CHEMICAL SECTION.

A study of the conditions under which the decline in the yield of Egyptian cotton had taken place led to the theory being put forward that the elimination of the *sharâqi* period from the Egyptian agricultural system was to a large extent responsible. A full account of the evidence in support of this theory has appeared in Bulletin No. 25 of the Ministry of Agriculture. The investigation of the conditions to which the soil is subjected during the *sharâqi* period has occupied the attention of the Chemical Section during the past year.

Two lines of investigation have been conducted: (1) a study of the soil temperatures during the *sharâqi* period; (2) a study of the partial sterilization of Egyptian soils from the point of view of the theory proposed by Russell and Hutchinson. As a full account of these investigations is in the press, only an outline of the work and the conclusions indicated will be given here.

Fig. X شكل ١٠

بيانات الترموجراف لحرارة سطح التربة . الأسبوع الذى آخره ١٦/٧/٢٢

Soil Thermograph. Surface soil. Week ending 16/7/22.

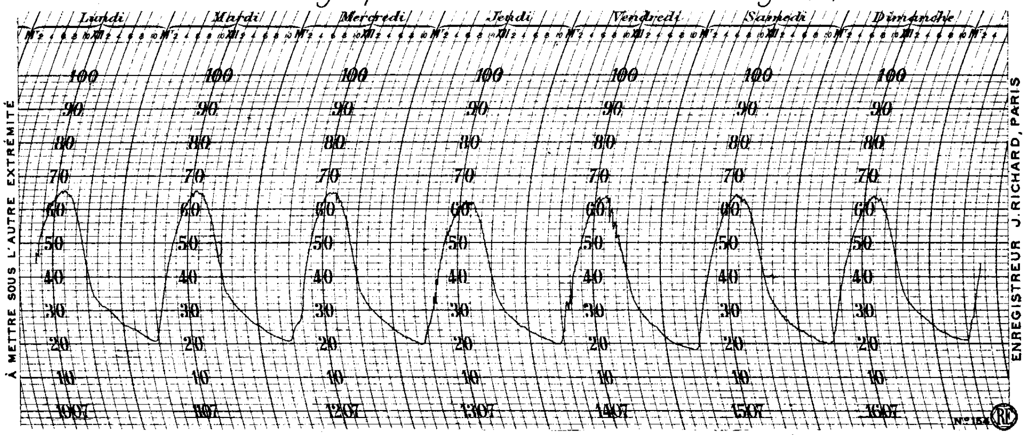


Fig. XI شكل ١١

بيانات الترموجراف لحرارة التربة على عمق ٥ سنتيمترات . الأسبوع الذى آخره ١٦/٧/٢٢

Soil Thermograph. 5 cms. depth. Week ending 16/7/22.

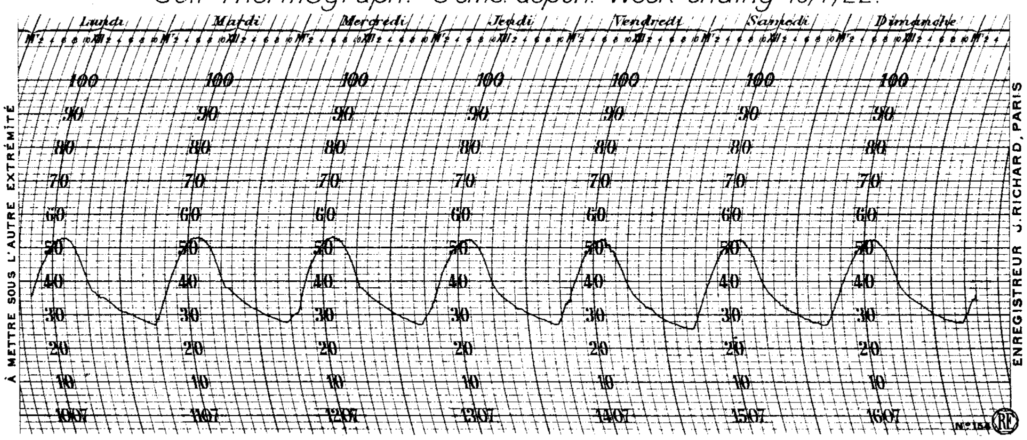
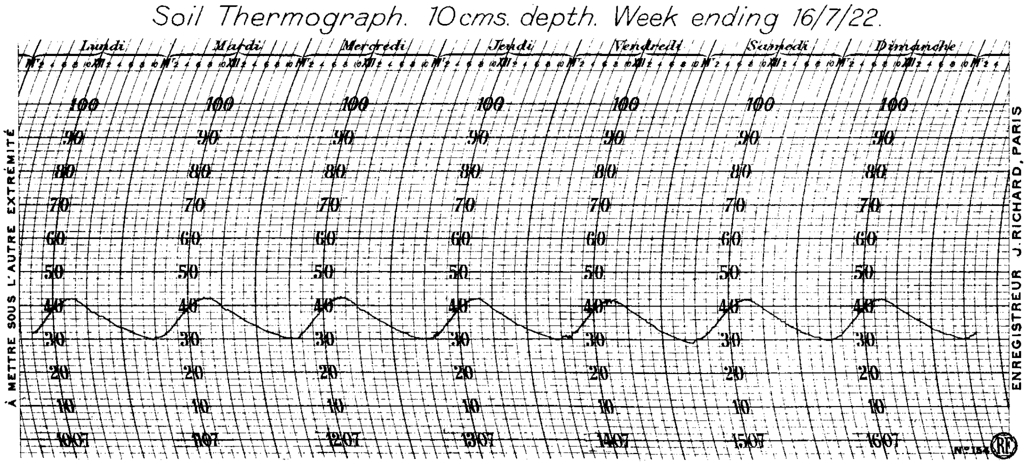


Fig. XII شكل ١٢

بيانات الترموجراف لحرارة التربة على عمق ١٠ سنتيمترات . الأسبوع الذى آخره ١٦/٧/٢٢

Soil Thermograph. 10 cms. depth. Week ending 16/7/22.



S. of E. 23/464

Fig. XIII شكل ١٣

بيانات الترموجراف لحرارة التربة على عمق ١٥ سنتيمترا . الأسبوع الذى آخره ٢٢/٧/١٦

Soil Thermograph. 15 cms. depth. Week ending 16/7/22.

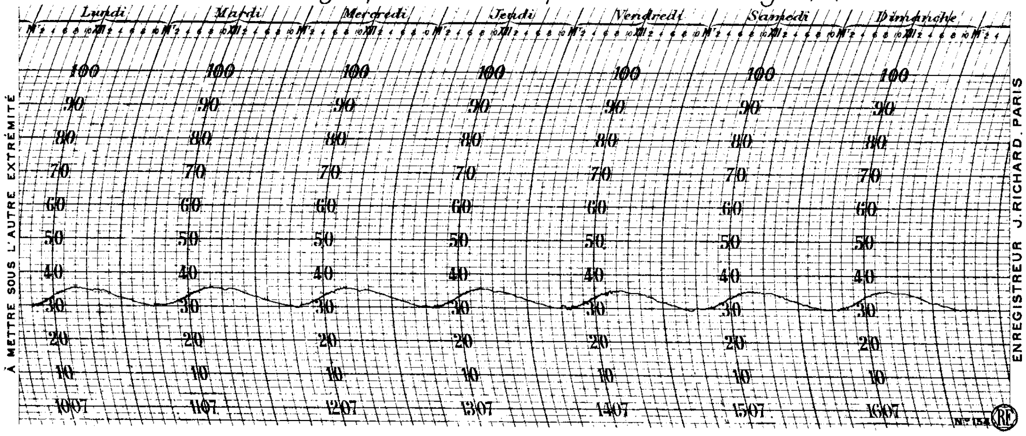


Fig. XIV شكل ١٤

بيانات الترموجراف لحرارة التربة على عمق ٢٠ سنتيمترا . الأسبوع الذى آخره ٢٢/٧/١٦

Soil Thermograph. 20 cms. depth. Week ending 16/7/22.

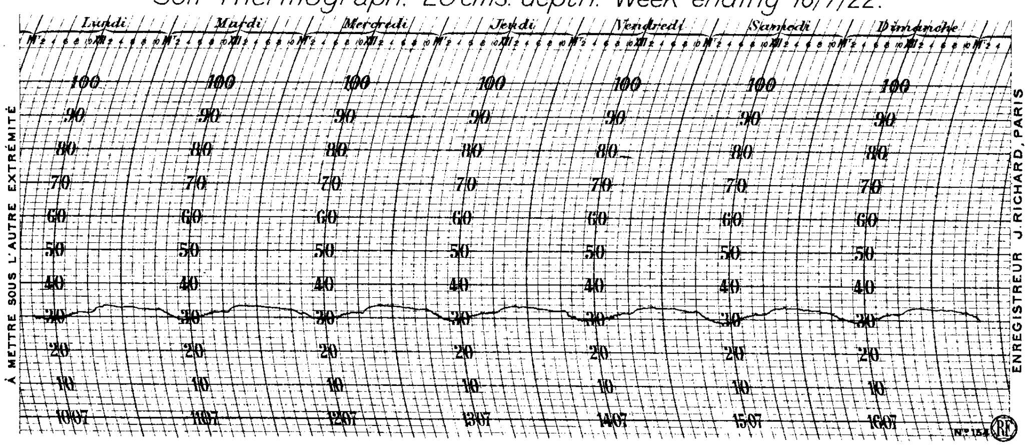
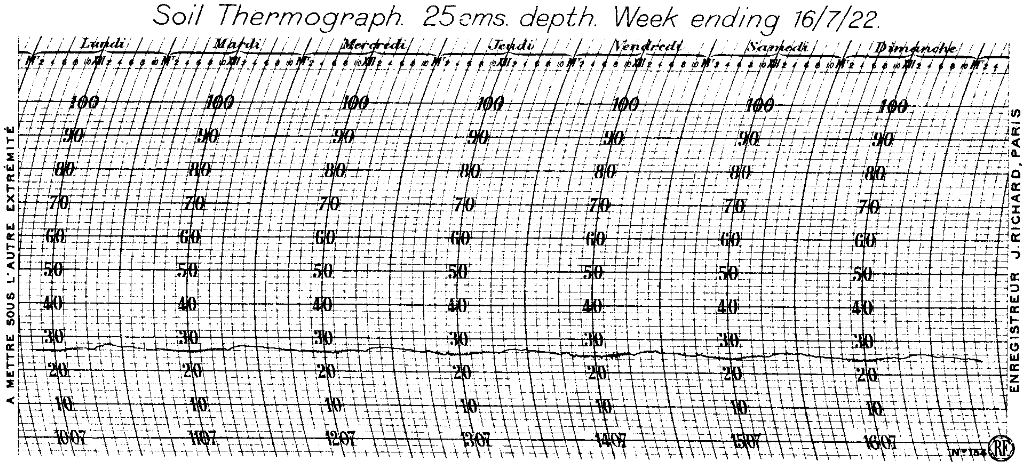


Fig. XV شكل ١٥

بيانات الترموجراف لحرارة التربة على عمق ٢٥ سنتيمترا . الأسبوع الذى آخره ٢٢/٧/١٦

Soil Thermograph. 25 cms. depth. Week ending 16/7/22.

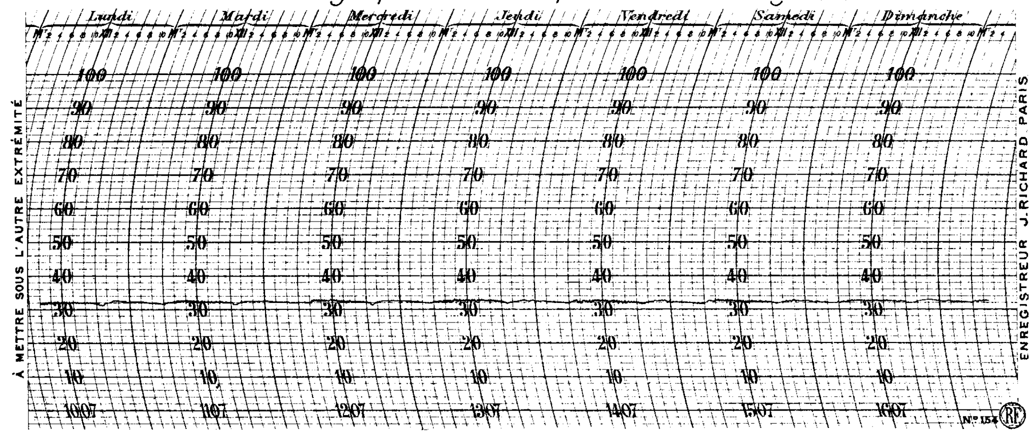


S. of E. 23/454'

Fig. XVI شكل ١٦

بيانات الترموجراف لحرارة التربة على عمق ٣٠ سنتيمترا. الأسبوع الذى آخره ١٦/٧/٢٢

Soil Thermograph. 30 cms. depth. Week ending 16/7/22.



S. of E. 23/454'

(1) THE SOIL TEMPERATURES DURING THE *SHARAQI* PERIOD.

Prior to this investigation, the records of soil temperatures in Egypt had been confined to isolated observations. These observations indicated that the temperature conditions of the *sharâqi* period were suitable for the partial sterilization of the soil. The present study was made with the object of determining whether partial sterilization of the soil could take place during the *sharâqi* period, and the extent to which the partial sterilization of the soil might be effected by the efficient use of the *sharâqi* conditions. The economic importance of the process of soil partial sterilization is seen from a study of the results obtained by Russell in England. If the process could be effected naturally in Egypt, the *sharâqi* period would be a considerable asset to the Egyptian agricultural system.

On a plot of *sharâqi* land at the Cotton Research Board Meteorological Station, a series of thermographs were installed. The thermographs were so constructed that the bulb, buried in the soil at the desired depth, communicated on the aneroid principle with the recording mechanism. The recording portions of the thermographs were enclosed in a screen, the wire gauze side of the screen facing approximately north, the direction from which the prevailing wind blows. The bulbs of the thermographs were buried at the following depths :—

Surface, 5, 10, 15, 20, 25, and 30 centimetres.

At each depth a mercury thermometer was also placed. The bulbs of the mercury thermometers were bent at right-angles to the stems and the stems so graduated that they could be read without removing the thermometers from the ground. The mercury thermometers were read every two hours during the day, at the beginning of the period, in order to check the thermograph readings. Later, it was found that less frequent readings of the mercury thermometers sufficed to correct the thermograph records. The thermographs were also checked for time.

The diameter of the thermograph bulb was 1 centimetre. The bulb was buried so that the long axis of the bulb lay at the desired depth. In the case of the surface thermograph, the bulb was placed horizontally in a groove in the soil so that the upper portion of the bulb was just below the original level of the soil surface. Soil was then packed into the groove so that the bulb was just covered. A typical series of soil thermographs is shown below, in Figures 10 to 16.

The following table summarizes the results obtained in the form of average monthly maxima :—

TABLE I.—SOIL TEMPERATURE DURING THE *SHARAQI* PERIOD.

(Average Monthly Maxima in °C.)

MONTH.	Average Monthly Maximum Temperatures.				
	Surface.	5 Centimetres.	10 Centimetres.	15 Centimetres.	20 Centimetres.
May	52·4	45·1	37·2	—	—
June	61·6	48·5	39·9	35·5	33·8
July	65·1	52·3	41·7	36·9	35·1
August	64·1	51·5	41·2	36·6	34·0

The above table indicates that, from the temperature point of view, the factor in the soil detrimental to plant growth will be completely suppressed to a depth of approximately five centimetres and temporarily suppressed in a further fifteen centimetres. With the object of obtaining more information on this point, the soil temperatures were treated from the point of view of the soil isotherms to which reference will be made later.

The maximum temperatures recorded at the various depths are shown in the following table :—

TABLE II.—MAXIMUM SOIL TEMPERATURES AT VARIOUS DEPTHS IN C°.

DEPTH.	TEMPERATURE.
Surface	68·5
5 centimetres	54·5
10 ,, ...	43·5
15 ,, ...	38·5
20 ,, ...	36·0
30 ,, ...	34·0

The soil surface temperature approximates to the temperature recorded by the black bulb thermometer, the maximum soil temperature on a clear day being about 2° C. below the maximum black bulb temperature. Down to a depth of ten centimetres the maximum soil temperatures are higher than the maximum air (screen) temperature. The maximum temperature at a depth of fifteen centimetres is slightly below the maximum air (screen) temperature.

The daily range of soil temperature at the surface exceeds considerably the corresponding air (screen) range. The maximum daily range of temperature observed is shown in the following table :—

TABLE III.—MAXIMUM DAILY RANGE OF TEMPERATURE IN °C.

DEPTH.	RANGE OF TEMPERATURE.
Surface	44·5
5 centimetres	26·0
10 ,, ...	12·5
15 ,, ...	7·0
20 ,, ...	4·0
30 ,, ...	1·5

The value of the *sharâqi* period, from the point of view of the partial sterilization of the soil, depends on two factors :—

(1) The actual soil temperatures attained at various depths.

(2) The length of time during which the soil at any depth is maintained at a given temperature.

It has already been stated that the temperature of the soil is high enough to cause complete suppression of the detrimental factor to a depth of five centimetres and a temporary suppression in a further fifteen centimetres. The length of time during which various layers of the soil are maintained above 55° C. and 35° C. during the months of May, June, July, and August is shown in the following table :—

TABLE IV.—NUMBER OF HOURS DURING WHICH THE SOIL IS MAINTAINED ABOVE 55° C. AND 35° C.

SOIL DEPTH.	Number of Hours above 55° C.	Number of Hours above 35° C.
Surface	476	1,200
5 centimetres ...	Few	1,150
10 ,, ...	Nil.	1,100
15 ,, ...	,,	700
20 ,, ...	,,	140
30 ,, ...	,,	Nil.

It will be seen from the above table that the complete suppression of the factor will be secured to a depth of five centimetres. It will be further noted that the number of hours during which the soil at a depth of twenty centimetres is maintained at a temperature of 35° C. is small, and, hence, it is improbable that any temporary suppression takes place at this depth. The soil at a depth of fifteen centimetres is maintained at 35° C. for a period of 700 hours, a period sufficiently long to produce temporary suppressionl It appears probable that the temporary suppression of the detrimenta. factor is secured to a depth of between fifteen and twenty centimetres from the surface of the soil. The soil isotherms show that the conditions of temporary suppression are fulfilled to a depth of eighteen centimetres.

The probable result of the *sharâqi* effect upon the soil, if the *sharâqi* period lasts until August 21, is a complete suppression of the detrimental factor to a depth of five centimetres and a temporary suppression in a further thirteen centimetres.

In order to obtain information regarding the relative value of the individual months of the *sharâqi* period, the soil isotherms were drawn. A typical series of soil isotherms is shown in Figure 17. The area enclosed by the curve of the 55° C. isotherm represents the value of the period as a period of complete suppression of the detrimental factor. The area enclosed by the 35° C. isotherm represents the value of the period as a period of temporary suppression. From the summation of the value of the days, the value of the months is obtained. By this method the months may be arranged in the order of their value as periods of partial sterilization. This order is shown below.

(1) July.
(2) August.
(3) June.
(4) May.

A detailed study of the results obtained shows that August is very little inferior to July in value, and that after August 21 the value of the days rapidly decline. Complete suppression of the detrimental factor becomes only just possible in June, the value of June being considerably below that of both July and August.

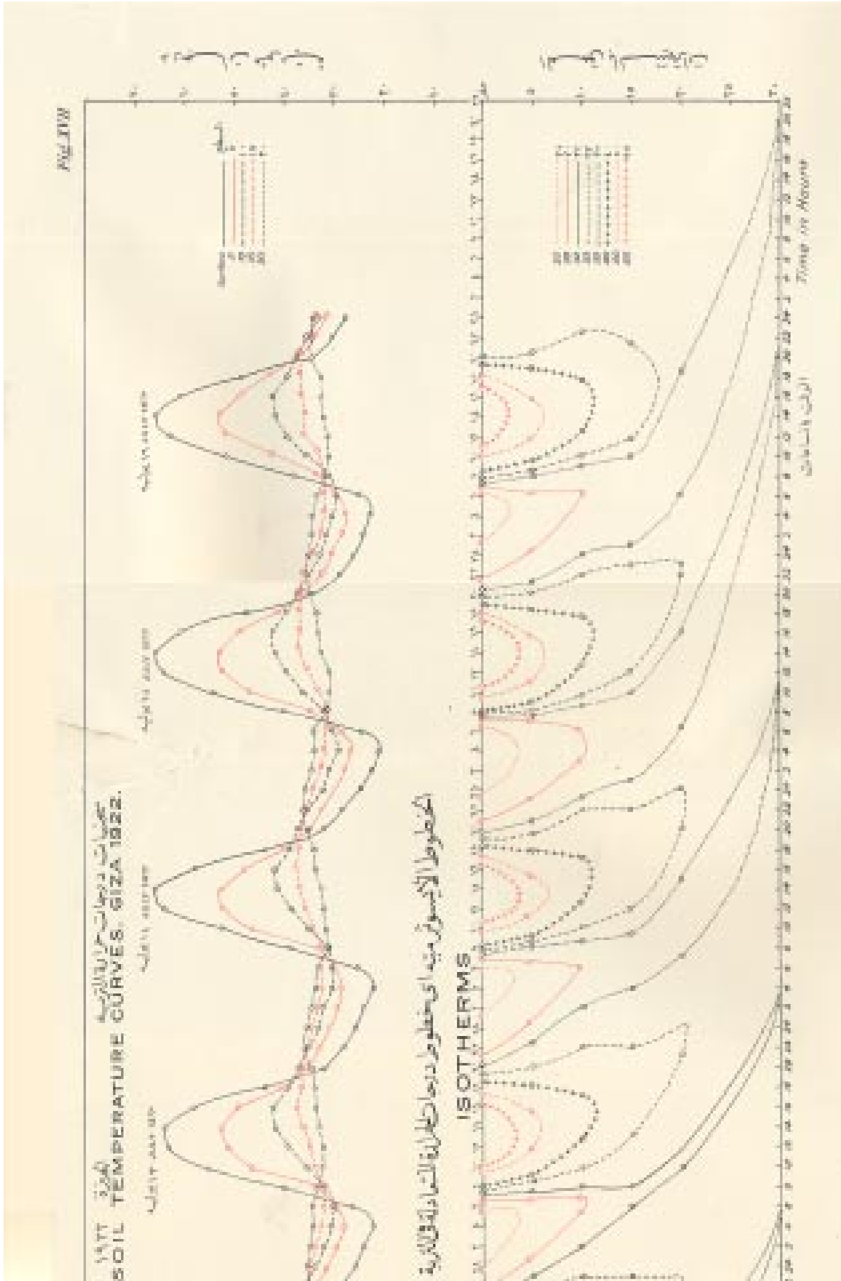
The *sharâqi* effect with regard to crop production may be studied from two points of view :—

(1) The area of the land that is *sharâqi*.
(2) The length of time that the land is subjected to the *sharâqi* effect.

(1) The area of land that is *sharâqi* each year has already been dealt with. It was shown* that the Mudîrîyas in which a reduction of soil fertility had probably taken place, due to the reduction of the *sharâqi* area below the economic limit, were Gharbîya and Daqahlîya. In the remaining Mudîrîyas of Lower Egypt, it was shown that fifty per cent or over of the land was subjected to the *sharâqi* effect and that, therefore, no decline in

---

* Bulletin No 25. Ministry of Agriculture.



Foldout reduced to 70 % and rotated 53° to fit on page.

the fertility of the soil in these Mudîrîyas could be attributed to the reduction in the *sharâqi* area.

(2) Attention has already been called to the fact that the length of the *sharâqi* period has been seriously curtailed owing to the fact that maize is now sown in July instead of at the end of August, as was formerly the practice.* At the time when attention was called to this fact, it was impossible to evaluate the *sharâqi* effect of the period July 25 to August 31. From the temperature records now available, the importance of this period as regards partial sterilization of the soil is seen. It appears, therefore, that the curtailing of the *sharâqi* period by this early sowing of maize eliminates a considerable portion of the *sharâqi* effect which is of great value to the process of soil recuperation. The importance of this factor is indicated in the following table :—

TABLE V.—AVERAGE PERCENTAGE OF CULTIVATED LAND UNDER MAIZE IN THE MUDIRIYAS OF LOWER EGYPT, 1989–1913.

Mudirîya.	Percentage Cultivated Land under Maize.
Gharbîya	28·9
Daqahlîya	27·2
Beheira	26·6
Sharqîya	44·9
Qalyûbîya	52·1
Minûfîya	61·2

From the above table it will be seen that the curtailment of the *sharâqi* period is not of the same magnitude in all the mudîrîyas. The greatest percentage area under maize is situated in the Mudîrîyas of Minûfîya and Qalyûbîya and, hence, the greatest effect from the curtailment of the length of the *sharâqi* period will be felt in these mudîrîyas. This may account for the decline in the yield of cotton experienced in the Mudîrîyas of Minûfîya and Qalyûbîya.

The Mudîrîya of Sharqîya is next in importance as regards the percentage of cultivated land under maize. The *sêfi* cultivation remains in the neighbourhood of fifty per cent of the total cultivated land in Sharqîya, so that the principal factor affecting the soil fertility in this mudîrîya will be the curtailment of the length of the *sharâqi* period.

The Mudîrîyas of Gharbîya and Daqahlîya have each about thirty per cent of the cultivated land under maize. The curtailment of the *sharâqi* period by the early sowing of maize does not assume the same importance here as in the other mudîrîyas, though, when it is considered that the effect

* Bulletin No. 25 Ministry of Agriculture.

of this factor has to be added to the effect of the considerable reduction in the *sharâqi* area, it cannot be neglected.

From the point of view of the partial sterilization of the soil, the decline in soil fertility, as measured by crop-producing power, may be ascribed to three causes :—

(1) The reduction in the *sharâqi* area, probably most evident in Gharbîya and Daqahlîya.

(2) The curtailment of the length of the *sharâqi* period, probably most evident in Minûfîya, Qalyûbîya, and Sharqîya.

(3) A combination of (1) and (2), the greatest effect being felt in Gharbîya and Daqahlîya.

The records at Qurashîya are interesting from the point of view of the *sharâqi* period. Although they do not prove the positive proposition that the reduction in the *sharâqi* area causes a decline in yield of cotton, they furnish strong presumptive evidence as they show that, providing cotton is always sown on land that has been *sharâqi* the previous year, the yield of cotton is maintained. Table VI is taken from the Qurashîya records by permission of the State Domains Administration.

Table VI.—PERCENTAGE AREA OF LAND *SHARAQI*, PERCENTAGE OF LAND UNDER COTTON, AND THE AVERAGE YIELD OF COTTON PER FEDDAN AT QURASHIYA.

Year.	Percentage Area of Land *Sharâqi*.	Percentage Area under Cotton.	Average Yield per Feddân.
			Qantârs.
1905	61·5	38·0	4·54
1906	59·5	39·0	5·05
1907	58·7	38·5	4·41
1908	58·3	38·0	4·54
1909	58·7	36·0	3·24
1910	58·6	35·0	4·77
1911	52·0	39·5	4·68
1912	49·0	45·5	4·82
1913	51·3	43·0	5·65
1914	49·3	48·0	4·48
1915	81·9	17·0	4·59
1916	64·1	35·5	4·20
1917	63·2	35·0	4·36
1918	70·2	26·0	3·96
1919	70·7	26·0	5·22
1920	65·0	35·0	4·44
1921	64·1	35·0	4·26

Table VI shows that generally about 60 per cent of the cultivated land at Qurashîya is *sharâqi* each year. The cotton area has never exceeded 48 per cent of the cultivated land and is on the average only 36 per cent. It has, therefore, been possible to sow cotton every year on land that had been subject to the effect of the *sharâqi* period immediately prior to the sowing. The yield has been almost constant throughout the period, being subject to seasonal variations due to insects and climatic factors. The average yield for the period 1905–1921 is 4·42 qantârs per feddân, a yield which is almost identical with that of 1905 at the beginning of the period. The maize area at Qurashîya has not been sufficiently large to warrant a statement as to its effect on the yield of cotton. It will be seen from the above that, providing the *sharâqi* area is such that cotton is always sown on land that has been *sharâqi*, no decline in yield takes place.

As a result of this investigation, the following modifications in agricultural practice have been suggested as a means of utilizing the effect of the *sharâqi* period to its maximum.

(1) The intensification of the *sharâqi* effect by the thorough tillage of *sharâqi* land.

(2) The postponement of the sowing date of maize until about August 21.

These suggestions present certain difficulties, especially to the small holder, before they can be put into operation. These difficulties and the means by which they may be overcome are discussed in the bulletin now in the press.

(2) THE APPLICATION OF THE PROTOZOAN THEORY OF PARTIAL STERILIZATION TO EGYPTIAM SOILS DURING THE *SHARAQI* PERIOD.

Simultaneously with the investigation of the soil temperatures of the *sharâqi* period, an investigation of the effect of the *sharâqi* period upon the protozoan content of the soil was also undertaken with the object of establishing a further relationship of this period to the process of partial sterilization.

A preliminary examination showed that, in cropped land, protozoa were present in large variety. Protozoa were also proved to be present in the Nile, the main canal, and in the field canal delivering water direct to the land.

For the investigation of the effect of the *sharâqi* period upon soil protozoa, a plot of land, which had been normally cropped, was selected at Gîza. After the removal of the wheat crop, the land was divided into strips by means of string stretched across the plot. The necessary samples were always taken at points along the strings to a depth of 15 centimetres.

As the moisture content of the soil at the beginning of the investigation was 3·9 per cent, it seemed probable that the protozoa would be present in the form of cysts. An examination of the soil by the method devised by Cutler* showed that the number of active protozoa in the soil was small

* A Method for estimating the Number of Active Protozoa in the Soil. W. W. Cutler, Journal of Agric. Science, Vol. II, Part 2, 1920.

compared with the total number of protozoa present. For the purpose of this investigation, therefore, only total counts of protozoa were made. The dilution method of determining the number of protozoa was adopted. The soil was sampled daily at the beginning of the period, but as no great day-to-day variation in protozoan content was noticed, weekly samples were afterwards taken.

It was found that, though there was a slight reduction in the number of ciliates and amœbæ present in the soil, the protozoan factor was not extinguished to a depth of 15 centimetres by the heat effect of the *sharâqi* period. The temperature records of the *sharâqi* period show that the soil temperatures are high enough to effect a complete suppression of the detrimental factor to a depth of 5 centimetres and a temporary suppression in a further 13 centimetres. It appears, therefore, that, either—

(1) Partial sterilization did not take place under field conditions owing to the operation of some factor or factors to prevent it, or

(2) If partial sterilization did take place, the protozoan theory cannot account for the facts on a field scale.

In order to determine which of the above alternatives was correct, further investigations of soil protozoa were undertaken in the laboratory.

As there appeared to be no definite indication of suppression of the protozoa during the investigation of the *sharâqi* effect, a determination of the thermal death points of the protozoa in the soil of the *sharâqi* plot was made in the laboratory.

Soil from the *sharâqi* plot was spread out in a thin layer on the shelf of a water-jacketed oven, and a thermometer was inserted through the door of the oven so that the bulb of the thermometer was buried in the soil. The *sharâqi* soil was then heated for definite periods and to definite temperatures as indicated by the thermometer in the soil. Samples of the soil were taken periodically, suitable dilutions being made in sterile water, and the suspension plated on nutrient agar. It was found that little suppression of the protozoa took place until a temperature of 70° C. was reached. At 70° C. the ciliates no longer persisted. The amœbæ and flagellates were not extinguished until the soil had been heated to a temperature of 81·5° C. In this connection, the results of Cunningham and Löhnis are interesting. The thermal death points of protozoa, as determined by them, are shown in the following table.

TABLE VII.—THERMAL DEATH POINTS OF PROTOZOA.
(CUNNINGHAM AND LOHNIS.)

Types.	Death Points.	
	Active Forms.	Cysts.
Ciliates	54° C.	72° C.
Amœbæ	48° C.	72° C.
Flagellates	44° C.	70–72° C.

From Table VII, it appears that all active forms of protozoa can be killed by heating them to a temperature of 54° C., but that, if the protozoa are in the cyst forms, considerably higher temperatures are necessary before death takes place. It will be noted that the thermal death point of the ciliate cysts, as determined in this laboratory, is the same as that determined by Cunningham and Löhnis, but higher temperatures are necessary here for the extinction of amœbæ and flagellates than their results indicate. As the soil used in the experiments here on the thermal death points was practically air-dry (3·7 per cent moisture content) and as the protozoa persisted at temperatures considerably above the thermal death points of active forms, the protozoa must have been present in the cyst state at the time when the soil was removed from the field.

It appears, therefore, from the behaviour of the protozoa when *sharâqi* soil is heated in the laboratory, that under *sharâqi* conditions in Egypt, cysts and not active trophic forms of protozoa in the soil are being dealt with. *Sharâqi* land in Egypt usually follows either wheat or berseem. In either case, the moisture content of the land on the removal of the crop is low and, hence, the protozoa enter the cyst state before being subjected to the high soil temperatures of fallow land during the *sharâqi* period. Further, the thermal death points of active trophic forms are not reached beyond a depth of 8 centimetres with the present type of *sharâqi*. As the examination of the soil reveals the presence of protozoa in layers below this depth, no extinction of the protozoa can take place in the soil under *sharâqi* conditions. It appears, therefore, that, if the complete suppression of the protozoa is essential to partial sterilization, no partial sterilization can take place during the *sharâqi* period.

An examination of the soil after the irrigation of *sharâqi* land indicates that the conditions to which the protozoa have been subjected have had little influence upon their power of excystment when suitable conditions are again presented to them. The total number of protozoa was determined in the *sharâqi* soil before irrigation and again three days after irrigation. It was found that there was an increase in the number of amœbæ and flagellates present, the number of ciliates remaining about the same. An examination of the irrigation water showed that, although protozoa were present, the whole of the increase in the protozoan content of the soil following irrigation could not be attributed to this cause, as active forms of amœbæ were found in the soil which could not be detected in the irrigation water. It appears, therefore, that, if temporary suppression of the detrimental factor in the soil is obtained by means of the *sharâqi* period, the temporary suppression cannot be attributed to either the reduction in the number of protozoa present or to any delay in the protozoa again assuming the active trophic form under suitable moisture and temperature conditions.

As the extinction of the protozoa in the soil did not take place when the soil was heated in the laboratory to temperatures considerably above that necessary for partial sterilization, the experiments on partial sterilization detailed in Bulletin No. 25 were repeated. The results on this occasion were similar to those obtained previously and confirmed the fact that in

Egyptian soil, a factor detrimental to nitrate production is suppressed at 58° C.

The soil used in these experiments was examined qualitatively for protozoa after heating and on the occasions when determinations of nitrate were made after moistening. Ciliates and amœbæ were always present, active forms of amœbæ being sometimes detected.

The preceding experiments, taken in conjunction with those described in Bulletin No. 25, lead to the following conclusions:—

(*a*) A factor in the soil detrimental to nitrate production can be destroyed by heating the soil to 58° C.

(*b*) If the protozoa in the soil are present as cysts, the detrimental factor can be suppressed without killing the protozoa owing to the fact that cysts are capable of withstanding high temperatures.

(*c*) The protozoa in soil that has been heated to 58° C. become active trophic under suitable moisture conditions.

(*d*) The biological properties ascribed to the detrimental factor in English soils by Russell apply to the factor suppressed by heat in Egyptian soil.

The evidence so far accumulated appears to show that the detrimental factor in Egyptian soils is not the soil protozoa. The question is, however, being further investigated.

Applying the laboratory results to the effect of the *sharâqi* period, it appears that, although the soil protozoa were not suppressed, partial sterilization of the soil may still have occurred.

Appendix VII.—GLOSSARY OF ARABIC TERMS USED IN THIS REPORT.

Baladi.—Native, appertaining to the village. *Baladi* manure consists of the liquid and solid excrements of farm animals mixed with the ordinary earth which is spread on the floors of cattle sheds, stables, etc., in lieu of litter. Straw is rarely used for bedding. The solid excrement is frequently dried and used for fuel.

Bamia.—A malvaceous vegetable, *Hibiscus esculentus.*

Berseem.—Egyptian clover, *Trifolium alexandrinum.*

Fellah, pl. *fellahîn.*—Egyptian peasant.

Gamaiya.—Society. Of cotton seed, term proposed for distinguishing seed produced by the Sultania Agricultural Society.

Hukûma.—Government. Of cotton seed, term proposed for distinguishing seed produced by the Ministry of Agriculture.

Kôm.—A mound, the crumbled remains of an ancient village, used after sifting as a manure.

Koufri.—See *Kûfri.*

Kûfri.—Manure obtained by sifting the crumbled remains of ancient villages.

Mabrûma is seed cotton composed of locks in which the lint has failed to develop properly. This may be due to the effect of insect of fungous pests or to other causes. Such locks are frequently picked out by hand before the bulk of cotton is ginned.

Moawen, pl. *moawenîn.*—A junior official in the Egyptian Government service.

Nîli.—Nile (adj.) Of crops, those which are grown while the river is in flood on land which has been fallow during May, June, and July.

Sabakh.—Manure.

Sarraf.—Tax-collector.

Scarto is ginned cotton of a very low grade derived from the following sources :—

(1) From locks of *mabrûma* cotton picked out from the main bulk of the seed cotton and ginned separately.

(2) From locks of *mabrûma* cotton separated out by the action of the ordinary Platt roller gin and ginned separately.

(3) From the reginning of cotton seed for the purpose of cleaning off the portions of fibre which still remain adherent.

Sébakh.—See *Sabakh.*

Sêfi.—Summer (adj.). Of crops, those which are in the ground during May, June, and July before the arrival of the flood.

Sharâqi.—Land left without water during low Nile, *i.e.* from May to July inclusive.

Taftîsh.—An inspectorate, estate.

Taqâwi.—Seed used for sowing.

Tîl.—Hemp, *Hibiscus cannabinus.*

Tugâri.—Commercial. Of cotton seed, that which is sold to the mills for oil-extraction.

Fig. XX شكل ٢٠

APPENDIX IX الملحق ٩

Reproduced by the Survey of Egypt 23/454.

Foldout reduced to 70 % and rotated 90° to fit on page.