap. V, 1, *b*). The universities should be encouraged to take up some of the fundamental scientific problems of soil formation, as in Palestine, and the work should be assisted by a small central fund and an advisory committee. (Chap. IV, *a*.)

There is urgent need in some territories for more understanding of the chemical and physical behaviour of semi-arid soils when brought under irrigation. The Agricultural Service of these territories should include a Soils Department, staffed by competent research workers and technologists, as in Egypt and the Sudan. (Chap. IV, *a*.)

The construction plans for new irrigation schemes should be based on soil-classification maps prepared by experts, who would also closely watch the soil behaviour after irrigation begins, in order to make any needful modifications in water usage. This recommendation and the previous one call for a closer association between Agricultural and Irrigation Departments and, where necessary, for a readjustment of their respective responsibility and authority. (Chap. V, 1, *b*.)

In general, irrigation engineers are not familiar with modern knowledge of the water-régime in soil that has come from the physical researches on soil and soil

moisture. There is a real need for a graduate school for hydrological engineering, with adequate facilities for post-graduate work, for the matter is of more than Middle East interest. (Chaps. IV, *d* and V, 1, *b*.)

Poor fertility and erosion are generally attributed to lack of organic matter in the soil; but this belief has been taken over from experience in temperate climates. In the Middle East organic matter decomposes very rapidly in the soil, and the equilibrium content is very low. There is, as yet, no proof that any marked augmentation of soil organic matter is either necessary or possible; indeed, the bulk of the evidence so far available points in the other direction. In any case, the amounts needed would be far beyond what the indigenous system of agriculture could provide. The supply of town-refuse and other composts is limited, and they are, in general, of low manurial value, so that the emphasis falls more on the hygienic aspects of disposing of waste products than on their agricultural value. The regulations attending their manufacture, laid down by the medical authorities, tend to be over-elaborate. More research and field experiments on organic matter problems are imperative. They must include a study of soil microbiological conditions, especially the nitrogen-fixing group of organisms, and the effects of a vegetation cover on the soil structure. Further study is desirable, on the lines of the Sudan experiments, of the effect of deliberately burning or charring the top inch or so of arable soil. The custom is traditional in Ethiopia, and the Sudan work shows that a marked increase of fertility is produced. (Chap. IV, *b*.)

The indigenous system of soil tillage and the implements have been adversely criticized by Western agriculturists. But this was before the results of recent researches and field experiments in different parts of the world became available. It now appears that moisture control and crop yields are less influenced by cultivation methods than was formerly thought, but that weed control in the early stages of crop growth is very important. The indigenous system of tillage can no longer be condemned without trial, and full-scale cultivation experiments comparing different systems must now be made. The points studied must include crop yield, soil-moisture control, and the effects on soil structure in relation to erosion tendencies. These matters assume special importance now that tractor cultivation has been introduced under the pressure of necessity during the war. (Chap. IV, *c*, *d*, *e*.)

Until more is known about the effects of cultivation by tractors in Middle East conditions, their unrestricted use in private hands is most inadvisable. For the present, the machines should be under some form of Government control, and leased only under agreed conditions. The suggestion that the fodder problem for animals might be circumvented by replacing the work animals by small power units working on the cheap supplies of Middle East oil is not a practicable one so long as the present systems of land tenure persist. (Chap. IV, *c*.)

Soil-moisture problems are obviously important in both irrigated and non-irrigated agriculture. They embrace scientific work, that must be carried out in research laboratories and university departments, on the movement of water in soil. At present the subject is incompletely covered. More work is needed on the lines of that done in the Physical Department of the P.W.D. Egypt, and in the Hydraulic Laboratory of the Haifa Technical Institute, Palestine, as the results bear directly on practical problems of drainage in irrigation areas. (Chap. IV, *d*.)

Owing to the special conditions in Egypt, the replacement of open drains by covered ones merits favourable consideration by the Government. Further work is needed on technical problems, such as the best material for the pipes, and the

control of silting, in order to reduce the present cost of installation and maintenance. (Chap. IV, *d*.)

More information is needed on duty of water in various conditions. Too many variables exist for a complete specification to be feasible, but the fullest information is desirable for practical advisory purposes and for the plant-breeder. It is recommended that studies in different centres should be co-ordinated and made on a common plan as far as possible, and that special attention should be given to the problem by those countries, e.g. Iraq and Persia, where the area of irrigable land is more than the potential water resources could supply. More information is also needed on the economic aspects of overhead (spray) irrigation. (Chap. IV, *d*.)

Erosion problems are widespread, but it is not certain that erosion is rapidly increasing, and in many instances it seems to be in a state of dynamic equilibrium. The troubles are by no means entirely due to human agency. Some are the inevitable results of natural causes, e.g. the marsh area in southern Iraq, and the 'hummocks' bounding the Mesaoria plain in Cyprus, and with these some degree of control of the course of erosion is all that can or should be attempted. Erosion due to human agency arises from many causes, most of which are obvious malpractices: bad water-control; cultivation of steep slopes; over-grazing; destruction of forests. The remedies are equally obvious: contour ploughing, and maintenance of terraces; control of grazing, and of collection of vegetation for fuel and fodder. Unfortunately the fact that the remedy is obvious does not mean that it can be used. The social and agricultural system, although basically simple, has many technical complexities that necessitate the continuance of the very practices the reformers deplore. The Agricultural Department must be closely consulted over every anti-erosion measure proposed by another Department. The best way is to form a Soil Conservation Committee of departmental representatives, so that any technical proposal by one department can be examined from the viewpoint of all the others. The Public Works Department must be included: a highway improvement, such as a culvert or bridge, not infrequently initiates new erosion that could have been prevented. The arrangement is working well in Palestine and in Cyprus, whose laws for adjusting the conflicting interests of foresters, stockmen, and farmers well merit the attention of other territories. Recently the Sudan has set up an analogous inter-Departmental Committee. Similar bodies, suitably adapted to the Government framework, should be set up in other territories. Some central machinery—such as the proposed Middle East Council of Agriculture (Chap. V, 2, *a*)—for interchange of experiences and methods would be a valuable help. (Chap. IV, *e*.)

Plant-nutrition problems have been worked out mainly in temperate climate conditions, and analogies drawn from results there may be misleading under Middle East conditions. Field trials on, e.g. manurial problems, must be accompanied by investigations in plant physiology and agronomy; the method has been adopted with success in Egypt and the Sudan. Where the economic level of a farming system is high, its stability often rests on relatively small differences in yield and production costs. These differences cannot be tracked down unless the methods of modern statistical technique are employed in the layout of the experiments. The most important single group of problems is that dealing with the influence of salts in the soil and in irrigation water on the normal processes of plant nutrition and growth and the best manurial treatments to counteract the adverse effects; experiments on these lines should be made wherever irrigation developments are planned. In the ordinary non-irrigated systems of agriculture there are important agronomical problems and, as with cultivations and organic matter, the results of

experiments in temperate climates are not necessarily applicable. Among matters requiring attention are the curious reversal in the effect of a legume on the succeeding cereal; the question whether, over a period of years, the use of cheap artificial manures would be profitable, in view of the so-called drying-up effect that even organic manure may have on the plants in dry-farming conditions; and the extent to which the fairly widespread practice of growing mixed crops in the same field serves the purposes commonly attributed to a rotation. (Chap. IV, *f.*)

The improvement of plants by genetical and selection studies has reached its greatest development with cotton, because of the financial resources available for research from its importance as a cash crop. But other crops—cereals, pulses, oil seeds, and fodder—that are the background of the agricultural system over most of the Middle East have received far less attention, except in a very few territories. As these are sustenance rather than cash crops, with the partial exception of oil seeds, the responsibility for financing work on their development will rest with the Governments. There are technical reasons (see Chap. III, 1, *d*) why cereals will continue as important and inevitable crops even under improved farming systems. The position with regard to fruits, nuts, and to a lesser extent, vegetables is more encouraging. The development of nursery stations and gardens for raising quantities of young trees, seedlings, and seeds for sale at nominal prices is going steadily ahead, and will ultimately have appreciable effects on the diversification of the agriculture. (Chap. IV, *g.*)

The Palestine citrus industry has already nearly reached its most likely optimum area (75,000 acres with 15 million trees). Readjustments of marginal plantations and development of by-products and processing industries are desirable. The absence of co-operative marketing arrangements in the Arab section of the industry is a handicap. Although the reputation of the industry has been built up on the Jaffa orange, the season is short, and it is desirable to extend it by including a proportion of other varieties, particularly early ones. The present abnormal conditions provide an opportunity for top-working to new varieties. The Mikveh Israel and Rehovot Stations have much information on this matter. (Chaps. III, 1, *e*, and V, *g.*)

There is a definite opportunity for the Middle East to enter the seed-production industry as part of its peace-time agriculture. The territories in the Mediterranean littoral, and parts of Iraq, are suitable areas, and war-time experiments on seed production have on the whole been encouraging. The industry is complicated both in its commercial and technical ramifications and no unorganized entry could succeed. It might be a suitable activity for a Public Utility Corporation. (Chap, IV, *h.*)

With valuable cash crops, the study of their pests and diseases, as a basis for methods of control, is essential. Hence cotton and oranges have received most attention. Over much of the Middle East the study, and even the mere recording, of pests and diseases is rudimentary. But there is a wide variety of diseases, and though not all are as spectacular in their effects as the locust, the aggregate damage they cause, not only in growing crops but in the stored or processed products, is certainly as great. As there is no possibility of the less-developed countries having adequate plant pathological services for some time to come, there is a real immediate need for close co-operation by the few workers on these subjects in the Middle East, so that the fullest use can be made of what information is available in adjusting their programme to cover as much ground as possible. This co-operation would be of service in keeping quarantine regulations up to date and could well take the form of regular technical conferences. (Chap. IV, *b.*)

More attention must be given to work on live-stock improvement and nutrition, which lags behind that on the cure and prevention of diseases. Until this lack of balance is set right little real progress can be made in answering the basic question whether some form of mixed farming is feasible in Middle East conditions. It was for this reason, in addition to the intrinsic importance of the subject, that a recommendation was made, early in the present inquiry, for an expert examination into live-stock improvement and nutrition and related matters. This examination is now being made by Dr. N. C. Wright, and the report will shortly be available. At the moment the work on cattle is confined mainly to crossing native cattle with imported European breeds. Crossing with, or replacement by improved breeds from other countries, e.g. India—whose conditions resemble the Middle East—has not, so far, been tried on any scale; there are one or two examples where private initiative has graded-up native cattle under town-dairying conditions to produce good milk yields. With sheep and goats the bulk of the work has been in the introduction of Merino and Angora blood respectively. Pigs are, for obvious reasons, of limited importance, but there should be an opportunity in suitable areas for developing a pig-product industry to supply the small Middle East market and adjacent foreign ones. Palestine work has shown that the egg and body-weight and laying capacity of the native fowl can be markedly improved by straightforward up-grading, and other territories might consider this addition to their programme of work on imported breeds. The methods of getting better live-stock of all kinds to the cultivator should receive further attention and development. The Cyprus system of issuing good-class sires on generous terms to approved farmers, and the Palestine system of chick distribution with appropriate modifications to avoid spreading diseases, are examples of attempts to meet this problem. (Chap. IV, *j*.)

Improvement of live-stock is not likely to be effective or to be maintained unless adequate fodder can be provided. It has several aspects: pastoral, settled agriculture without irrigation, and irrigation farming. In the first and second of these there must be a survey of the distribution and nutritive value of indigenous vegetation (including weeds and stubbles) and experiments on the possibilities of introducing other and better types of grazing vegetation over wide areas; the work of the Imperial Veterinary Institute, India, and the Departments of Agriculture of South Africa and Tanganyika will afford invaluable guidance. The third aspect, irrigation farming, necessitates the introduction of suitable fodder crops either as courses in the normal rotation or as a complete rotation. This aspect is receiving considerable attention in Palestine; important experiments are in progress at the Acre Experiment Station, Rehovot, and Mikveh Israel, and the associated agronomical problems are under review in some of the Jewish colonies. The results merit full attention in their application to other existing and potential irrigation areas. (Chap. IV, *j*.)

As crop husbandry and animal husbandry are not so closely integrated as in temperate climate conditions, there is often a difference of outlook between the veterinarian and the agriculturist in the Middle East. The intrinsic importance of fodder and nutrition problems and their special bearing on the question of mixed farming stress the necessity for the agriculturist to be closely associated with the development of a policy of live-stock improvement. (Chap. V, 1, *c*.)

APPENDIX I

Note prepared by the Imperial Bureau of Soil Science, on 'Additions of Organic Matter to Tropical Soils'

The greater part of the somewhat scanty experimental work on application of organic matter to tropical soils is concerned with green manuring. The general conclusion is that the benefits of green manuring derive mainly from the mineral matter; in some cases larger yield increases were obtained by burning than by digging-in the green manure crop.

With green manures a common cause of loss of productivity is loss of soil moisture by transpiration of the green manure crop (1, 2, 3). The correct time of digging-in green manures is important; they should not be turned in prior to or during dry weather, or great soil-moisture losses will occur (1). In Ceylon the most suitable time for digging-in green manures is towards the end of the rains when dry weather alternates with wet. Their effect then is to increase soil moisture at the beginning of a dry spell and to decrease it slightly at the end of a long drought.

In the Punjab (4) the efficacy of green manuring, particularly on light soils, was attributed to an increase in the water-holding capacity. Successful use depends primarily on the moisture conditions following the turning-under of the crops.

Work in Nigeria has thrown some light on the nature of the effects of green manuring (5). Lewin (6) found that (i) a late-sown green-manure crop is as effective as an early-sown crop provided adequate cover is produced; (ii) the eventual treatment of the crop, i.e. digging it in green, digging it in dry, or burning, was immaterial provided the cover is not removed from the land; (iii) the after-effects are not lasting.

On poor land with low nitrogen content, digging-in may be preferable. Doyne (7) found that though there was little in the effect on yield to choose between digging-in and burning, the former produced a higher nitrogen and absorbed-base content in the soil.

Some instructive green-manuring experiments have been carried out since 1930 at Potchefstroom, South Africa (summer-rainfall area, average 23 inches per annum). Maize is alternated with sunnhemp, millet, and cowpeas ploughed-under. Since 1935, 1·7 cwt. per acre of superphosphate has been given to one-half of each plot.

During the first ten years only cowpeas ploughed-in produced a significant increase over the mean in the yield of maize grain (8·1 per cent., significant difference 4·7 per cent. in the unfertilized series; 5·5 per cent., significant difference 3·5 per cent. in the fertilized series). These differences are economically insignificant (3).

Comparison of the residual effects of green manures with fallow showed that the effects were only significant in the first year after ploughing in. As regards the green manures 'they brought about a marked increase in the carbon and nitrogen of the soil, but the effects are transitory. Within less than a year of being ploughed-in the plant residues had decomposed so effectively that there was hardly any trace left of them. Earlier investigations had shown that, as would be expected, residues from millet persisted longer, though the rate of disappearance was still high. In sum the data do not lend much encouragement to the prospect of building up soil fertility to any considerable extent by means of green manuring.

'On the other question of how the green manures have affected the physical condition of the soil no exact information could be produced, but to the eye there is not the slightest difference between treatments. Nor can soil which has been under cultivation for only one year be distinguished in appearance and texture from that which has been cropped for over twenty years. Obviously if the physical state of the soil

is to be noticeably altered this would probably require the incorporation of much larger quantities of organic material than have been applied either in the form of green crops ploughed in or of kraal-manure' (3).

Theron (2) likewise concluded from work at Pretoria that green-manuring is ineffective in the summer-rainfall area except possibly on soil of very poor physical condition.

Farther north, in Southern Rhodesia, green manuring is described as a 'partial success' (8). Good results are obtained when sunnhemp is ploughed-in from mid-February onwards, but if there is much heavy rain after the ploughing in there is too quick a destruction of organic matter and a leaching-out of much of the nitrogen, with the result that in the following year the succeeding crops suffer. The limited effectiveness of green manuring depends on the long dry period between the time of ploughing in the crop and the advent of the planting rains. Much more satisfactory results, as judged by cotton yields, are obtained by using composts of the Indore type. Five tons per acre of such compost increased yields by 80 per cent., 10 tons by 120 per cent., and 20 tons by 160 per cent.

In Uganda it is not usually possible to maintain fertility by green-manuring. Martin (9) writes: 'In temperate lands there appears to be no doubt that green manures have played a useful part in the maintenance of soil fertility, but there is evidence that this is not the case in Uganda.

'Results from experiments at Bugusege at first indicated that a leguminous crop planted in October and dug-in during March was more effective than two covers a year or even than mulching. Later results from these experiments show clearly that none of the treatments used on them approach the value of the mulch.

'On the whole it appears unlikely that any use of green manures or cover crops will be as effective as mulch in maintaining yields and preventing erosion.

'Field experiments on the use of green manures and rotation embodying the same principle have been carried out in Uganda over a period of ten years; in only one instance has the use of a green manure improved the yield of cotton.'

Iosava (10), in South Russia, found that leguminous green manures had marked drying effect on the soil of tea, citrus, and tung-tree plantations. The only safe time for sowing green manures was August–September. Mitropolskaya (11), however, got increases of 25 per cent. in tea yields by green manuring with peas. She attributed the beneficial effects to the physical action of the pea roots; there was little or no permanent accumulation of organic matter in the soil.

The general indication of these and other experiments on green manuring in hot countries is that its value depends on the NPK content of the manure, and not very much on the organic matter.

Similarly, although authentic cases have been reported of tropical crops failing entirely when dressed with artificials, but growing well when treated with dung, most of the evidence indicates that the value of dung on tropical soils is confined to its nutrient content. Any physical effect on the soil is transitory. Turner (12) has shown that at least for sugar cane organic manures such as pen manure and fish manures are not essential; even in a dry year a complete inorganic fertilizer with a mulch of megasse has given better results than did 30 tons per acre of pen manure supplemented with organic nitrogen. Wood and Hardy (13), in a critical review of results from a set of sixteen single plots in Trinidad treated annually with the same manures, found no benefits from the use of organic manure that could not be attributed to its nutrient status. This conclusion corresponds closely with those of Doyne, and Hartley and Greenwood in Nigeria.

The remarkable responses obtained by Hartley and Greenwood (14) in Nigeria to small (1–2 tons per acre) dressings of farmyard manure were subsequently shown to

be due to the phosphate content of the manure (15). Similar responses were obtained from dressings of phosphate only.

Results with tea in Assam (16), Malaya (17), and elsewhere (18) have shown conclusively that sulphate of ammonia is at least as efficient as, if not more efficient than, an equivalent of organic manure in maintaining both quantity and quality of the yield.

Reference should be made to the work in India of Dhar and collaborators who claim that additions of carbonaceous material to tropical soils are accompanied by active nitrogen fixation, particularly in the presence of light. These claims, however, have not been confirmed by other workers.

One of the most important functions of organic matter in tropical soils from the agricultural point of view is to create a structure resistant to erosion. Organic manures do not appear to be such efficient structure-formers in tropical as in temperate climates. Evidence is accumulating, however, that the desired effect on soil structure can be obtained under certain conditions by the growth of a perennial-grass crop for a period of years. Not only does the grass crop provide organic matter, but the roots have a direct mechanical structure-forming effect. In Uganda a 'resting period' of 2–3 years under elephant grass (*Pennisetum purpureum*) is becoming a recognized feature of a fertility-conserving agricultural rotation. The following is taken from the Uganda Department of Agriculture Report for 1942:

'Water-stable crumbs exceeding ½ mm. size were found to be an efficient indication of soil structure and consequent inherent fertility. The Tiulin technique was applied to a number of fertility experiments, and it was found that farm-yard manure merely feeds the crop and has no effect in reforming the structure of the soil. In the experiments where resting periods are included it was found that resting under grass regenerates the fertility of the soil by building up the crumb structure to a high level before cropping. It was possible to construct a tentative empirical scale showing the relation between the percentage over ½ mm. and the fertility level of the soil. In Buganda, red loam soils which had rested under elephant grass attained about 60 per cent. of these crumbs; in the short grass areas well-rested silt loam soils attained about 40 per cent. These percentages declined steadily with cultivation, falling as low as 30 per cent. after continuous cultivation in both areas and 20 per cent. if the destructive process is assisted by erosion. These results provide for the first time proof that, under local conditions, the resting period under grass does regenerate the structure of the soil and that manure does not, thus supporting the earlier field observations which led to the adoption of the grass resting period in 1934.'

There is evidence that grasses differ widely in their effect on soil structure. *Pennisatum purpureum*, *Paspalum notatum*, and some *Brachiarias* have a marked effect on structure formation and porosity in two years. *Rynchelytrum repens* and *Chloris gayana* are comparatively ineffective (19).

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APPENDIX II

Outline of Itinerary

Oct. 23rd, 1943. Arrived by air at Cairo.

Oct. 24th–Nov. 18th. *In Egypt.* Toured Delta region; drainage schemes at Fisha, experiment stations at Gemusa and Sakha, reclamation work at Kafr Saad, ginning factories at Mahalla Kubra. Visited laboratories of Cotton Research Board, Technical Sections, Ministry of Agriculture, Agricultural Museum. Discussions with the Minister of State, officials of Ministry of State, M.E.S.C., British Embassy and British Council, the Under Secretary, Ministry of Agriculture, and officers of the Ministry.

Nov. 19th. By air to Palestine.

Nov. 19th–Dec. 12th. *In Palestine.* Toured dry-farming areas, around Gaza and Beersheba, citrus area, north Palestine, Hula and Jordan areas, Jewish agricultural settlements. Visited Experiment Stations at Acre, Ain el Arrub, El Majdal, Rehovot, Mikveh Israel, Veterinary Laboratory, fish-ponds, afforestation, Palestine Potash Company factory. Inspected Arab College, Jerusalem; urban and village schools and school gardens; Deir Amir Farm School (Waqf); Haifa Technical Institute; Hebrew University. Discussions with the High Commissioner, officers of Government Departments, War Supply Board, Scientific Advisory Council, British Council, Jewish Agency and scientific and educational organizations, and U.S.A. Consul-General.

Dec. 12th. By car to Transjordan.

Dec. 12th–15th. *In Transjordan.* Toured northern Transjordan, and dry-farming area south of Amman. Visited agricultural stations and tree nurseries at Teneib, Jerash, and Reseifi, forest reserve, Reseifi rock phosphate quarry. Discussions with British Resident and the Superintendent, Minister of Finance and Justice, Director of Lands and Surveys, Director of Agriculture.

Dec. 15th. By car to Palestine.

Dec. 15th–19th. *In Palestine.* Continuation of discussions with staffs of Agricultural Department and Hebrew University.

Dec. 20th. By air to Cyprus.

Dec. 20th, 1943–Jan. 4th, 1944. *In Cyprus.* Toured central Mesaoria plain, vine, fruit, olive, and forest areas of northern and southern ranges, and coastal areas. Inspected Experiment Stations at Morphu, Athallassa, Saitta, Trikoukkia, Stavros, Larnaca; Akrotiri marsh reclamation, Xylotymbon minor State Forest; erosion in Mesaoria plain, numerous water and irrigation improvements, olive-oil factories, Schisa gum factory (carobs); Teachers' Training College and Rural Central School at Morphu, school gardens; welfare and educational work of Cyprus copper-mines, Near East Foundation and Government Rural Development Schemes. Discussions with the Governor, officers of Departments, Land Utilization Committee.

1944.

Jan. 5th. By air to Palestine.

Jan. 5th–17th. *In Palestine.* Inspected Sieff Institute, Rehovat, the Kadoorie agricultural schools at Tulkarm (Arab) and Mt. Tabor (Jew); supplementary visits to Hebrew University, Rehovat, Mikveh Israel, &c. and completion of discussions with Government officers, Scientific Advisory Council, and Development Commissioner.

Jan. 18th. By air to Egypt.

Jan. 18th–Feb. 6th. *In Egypt.* Toured Upper Egypt; Aswan dam, Nag Hammadi barrage, basin and perennial irrigation, farms at El Minya, and in Delta. Visited Agricultural Institute at Shibin el Kom, Ministry of Agriculture arboretum on Kings Island, Trade School at Aswan, Cairo University, Ministries of Education and Public Works. Discussions with officials of Ministry of Education, Public Works, I.C.I.

Feb. 7th–13th. Conference on Middle East Agricultural Development. Meetings on seed supply and economic conditions in the Middle East.

Feb. 14th. By air to the Sudan.

Feb. 14th–27th. *In the Sudan.* Toured Gezira area; Sudan Plantations Syndicate, Alternative Livelihood schemes at Abd el Majid, Um Garr, Fetisa; education schemes at Bakht er Ruda; markets at Ed Dueim; water-holes in Jebel Biyut area; camphor, cotton-seed oil and charcoal production, harig cultivation, Jebel Aulia and Sennar dams, agricultural research stations at Wad Medani, Turabi, and Shambat. Visited School of Science and Medical School, Khartoum, Shambat Agricultural School. Discussions with the Governor-General, heads and officers of Government Departments, Sudan Plantations Syndicate, and Empire Cotton Growing Corporation officers.

Feb. 28th. By air to Eritrea.

Feb. 28th–29th. *In Eritrea.* Discussions with Chief Administrator, British Military Administration, heads and officers of Departments. Inspected milk and animal development work, Farmers' Association farms, entomological and locust work.

Mar. 1st–3rd. By road from Asmara (Eritrea) to Addis Ababa (Ethiopia).

Mar. 4th–15th. *In Ethiopia.* Tours to Hollata, ex-Italian settlement, and Biscoftu. Visited Veterinary Laboratory, flour and macaroni mill, sacking factory, labour

camp, British Council, and American Presbyterian Mission. Discussions with the Emperor, British and American Ministers and staffs, British Advisers, Minister of Commerce, Labour Adviser, and M.E.S.C. representatives.

Mar. 16th. By air to Asmara, Eritrea.

Mar. 17th. By air to Egypt.

Mar. 18th–30th. *In Egypt.* Discussion with Minister Resident. Working on Report at M.E.S.C. offices.

Mar. 31st. By air to Iraq.

Apr. 1st–12th. *In Iraq.* Tour of northern Iraq; Kirkuk, experiment farm, Howeya irrigation scheme, Erbil, Shaqlawa fruit industry, Mosul, tree and fruit nursery, technical, urban, and domestic economy schools. Tour of date-groves, Shatt el Arab, Basra. Inspected Abu Guraib and Zafaranyieh experiment stations and agricultural school, Rural Normal School, Rural Teachers' Training College, Rustamie. British Council Institute. Discussions with British Ambassador, and Embassy staff, Political Advisers, Public Relations Officer, British Council Officers, Ministers of Education, Interior, and British Advisers, Director-General of Irrigation, Director-General of Agriculture and staffs, Chief Veterinary Officer, M.E.S.C. representatives, Manager of Latifiyah Estates, President of Date Association, officers of Andrew Weir & Company and Africa & Eastern Company.

Apr. 12th–14th. By road from Basra to Ahwaz; by rail from Ahwaz to Teheran.

Apr. 14th–24th. *In Persia.* Tour of north Persia; mountains, foot-hills, rice, and tea. Tours in Teheran area; Jaji Rud and Rud-i-Hind valley areas, estates and farms near Shahr-i-yor, dairy farm, qanats. Visits to University, Veterinary College, Karaj Experiment Station and Agricultural College, Haidarabad Animal Breeding and Husbandry Station, Hasanabad Serum Institute, Technological Institute, Teachers' Training College, secondary, elementary and village schools, British Council Institute. Discussions with British Ambassador and staffs of Embassy, British Council, and M.E.S.C., Head of the American Advisory Mission, Ministers and staffs of Education, Agriculture and Health Ministries, Chancellor and staff of the University.

Apr. 25th. By air to Syria and the Lebanon.

Apr. 25th-May 2nd. *In Syria and the Lebanon.* Tour—Damascus, Homs, Hama Aleppo, Latakia, Beirut; terracing in Lebanon mountains, Bekaa valley, Amik marsh, irrigation, strip farming, olive-groves. Visits to American University and Institute of Rural Life, town refuse factory, agricultural experiment stations, tractor and implement depot, tobacco and nicotine factory. Discussions with officers of Spears Mission, American University, Director of Agriculture for Lebanon.

May 3rd. By road to Jerusalem.

May 4th–5th. Discussions on the re-organization of the Scientific Advisory Council.

May 5th. By road to Cairo.

May 6th–13th. *In Egypt.* Working on Report at M.E.S.C. offices.

May 14th–16th. By air to England.

May 17th–Oct. 22nd. *In England,* for discussions, and completing draft Report.

Oct. 25th. Returned by air to Cairo.

Oct. 26th–31st. *In Egypt.* Discussions of draft Report.

Nov. 1st. By air to Cyrenaica.

Nov. 1st–8th. *In Cyrenaica.* Tour from Barce, across Jebel to Derna, Alba, Barce; Italian settlements, Einmara pumping-scheme, Alba port and Arab farm settlement, Hill farms scheme for Arabs; Barce plain wheat scheme and settlements,

Italian concession estates, Experiment Station at Fuchat, near Benghazi; Rural School at Barce. Discussions with Chief Administrator of B.M.A., and members of agricultural and education staffs.

Nov. 9th. By air to Tripolitania.

Nov. 9th–17th. *In Tripolitania.* Tour west and east of Tripoli, and into Jebel; Italian and Arab settlements, concession estates, wine factory, tobacco factory, flour-mill, and oil presses; date-groves and settled Arab farming; Sidi Mesri Experiment Station, and sub-stations at Sghedeida, Zhariet el Mahgiub, Tahuna. Discussions with Chief Administrator of B.M.A. and members of agricultural and education staffs.

Nov. 18th. By air to Cairo.

Nov. 19th–23rd. *In Egypt.* Working on Report. Discussion on future of Barce plain wheat scheme.

Nov. 24th. By air to the Sudan.

Nov. 24th–Dec. 4th. *In the Sudan.* Tour to Wad Medani, and Kassala; Gash Board scheme, further inspection of experiments at Wad Medani and Sudan Plantations Syndicate, and discussions with Government officers.

Dec. 5th. By road to Eritrea, inspecting Tessenai irrigation area.

Dec. 6th. By air to Aden.

Dec. 6th–14th. *In Aden Protectorate.* Tours to Dhala area, Abyan area, Hadhramaut; flood irrigation, dry farming, land settlement, dam construction, and erosion control, famine relief. Discussions with Governor, Director of Agriculture, and staffs.

Dec. 14th–15th. By air to Cairo.

Dec. 15th–19th. Discussions in Cairo.

Dec. 19th. By rail to Palestine.

Dec. 20th–24th. Discussions in Palestine.

Dec. 25th. By rail to Cairo.

Dec. 26th, 1944–Jan. 1st, 1945. Discussions in Cairo.

1945.

Jan. 2nd. By air to Syria and the Lebanon.

Jan. 2nd–8th. *In Syria and the Lebanon.* Tour of north-east Syria; Dir ez Zor, Hassetche, Qamichlye, the 'Ducks Bill'; communal strip farming. Visited farmers' co-operative society near Beirut.

Jan. 8th. By air to Cyprus.

Jan. 8th–12th. *In Cyprus.* Visit to Famugusta, Gastria, and Kyrenia areas. Discussions with Development Commissioner, and Registrar of Co-operative Societies.

Jan. 12th. By air to Cairo.

Jan. 13th–20th. Completion of discussions in Cairo.

Jan. 21st. Returned by air to England.

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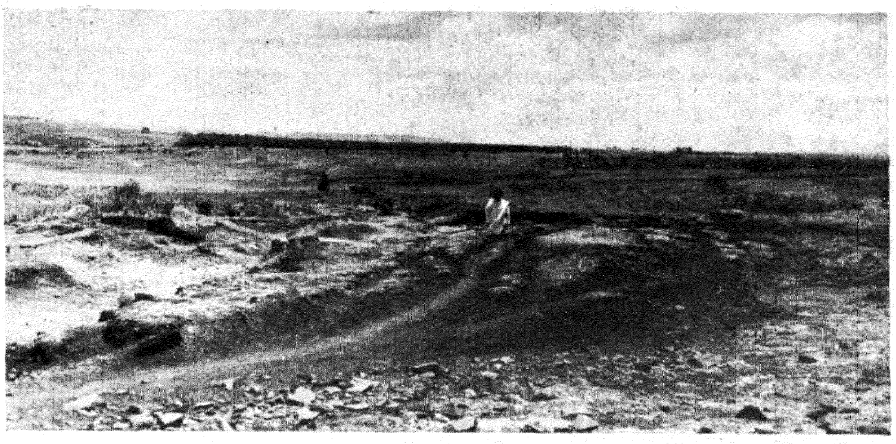


PLATE 1*a*. Beginning of erosion along human and animal tracks, between Addis Ababa and Hollata, Ethiopia.

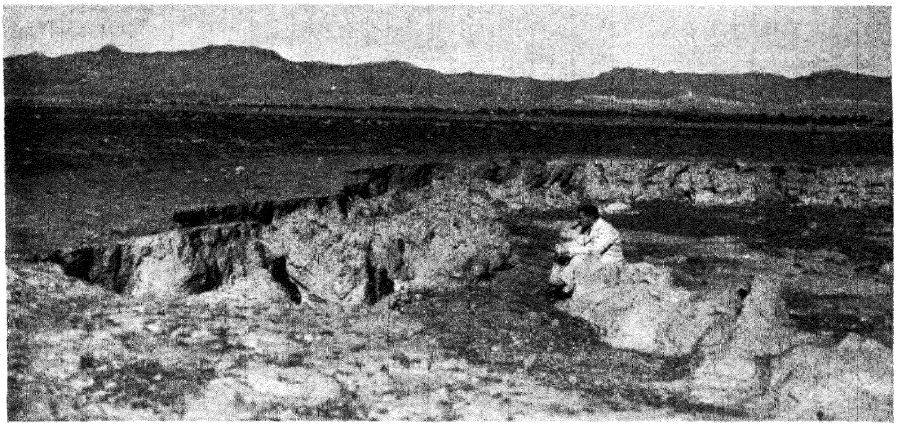


PLATE 1*b*. Gully erosion near Palekythro, Mesaoria plain, Cyprus.

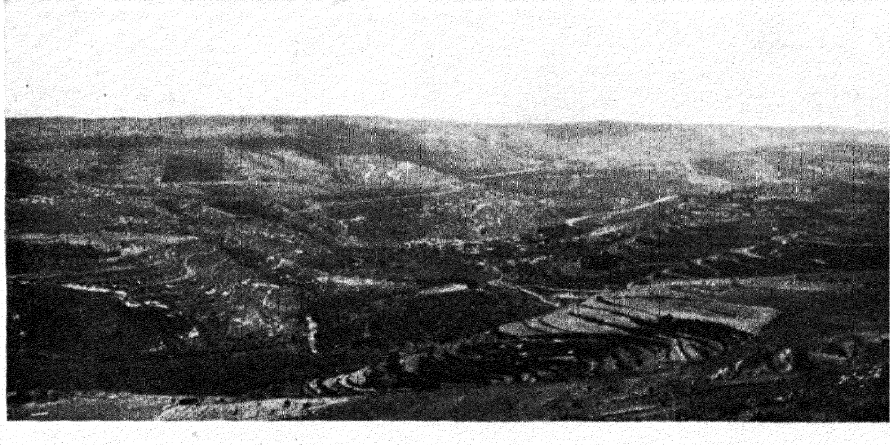
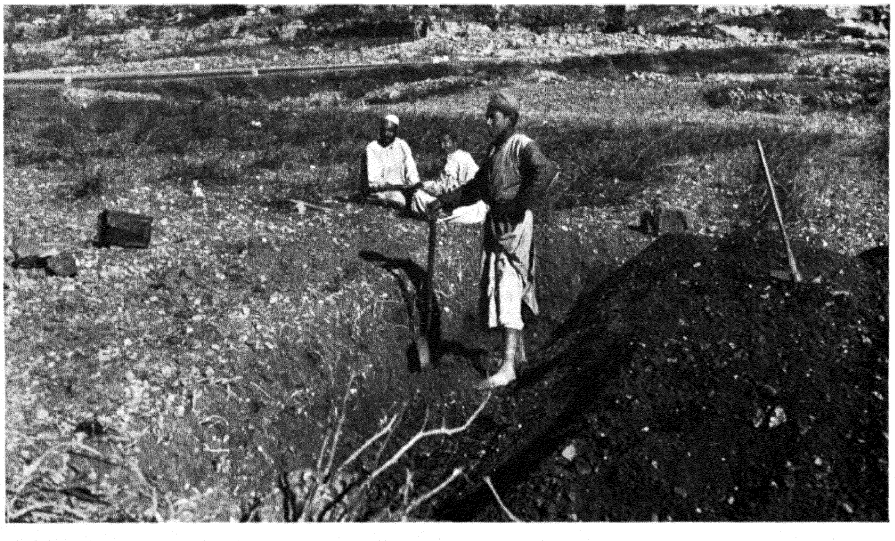


PLATE 1*c*. Efficient valley terracing near Zefta, 8 miles south of Sidon, the Lebanon.

PLATE 2*a*. Hand forking in lieu of ploughing. Large clods are broken off and inverted. Near Addis Ababa, Ethiopia.

PLATE 2*b*. Hand-digging one metre deep, for tomatoes. Top soil and surface soil are mixed, and goat manure incorporated. Tomatoes are grown for 3–4 years without irrigation. Near Bethlehem, Palestine.



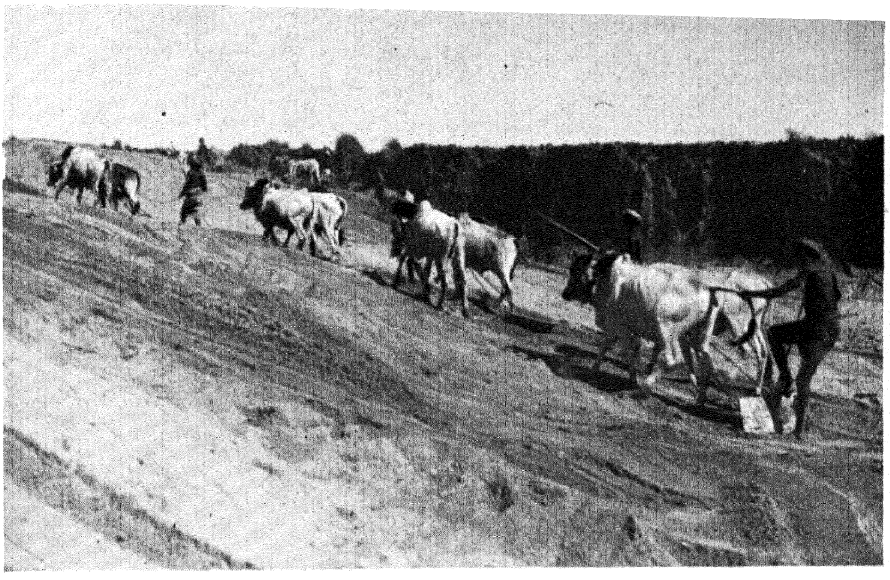


PLATE 3*a*. Building an earth dam for flood irrigation across the Wadi Bana, at Al Küd, Abyan area, Aden Protectorate. The driver of the rear team is bringing the scraping-board into operation with his foot.

PLATE 3*b*. The dam at Al Jol, Abyan area, Aden Protectorate. It is the head dam, and the largest, of the lower Abyan system of deflectors. It has been breached just beyond the group of figures, and the surplus water has run to the next lower dam. Notice the sorghum crop on the right.

PLATE 4*a*. Cotton (N.T.2) 3 months after sowing. Gash Delta, the Sudan

PLATE 4*b*. Deep ploughing (25–35 cm.) gives a crop of dura on land infested with sedge-grass. Right: deep tractor-ploughed area. Foreground and left: normal shallow ploughing. Ali Giddu, near Tessenei, Eritrea.

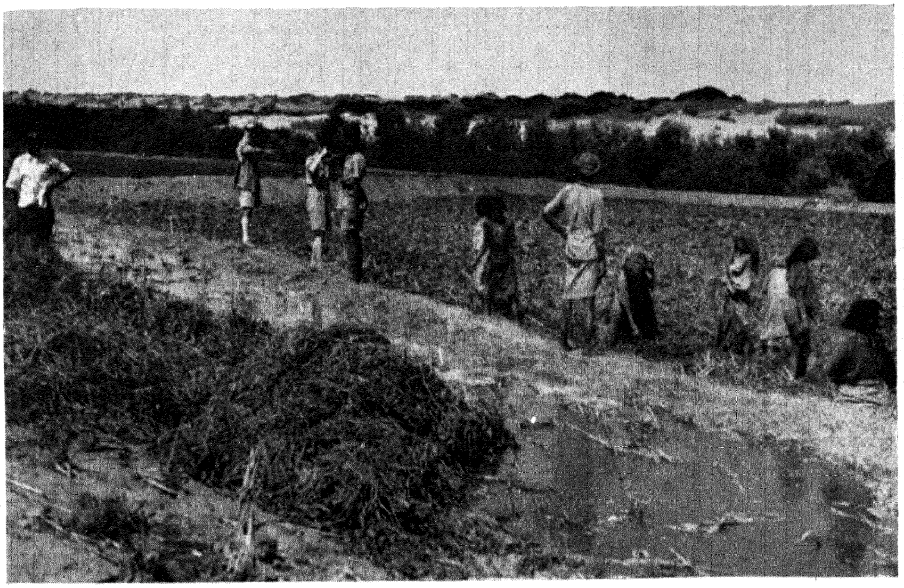


PLATE 5*a*. The heap of sweet potato 'vines' (left foreground) is being planted out in irrigated land. Near Lahej, Aden Protectorate.

PLATE 5*b*. Cultivating grape vines. The vines are grown on the sides of broad deep trenches. Alard, near Tehran, Persia.

PLATE 6*a*. Experiments on the manurial requirements of orange trees. Each tree is grown in a large cylinder with arrangements for collecting the drainage water for analysis. Mikveh Israel Agricultural School, Palestine.

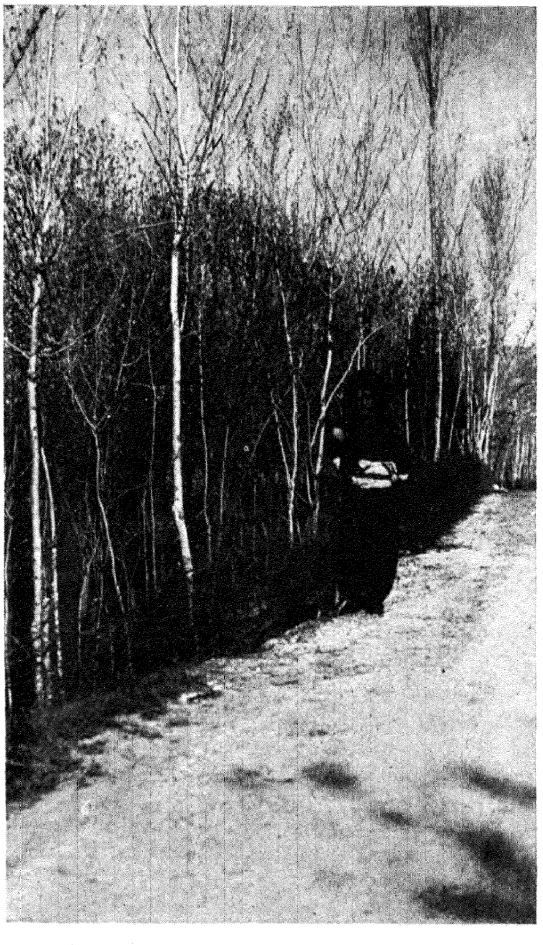
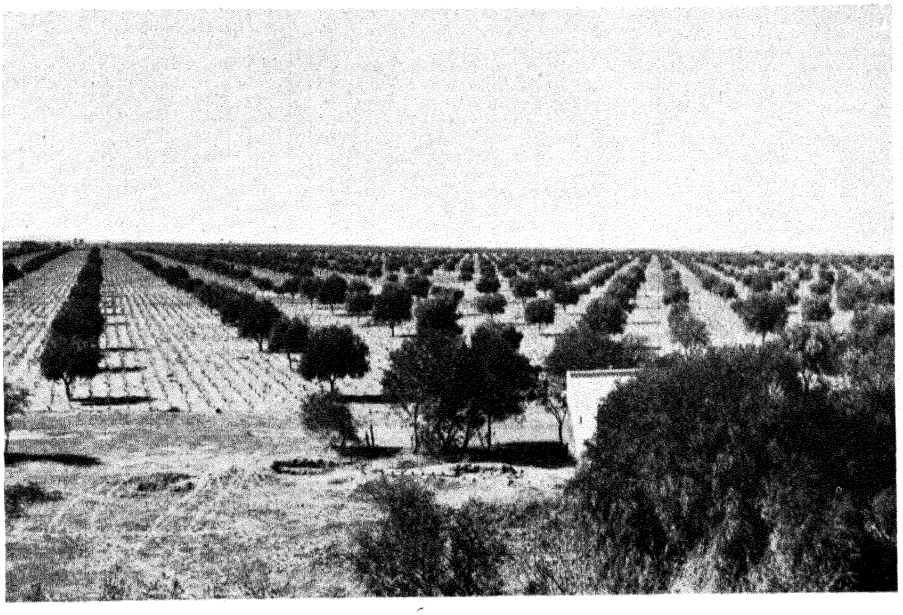
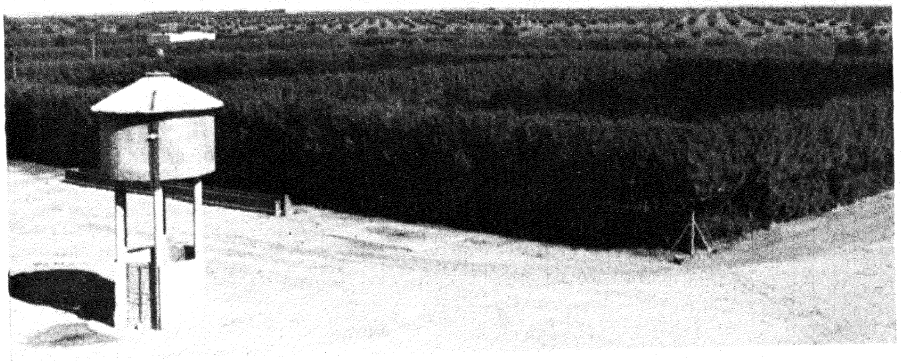


PLATE 6*b*. An apple plantation bordered by poplars in the fruit and timber area. The industry is run on primitive lines, to supply the local market. Shaqlowah valley, near Erbil, Iraq.



a. Olives interplanted with vines.



b. Citrus blocks surrounded by tamarisk wind-breaks.

PLATE 7. Two views of the Calo concession, Gaar Chiar, between Tripoli and Homs, Tripolitania.

a. Lucerne, end of first season's grazing.

b. Dominant stand of Rhodes grass, typical of third year.

PLATE 8. The 'dynamic' pasture experiments at Acre Experiment Station, Palestine. (Chapter IV, *j*.)

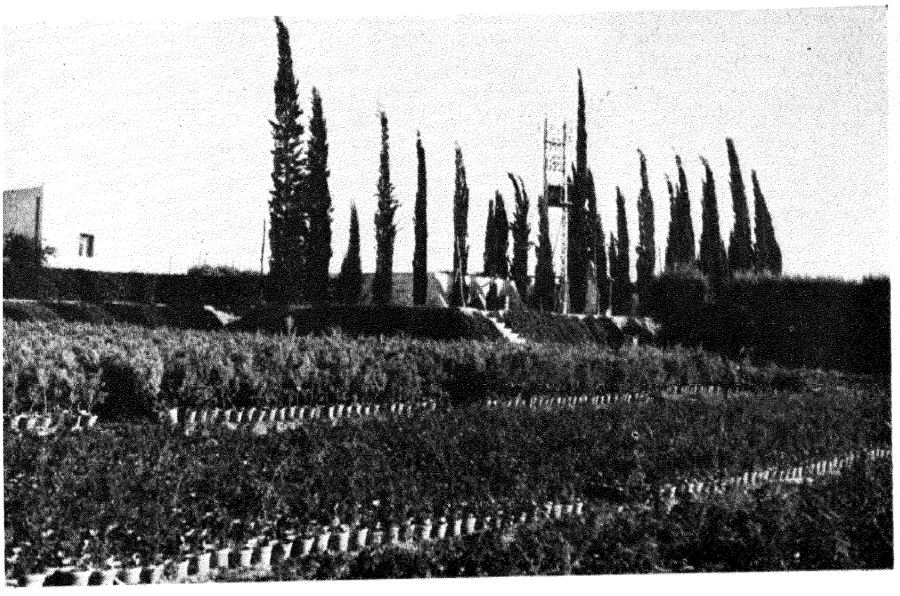


PLATE 9*a*. The Sghedeida Forest Nursery, near Tripoli, Tripolitania. Several Middle East territories have nursery stations for raising and distributing seedling forest and fruit trees, bushes, vegetables.

PLATE 9*b*. Wheat variety trials, Abu Gurieb Experiment Station, Iraq. Note the level crop and the absence of any border or edge-row effect.

PLATE 10*a*. Threshing rice by machinery. Gemusa Experiment Station, Egypt.

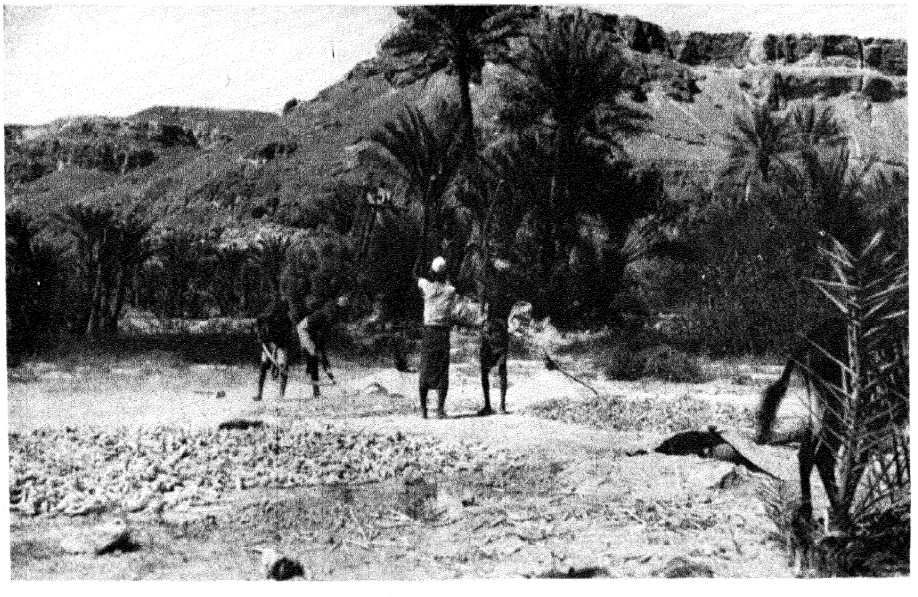


PLATE 10*b*. Threshing millet with sticks, in Wadi Thibi, Hadhramaut, Aden Protectorate.

PLATE 11*a*. Beginning a garden for a small village school, Beituniya, near Ramallah, Palestine.

PLATE 11*b*. A developed school-garden, Beit-Dajan, near Jaffa, Palestine.

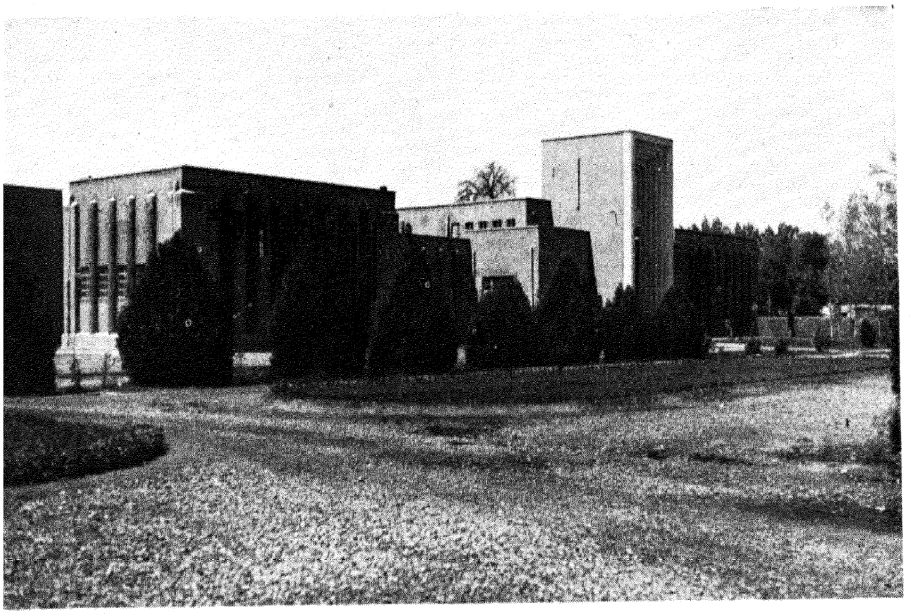


PLATE 12*a*. Part of the Agricultural College, Karaj, Persia.

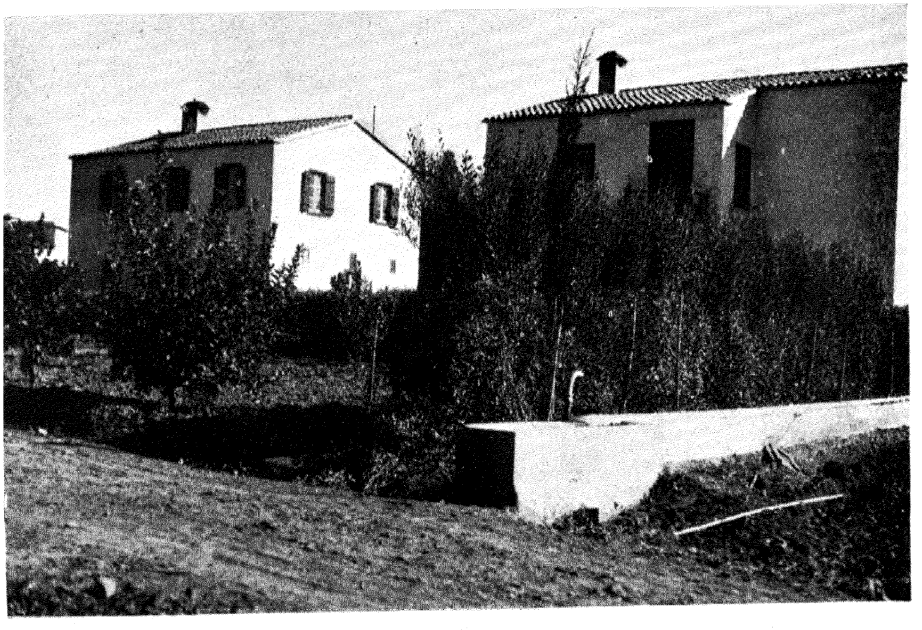


PLATE 12*b*. Two of the simple hostels, Rural Central School, Morphu, Cyprus

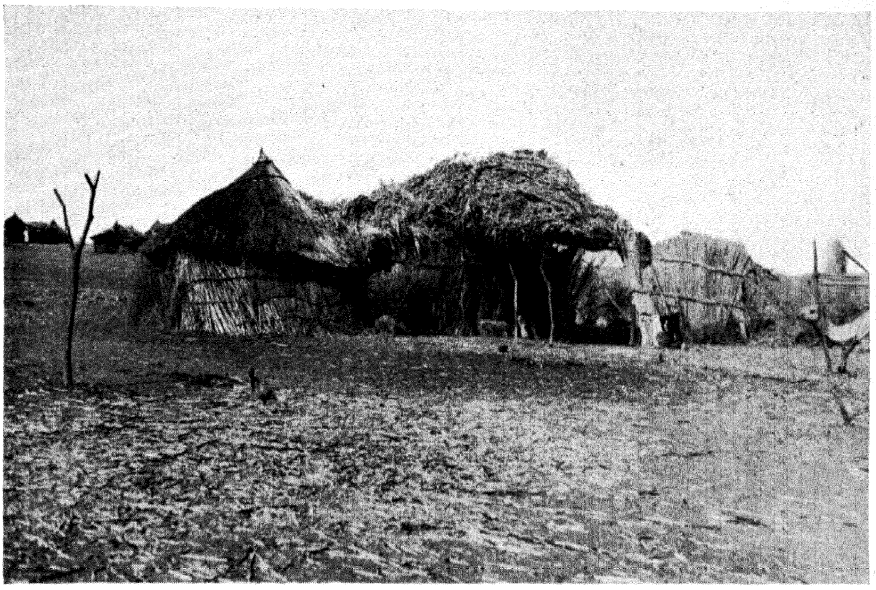


PLATE 13*a*. Grass huts of semi-nomads, near Esh Shawal, White Nile, the Sudan.

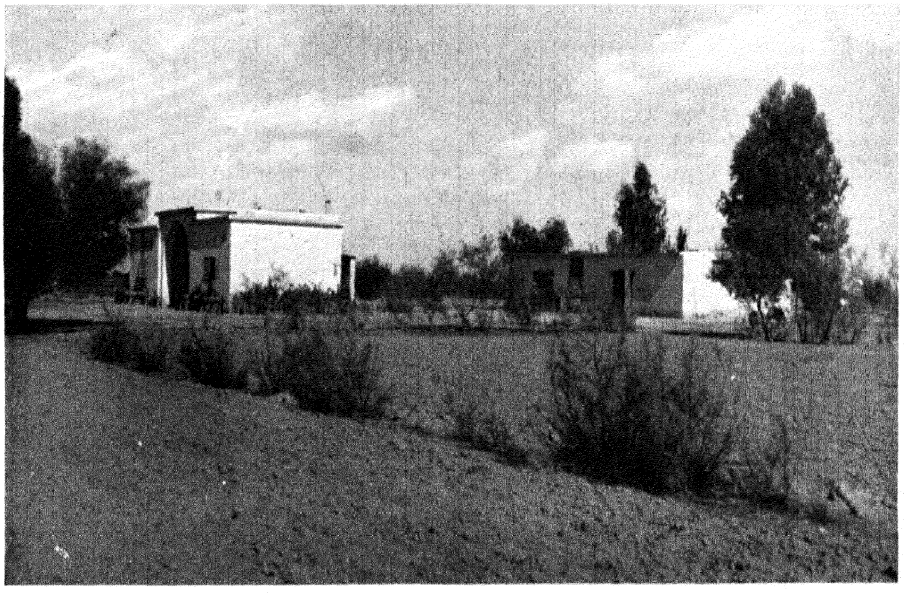


PLATE 13*b*. Settler's house and farm buildings. Crispi Settlement, Tripolitania

PLATE 14*a*. Block plan of typical 'strip' holdings. Ramle sub-district, Palestine. (*Reproduced by permission of the Government of Palestine.*)

PLATE 14*b*. Block plan of typical 'fragmented' holdings. (Dashed lines represent crude retaining walls to combat flood-water erosion of the soil.) Kalo Khoria, near Morphu, Cyprus. (*Reproduced by permission of the Government of Cyprus.*)

PLATE 15*a*. The headquarters (church, post office, shops, hostel, meeting and administrative buildings) of an Italian 'demographic' settlement. D'Annunzio Settlement, Cyrenaica.

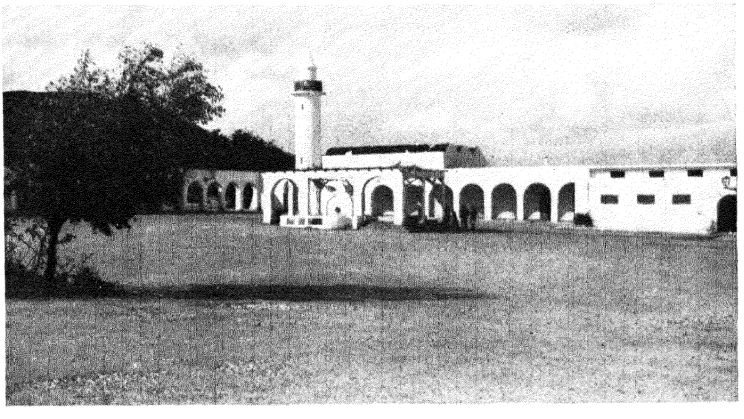


PLATE 15*b*. The headquarters of one of the two settlements erected by the Italians and designed for Arab occupation. Alba (el Fager), Cyrenaica.

PLATE 15*c*. Part of Beda Littoria settlement headquarters, Cyrenaica. The animals belonged to the former Italian settlers and are now loaned to the Arabs under the Hill Farms scheme (Chapter V, 1, d, Cyrenaica). They are brought regularly to the headquarters for inspection and advice.